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Proceedings of

The Second International Workshop on Conservation and Utilisation of Commercial Insects

28th November to 1st December 1999

Sericulture and Apiculture Prospects for the New Millennium

Edited by: S.K. Raina, B. Nyagode, K. Adolkar, E. Kioko and S. W. Mwanycky

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The female sign on the cover signifies the promotion of women (♀) in apiculture and sericulture microenterprises in Africa

Cover design by David Kimbu, ICIPE

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Held at the International Centre of Insect Physiology and Ecology (ICIPE) Headquarters, Duduville, Nairobi, Kenya
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Citation: Raina S.K., Nyagode B., Kioko E., Adolkar V. and Mwanycky S.W., Eds (2000) Sericulture and Apiculture: Prospects for the New Millennium. ICIPE Science Press, Nairobi, Kenya

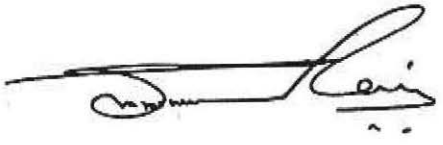
First published in 2000
ISBN: 92 9064 133 9

Published by ICIPE Science Press
P.O. Box 72913, Nairobi, Kenya
Email: isp@icipe.org
Tel. 254-02-802501/861882/3

Typeset by International Journals Centre,
P.O. Box 46829, Nairobi, Kenya

ACKNOWLEDGEMENTS

We are grateful to the International Fund for Agricultural Development (IFAD) for the major research grant to ICIPE in support of the Second International Workshop on the Conservation and Utilisation of Commercial Insects. The African farmers had the opportunity to enhance their knowledge base by interacting with the globally renowned sericulture and apiculture experts, through this forum. Farmers exchanged their ideas and constraints. The professional and moral support offered by Dr Hans R. Herren, ICIPE Director General, is gratefully acknowledged. Heads of all departments and programmes were a great source of inspiration in the successful organisation of the Workshop. My personal thanks to the Workshop Committee and my technical staff of apiculture and sericulture for contributing their best individually and collectively in making the Workshop a success. Special mention to my staff Harrison Muiru, David Kimbu, Jael Lumumba, Dickens Ogolla and my Secretary, Rose Onyango, for tirelessly working on the Proceedings of the Workshop. To all of you, I say thank you.



Suresh Kumar Raina
Programme Leader
Commercial Insects

FOREWORD

Sericulture and apiculture are two activities with great potential for increasing income in African rural areas. Additional income, from non traditional farming activities, is necessary to support sustainable development through empowerment of the people living close to what is defined, the poverty line, getting about US$1 a day. New income sources, which do not compete for prime land and labour resources, represent a new opportunity to provide the necessary extra income. It is also important that such income generating activities, requiring small investments, are easy to implement and have a good marketing outlook, to ensure that whatever capital and training investments are made, will show good returns.

ICIPE has over the last 4 years promoted the development of both sericulture and apiculture with a difference. The difference from earlier attempts in Africa to develop these activities, is that it now rests on solid scientific and capacity building bases, established in Africa, near the users. ICIPE has a mandate in promoting insect science for development. Taking this mandate to its full length, the Centrre has taken the initiative to create a research capacity and institution building programme within its Nairobi Headquarters, where know-how in insect science and modern facilities are available for such an endeavour.

The Second International Workshop on the Conservation and Utilisation of Commercial Insects held at ICIPE shows the commitment of the Centre to promote science-based apiculture and sericulture in Africa. The topics covered in this workshop ranged through the full spectrum of activities, from the production through the marketing. This is key to a successful implementation of sericulture and apiculture projects at national and regional levels, as the marketing is often left open and the producers exposed to exploitation. It is part of ICIPE's philosophy, to insure that the producers receive a fair share for their hard work, and investments made from their meagre resources. It is also ICIPE's philosophy to insure that there is a sound marketing system, to allow for the products to find their way to the best markets. These concepts are not mutually exclusive, but need to be managed carefully from an early stage.

The development of apiculture and sericulture has added benefits for the environment. Bees as pollinators contribute immensely to agricultural production and the reproduction of plants. Over 60 % of the plants require pollinators for reproduction, and so do 30 % of the food crops, in particular vegetables and fruits. Utilisation of biodiversity will lead to its conservation, and this is what is being promoted with the utilisation of wild silkmoth, endemic to East and Southern Africa. The utilisation of this "natural resource" in a sustainable way is being developed through research. It will not only allow for added income, but for the protection of the wild lands.

I would like to thank the participants to this workshop for their valuable input. I would also like to thank IFAD, for its support for the ICIPE sericulture and apiculture programmes and for this workshop. I have, no doubt, that sericulture and apiculture initiatives will contribute greatly to sustainable development, empowering rural populations, and in particular women. The extra income will help in financing better health care and education, improve nutrition, as well as increasing the potential for input purchases for on- and off-farm activities.

Hans R. Herren,
Director General
ICIPE

TABLE OF CONTENTS

SESSION I

WILD AND MULBERRY SILK FARMING IMPLEMENTATION STRATEGIES

1. ICIPE'S GROUNDWORK IN BUILDING AFRICAN COMMERCIAL INSECTS FARMING INDUSTRIES FOR THE NEW MILLENNIUM

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Background

As population growth strains the world's forests and agricultural lands, the adaptation of research and extension services to meet the needs of farmers whilst conserving the environment, is becoming increasingly relevant. In apiculture and sericulture, there is a need to develop innovative technologies, which will meet these needs.

Apiculture (honeybeekeeping) and **sericulture** (silkworm rearing) can be undertaken as a rural micro-enterprise initiative by resource-poor farming communities. These initiatives can be integrated with the community's routine farming activities, but are particularly attractive options for rural off-farm employment and for income generation in harsh agro-ecosystems where food production is marginal and the risk of crop failure is high. Farming systems based on these practices conserve natural resources, since resource management is an intrinsic component of the production technology.

Beekeeping is practised throughout Africa. However, the technology used by small holders is generally very basic and results in extremely low yields, poor quality of products and often destruction of the colonies. It is also a potentially hazardous activity. However, apiculture cannot only generate income, but can aid nutrition and lead to an increase in the yields of many tropical crops through enhanced pollination.

Sericulture has a long history in Africa, but development has been constrained, because of the lack of facilities for the commercial production of eggs and the limited attention paid to the processing requirements of cocoons. Cocoon

production is a normal farming activity, and is only part of a chain of activities which needs to be completed to produce high value outputs. The habitat and species loss of the wild silkmoth in Africa is immense, whilst the potential for harvesting wild silk is not widely realised.

To investigate the potential for apiculture and sericulture to contribute to the improvement of the livelihoods of resource poor farmers and rural dwellers, a Technical Advisory Grant(TAG) was approved in 1995 to support the Commercial Insects Programme of the International Centre of Insect Physiology and Ecology (ICIPE) for applied research and technology development (this is referred to as the Phase I TAG). A further Phase II TAG is now being sought to continue and extend this programme.

I. Progress With Phase I

In Phase I, lasting 1996 -1998, the intention was that ICIPE would develop innovative sericulture and apiculture technologies and training modules for use by small-scale land users. The project focused on three themes:

(a) improved practices for beekeeping to increase honey production and generate additional hive products
(b) wild silkmoth conservation and utilisation
(c) domesticated silkworm rearing for silk-based products.

The outputs were intended to be of particular relevance to women's groups and to emphasise the conservation and utilisation of natural resources for future sustainability.

Apiculture

Improved technologies for traditional beekeepers have been developed, concentrating on sustainable production of higher quality products. This included identifying the swarming and migration patterns of the bee races in Kenya, in order to understand the potential of local races and their characteristics. The result of this has been that ICIPE was able to demonstrate that different bee races are more appropriate under certain conditions of climate and altitude, and that certain races are applicable where pollination is a priority, whilst others are applicable for the production of honey and other hive products. In addition, the floral calendars of various districts have been studied and methods of African honeybee queen rearing for controlled colony multiplication and upgrading

have been devised[1]. Recommendations are now available in Kenya for bee races suitable for local conditions to allow beekeeping to become more productive.

The traditional African practice of harvesting involves the destruction of the colony and the contamination of the honeycombs: ICIPE has introduced more modern box hives, which allow continuous harvesting without damage or disturbance to the broods. This has permitted a traditional male occupation to be practised by women, because the hives are more conveniently located on low stands (rather than being hung in trees). Increases in honey and wax harvest are of the order of 50 -70% compared to traditional hives.

A post-harvest facility has been established at ICIPE to demonstrate manual extraction, processing and quality control of honey.

At the end of phase I TAG, ICIPE was at the stage of validating this technology with village based groups in Kenya, Uganda and Tanzania. In Kenya, groups have been assisted in Mwingi, Eldoret, Baringo and Muka Mukuu. These groups are in resource poor areas, where agricultural production potential is very low and alternative sources of income are scarce. In these circumstances, beekeeping can have a major impact on the communities[2]. The groups are at various stages of development, with the newer hives being gradually adopted (the limitation is credit), but all the groups have received training from ICIPE and some Training of Trainers(TOTs[3]) have been placed with the groups. The total number of farmers who have received training through ICIPE is about 4,500 in Kenya and 1,500 from other areas; the total membership of the demonstration groups is not recorded, but is thought to be about 600. By the end of 2000, it is anticipated that processing facilities will be supplied to all four groups in Kenya, so that they will become largely self-sufficient. The higher quality outputs are finding ready markets in local outlets, assisted by ICIPE. The groups are growing rapidly and new groups are being formed locally.

The situation in Tanzania (Arusha) and Uganda (Hoima and Kabale) is similar to Kenya, but group development lags by about 1 year. In Hoima, the apiculture demonstration has been established on the farm of a member of one of the IFAD farmer groups. Other donors are assisting in various ways — especially through the UNDP trickle up programme (described later), for which ICIPE has been the intermediary. ICIPE's concern in Phase II is to continue some of the demonstration aspects of the apiculture programme and to pass over the group development role to other intermediaries.

Domesticated silkworms

The rationale for sericulture in phase I was to develop and introduce technology appropriate to local conditions, in an attempt to produce an alternative income activity. Mulberry, which is used for rearing silkworms, is drought resistant and is an ideal crop in the arid and semi-arid lands (ASAL) of Kenya, which are the focus for IFAD development strategy in Kenya. Mulberry is also a good livestock feed. ICIPE has screened various cultivars of mulberry to suit local conditions and developed silkworm races (now called ICIPE1 and ICIPE2), which are appropriate to many semi-arid areas throughout East Africa. A technology package for small scale silkworm rearing is now available, including disease control measures. ICIPE has also established a post harvest facility at its headquarters in Nairobi for testing the strength of raw silk and demonstrating the techniques of unreeling the cocoons and processing the filaments to the weaving stage. This is partly being done using manual methods applicable to cottage industries. There is a tradition of cotton weaving in western Kenya, which uses similar practices.

Sericulture demonstration groups have been established in Naro Moru, Laikipia, Nanyuki, Machakos, Othoro and Bondo. The membership of these groups amounts to about 350. The groups in Laikipia and Naro Moru (which are in the IFAD-funded project area for Nyeri Phase II and Phase I, respectively), were established with assistance from a Nairobi-based NGO and are supported by GOK staff — all have received training from ICIPE. The group in Bondo is in the IFAD/BSF Funded Farmers Group and Community Services Project Area: the group members are unemployed youth, whilst many of their parents are members of the IFAD groups. Long-term training of TOTs has been part of this training; all the groups are producing cocoons. At present, these cocoons are sent to ICIPE for processing (in some instances the group members undertake the reeling at ICIPE). Reeling machines will shortly be located in production centres in Western and Central Kenya (and have already been provided to Uganda).

The outlets for raw and processed silk have been identified in central Kenya; local markets already exist in East and West Africa for silk to be used in religious and traditional clothing. In Uganda, ICIPE staff have established a reeling facility at the government sericulture centre at Kawanda and have assisted with linking the producers to an export market (for raw silk). Sericulture activities in Uganda are more advanced than in Kenya as cocoon production was promoted by the Japanese in the 1970s and recently received some support from the EU.

In one District (Bushenyi) in western Uganda, there are extensive mulberry plantations and a sericulture sub-centre is being established (by MAAIF). This technology package is proving very popular and demand will shortly outstrip the capacity of ICIPE. Alternative mechanisms for promoting the industry are being sought.

Wild silkworms

In phase I, ICIPE was also required to evaluate the need for conservation and the potential for utilisation of wild silk. This was to minimize the damage to the ecology through the destruction of the natural habitat of the silkworms for charcoal production. ICIPE has studied the population dynamics of wild silkmoths in selected locations, and the mortality factors affecting production in the wild. From this, mechanisms have been devised to protect the species, and also to harvest the silk cocoons, providing the possibility of an alternative income source. The harvesting of wild silkmoths compliments honey production as the same trees are used as a source of pollen and nectar by the bees. The silkmoths also tend to increase flowering by eating a proportion of the leaves. The method of unwinding such silk using a specially adapted reeling machine has been demonstrated, giving the possibility of a high quality product.

Product marketing

In order to develop the marketing strategy for the products of commercial insects, the commercial insects programme has published a book on the *"Economics of Apiculture and Sericulture Modules"* based on the research data collected at ICIPE . Activities under the TAG include the validation of the technology with farmer groups, as described earlier. This has also necessitated that ICIPE assess the financial viability of the activities and explore the market outlets. So far, marketing strategies have been devised and modules constructed to show profitability at various levels of production. These have indicated that both apiculture and sericulture, potentially offer very attractive returns to small scale operators, but require validation by the collection of production data from the demonstration groups. Actual market outlets proposed are available in East Africa. In the case of sericulture, the main output is raw silk; this would be produced either directly by the farmer groups, or by separate unreeling facilities. At the moment, unreeling machines are located in ICIPE and Kawanda; the first manual machine for farmer use will be supplied in 2000 and will be located in the sericulture sub-centre at Bushenyi in Uganda.

Capacity building

During the course of phase I, the Commercial Insects Programme has developed at ICIPE and there are now 7 professional staff. Each staff member has a specific research area, and is also required to conduct training courses. One day training for farmers is held twice a month and each year there are longer (2-month) courses for group representatives. Local operational capacity has been created, but the technical backstopping is still rather weak, and depends overly on ICIPE core staff.

Linkages with IFAD Projects

ICIPE demonstration groups at three locations have coincided with IFAD-supported project activities, as follows:

(a) All of the Naro Moru sericulture group members are also members of IFAD supported groups for small-scale irrigation, formed under the Nyeri Dry Area Smallholders and Community Services Project
(b) In Bondo District in Siaya, members of three self help groups, which are producing silk and hive products are members of IFAD supported groups formed under the Farmers Group and Community Services Project;
(c) In Hoima, the Kihambye women's group, which is a demonstration group for sericulture and apiculture products, consists entirely of members who also belong to groups formed under the Hoima–Kabaale Agricultural Development and Community Support Project.

Technology dissemination

As well as the local developments in East Africa already described, two international workshops were held to demonstrate the newer technologies; these attracted a number of eminent sericulture, apiculture and marketing specialists. As a result, ICIPE staff have been asked to introduce the technology developed under the TAG in Ghana, Nigeria, Senegal, Cote D'Ivoire, Zambia, Zimbabwe, Ethiopia, Eriteria, Sudan, Namibia, Madagascar, Libya, Tunisia, Algeria and Morocco. A network of interested partners has been established called Sericulture Apiculture Research and Development Network (SARDNET). So far, training has been provided at ICIPE in Nairobi to representatives (all from governments) from these countries; further developments are in process, awaiting funding.

Co-financing

1. UNDP Trickle Up Programme (TUP)

A partnership has been created between TUP and the Commercial Insects Programme in which farmers may expand their apiculture and sericulture enterprises through training from ICIPE and conditional grants of US$ 100 per farmer from TUP. Together, ICIPE and TUP assist farmers to increase the opportunities for self-employment and help. The grants are channeled through ICIPE, which provides the materials (such as gloves, veils, rearing racks, hives, etc) to the farmers, according to their business plans, which are submitted before the grant is approved. To date 100 farmers have benefited from these TUP grants including:

(a) The Radat Beekeepers Group in Baringo
(b) The Mathyakani Beekeepers Group in Mwingi
(c) Narumoru (Nyeri) and Mutirithia(Laikipia) self help sericulture farmers.

2. The US Ambassador's Self-Help Fund

This fund provides small grants to registered self help groups for women's income generating projects. Groups trained at ICIPE under the Commercial Insects Programme are eligible for such funds: grants range from US$ 1- 10,000 and are not paid directly to the group, but to the suppliers of equipment and materials. Two groups have received US$ 5,000 each, and two have been sanctioned, as follows:

(a) Ditime Apiculture Self Help Group, from Mganga Village, Wundanyi
(b) Kamiro Women Group (sericulture) from Othoro Village, Rachuonyo
(c) Sambut Self Help Group, Eldoret
(d) Nguni Self Help Group,Mwingi (pipeline)

In addition, potential co-financing, which could expand the activities started under the TAG are being proposed. ICIPE has been invited to submit proposals to USAID under their micro-enterprise development programme to develop both the apiculture and sericulture industries of East Africa. In addition, FAO has requested that proposals be prepared for TCP grants for the establishment of training and demonstration centres (similar to the ICIPE facilities) in five East and West African countries. A regional grant from FAO has also been proposed in order to establish a grainage (silkworm egg production facilities),

which is required to regularly supply farmers and maintain cocoon quality in Africa. Finally, UNDP/GEF (block C level) has requested a proposal for cross-border silkmoth conservation to preserve bio-diversity, covering Zambia, Uganda, Tanzania and Kenya.

II. Rationale and Objectives for a Second Phase

Rationale

Much has been achieved in phase I of the TAG, and activities have continued to expand. However, not all the research or demonstration aspects have as yet been completed, and although groups have begun commercial production, there are still questions relating to the financial viability of the technology. Nevertheless, the TAG has demonstrated that income generation through small scale apiculture and sericulture is not only possible, but has the potential to become an important source of income for the poorest farmers in the most difficult circumstances. ICIPE's demonstrated strengths lie in the development of technology through research and capacity building. This has been shown effectively in phase I.

The rationale for further support by means of a second TAG is that, the activities which have been started, need more time to be fully realised, and to become sustainable. In addition, the Commercial Insects Programme has become pivotal as a catalyst for the development of these activities, both in East and West Africa. The additional potential donor funding currently being sought would allow the dissemination of the technology and the commercialisation of the apiculture and sericulture industries, but at this stage this needs the consolidation, which IFAD funding of the core activities of the Commercial Insects Programme has allowed. The major benefits are close to realisation.

The Commercial Insects Programme links the developments of sericulture and apiculture. However farmers may undertake these activities separately in resource poor areas, where there is considerable synergy in undertaking both activities. In practice, the demonstration groups in Kenya have chosen to undertake both activities. Their main constraints are that agricultural production is very low, unreliable and produces almost no opportunities for cash incomes. Both apiculture and sericulture are agro-based cottage industries which can fit into the farming calendar, but are relatively independent of climatic conditions. In addition, the skills required can be easily taught. Apiculture, in addition to honey production is an aid to crop pollination, and the periods of honey

collection occur during the dry season when crop harvest is complete and the farmers have little demand on their time. Sericulture can provide income throughout the year, but the production periods can be conveniently geared to the farming calendar. In addition, ICIPE has found that the promotion of wild silk, results in the protection of the natural habitat, which then leads to more flowering, and hence honey production.

Objectives

In order to complete, validate and extend the technologies developed in phase I of the TAG, the following four objectives are proposed for Phase II:

1. To continue research activities in apiculture and sericulture, building on the achievements of phase I, in order to further develop and validate the technology packages developed so far. Specifically there is a need:

   (a) To develop silkmoth grainages and honeybee line breeding facilities adapted to local conditions.
   (b) To undertake further data collection and analysis required to address the location-specific production and adoption issues, for both apiculture and sericulture.
   (c) To assess pollination services provided by bees, in order to estimate impacts on crop production and the environment.
   (d) To define product quality requirements of the markets.

2. To provide technical backstopping in sericulture and apiculture, both during design and implementation, to organisations involved in the promotion of rural micro-enterprises for income generation. This would particularly apply to NARS and also to support NGOs and others involved in the promotion of rural development.

3. To provide training for farmers and farmers groups in appropriate technology for apiculture and sericulture, both at ICIPE headquarters and also on-site. Training programmes would include TOTs for local groups and NGO and government personnel. Also, to increase scientific capacity by means of graduate and post-graduate training and scholarships, in order to provide a solid scientific base for practitioners throughout Africa. To further promote the dissemination of the technologies developed through SARDNET.

4. To continue the support for the demonstration groups from phase I, including development of their marketing strategies and identification of marketing constraints. This would include the identification of relevant market linkages with private traders.

III. Key Programme Activities

Output 1: Validation of production modules

Apiculture and sericulture technologies used in the field were validated in various geographic locations.

Activities: ICIPE's **sericulture** and **apiculture** production modules will continue to be verified under field conditions and their validity and sustainability will be tested for adoption by local groups. Variables such as cultural patterns, financial resources and agro-ecosystem factors will be considered when implementing technologies in the field. Activities will be confined to the groups already contacted in Kenya, Uganda and Tanzania, but assistance will also be offered to NARS and NGOs adopting the technology to field test and adopt it under their own local conditions.

Output 2: Establish grainages for the production of silkmoth eggs

ICIPE has built a mini-grainage for the local production and supply of silkworm eggs, but this is only sufficient for a few local groups. Attempts to establish domesticated silkworm farming have previously failed, because there are no local grainages for the production and regular supply of pure quality eggs for commercial rearing. Outside suppliers have proved erratic, the arrival of eggs has not always coincided with periods of mulberry bloom, and diseases have been imported, resulting in rearing failures. A grainage requires carefully controlled conditions.

Activities: ICIPE will establish 2 grainages, one at its Mbita Point Field Station in Western Kenya and the other at the Sericulture Development Centre in Uganda. In both sites there is sufficient land for mulberry production and adequate laboratory facilities. The vital reason for having two egg or seed production sites (grainage) is that maintenance of pure lines of silkworm races is a highly delicate, laborious and time consuming job, which cannot be handled by farmer groups. In all the silkworm producing countries, it is organized by the NARS or an International Organisation. Two breeding sites will therefore

minimise the risks of losing races due to unforeseen technical or political problems; they will also become training bases and will be self-sustaining through the sale of eggs. The TAG funding will allow for partial equipping of the laboratories to maintain the quality required (the remaining funding comes under the regional FAO/TCP). This is further described in Annex 3.

Output 3: Honeybee line-breeding

Establish honeybee line-breeding facilities at ICIPE.

Activities: Test honeybee races in the field and select the most productive races for commercial application. The honeybee line breeding programme will be employed, to produce breeds of bees for specific traits. Queen rearing and colony multiplication techniques will be used to produce high quality bees for optimal product generation. The major issues to be resolved are increased honey production, aggressiveness, absconding, resistance to brood diseases, effectiveness in pollination of crops and high potential rate of egg laying by the queen.

This requires that several queens be reared at the same time, in order to take account of the colony conditions required at each stage of development. Apart from genetic considerations, there are other factors crucial to the quality of the queen produced. Each queen passes through five environments during rearing: (i) the "genetic" colony in which the fertilized eggs are laid; (ii) the cell starter colony; (iii) the finishing colony; (iv) the incubation of the queen cell; and (v) the mating colony. Drones from specific colonies are selected to father the next generation of workers: these come from drone producing colonies. The mating apiary (with the drone colonies), must be isolated from all other hives and from any colonies nesting wild bees, by a distance greater than the flight range of the queen plus the drones from outside. A commonly used method is to select an island. Another method of mating is by artificial insemination, which guarantees the identity of the drones that fertilize the queen. Queen banks will be developed for the transport of young mated queen rearers to the beekeeper, who could also store the queens received in the "bank" for a short time during the active season.

Output 4: Location specific issues

Geographic constraints to the adaptation and adoption of apiculture and sericulture technologies are identified and resolved.

Activities: The disease and pest problems in various geographic locations will be identified. Cultural and traditional influences in technology adoption will be determined. The constraints to successful product development in different locations will be resolved and quality control practices to comply with international standards, will be implemented.

Output 5: Pollination services

The extent of the increase in production of field crops due to adequate pollination will be assessed, and information disseminated to farmers.

Activities: Assess the contribution of bee species to crop pollination and develop strategies to conserve key pollinators. Many commercially important crops require cross pollination to set seed. Such plants utilise the services of various agents, including insects, to transfer pollen from anthers to stigmas. The "reward" these insect pollinators receive for this service is food, particularly nectar and pollen. This reward is often "advertised" through floral markers (or cues), such as colour, odour and form. Despite such markers and rewards, the food crop that requires pollination (i.e. the target crop) is often less attractive, or rewarding than other plants flowering in the same area. Bees are known to have preference for certain plants. Insect pollinators frequently desert the target crop when pollination is urgently required and there is a consequent loss in yield. Honeybees locate flowers by sight and odour. They respond to visual nectar guides and the colour of petals in the ultraviolet, blue-green and yellow spectral range. After visually locating flowers and approaching them, bees respond to floral odours that include olfactory nectar guides as well as pollen odours. Aroma may be used by bees as a label to locate and mark flowers which yield a reward of nectar or pollen

The assumption that when bees are foraging on a crop are also pollinating it sufficiently, is not necessarily valid. Therefore, information about the behaviour of bees on flowers and how this affects pollination efficiency and crop yields is essential; unfortunately, few studies to date include such information. The solution to this problem would also demonstrate the value of bees in increasing food production. The project would therefore explore the role of floral volatiles of specific cucurbitaceae species (pumpkin and cucumber) in their attraction to the foraging worker honeybee, *Apis mellifera* , and to investigate the use of a volatile blend to enhance pollination and therefore increase yield. This technology once developed, will be applicable to other crops.

Output 6: Project design and implementation

On the basis of technologies developed in sericulture and apiculture during Phase I of the project, ICIPE will facilitate the transfer of information to NARS, farmers, government extension workers and local NGOs, through intensive courses and demonstrations. ICIPE will implement this activity using a demand-driven approach, which is directly related to the needs of the rural poor and their environment. In this manner a two-way transfer of technology — from the laboratory to the farmer, and from the farmer to the scientist — will be created. An effective technology transfer system would assist in fulfilling research and extension goals, identify the organisational and institutional arrangements necessary to achieve these goals and improve linkages between research, extension and farmers.

Activities: Establish facilities for demonstrating improved apiculture and sericulture practices in selected African countries. Collaborate with NARS and NGOs to transfer on-site technology and launch applied field training programmes.

Output 7: Capacity building

Capacity of local farmers and research staff improved.

Activities: Undertake training courses for beekeepers, NGOs and government officers. Arrange for the strengthening of the scientific staff to undertake local/ regional research and backstop the adoption of the technology packages. Arrange for the dissemination of technology, developed through the promotion of SARDNET, by undertaking two international workshops and training NARS as appropriate.

Output 8: Marketing strategy

Propose and demonstrate a marketing strategy for apiculture and sericulture based products

Activities: Identify problems in the marketing of apiculture and sericulture products and develop a marketing strategy for beekeepers and silkworm farmers. This would include the identification of relevant market linkages with private traders.

The development of a strategy for honey and beehive products and silk and silk based products, depends on the specific circumstances of the different regions, and needs interactive communications between partners at each stage of production, processing and distribution. This will take place in three phases: (i) research and investigations; (ii) coordination and coaching of stakeholders; and (iii) monitoring and evaluation. The research will examine the processing, packaging and marketing of apiculture and sericulture products, and develop a framework which describes the performance of the partners. Quality, pricing and placement, are the most important factors for the development of the marketing strategy: ICIPE will act as a catalyst in these linkages.

IV. Implementation, Monitoring and Supervision

ICIPE will serve as the implementing agency for the project, but will work closely with IFAD to ensure strategic objectives are achieved. ICIPE's role will be limited to the objectives described above, and a clear demarcation will be made in phase II between the research and dissemination activities and the commercial development of farmer groups. This will include withdrawal of direct support for the existing demonstration groups; for example ICIPE will no longer buy or sell honey or cocoons on behalf of the farmers.

The project will be run by a principal scientist who will act as the leader responsible for all aspects of implementation of the project. It is expected that the current project leader will continue with Phase II. The project leader will answer to ICIPE's Head of the Department of Population Ecology and Ecosystem Sciences. The project will disseminate sustainable working and training modules compiled during Phase I.

The Project Team (PT) will establish a Technical Development Team (TDT) with the participation of CPMs from PF and PA in order to: (i) further develop specific activities and links with the loan portfolio in the participating countries; (ii) endorse the final design of the programme and finalise roles and responsibilities of all actors to be involved in implementation; and (iii) monitor and supervise the TAG via annual field supervision missions. Output materials will be made available to interested institutions and individuals from ICIPE Headquarters in Nairobi, Kenya, or IFAD Headquarters in Rome, Italy.

Returns to smallholders

Apiculture practices will generate revenue in a number of ways. Quality honey and wax have ready and established markets. The wax has commercial and industrial value, especially in the cosmetic and candle industries. The sale of colonies developed through queen rearing will provide additional income. Other high value products, such as royal jelly, bee venom, propolis and pollen, are in high demand by pharmaceutical companies and may be produced at a later date. During nectar and pollen gathering, honeybees effect pollination and improve the quality and quantity of crops, a benefit enjoyed by the whole community, as well as the beekeeper. This benefit will be investigated and assessed for various crops.

Sericulture produces cocoons or raw silk and will provide a regular income (the cycle may be as little as 30-40 days). As well as feeding silkworms, mulberry leaves can serve as animal feed and provide fruit. After reeling, silkworm pupae can be used as fish or chicken feed. Economic values will be enhanced by quality control procedures for sericulture and apiculture products. A quality control laboratory will test honey, hive products, cocoons, raw silk, twisted yarn and silk cloth, to ensure the products meet industry standards.

Apiculture and sericulture require the services of local traders and craftsmen, to make beehives and rearing frames or to repair reeling equipment. Both apiculture and sericulture help to promote cottage industries (for example in processing of outputs) and enhance industrial technologies in the rural sector: they can also create off-farm employment. Both technologies are particularly appropriate for women groups.

Environmental impact

The promotion of beekeeping and wild and domesticated silk production, will have positive impact on the environment, as by definition, these activities require the conservation and improved management of natural resources.

Other Benefits

Training modules will be further developed at ICIPE and will have two major components: one to explain apiculture and sericulture procedures and the other to describe training strategies. Each working module will comprise a curriculum,

description of working approach, methods and techniques, The working modules will focus on field planning, monitoring progress and evaluating the results achieved. The training portion of the modules will provide "researcher-trainers" with management plans and training materials, which will have been designed to improve the existing infrastructure and knowledge, attitudes and skills, needed to manage apiculture and sericulture in a sustainable manner. These modules will be shared with the organisations charged with the promotion of the technologies in cooperating countries.

ICIPE will collaborate with national and international agricultural livestock research organisations in Africa to transfer apiculture and sericulture technologies to smallholders, and develop linkages for collaboration with National Agricultural Research System (NARS) and NGOs in countries in Africa. ICIPE will serve as the focal point in a network that will facilitate collaboration between the scientists of ICIPE, NARS and NGOs.

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1 When a hive becomes full, the colony divides swarms to find a new location. This results in the loss of production to the beekeeper. Controlled colony multiplication by the introduction of a new queen allows the beekeeper to continue to build production.

2 These area are also appropriate to wild silkmoth production.

3 Group members have received a 2 months course at ICIPE.

2. SERICULTURE IN ZAMBIA

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Abstract: In 1985, Small Industries Development Organisation (SIDO) introduced sericulture in Zambia. With initial funding from FAO, a pilot project was started, with eggs from Mauritius. The project was successful with the first production of mulberry silk in 1987. A lot of farmers were encouraged to go into sericulture. More donor support has been received from the Commonwealth Fund for Technical Cooperation (CFTC), which includes reeling machine and rearing equipment. The sericulture project is currently based at the National Irrigation Research Station, Mazabuka.

Despite attempts in sericulture, we are not able to attain full commercialisation of silk production and export market facilities, because of various constraints such as lack of marketing facilities of cocoons/raw silk and sufficient silkworm egg supply.

Background

One of the major policies of the Government of Zambia is to improve the living standards of small scale farmers and to enhance the utility of land in rural areas. It also involves creating of employment opportunities by establishment of small enterprises. There is a growing interest in self employment within the small business sector among the Zambians, largely because of the fact that there are no jobs available for them in the formal sector.

In this regard, Small Enterprises Development Board (SIDO) promotes the development of small scale enterprises; sericulture being one.

History of Sericulture in Zambia

Sericulture is an agro industry, with silk as the product. Silk is produced by silkworm either wild or domesticated, depending on the species. Sericulture in Zambia was introduced in 1985 after the first two officers were trained in India. After a survey was carried out to establish the availability of mulberry in Zambia, a project proposal was submitted to donor agencies. In 1986/87, a pilot project, TCP/ZAM/6656 Assistance to Sericulture production was implemented at Mazabuka in Southern Province. This project was implemented with the financial assistance of Food and Agricultural Organisation (FAO). It was during this period that silk was produced for the first time in Zambia and the first silkworm eggs were brought from Mauritius. In 1988, a Korean consultant was sent to Zambia to carry out feasibility study on sericulture and further recommendations for funding.

Following the success of the pilot project in Mazabuka, a similar one was introduced in Kasama, Northern Province, with the view to expand to other provinces. Further assistance was sought and in 1990, the project was assisted by Commonwealth Fund for Technical Cooperation (CFTC). Under this asssitance, CFTC provided a set of reeling and testing machines, some rearing equipment and sericulture experts from India. The rest of silkworm rearing equipment and a boiler was provided by Small Enterprises Development Board (SEDB).

Small Enterprises Development Board (SEDB) continued to promote the sericulture industry through awareness seminars countrywide. Many farmers got very interested and some of them planted mulberry and started producing cocoons. Some commercial farmers also ventured into sericulture. Some of them included Zambezi ranching and Galaun Farms. NGO's like Mazabuka and Monze Youth Projects started producing silk. In Choma District, a group of about 35 farmers came together with a view of setting up an outgrowers scheme. These farmers were ready to start production and one of the farmers was trained by SEDB staff and started producing silk. He was the leader of this group. Other interested parties included farmers registered with Zambia National Farmers Union in southern, central and northern provinces. They have continued to come for advice.

Egg production centre was established at Nanga. This centre is producing hybrid eggs for supplying to farmers, though at a very low quantity. Suitable mulberry varieties were under research in order to identify the best variety. Five varieties of mulberry have so far been identified in Zambia. A lot more

could still be identified, given the resources to establish a gene bank. The silk reeling machine was installed at Mount Makulu Research Station.

Current Position

Many farmers are still interested in sericulture industry. The result of the pilot project carried out in Mazabuka and Kasama indicated that the climate and soil conditions are favourable for sericulture development in Zambia. This encourages many farmers. Small Enterprises Development Board still promotes the development of the project.

SEDB's role in sericulture

Small Enterprises Development Board undertakes the following:-

(a) The running of a grainage for hybrid egg production to sell to farmers at a commercial rate. This is being undertaken at Nanga Research Station.
(b) The reeling of cocoons to raw silk on behalf of farmers at a fee. The reeling machine is already installed at Mount Makulu Research Station.
(c) The preparation of feasibility studies project profiles and business plans on sericulture, on behalf of entrepreneurs for onward transmission to prospective financiers.
(d) Undertake to coordination of the promotion and development of sericulture with other key stakeholders.
(e) To provide extension and technical services including training of farmers.
(f) To avail project staff. Currently there are three trained staff.

Government's role

Small Enterprises Development Board is running the sericulture project in conjunction with the Ministry of Agriculture Food and Fisheries. The government is therefore contributing to the project in the:

(a) provision of land at Nanga for mulberry cultivation
(b) provision of some rearing equipment
(c) building of reeling plant at Mt Makulu Research Station

Constraints of developing sericulture industry

Many farmers and other interested parties are willing to venture in sericulture, but the industry has made very little progress since it was introduced in the country. The main problems that have led to this little progress are as follows:

(a) Marketing

Farmers are worried by the market position. So far there is no definite market for either cocoons or raw silk. They are interested in knowing the price and who is to buy the product. Small Enterprises Development Board is trying to establish this market. It is in view of this that by the end of this seminar, we will have learnt from those ahead of us how to go about this problem.

(b) Transport

We are finding it very difficult to visit our farmers for continued technical assistance and delivery of silkworm eggs. This has greatly discouraged farmers and some of them have abandoned the project. Farmers want to be visited from time to time. Small Enterprises Development Board has little resources to carry out these activities.

(c) Improved Grainage

This existing grainage is operating with very little equipment. There is no cold storage facility to maintain eggs at different temperatures. This makes it very difficult to control parent eggs. The Commercial Insects Programme needs assistance in this regard.

Promotion and development of sericulture can be revamped to start exporting silk if these facilities are provided. It is our aim to export silk and earn the much needed foreign exchange in the new millenium.

Future of Sericulture

The future of sericulture in Zambia is still bright, although the prices of silk on international market has gone down. The industry is still technically and economically viable. Many farmers are still interested to visit Small Enterprises Development Board for assistance.

Sericulture can become an ideal industry, by starting as an agricultural activity capable of employing a large number of rural labour and culminating in the exportation of silk yarn manufactured with labour intensive methods at small enterprise level. Sericulture is expected to provide employment opportunities and contribute to foreign exchange earnings and in the development of cottage and small enterprises.

Small Enterprises Development Board will work with the Ministry of Agriculture for provision of infrastructure, e.g. building and land. It is also anticipated to use the services of the National Agriculture Information Services (NAIS), to promote the sericulture industry. The Board will also work with Zambia National Farmers Union, Peasant Farmers Association of Zambia, to encourage more farmers to venture in sericulture. Other notable agencies will include Manufacturers Association of Zambia (MAZ) and Zambia Association of Chambers of Commerce and Industry (ZACCI).

3. SERICULTURE DEVELOPMENT IN UGANDA — CURRENT STATUS AND PLANS FOR THE 21ST CENTURY

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Abstract: Uganda is one of the leading silk producers in Africa. Attempts to introduce sericulture in Uganda started during the first quarter of this century, but systematic development started 13 years ago. Mulberry growing and silkworm rearing are practised by farmers in all regions. A brief account of the status of the industry including current and planned activities, prospects and constraints, are illustrated in this paper.

Introduction

Uganda is one of the leading silk cocoon producers in Africa. Systematic development of the silk industry started about 13 years ago. Bivoltine silk cocoons of good quality have been produced over the last 7 years, supported by the government of Uganda and the silk sector development project funded by the European Union.

Sericulture is a new technology to the people of Uganda and has proved to be adaptable and remunerative, when compared to other non-traditional crops. Cocoon quality of acceptable international standard has been achieved. Infrastructures, which includes 22 silk development centres with equipment and mulberry gardens for young silkworm production and equipment, have been established in 16 districts. It has been practically demonstrated that a farmer can get regular income from sericulture farming throughout the year (3-9 times/year) without irrigation.

There has been an upward trend in cocoon production from 8.7 tons in 1994 to 14 tons in 1998 and the minimum standards for efficient production have been achieved by a reasonable number of farmers. Significant improvements in production have been witnessed in Central and Western regions. Farmers in the northern region have planted mulberry and successful silkworm rearing trials carried out , but activities have been limited by lack of logistical support. In the active areas, average cocoon production per box of silkworm eggs, increased from 15 kg in 1994 to 19 kg in 1998. About 21% of farmers produced more than 25 kg per box of eggs and 34% of the farmers produced 21-25 kg/ box. Productivity in excess of 25 kg/box is considered to be profitable for a sericulture enterprise. Farmers (31%) reared silkworms more than 2 times in a year. Surveys conducted in farmers' fields showed that, on average, each sericulture farmer has planted 0.5 acres of mulberry. Average cocoon yield per acre of mulberry among the best farmers, is 160 kg. The expected minimum yield is 400 kg/acre. Data on farmers who are rearing and producing silk cocoons regularly, is comparable to that of farmers in advanced sericulture countries. This indicates the possibility of improving the current situation through training, adequate extension services and better marketing of cocoons and silk products.

The Ministry of Agriculture, Animal Industry and Fisheries is taking the lead in silk development to increase farmers' production and productivity and to enable the private sector to take up commercial activities.

Constraints

The major constraint affecting sericulture production in Uganda is lack of post-harvest technologies for processing the cocoons into products that can readily find a market or be promoted in the market. It has been found difficult to export dry silk cocoons, pay the freight and insurance charges and obtain a profit on the undertaking, because cocoons are voluminous. The only reliable and sustainable way to establish a silk industry in Uganda would be for arrangements to be made to establish filatures and reel the silk locally. The other major important constraint is lack of silkworm eggs. Uganda does not produce silkworm seed and depends on other countries for imports. Originally, eggs were imported from Japan at US $ 25/box (20,000 eggs). Later on, the eggs were imported from India. Now the eggs cannot be imported, partly because of lack of funds. Although it is recommended to use only F1 hybrid eggs, trials with F2 generation eggs produced locally have been carried out, but production is also limited by lack of suitable F1 hybrids. Other major constraints include high incidence of mulberry and silkworm pests and diseases, lack of silkworm

rearing houses, equipment and disinfectants and inadequate extension services and training.

Strategies

Arrangements for introduction of post harvest technologies have been made under the ICIPE/IFAD funded project. Efforts and time will be spent on weaving and designing silk fabrics, especially typical African designs for easy marketing to tourists, export to the African region and outside markets. The project will work progressively towards commercialisation of profitable sericulture and silk production activities. A scientific and technological base for sericulture development will be created through establishment of mulberry and silkworm egg stocks for breeding and egg production. A silk products quality control and testing unit will be established. Mulberry plantations have been established at the National Sericulture Development Centre based at Kawanda and the Western Regional Sericulture Centre, Rubare in Bushenyi district. Work on establishment of another centre in Eastern region (to cover Jinja, Kamuli, Iganga, Pallisa, Kapchorwa, Busia, Tororo, Soroti, Kumi and Mbale districts), has already started. Mulberry has been planted in these districts and farmers are already producing silk cocoons, but lack the essential services. The regional centres are meant to bring essential services nearer to the farmers in the decentralised districts. The establishment of essential services at regional level will also ensure synchronisation of crops by area, to make adequate marketing arrangements for farmers' produce to reduce costs of transportation over long distances. It will also be possible to process the silk cocoons separately or relocate reeling mills to regions for quality control. This may lead to production of different brands of raw silk/yarn in Uganda. Other advantages of establishing technological bases at regional level are pests and disease control, emanating from crop synchronisation and limited movement of larvae, silk cocoons and by-products such as pupae.

Studies aimed at generating appropriate technologies will be undertaken as follows:

(a) rearing techniques and equipment
(b) young silkworm production and distribution
(c) mulberry planting, spacing and harvesting techniques
(d) mulberry pest and disease control
(e) quality characteristics of reeling water
(f) silkworm breeding for local egg production
(g) mulberry variety and silkworm race

(h) multi-locational trials
(i) quality characteristics of silk cocoons produced in different ecological zones
(j) socio-economics of sericulture production in Uganda.

Wild silk cocoons spun by silk-spinning insect species can be used to produce characteristic silk fabrics from reeled raw silk or spun silk. Silk loving consumers are now interested in some of the wild silks which have different characteristics from those produced by the domesticated silk moths. Wild anaphe silk which is widely distributed in Uganda was once Uganda's export to Europe. Activities aimed at sustainable exploitation of wild silkmoths are on-going in collaboration with International Society for Wild Silkmoths and results to date show that anaphe silk filament has a unique structure, which gives quality characteristics admired by consumers. Wild silk production will be integrated into agro-forestry development programmes and the general pattern of agricultural development.

The studies will be based on production constraints and particular attention will be paid to production techniques appropriate to Uganda, without compromising production standards and quality. An effective extension system will be set up for transfer of technologies to the village level.

4. GEF'S VISION FOR THE CONSERVATION OF BIODIVERSITY IN AFRICA

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Abstract: The Global Environment Facility (GEF), promotes and fosters international actions to protect the global environment. Global Environment Facility provides funding to developing countries and those with economies in transition for projects and activities targeting global benefits in one or more of the four focal areas:

(a) Biological diversity
(b) Climate change
(c) International waters
(d) Ozone layer

Activities concerning land degradation, primarily desertification and deforestation, as they relate to the focal areas, are eligible for Global Environment Facility funding.

The grants and concessional funds disbursed, complement traditional development assistance by covering the additional costs (also known as "agreed incremental costs") incurred, when a national, regional or global development project also targets global environment.

The programmes and projects eligible for funding in the areas of biological diversity and climate change are based on the guidance provided by two international treaties: the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change. These conventions have requested that the GEF operate the funding mechanism for their activities.

GEF Global Environment Facility

This comprises of the following:

(a) 160 countries in the assembly
(b) A subset of 32 as council (donor and recipient)
(c) A secretariat in Washington
(d) A scientific & technical advisory panel

Three implementing (facilitating) agencies:

WB[1]	UNDP[2]	UNEP[3]
	Projects	
	Programmes	
	Linkages	
	Awareness	

(e) Council members (regions)
(f) Country operation focal point

GEF Projects: ideas to implementation

Any individual or group may propose a project idea, as long as the idea reflects the national or regional development priorities of the country involved.

Proposers, whether from national institutions, non-governmental organisations, the private sector or academia, should be aware that GEF financing is for projects that either improve the global environment or advance the prospect of reducing risk to it.

Funding for preparation of projects may be available through GEF's Project Preparation and Development Facility (PDF). PDF grants normally complement other sources of finance for preparation of a project proposal (such as World Bank loans, UNDP technical assistance, bilateral finance, national support and private funds).

The GEF does not finance:

(a) basic scientific research
(b) projects that may benefit one of the four focal areas, while concurrently causing adverse conditions in another

(c) project in the areas of biological diversity and climate change that do not conform, respectively, to the guidance of the Convention on Biological Diversity or the United Nations Framework Convention on Climate Change.

GEF Programmes

Four focal areas:

(a) Arid and semi arid ecosystems
(b) Coastal marine and fresh water ecosystems (including wetlands)
(c) Forest ecosystem
(d) Mountain ecosystem
(e) These are operational programmes, large, medium and small
(f) Enabling activities and short term response measures

Convention on Biological Diversity (CBD)

Three principal objectives:

(a) Conservation of components of biological diversity
(b) Sustainable use of those components
(c) Equitable sharing of benefits from sustainable use

GEF vision links to CBD vision:

(a) GEF finances "global" aspects of CBD
(b) Countries "steer" GEF and CBD
(c) GEF programmes "are country driven" to global aims
(d) GEF vision for Africa becomes a summation of African country visions
(e) Africa country visions are started in:
    - country reports to COP-CBD
    - Nations BSAPs
    - NEAPs/NCSSDs
    - Country studies on biodiversity

GEF activities (operational guidance) :

The objectives of this operational programme is the conservation and sustainable use of the biological resources in arid and semi-arid zone ecoystems as follows:

(a) Conservation or in-situ protection, will be sought through protection of systems of conservation areas, focusing primarily on countries in Africa threatened by increased pressure from intensified use, drought and desertification, which lead to land degradation

(b) Sustainable management will be sought by combining production, socio-economic and biodiversity goals. The strategy calls for a range of uses from strict protection on reserves, through various forms of multiple use with conservation easements, to full scale use.

Typical outputs:

(a) Protected areas: well established systems of conservation units with effective management plans
(b) Threat removal: Removal of the causes of biodiversity loss and the specific threats to the ecosystem, arising in the surrounding productive landscape, e.g. reduced fragmentation
(c) Sectoral integration: Incorporation of biodiversity protection into the main productive sectors of the economy and integrated community development, addressing livelihood issues of local and indigenous communities living in the buffer zone and areas of influence of protected areas
(d) Sustainable use: sustainable livestock grazing, hunting, and tourism as well as sustainable use of commercial and industrial products of drylands, e.g. gums, resins, plant-based waxes, oils and biocides
(e) Institutional strengthening: stronger institutions and well-trained staff to address these issues.

Partnerships

- Local national global values of BD
- Local national global inputs for BD
- GEF provides global input in addition to and in partnership with, other sources of support — co-financing
- GEF seeks to "leverage support"
- GEF cannot do it all — so innovative and replicable

GEF: Ten operational principles

1. The GEF will function under the guidance of, and be accountable to, the Conference of the Parties (COPs) for purposes of the financial mechanisms for the implementation of the Convention on Biological Diversity.
2. The GEF will provide new, and additional grant and consessional funding, to meet the agreed incremental costs of measures, to achieve agreed global environmental benefits.
3. The GEF will ensure the cost-effectiveness of its activities, to maximise global environmental benefits.
4. The GEF will fund projects that are country-driven and based on national priorities designed to support sustainable development, as identified within the context of national programmes.
5. The GEF will maintain sufficient flexibility to respond to the changing circumstances, including evolving guidance of the parties and experience gained from monitoring and evaluation activities.
6. GEF projects will provide for full disclosure of non-confidential information.
7. GEF projects will provide for consultation with participation as appropriate of, the beneficiaries and affected groups of people.
8. GEF projects will conform to the eligibility requirements set forth in paragraph 9 of the GEF instrument.
9. In seeking to maximise global environmental benefits, the GEF will emphasise its catalytic role and leverage additional financing from other sources.
10. The GEF will ensure that its programmes and projects are monitored and evaluated on a regular basis.

The GEF will actively encourage bilateral, regional and other multilateral organisations and foundations to contribute to or co-finance activities to address global environmental objectives. The GEF will leverage additional financing through collaboration with the private sector. The GEF will support innovative financing approaches to ensure that recurrent costs of funded activities are met without continued GEF support. The GEF will examine the role it might play in facilitating and promoting international cooperation, thereby leveraging financing, to address environmental multiactor contact.

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[1]WB - World Bank
[2]UNDP - United Nations Development Programme
[3]UNEP - United Nations Environment Programme

5. PROJET DE DÉVELOPPEMENT DE LA SÉRICULTURE EN COTE D'IVOIRE

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Introduction

A région du centre de la Côte d'Ivoire a été retenue pour l'implantation d'un projet de développement de la sériciculture, qui intègre partfaitement le programme gouvernmental de développement du pays.

Justification

Les raisons suivantes ont motivé l'implantation du projet:

Diversification des productions pour entrée de devises
Amélioration des revenus des paysans encadrés;
Introduction de nouvelles spéculations pour les régions des svananes du centre don't les polulations valides sont sujettes a l'exodes vers les régions forestières, faute de culture de rente.

Objectifs Quantitatifs

- Au depart, les objectifs initiaus pour la premiere décennie (1990/2000) sont les suivants
- 180 tonnes de soie grège sur le base de 20 kg de cocon frais par boîte
- 100 000 familles concernées par l'activité
- Compte tenu difficultés de financement, le projet n'a pas connu l'exanciosn souhaitée. Ce qui a motivé une étude de définition de stratégie.
- Les conclusions de cette étude ont abouti au réajustement des objectifs initiaux figureaant dan les tablaue I et II suivants:
- Cette stratégie envisage une production de 81,920 tonnes de soie grège sur une période de 11 ans avec 800 paysans sur la base de 30 kg de coton fairs par boite, ce qui donne les éléments suivants

- 409,600 tonnes de cocons secs (5kg cocon sec = 1kg soie grège)
- 1,024 tonnes de cocons faris (2,5 kg cocon faris = 1 kg de cocon sec)
- Le project de développement de la sériciculture en Côte d'Ivoire initié en 1988 par la CIDT a connu plusieurs étapes dan son évolution:

(a) 1-1ère etape 1989 - 1991

Années d'exploration et d'expérimentation qui onto consisté en la recherche et assai de matérials végétal et animal de base, ainsi que la formation du personnel.

(b) 2. 2éme étape 1992 - 1995

Période intermédiarie au course de laqualle des actions de pré-vulgarisation ont été menees. Des contacts extérieurs pour la recherche de financement, ainsi que le partnenaires techniques et commerciaux, ont été égalments menés.

(c) 3. 3éme phase depuis 1996

Depui 1996, le projt se trouve dans sa phase de vulgarisation avec comme objectif:

- Amélioration et adaptation des technologies
- Recherche de financement pour consolider les acquis
- Valorisation des productions par l'exploration de cocons de qualité et de soie grège
- Développement d'un artisanat textile local pour la soie
- Mise en place d'une filature d'une capacité de 15 tonnes de soie grège par an a partir de 1998

L'évolution de productions de 1990 a 1997 (Tables1) montre bien que le projet n'a pas connu le développement souhaité dix (10) ans apres son intitiation.

Table 5.1: 1990 Evolution de productions de 1990 a 1997

Année	Nbre de paysans ayant élevé	urface muraie exploitée	Nombre de cycles d'élevage par an et par paysan	Nombre de boîtes recues	Nombre de boîtes élevées	Rendement cocons faris kg /boite élevée	Productions	
							Cocons frais/kg	Cocons secs (kgs)
1990	9	45	3	30	25	24-20	605	260
1991	36	18	3	90	72	21,70	1 565	681
1992	60	30	4	150	133	21,50	2 858	1 300
1993	60	45	4	240	209	21,10	3 376	1 455
1994	60	50	4	360	320	13,90	4 463	1 585
1995	36	50	4	340	201	18,40	3 700	1 480
1996	63	75	4	325	278	23	6 483	2 333
1997	102	107	6	500	366	22,60	8 278	3 722

C'est pour apporter un souffle nouveay au développement de la sériciculture en Côte d'Ivoire que le programme de coopération technique établi centre le Governement et la FAO a été adopté et signé le 21 Aout 1997 pur une période de duex (2) ans.

Objectifs et plan de travail de projet FAO

(a) Evaluation préalable de la sériciculture en Côte d'Ivoire pour mieux définir le plan de travail avec efficacité.

(b) Assiter les nationaux dans:
- Organisation de paysans
- Conduite des élevages de avers a soie
- Controle des maladies
- Amélioration des techniques
- Fabrication et adaptation des équipement et matériels nécessaries pour les élevages

(c) Formation des cades nationaux à l'étranger

(d) Mise en place de structure de recherche et développement (R/D)

(e) Création d'un cadre de cadre partenariat avec les instituts de recherche.

Cooperation Ivoiro-Canadienne

Le Canada intervient également pour une contribution financière a travers le FDC IC. Depuis 1995, le FDC IC contribue au développement la sériciculutre en Côte d'Ivoire avec un montant de 365 000 000 FCFA sur une période de quatre (4) ans.

Situation Actuelle du Projet Sericulture

Compte tenu des difficulté de financement que connait le projet, ses activités se limitent dan un rayon moyen de 50 km autour Bouaké.

(1) Personnel (21 personnes)

(a) Cadres (04)
- 1 Chef de projet
- 1 Responsable du centre séricicole de Bouaké
- 1 Responsible de la vulgarisation et encadrement de paysans

- 1 Chef de la filature

(b) Agents de maitrise
- 7 Conseillers agricoles pour encadrement des payans
- 1 Contremaitre

(c) Ouvriers
- 6 Ouvrier pour les travaux au CSB

(d) Chauffeurs
- 3 chauffeurs

(2) Sources de financement de projet sériciculture

(a) *CIDT*

La CIDT constitue le soutien financier le plus régulier en matière de functionnement de structures et charge de personnel

(b) *BSIE*

L'Etat de Côte d'Ivoire intervient à travers le budget spécial de'investissement et d'équipement

(c) *FDCIC*

D'un montant de 356 000 000 FCFA octroyé sous forme de don, le financement FDCIC à été mis en place in 1996 pour une période de 4 ans (1996-1999). Ce financement don l'objectif principal est de contribuer à l'amélioration des conditions de production des paysans, est exclusivement destiné à l'acquisition d'équipements.

(d) *FAO*

Le programme de coopération technique (PCT) en cours depuis 1997 se chiffre à 150 000 000 FCFA pour une période de deux (2) ans.
Il s'agit principalement de missions d'experts et voyages d'études.

(3) Situation des équipements du projet

Table 5.2: Equipements materiels acquis par le financement FAO

Désignation	Quantité	Observation
Pulvérisateu		
• Atomiseurs	7	Désinfection des locaux d'élevage au CSB et milieu paysan
• Fumigateur	1	Désinfection des locaux d'élevage au CSB et milieu paysan
Equipements de protection contre Intoxication	10	Désinfection des locaux d'élevage au CSB et milieu paysan
Appareil fax	1	Communication avec l'éxterieur
Réfrigérateur (2portières)	1	Conservation de produits
Véhicule doubles cabines (4x4)	1	Encadrement des payans
Climatiseurs	2	Salle d'incubation et nourricerie
Thermo-hygromètre	20	Pour encadrement des paysans
Balance de précision	1	Travaux de précision
Télévision	1	Equipement de formation
Magnétoscope	1	Equipement de formation
Incubateur	2	

Table 5.3: Equipement et matériels acquis par financement FDCIC

Désigantion	Quantité	Observations
• Unité de filature d'occasion	1	Manuel et semi-automatique
• Etouffement	1	
• Camionnette	1	
• Cadres pour fileuse	-	
• Cadres d'encabanage	450	
• Moto pour encadreurs	7	
• Magnaneries paysannes	120	

(4) Le Centre séricicole (CSB)

(a) Situation actuelle

Les possibilités offerts par le CSB sont les suivantes

Une salle d'incubation:

- 3 structures métalliques de 203 boites chacune
- capacite théorique = 203 x 3 = 609 boîtes
- capacité réelle = 203 x 2 = 406 boîtes

(b) Deux salles de nourricerie:

- 2 salles de nourricerie de 132 boîtes chacune
- capcite totale - 132 x 2 = 264 boîtes

(c) Mûraie

- 07,5 ha de murier

(5) Milieu paysans (voir Annexe I-IV)

(a) Statistiques agricoles Annex I:

- 75 villages
- 263 agriculteurs possédant une muraie
- 117,5 ha de muraie
- 5 cycles d'élevage par un

(b) Caractéristiques des magnaries livrées aux agriculteurs
Deux types ont été retenus selon la capacité de travail du paysan:

(i) Petite magnanerie:

- Longuer = 10 m
- Largeur = 6 m
- Capacité = 3 boîtes par cycle d'élevage
- Surface muraie: 1 ha à 1,5 ha.

(ii) Grande magnanerie:

- Longuer = 16 m
- Largeur = 6 m
- Capacité = 6 boîtes par cycle d'élevage
- Surface muraie: 2 ha à 2,5 ha

(iii) Claie d'élevage

- Des claies montees à trois niveaux et entièrement demontables
- Revenu moyen des payans

  - Revenu brut par ha = 5550 000 FCFA
  - Revenu net = 325 000 FCFA

Difficultés recontrées

(1) Insuffisance de financement pour réaliser les magnaneraies adaptées et équipements nécessaires pur une bonne production niveau de paysans
(2) Formation insufficante de personnel d'encadrement et des payans
(3) Faible rendement à la boîte
(4) Apaparition fréqente de maladies

Perspectives Nouvelles a Court et Moyen Termes

A partir de 1998, de objectifs plus modestes ont été retenus au niveau de projet pour les raisons suivantes:

(1) Objectifs initiaux , trop ambitieux par rapport aux moyens financiers disponibles
(2) L'approvisionment entier de la filature est retenu comme objectif a court et moyen termes

Aussi l'évolution du projrt se caractérise désormais par deus phases:

Phase 1: Court et moyen termes
L objectif de cette phase est l'approvisionnement de la filature actuelle tout en se suitant dans un rayon moyen de 50 km autour de Bouaké

Phase 2: Long terme
La mise en oeuvre de cetter phase sera subordonnée à la saturation complète

de la capacité de la prémiere filature et une disponibilité suffisante de financement. Le projet pourrait s'ouvrir à d'autres régions du pays afin d'accroitre la production cocons frais.

L'objectif final de cette phase est l'acquisition d'une filature automatique plus grande:

(a) Les besoins liés a l'évolution de la production (1998-2003)

A partir de 1998, le première phase d'évolution du projet a été retenu et mise en oeuvre sur la base de la capacité de 75 tonnes de cocon faris de la filature naissante.

A partir de l'an 2001, les capacités de la salle de'incubation et de nourricerie seront dépassées. Pour répondre à ces besoins croissants, les invetiments et les actions suivantes devront constituer la priorité:

(i) Court terme

- Claies pour incubation = 60 unités
- Claies d'élevage en nourricerie = 250 unités

  Nombre de boîtes a élever = 1 500

(ii) Moyen terme

- Claies pur incubation = 400 unités
- Nombre de boîtes a elever = 2 500

(iii) Bâtiments

- Nourricerie: 8 m x 5 m, avec 462 claies
- Ramier aménage (stockage de feuilles): 6 m x 5 m
- Agrandissement de l'ancien bâtiment d'incubation et nourricerie
- Magasin de réception de cocons frais
- Magasin de stockage intrants et matériels

(iv) Mûraie

- Réhabilitation et extension de la muarie

(b) Encadrement et Production

(i) Projection de la production a court et moyen term (1998 à 2003)

Table 5.4.

Année	Nbre de paysans eleveurs	Surface muraie exploitation	Nombre de cycles d'élevage paysans	Nombre de boîtes a élever	Rendement cocons frais kg/boîte	Production	
						Cocons Frais (T)	Cocons Secs (T)
1998	209	107	5	914	25	22,85	9,14
1999	256	105	5	1 200	25	30,00	12,00
2000	300	200	5	1 500	26	39,00	15,38
2001	300	300	5	1 800	28	50,40	12,16
2002	300	450	5	2 000	30	60,00	25,20
2003	300	450	5	2 500	30	75,00	31,50

(ii) Investissement en milieu paysan

L'évolution positive du projet ne paut se faire sans la mise en place de magnaneries adaptées et entièrement équipées, car elles son considérées comme des unités de production.

Table 5.5: Objectif de construction de magananeries équipées a moyen terme (1989-2003)

Besoin total de magnaneries	Magnaneries construites et livrees en 1999	Reste a construie				
		Total	Plan de réalisation			
			2000	2001	2002	2003
400	130	270	75	75	75	45

Table 5.6: Besoins estimés de financement a moyen terme

Désignation	**Quantités**	**Montant**
- Constructeur magnaneries paysannes	270	312 660 000
- Extension centre de Bouaké		100 000 000
- Equipement de filature		500 000 000
• Machines a dechets		
• Etouffement complet		
• Balance a denier		
• Sériplane		
• Testeur d'humidité		
• Cuiseur automatique		
Total		**912 660 000**

(c) Les actions d'accompagnement

(i) Vulgarisation et encadrement

Pour atteindre ou dépasser les objectifs retenues, les points suivants doivent faire l'object d'une attention particuliere:

- Fédilisation des payans sériciculteurs
- Augmentation du nombre du paysans serciculteurs
- Augmentation du nombre de boites a élever
- Amélioration de la surface de muraie avec une densité de 20 000 pieds/ ha
- Intensification des muaraies selon la dose d'engrais préconisee:
  - NKP 300 kg/ha
  - Urée 100 kg/ha
- Fumure organique a partir de la litiere a détruire
- Entretien régulier des muraies
- Formation reforcée sur les techniques séricicoles
- Counceillers agricoles
- Paysans séricicoles.
- Production de cocons de qualite

(ii) Investissements

Pour une meileure application des techniques séricicoles par les payans, les équipements de base suivans sont indispensables:

- Une magnanerie adéquate pour chague éleveur
- Des claies d'élevage bien aménagees avec une surface suffisante
- Un kit d'entretien complet
- Des sécateurs adaptés
- Un équipement complet d'encabanage selon la capacité d'élevage de chaque paysan
- Un système efficace de lutte contro les magnans
- Sacherie en toile pour achat de cocons frais

(d) L'unité de filature

Tenant compte de la progression de la production de cocons a court et moyen termes, le Chef de la filature propose:

- Simulation de production de cocon et de soie grège (voir tableau I)
- Planification de la campagne de filature de soie (voir tableau II)

ANNEX I: STATISTIQUES AGRICOLES POUR LES PAYSANS POSSEDANT UNE MURAIE ANNEE 1999

Sections	Situation general			Recensement por elevage 1999					Magnaneries					
				Paysans					Prevision Production					
	Nombre de Villages	Nombre de Paysan	Surface Muriae	Anciens	Nouva-uex	Total	Surface Muriae (ha)	Nbre de boites de vers	Nombre Cycle	Rendt Moyen Kg/boite	Prod. (T)	Total	Cons-truite	Rest a const-ruite
Katiola	5	86	26,5	42	14	56	20,75	200	5	-	-	56	23	33
Kahankro	8	26	14	15	5	20	11,25	120	5	-	-	20	9	11
Diabo	9	26	13,25	15	2	17	7,05	130	5	-	-	17	15	2
Beoumi	14	31	14,5	19	5	24	12	160	5	-	-	24	19	5
Sakassou	9	12	6,75	13	6	19	11,9	160	5	-	-	19	15	4
Brobo	15	46	29,5	20	7	27	15,25	220	5	-	-	27	20	7
Djebonoua	15	36	19,75	24	5	29	16,25	250	5	-	-	29	27	2
Total Section	75	263	117,25	148	44	192	94,95	1240	5	24	30	192	128	64
Centre Séricicole de Bouaké	-	0		-	-	-	-	10	-		-	2	2	0
TOTAL Generale	75	263	117,25	148	44	192	94,95	1250	5	24	30	194	130	64

REMARQUES: Il s'agit essentiellllement des elements des paysans devant effectivement eleveer

ANNEX II: RECAPITULATIF RECENSEMENT DES NOUVEAUX PAYSANS POUR LA SERCICULTURE ANNEE 1999 (Ahissi 2.doc)

Section	Villages	Nombre de paysans	MURAIE A PLANTER				MAGNANERIES A CONSTRUIRE			ANNEE DE CONTRUCTION	
			Total	Evolution des realisations			Privee	CIDT	Total	1999	2000
				1999	2000	2001					
Katiola	8	20	19,5	9,25	9	1,25	7	13	20	0	20
Kahankro	9	20	18	9,5	5,75	2.75	4	16	20	0	20
Diabo	4	11	9,5	4,5	3	2	1	10	11	0	11
Beoumi	9	23	21.25	12	9	0.25	18	5	23	0	23
Sakassou	6	11	8,5	5	3	0,5	0	11	11	0	11
Brobo	7	18	27	11,5	10,75	4,75	1	17	18	0	18
Djebonoua	10	16	19	11	5	3	11	5	16	0	16
TOTAL 7	53	119	122,8	62,75	45,5	14,5	42	77	119	0	119

ANNEX III: SIMULATION DE PRODUCTION DE COCON ET DE SOIE GREGE (Ahissi 3.doc)

Cette simulation suppose quelusine est performanted a 100% des le demarrage et la rentree est de 5 (Rentre = quantite de cocons secs en kg pour produire un ke de fil)

	1999	2000	2001	2002	2003	Observations
Nombre de jours travailles	105	255	255	255	255	
Stocks cocons debut campagne (en kg)	4954	5404	-	-	-	
Production cocons (en kg)	12000	15380	21160	25200	31500	
Production journaliere de soie en kg	22	22	22	22	22	
Performance filature en %	100%	100%	100%	100%	100%	
Rentree	5	5	5	5	5	Quantite de cocons en kg pour 1 kg in fil
Desoin filature en cocons (en kg)	11550	28050	28050	28050	28050	
Production totale de soie grege (en kg)	2310	5610	5610	5610	5610	
Stock cocons fin campagne (en kg)	5404				3450	

ANNEX IV. PLANTIFICATION CAMPAGNE FILATURE SOIE

Pour l'annee 199. Les mois d'avril a Julliet couvrent la periode des essais et de formation
La cammpagne normale devra s'etendre sue la periode de'octobre a Julliet de chaque annee
Le congre de personnel sera en aout et les revisions se feront en septembre

	1999												2000												2001												2002												2003											
					*												**																																										
Jours duMois	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
2				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
3				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
4				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
5				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
6				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
7				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
8				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
9				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
10				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
11				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
12				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
13				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
14				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
15				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
16				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
17				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
18				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
19				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
20				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
21				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
22				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
23				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
24				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
25				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
26				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
27				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
28				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
29				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
30				X	X	X	X			X	X	X	X	X	X	X	X	X	X			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		
31					X		X			X		X	X		X	X		X		X			x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		

* Periode de formation
** Periode de devidage

6. A SUCCESSFUL EXAMPLE OF WILD SILK DEVELOPMENT FROM *CRICULA TRIFENESTRATA* IN INDONESIA

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Abstract: *Cricula trifenestrata*, which produces a beautiful golden cocoon, is a member of the Saturniidae, and inhabits throughout Indonesia and elsewhere in South Asia. It is awell-known pest in Indonesia and sometimes causes serious damage to mango farms and also to roadside trees. Recently, Japanese scientists and technologists succeeded in developing these cocoon sheets, yarn and textiles. Because of their natural golden colour and very fine filament, all goods commanded a price more than several times higher than *Bombyx* silks.

What is *Cricula trifenestrata*?

Cricula trifenestrata belongs in the Saturniidae family. It is classified into 12 species taxonomically (see Table 6.1), and inhabits throughout Indonesia and elsewhere in South Asia. It is also classified into 6 subspecies (Table 6.2), and is well known as a notorious pest insect in tropical areas for the defoliation it causes in outbreaks (Fig. 6.2).

Fig. 6.1. Food plant eaten up by *Cricula* larvae

Fig.6.2. Newly-spun *Cricula* cocoons and the mature larvae

Table 6.1: Taxonomy and distribution of *Cricula* genus

Taxonomy	Distribution
C. trifenestrata	South Asia, India, Thailand
C. andamanica	Andaman islands, India
C. bornea	Borneo
C. agria	India
C. ceylonica	Ceylon
C. andrei	East Himalaya, Assam
C. jordani	Burma, North Thailand
C. zubsiana	South China
C. sumatrensis	Sumatra
C. elaezia	Burma
C. luzonica	Philippines
C. guinauefenestrata	Sulavesi

Table 6.2: Subspecies of *Cricula*

Taxonomy	Distribution
C. t. trifenestrata	South Asia to Thailand, North India
C. t. agrioides	South India
C. t. javana	Sunda islands
C. t. serama	Indonesia
C. t. treadauayi	Philippines
C. t. kransi	Sulavesi

The caterpillars are black with white spots and hairs; the head and abdomen are bright red (Akai et al., 1996). They grow to be 60mm long and the mature larvae spin golden mesh-shaped cocoons (Figs. 6.2-4). Their food plants are several species of fruits, garden and wayside trees, and they especially favour mango and avocado, which are important agricultural products.

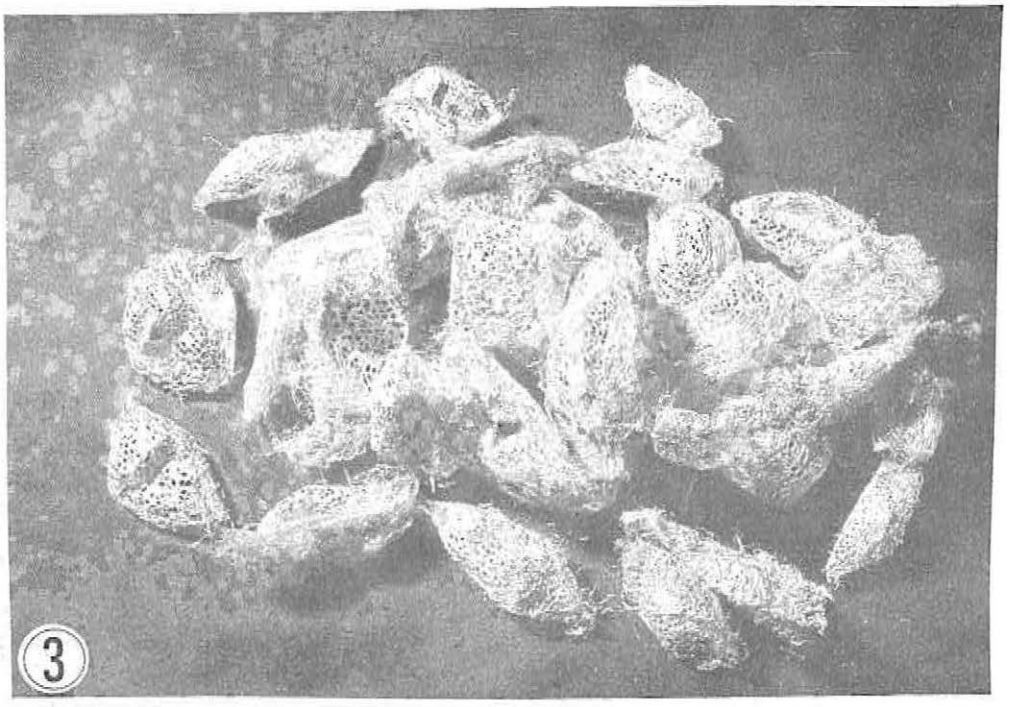

Fig. 6.3. Collected *Cricula* cocoons

Full-grown larvae wander on the leaves and branches of the food plant, and start to spin the cocoons. They make cocoons at random, single, twin, and grouped (see Fig. 2).

No one has been interested in these weird insects which make the human skin itch, nor has there been interest in their poorly shaped cocoons. However, we were extremely attracted by their shiny golden-coloured cocoons which had a specific character with a high value in the market.

At our suggestion and with our collaboration, a tiny industry of *Cricula* silk started a few years ago in Indonesia and is now growing slowly (Akai, 1996).

Structural characteristics of cocoon and cocoon filament

The cocoons of *C. trifenestrata* are noted for their beautiful golden colour and mesh-like shell. However, the shell is not uniform mesh, but mixes typical mesh parts with various size holes or windows and a flat part, resulting from an accumulation of filaments (Fig. 6.4). Under a light microscope, the cocoon shell surface is composed of numerous filaments with random orientation. These filaments attach to each other smoothly and are covered with a sericin layer, resulting in a surface with a shiny gold colour (Fig. 6.4).

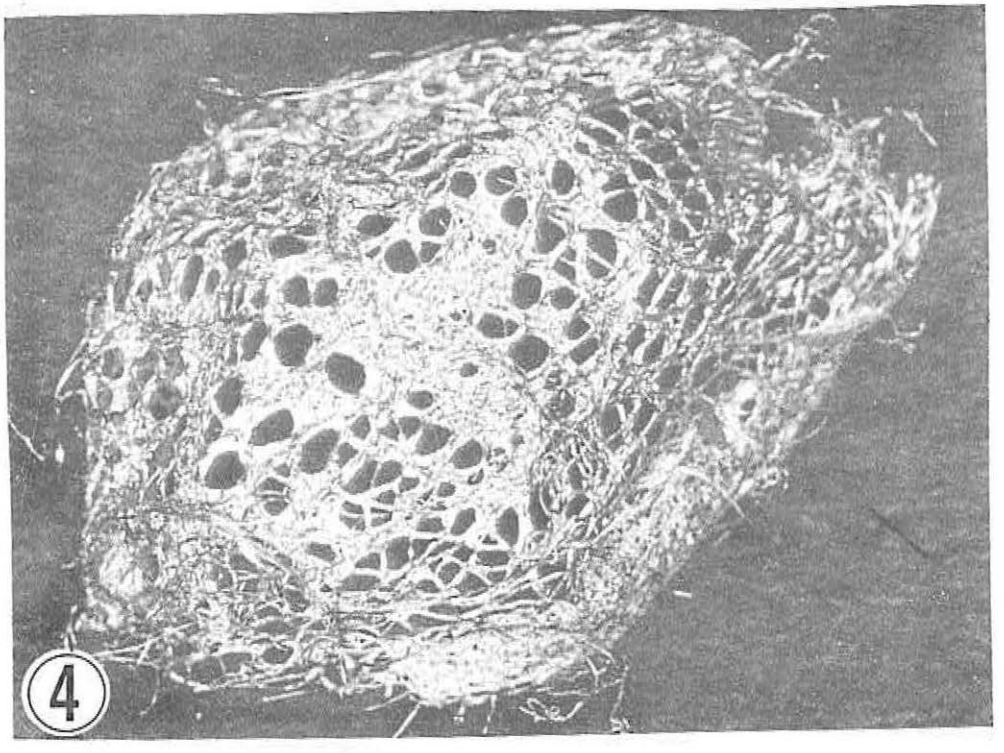

Fig. 6.4. Enlarged cocoon shell

Silk yarn spun from *C. trifenestrata* is obtained by boiling the cocoons in hot alkaline water. The yarn and textiled fabric are less shiny than the cocoon shell, because the filaments separate and the sericin is reduced by the boiling water (Fig. 6.5). However, the yellow colour remains in the yarn and fabric and has a feeling very soft to the touch.

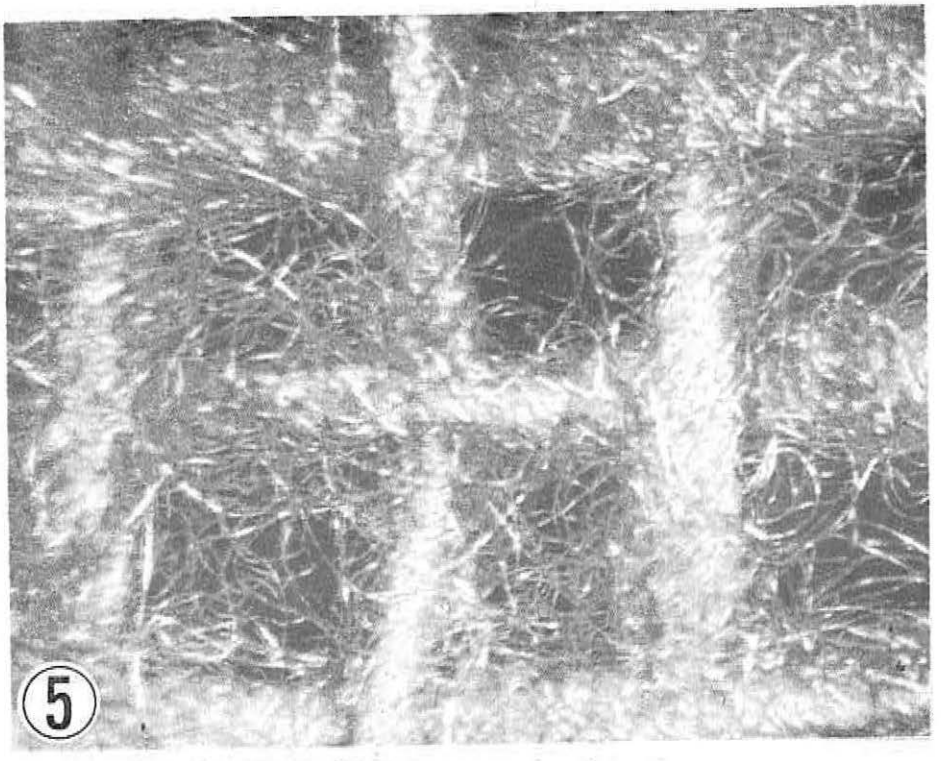

Fig. 6.5. Part of fabric woven by *Cricula* cocoon

Under scanning electron microscope SEM), the cocoon shell layer was clearly composed of numerous cocoon filaments in random orientation. Each filament is also composed of two fibroin filaments covered with a sericin layer. Comparison of the outer and inner surface of the shell showed a considerable difference in cocoon filament size. The filaments on the outer surface were larger (about 50% greater in diameter) than those on the inner surface. In *Bombyx mori*, the deviation in cocoon filament size is usually higher on the outer parts of the cocoon shell and lower on the inner (Akai et al., 1996). In *C. trifenestrata*, the deviation is greater than that of *Bombyx* cocoons, because of the shorter length of the filament and the lighter weight of the shell. The SEM observations clearly confirmed this difference.

In a cross section, thickness of the cocoon shell was seen to be extremely irregular in *C. trifenestrata*. Also, the density of filaments in the shell is much less and looser than other species of silk-spinning insects, *B. mori*, *Attacus atlas* and *Antheraea mylitta*. Each coccon filament, shows an ellipse in cross section, containing various sized tubules oriented along the long axis.

In a previous paper (Akai et al., 1977), we stated that only the silk-spinning insects belonging to the Saturniidae family produce a porous type cocoon

filament, while others produce a compact filament. The former provides a more comfortable and soft feel to textiles than do the compact types (Akai, 1998). These observations showed that the cocoon shell of *C. trifenestrata* has many structural characteristics:

(1) remarkable variation in filament size
(2) irregular spinning pattern of cocoon shell formation
(3) porous type cocoon filaments
(4) the sericin of the cocoon filaments contains a high ratio of the yellow pigment detected in both *A. yamamai* and *A. assama* (Yamada and Akai, unpublished observation).

Utilisation of Cricula silk

The utility value of the *Cricula* cocoon and filament depend largely on the beautiful golden colour. Therefore, the silk commodities made with this natural golden colour are expected to have a high commercial value in the market. In Japan, various patterns from *Cricula* golden cocoon are used for the traditional kimono and obi, and these create a new additional value in the silk market. In this case, small patterns are hand-made from the cocoon shell and affixed by a special adherent. Also, golden cocoon sheets which are manufactured by pressing the boiled *Cricula* cocoons are widely utilised for women's hand bags (Fig. 6.6), purses, book covers and other small items. Such finely sized patterns of the cocoons convey a high class image of these commercial goods. The golden cocoons are also utilised for Japanese family crests, various cocoon crafts and ornamental articles, all of high value.

We succeeded in producing a spun yarn from these golden cocoons, and manufactured a limited number of women's scarves and mufflers. Although the brilliance is somewhat reduced, the natural yellow colour is retained. Silk lovers appreciate these wild silk items because of the natural colour and the special feeling to the touch.

The price of the *Cricula* cut cocoon varies widely depending on its use, but now is in the range US$ 50- 100 per kg. The wild cut cocoons, Eri and Chinese tasar are sold for US$ 3-8 and US$ 5-10, respectively. It is recognized that *Cricula* cocoons are very expensive, because of their characteristic shiny colour and finer porous filament.

Strategy for Wild Silk Development

In Jogjakarta, Indonesia, a nursery silk industry of *Cricula*, which is the only

pest that can be harmful in the orchard and for which there had previously been no concept of utilisation, is now slowly growing. Successful production of a small amount of *Cricula* cocoons, cocoon sheets and spun yarn has begun and egg production of the *Cricula* silkmoth is also being studied with the aim of protecting this natural resource.

This case can certainly be called a successful example of wild silk development. In the development and utilisation of wild silkmoths, an additional high value, based on special characteristics of the silk is an essential factor of success. The system of mass production, small profit and quick return can destroy the growing wild silk industry. Instead, small industries focusing on special characteristics of the silkmoths, are conditions which will prove successful.

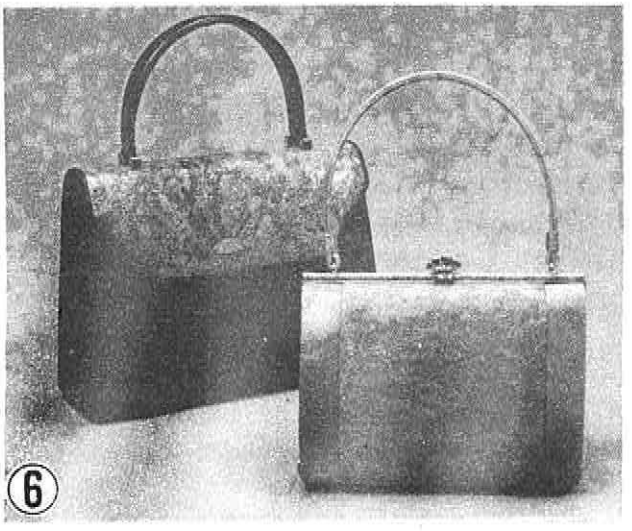

Fig. 6.6. Women's hand bags

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7. STRATEGIES FOR DEVELOPMENT OF MULBERRY AND SILKWORM GENE BANK IN AFRICA

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Abstract: Silk with its unmatched luxury, lustre and elegance, is known as "the Queen of Fabrics" and is in high demand for the affluent. Silk production is an agro-based industry which can provide employment to about 13 persons per acre of mulberry garden and is therefore well suited as a tool for rural employment and poverty alleviation in populous developing countries. The high manpower requirement, forced the industrialised countries either to reduce or discontinue silk production. Thus, enhancing the prospects of sericulture in developing countries. Sericulture involves cultivation of mulberry, *Morus* sp. L., the food plant and rearing of the silk insect, *Bombyx mori* L., which feeds on mulberry leaves and produces silk. Therefore, the success of silk industry depends on the productivity and quality of mulberry and the silk insect, which is an outcome of the gene-environment interaction. It is therefore desirable to collect and conserve the mulberry varieties and silkworm breeds for development of silk industry on sound lines. Besides this, it is also essential to make systematic efforts for optimum utilisation of the genetic material as required by the industry in the specific environment. This study gives in brief a systematic approach needed to build up such gene bank for mulberry and silkworm in Africa, and measures to be taken for effective utilisation of the genetic material for the development of silk industry in the region.

Introduction

The history of mulberry sericulture dates back to 5000 years (Zhuang Da-huan, Liu Shi-xian and Li Long 1994). Silk production was confined to China for a long time due to restrictions on transfer of technology. By the century B.C., the fabulous silk was carried for the first time to Korea. Later, the secrets of silk were spread to the world through "Silk Road", leading to the establishment of seiriculture industry in many countries. Silk, with its unmatched luxury, lustre and elegance, is called "the Queen of Fabrics" and the demand for silk has been ever increasing.

Sericulture with its agro-base, can provide employment to about 13 persons per acre (32 persons per hectare) of mulberry garden and is therefore well suited for populous developing countries as a tool for rural employment and poverty alleviation. Due to the high manpower requirement, industrialized countries have either reduced their sericulture establishment or discontinued silk production. With this, the prospects of developing sericulture in developing countries have brightened. Estimated world raw silk production is presented in Table 7.1.

Sericulture involves cultivation of the food plant, mulberry, *Morus* sp. L., and silkworm, *Bombyx mori* L., the silk producing insect. The quality and productivity of mulberry and the efficiency of the silkworm to convert the food material into quality silk, ultimately decides silk productivity both in terms of quality and quantity. Therefore, the availability of improved mulberry varieties and silkworm breeds suited for the local agro-climatic conditions will become the prime requisite for the development of the silk industry.

Climate Required for Mulberry Sericulture

It is well established that mulberry grows well at a temperature range of 20-30^{o} C (68-86^{o} F) with a capability to sustain wide variations in the climate. On the other hand, silkworm ideally requires a temperature of 24-28^{o} C (75-85^{o} F), with a marginal tolerance of about 5^{o} C (8^{o} F) variation, both on the upper and lower limits. Therefore, the availability of the required temperature range within one or more seasons in a year, becomes the prime deciding factor for sericulture. Besides, a moderate relative humidity of 65-85% is ideal for silkworm. There are silkworms with different voltinisms, viz., univoltine, bivoltine and multivoltine, indicating the number of generations per year. Univoltines and bivoltines are known for their quality and productivity of silk, while multivoltines are known for their hardiness. Depending upon the number of favourable rearing seasons per year and their intervening harsh seasons, rearing and other sericulture activities have to be scheduled.

Table 7.1: Estimated world mulberry raw silk production (tons)

Country	1990	1991	1992	1993	1994	1995	1996	1997
China	43800	48400	54840	69300	72000	64613	59000	52700
India *	10805	11486	10658	13000	12550	13450	12884	12954
Japan	5700	5520	5100	4200	3900	3228	2578	1902
Brazil	1680	2100	2280	2340	2520	2468	2270	2120
S.Korea	780	660	660	840	780	643	130	-
Others	7320	7320	6900	6300	6600	7115	6185	-

Source : International Silk Association (ISA), Sericologia (1995-1998).

* Financial year (April-March) 1997 implies 1 April 1996 - 31 March 1997. Indian mulberry silk production in 1997-1998

How the African continent is suited for sericulture

African continent spreads between 35° North of Equator and 32° South of Equator latitude and 20° West of Greenwich and 50° East of Greenwich longitude and consists of varied climatic regions. Excepting the desert and the semi-arid regions, the continent receives a fairly good rainfall of about 40" (100 cm) and above, which is good enough for mulberry cultivation. The continent with its rich flora and fauna stands testimony for the luxuriant growth of a variety of plants. Leaving the hot and dry (desert) and semi-arid areas, most of the continent is well suited for silkworm rearing at least in two or three seasons.

Need for Gene Banks

A broad genetic base is the prime requirement for any systematic object oriented successful breeding programme. Vavilov, as early as in 1926 realised the need for a broad genetic base for crop plant improvement. This also equally applies to mulberry and silkworm crop improvement.

With growing civilisation, urbanisation and human population, the needs have also been increasing, resulting in deforestation and thereby loss of genetic resources existing in nature. With the increased requirement of agricultural products, farmers have been switching over to highly productive breeds, thereby discontinuing the cultivation of native cultivars, which automatically get excluded from nature, which also results in the loss of valuable genetic material. Hence, special efforts for conservation of genetic resources was necessary. However, the problems relating to conservation of genetic resources attracted the world's attention only in 1972, during the United Nations Environment Conference at Stockholm, when both Food and Agricultural Organisation (FAO) and International Biological Programme (IBP) came together on this issue (Frankel and Hawkes, 1975).

The International Board for Plant Genetic Resources (IBPGR) was established in 1974 within the Consultative Group on International Agricultural Research (CGIAR), to promote, catalyse and coordinate activities on germplasm collection, conservation, documentation, evaluation and utilisation (Arora, 1993). However, most of the efforts were on the food and cash crops. The research institutions involved in mulberry and silkworm breeding have been maintaining the germplasm collections required for their breeding work.

Mulberry sericulture being almost a new venture in this region, depends to a large extent on the introduced breeds. Mulberry wealth in this region remained under-explored. It is also possible that a number of their wild relatives may be available in the region, which may be useful in breeding programme. The stability of silk industry in this region greatly depends on the locally adapted breeds. It is therefore essential to develop a wide genetic base by establishing germplasm banks for mulberry and silkworm for taking up breeding programme on sound lines. The endemism in the species of the genus, *Morus* L. is presented in Table 7.2 and a few Bombyciid species found in Eastern Asia are listed in Table 7.3. Popular silkworm hybrids reared in some important silk producing countries is listed in Table 7.4.

Table 7.2: Endemism in Species of the Genus *Morus L.*

Name of the country	Total no. of species	Total no of endemic species
China	24	17
India	4	1
Indonesia	3	2
Japan	19	14
Korea	6	1
Taiwan	4	1
Thailand	2	2
Argentina	1	1
Columbia	3	1
Mexico	3	2
Peru	1	1
USA	14	9

Table 7.3. A few bombycid species found in Eastern Asia (Choudhury, 1984)

Genus	Species	Chromosome no.	Distribution	Remarks
Bombyx	*mori*	n=28	Worldwide	Domesticated commercially exploited silkworm
	mandarina (i)	n=27	Japan	Wild silkworm can be crossed with *B. mori*
	mandarina (ii)	n=28	Ussuri, Manchuria	Wild silkworm can be crossed with *B. mori*
Theophila	*religiosae (huttoni)*	n=31	Himachal Pradesh and eastern India	Feeds also on *Ficus religiosa,* Flossy cocoon.
	affinis bengalensis		Bihar, Bengal and Sikkim of India	*feeds on mulberry leaf*
Andraca	*sherewilli*			
	bipunctata		Eastern Himalayas	Feeds on tea leaves Found in clusters in day time
Ocinara	*albilunata*		North-eastern region of India	
	diaphana			

Table 7.3. Contd.

Genus	Species	Chromosome no.	Distribution	Remarks
	cyproba		Meghalaya (India)	Feeds on *Ficus* leaves
Trilocha	*lactea*		Meghalaya (India)	
	varians		Meghalaya (India)	
Gunda	*albicotti*		Himachal Pradesh (India)	Feeds on *Ficus* leaves
	javanica			-
Mustilia	*sikkima*		Southern India and Sri Lanka	-
	phaepara			-
	columbaris		Central India Himalayan foothills Sikkim (India) Meghalaya (India) Himalayan foothills	-

Table 7.4.: Popular Commercial Silkworm Hybrids

Japanese hybrids:

for summer and autumn :
1. Kinshu x Showa
2. Kinshu.1 x Showa.1
3. Fuyo x Tokai
4. Shoko x Ryohaku

for spring :
1. Shunrei x Shogetsu
2. Shunrei x Shogetsu.1
3. Asai x Tokai
4. Shugetsu x Hosho
5. Taihei .1 x Choan.1
6. Doai x Kohaku

S. Korean hybrids:

1. Keongchu X Yeorel
2. Hangsaeng I Ho X Hangsaeng II Ho
3. Moodung X Gunho
4. Jam 113 X Jam 114

Russian hybrids:

1. Saniisch 8 X Saniisch 9
2. Belakokkonaya 1 X Belakokkonaya 2
3. Soviet 5 X Saniisch 30
4. Soviet 5 X Soviet 12

Chinese hybrids:

1. Tongsu 34 X Shansu 12
2. Tangsu X waha
3. Tong fei X hua he
4. Giangsu 16 X Giangsu 17
5. Chen 3 X Chen 4
6. Tong 34 X Su12.

Indian hybrids :

for summer and autumn:
1. N X G
2. N X OS616
3. PM X C Nichi
4. N X NB4D2
5. PM X KA

for autumn and spring :
1. KA X SH6
2. SH6 X NB4D2
3. NB18 X P5

Ideal characteristics of a germplasm bank

An ideal germplasm bank caters to the choice of its users, the breeders. Well defined breeds are the backbone for a breeding programme. The following characteristics of a germplasm bank are considered ideal:

(a) Classified working collections
(b) Genetic variability in specific traits
(c) Variability in desired agronomic background
(d) Genetic basis of the desired trait.

Basic functions of a germplasm bank

The purpose of germplasm bank is to provide well defined donors with specific traits to reach the breeding goals as per breeders' choice. To satisfy the breeder, the germplasm bank has to perform the following basic functions:

(a) Collection, introduction and accessioning of germplasm material
(b) Maintenance, charaterisation, evaluation, documentation and distribution of germplasm material.
(c) Conservation of germplasm material
(d) Conducting basic studies, focusing upon species relationships, bio-chemical or molecular identification of accessions, genetic diversity, etc.
(e) Maintaining museum and herbarium aiming at identification of taxa and serving as reference centre.

Constraints faced in proper utilisation of genetic resources

A breeder, utilising his basic knowledge of genetics and the information available on the genetic resources, systematically plans for achieving his specific breeding goals. This needs a clear definition of the problem, target and well defined and documented genetic material. A number of constraints coming in the way of utilisation of genetic resources have been identified. They are:

(a) Lack of proper evaluation of germplasm
(b) Limited genetic charaterisation of germplasm
(c) Incompatibility in the flowering of donor plants
(d) Lack of useful mutants in the desirable agronomic background
(e) Non-utilisation of the cultivated parents of the cultivated polyploids

(f) Lack of facilities for data storage and retrieval
(g) Insufficient trained staff and funds
(h) Difficulty in producing wide crosses
(i) Restricted gene flow in apomictic, polyembryonic and asexually propagated species
(j) Delay in quarantine clearance, etc.

Factors promoting effective utilisation of germplasm collections

The basic function of a breeder is to systematically incorporate the desired genes into a well adopted breed of the locality agronomical background aiming to achieve specific goals. The following factors are considered vital for a successful breeding:

(a) Identification of useful donors
(b) Pyramiding of genes
(c) Breeding of a few specific traits at a time
(d) Use of diversified sources
(e) Exploitation of inter-specific diversity
(f) Wide hybridisation
(g) Inter-disciplinary approach

Expected breeding goals of a mulberry breeder

To ensure that the germplasm bank is organised to satisfy the breeders' requirements, it is essential to identify the expected breeding goals of the breeder. Mulberry, *Morus* sp **L.**, being the sole food plant for silkworm, *Bombyx mori* **L.**, the production of silk directly depends on the quantity and quality of mulberry leaf produced.

With the increasing population and human needs for the land based products, the pressure on land has also been increasing. Hence there is a need for improvement of productivity per unit area, which essentially needs productive breeds apart from improvement in agronomical packages, protection from pests and diseases, etc. Breeding is one tool to bring about improvement in yield quality, resistance to pests and diseases, tolerance to environmental odds, tolerance to water stress, high input utilisation efficiency, suitability for different cultural practices, synchronisation of leaf production to ideal rearing season, etc. Considering the problems, the following mulberry breeding goals are expected:

(a) Improvement in quality and quantity of leaf production
(b) Compatibility of harvest schedules with silkworm rearing schedules
(c) Higher input utilisation capacity for areas rich in natural resources like soil fertility, water, etc.
(d) Tolerance to prolonged draught conditions or mechanism to avoid drought
(e) Water conserving efficiency
(f) Frost tolerant breeds for temperate or frost prone areas
(g) Salinity tolerance or mechanism for salt excretion for saline areas
(h) Pest and disease resistance as a requirement of the region
(i) Any other goal to overcome specific problem of a region

Expected breeding goals of silkworm breeders

A silkworm breeder mainly aims at improving the quantity and quality of silk output. This in turn depends on the leaf to silk conversion efficiency, cocoon quality, survival, etc. Survival in turn depends on their tolerance to hard climate, resistance to diseases, etc. Sometimes, breeds with special characters are evolved to produce specialised silk or other purposes. Considering these, the following breeding goals are expected:

(a) Improvement in quality and quantity of silk production
(b) Better leaf to silk conversion ratio
(c) Tolerance to extreme climatic conditions
(d) Resistance to diseases
(e) Better egg production
(f) Uniform hatching
(g) Synchronous larval moulting
(h) Short larval span
(i) Synchronous spinning
(j) Synchronous emergence
(k) Any special features for specific utility of silk

Measures recommended for effective utilisation of germplasm material

Utilisation of the genetic material can be done in two ways, i.e., by commercial exploitation in the same form or by using them as donors in breeding programme for evolving desired breeds. The yield and quality are the basic goals of any breeding programme, breeder will also set other goals to overcome various other regional problems such as tolerance to draught, frost, salinity, diseases, pests, rooting, etc. Unlike those propagated through seed, any desirable genetic variation can be preserved and well exploited through vegetative propagation.

The breeder according to his goals, shall draw up a breeding programme and selects the donors. In case of silkworm, a systematic maintenance and preservation of the desired characters is essential. Silkworm breeds are most often exploited as F1 hybrids. Hence, a breeder looks for genetic distance and combining ability to ensure better heterosis.

A correct selection of the donors shall depend on the understanding of the background material and the gene pool from which the donors have to be selected. Therefore, it becomes necessary to characterise, evaluate and document the available genetic material, preferably in an easily sortable manner. The following measures are recommended for an effective utilisation of germplasm material:

(a) Rapid evaluation and characterisation of germplasm collections.
(b) Development and use of efficient screening techniques.
(c) Gene cataloguing
(d) Transfer of useful genetic variability into desirable agronomic backgrounds.
(e) Strengthening facilities for maintenance and utilisation of wild primitive species cultivars.
(f) Establishing resource centres.
(g) Establishment of regional centres for germplasm storage under natural conditions, to serve as backup and correct characterisation and evaluation.
(h) Strengthening of computer facilities for data recording, processing and retrieval.
(i) Training in genetic resource management.
(j) Quick exchange of information between the scientists of gene banks and breeders.

Organising mulberry gene bank

Organisation of the germplasm bank primarily involves collection, charaterisation, conservation, documentation and utilisation of the genetic resources.

Collection

Genetic resources are usually collected by exploration, exchange and introduction. Exploration is basically a phytogeographical survey conducted to identify and collect the genotypes from their: (a) natural habitat or (b) areas of domestication or cultivation. Exchange is a process of collection from other

institutions or individuals on mutual cooperation. Introduction is the term used to indicate bringing the material from outside the country.

Sanjappa (1989) gave a brief account of the geographical distribution of the genus *Morus* , which indicates that mulberry is very little explored in African region (Table 7.1). Exploration involves identification of the variants at its natural habitat and requires thorough planning and preparation. The particulars of the earlier collections from the area have to be noted along with addresses. Flowering season is ideal for exploration, since it will be convenient to study some taxonomical studies in the field at the time of exploration. Herbarium of earlier collections is usually taken as a reference material to help in avoiding collection of duplicate material. Since mulberry is propagated vegetatively, the need for a subsequent trip for collection of seed, usually does not arise.

Each time a variety is collected, some primary information called passport data is collected and maintained. This includes in brief, the address and description of the place of collection, its description at the time of collection, pedigree and mode of origin in case of synthesized varieties/breeds, special features, donor's identification number if any, etc. The samples thus collected should be initially kept in isolation for quarantine check. Only after confirming that the material is free from any contagious disease, it should be brought out. After weeding out undesirable material, the collections are accessioned and charaterised.

Characterisation

Characterisation is a study of the germplasm collections leading to distinguishing the varieties from one another. Apart from the normal morphological studies, it is essential to establish the genetic distance from variety to variety with reference to a number of desirable characters which are useful in breeding. Better charaterisation ensures better utilisation of the germplasm. It is well known that what is visible is the result of gene-environment interaction. It is therefore suggested to charaterise the varieties at their respective agro-climatic zones, so that the breeders can have a better selection. Similarly, testing for disease resistance should be done at the hot-spots of endemicity of diseases. Evaluation can be carried out at three different levels, an initial charaterisation to include highly heritable characters, a primary evaluation which follows as a second step including agronomic features, which is of greater importance to the breeders and a secondary evaluation and the third in-depth evaluation (Hawkes JG, 1987). Hotta (1953 a, b; 1954 a, b) studied the taxonomy of a number of mulberry species in and around Japan. Most recent effort of

charaterisation of mulberry germplasm is done at the silkworm and mulberry germplasm station in India (Anonymous, 1997).

Conservation

Conservation is done in three different levels, base , active and elite collections. Base collections are those which are preserved as posterity without much disturbance. This forms the source material for any further work. Active collections are those which are under charaterisation and evaluation for their use. Elite collections are the improved breeds and those which are in active use. All living material is prone to the vagaries of nature and therefore essential to maintain at one or two other locations as a safety measure. In case of accidental loss of any genetic material at any place, the material from other unit is brought and maintained. It is therefore advisable to maintain regional centres for charaterisation and maintenance of back-up germplasm material in each agroclimatic region. One such centre is essential in each tropical and temperate region.

Tissue culture and cryopreservation techniques can also be employed to preserve the genetic material. Henshaw (1987), suggested restricted growth storage procedures for long term storage of meristem or shoot-tip cultures. Before this, a lot of work need to be carried out to standardize the procedures. At present, tissue cultured plants can be best used for exchange of disease-free genetic material. This can also be employed for screening the varieties for salt, draught and disease tolerance at miniature level, in the laboratory.

Documentation

Proper documentation is a prerequisite for proper utilisation of the charaterised genetic resources. Use of computers for storage and retrieval of such documented information makes it more convenient for the selection of breeds by the breeders. This also facilitates elimination of duplicates through scoring of morphometric characters (Huaman et al., 1977). Apart from storing the information on the index cards and computers, it is advisable to maintain a herbarium as a reference centre for the group.

Utilisation

Utilisation depends on how best the varieties are charaterised and catalogued. In addition, the breeders may have to study some of the characters they are looking for to achieve their breeding goals in their respective environment.

Therefore, a free flow of genetic material along with the catalogued information to the breeders is essential.

B. Organising silkworm gene bank

Just like mulberry, the organisation of silkworm germplasm bank also primarily involves collection, charaterisation, conservation and utilisation of the genetic resources.

Collection

Silkworm, except for a few of its wild relatives, is a fully domesticated insect totally depending on human care. Silkworms are collected from the breeders, rearers or other institutions maintaining them and explorations have very little relevance.

Characterisation

Characterisation of silkworm breeds can basically follow the same steps involved in charaterisation of mulberry. Apart from morphological studies, special attention is required on the yield and quality contributing characters, tolerance to odd climate, resistance to diseases and other special characters required for specific use of the breeds. Like mulberry, silkworms also evolved in parallell to suit various environmental conditions. Silkworms are very sensitive and respond well to the environmental stimuli and there is a high degree of variation in their response to different climatic conditions. It is therefore necessary to charaterise or evaluate them in their respective regions. Commercial exploitation of silkworms is always done in the form of hybrids and hence it is essential to establish the genetic distance between different breeds and group them. A good amount of work has already been documented by Yokoyama (1959), Tazima (1964), Chikushi (1973), Doira (1978), Anonymous (1997), Hiratsuka (1999), etc., which can provide necessary guidance for characterising silkworm genetic resources.

Documentation

The documentation in silkworm gerplasm is equally essential. A museum with specimens of different breeds and their photographs displaying their morphological characters has to be maintained as a reference material. However,

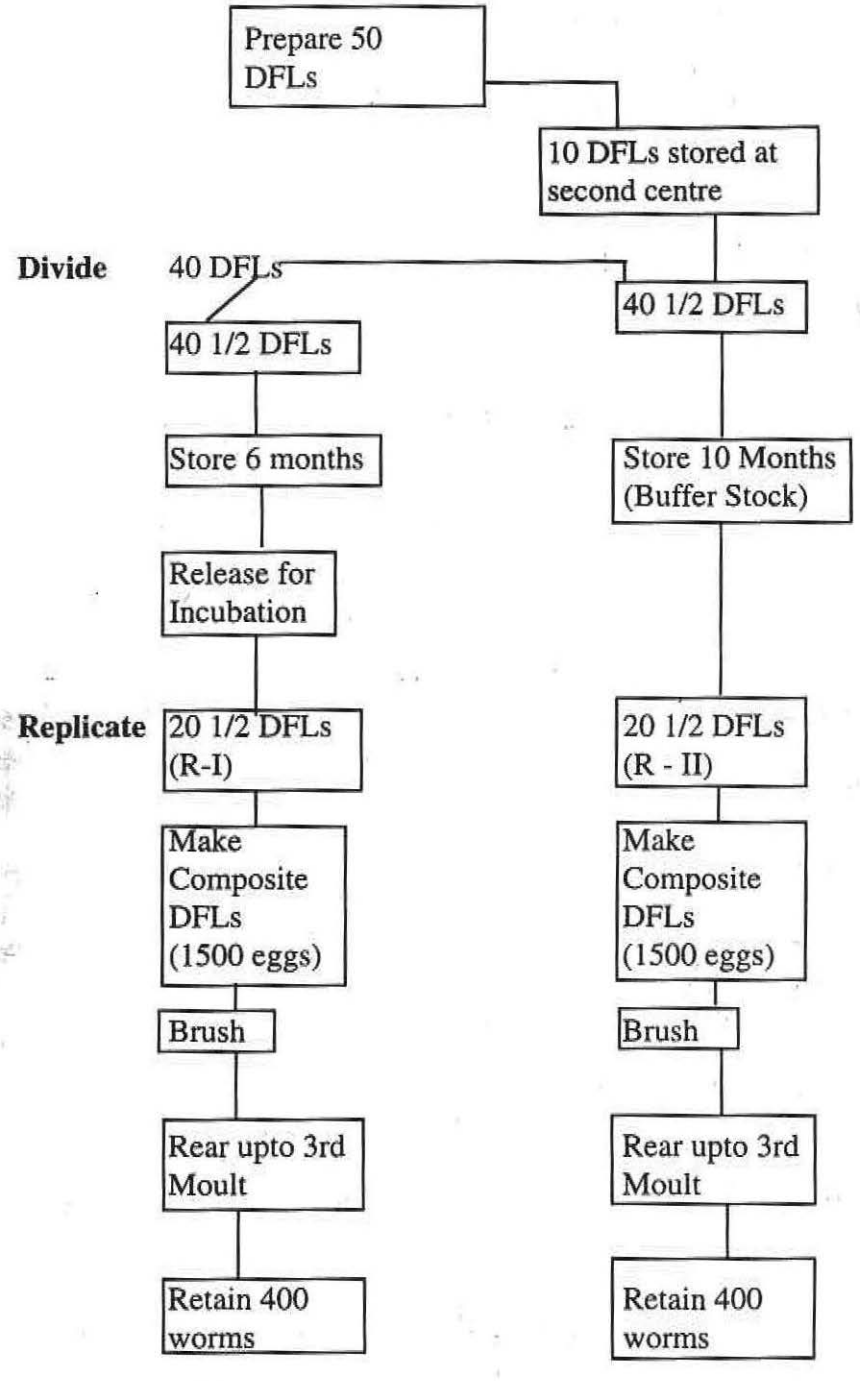
one has to largely depend on other characters also.

Conservation

Silkworms, being fully domesticated sensitive insects with a short life span of about 50 days, cannot live without human care, even for short duration. They are highly sensitive to environmental fluctuations and prone to some dreaded diseases which can wipe out the stocks within no time. Therefore, silkworm breeds have to be maintained over generations through great care. Depending on the voltinism, the number of generations of each breed varies with one (univoltine) two (bivoltine) or more (multivoltine) generations per year. The univoltine and bivoltine eggs can artificially be made to hatch in 10-12 days after laying or within 10 months. A scheme for their maintenance is given in Fig. 7.1. In case of multivoltines, 4-5 generations have to be reared in a year. In both cases, keeping back-up material as a safety measure is essential. Repeated sexual reproduction over years can cause a drift in their genetic constituents. It is therefore essential to find ways and means of reducing the number of generations to be reared. It has been reported that the multivoltine seed if incubated at a temperature just below 15^{o} C. Chawki reared at 18^{o} C and later reared at higher temperature, can produce hibernating eggs which can be stored for longer period. However, confirmatory work is needed to ensure such methods do not bring about changes at genetic level. It is advisable to maintain the wild relatives *Bombyx* sp. *in-situ.*

In addition, cryo-preservation of embryos and parthenogenesis in silkworms have a good scope for utilisation for germplasm maintenance.

A schematic organisational structure of an ideal mulberry and silkworm gene bank is given in Fig. 7.2. Above all, the success of a gene bank solely rests on how best the genetic material is used.



Continue rearing till end and repeat the process

Fig 7.1. Scheme for maintenance of bivoltine and univoltine silkworm breeds

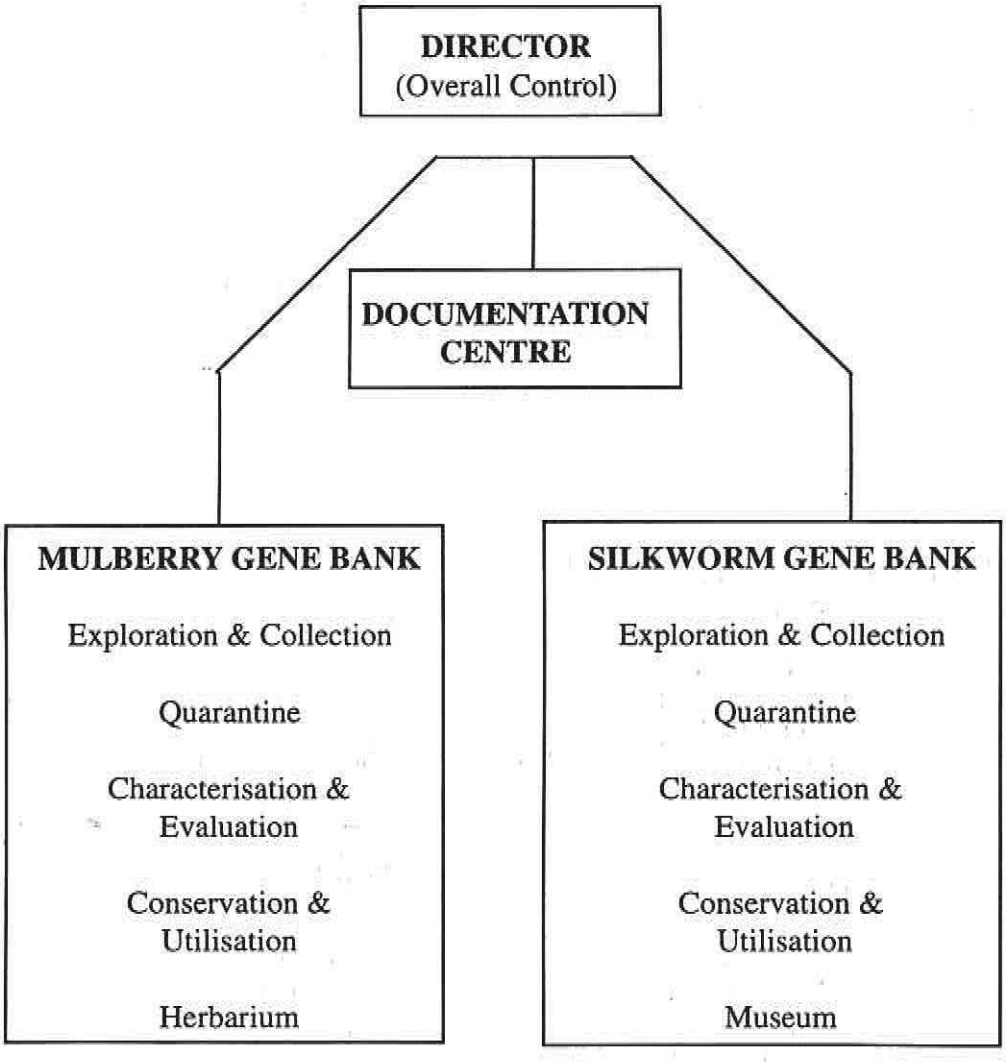


Fig. 7.2: Organisational structure of a mulberry and silkworm gene bank

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8. POST HARVEST CHALLENGES IN WILD AND MULBERRY SILK WEAVING IN AFRICA

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Introduction

In rural Africa, with its growing population, economic prospects do not look good, mainly due to limited resources, lack of skills, limited markets and lack of capital. It is imperative that any project in these areas be planned and managed within these parameters. The resources must be available and sustainable. The community should be informed and educated to utilise and not overexploit these resources. The skills necessary to process these resources must be within the capability of the community. Any training programme must be uncomplicated and inexpensive. The project must be able to run well with a minimum of management and logistics. It must above all be sustainable and economically viable as a business, and more so have a direct economic benefit to the participating community. The product must therefore be easily marketable and a constant demand created for it.

Weaving

The craft of weaving is one of the most ancient crafts of the world. Throughout history people have insulated themselves against the climatic variations of their homelands by weaving cloth, rugs and all manner of covers and trappings. Textile production has evolved over thousands of years from the simplest methods of finger–plaiting and the interlacing of animal and vegetable fibres, to the complexities of computer controlled power-loom weaving, and with it, textiles have developed from the most basic items of utility into the most elaborate artefacts of prestige.

The process of weaving was developed in various regions of the world at different times. There are many historical references to weaving and the nature and quality of the cloth in such books as the Old Testament of the *Bible* and even in Homer's *Illiad* of classical literature.

Many societies and cultures in Africa have long histories of weaving. One such example, is Kenti cloth of the Ashanti people of Ghana, which dates back to the 12th Century when it was woven exclusively for kings and queens. Certainly, among these African cultures there have been those weavers who have discovered and used cocoons of wild silk or were introduced to mulberry silk by European traders in the past and who continue to do so today.

As far as I am aware, the introduction of sericulture (the process of rearing silk producing insects in captivity and collecting their silk), is fairly new to Africa. Although mulberry silk was introduced to Madagascar in 1852, I do not have any information as to when it was introduced in other African countries. In South Africa, a government research programme was started in 1981 and privatised in 1994. It is now known as Tsinini Silk Farm.

Organised sericulture (mulberry silk), including the collecting of cocoons in the field (wild silk), the processing of the silk, the reeling or spinning of it and the weaving of fabric from it, open innumerable opportunities for job creation, even in the most rural of areas. I am not going to deal with the production or harvesting of the two types of silk, but rather the post production: spinning, dyeing and weaving. These three disciplines in themselves offer opportunity for even the most disadvantaged of communities, to learn a life-skill (that can be passed from one generation to the next) and uplift and empower themselves.

Funding: The first challenge.

Any project that will utilise post production silk in Africa, will require funding. The following are the concerns:

(a) Who is going to provide the funding?
(b) What sort of projects will be funded?
(c) How much funding will be available?
(d) Where will the project be located?
(e) Who will run the project?

Language and culture

Wherever possible, projects will need to be designed with the following factors in mind:

(a) Local customs
(b) beliefs
(c) language

I will separate the two types of silk for the purpose of this discussion. Many of the challenges faced by either will be the same.

Mulberry silk, Bombyx mori

As most cocoons will be produced on a silk farm (sericulture centre) or in close proximity to such a centre, it is fairly logical to assume that a spinning and weaving industry will develop. This could be industrial, semi industrial or artisanal. I am going to concentrate on the artisanal spinners and weavers, as it is these people who will face the biggest challenges. First and foremost we will have to identify these potential spinners and weavers and train them. A training programme specific to African conditions will have to be developed. Wherever possible, traditional weavers in an area should be consulted and traditional methods, if suitable used.

A training programme once implemented, and basic skills taught, opens opportunities for trainees either to form co-operative weaveries or go it alone as independent weavers. They could go on to become teachers. Co-operatives can be established in small towns, villages or where there is a concentration of people. The one challenge that will be faced when trying to introduce spinning and weaving into a culture that has never done this type of work, and particularly the very rural people, will be the need to show the benefits that can be gained, and how they are able to fit in with the local custom and culture and the daily routine of the people. It must not disrupt the normal activities such as planting and harvesting or the routine activities around the home.

An activity such as hand-spinning can be a very laborious task, which can be done between other tasks, or while doing other things such as waiting for buses or taxi's. With a drop-spindle, spinning can be done just about anywhere. The challenge will be in getting the people to accept the craft, learn it and practice it. Certainly this will be more important when dealing with the spinning and weaving of the wild silk. Mulberry silk is either reeled or hand-spun

Reeling the silk

This is the process of extracting a continuous thread directly from the cocoon by immersing the cocoons in about to water boiling and reeling off the threads.

It can be done using a "charakha reel" (India) which can be constructed by anyone with basic wood working skills. Hand-reeling of silk requires skill and patience. Even the experienced workers rarely produce more than 300g of raw silk a day

Multi-end reeling basins with 10 ends or more are used in Asian silk producing countries. However, they are expensive and need extensive training. Hand-spinning using cut open and de-gummed cocoons can be done either on a drop-spindle or a foot powered spinning wheel. There are many designs and one can even be constructed using parts of an old bicycle.

A relationship between co-op or independent spinners, weavers and cocoon producers must be established, in order for these people to understand the causes in the fluctuation of supply and price of cocoons. Obviously, the number of co-operatives or independent spinners and weavers, is going to be relative to the amount of silk produced and by whom. The more small silk producers or farmers, the more spinners and weavers it will be possible to train and empower. One challenge will be to find a way to ensure that there is always silk available for the spinners and weavers 12 months of the year. Without this, it will be very difficult to convince these people of project sustainability and worth.

As a co-operative is basically a social structure where people interact on a continuous basis in pursuit of a common goal, one needs to look at the social relations of the group. beliefs of the group and their culture, and marry these. Someone will have to be trained or brought in with managerial skills and the understanding of these beliefs.

Personal satisfaction and efficient production are mutually interdependent in work activity. Neither of these is possible without recognising the total social situation in which people find themselves. One needs to ensure that the focus of attention is not shifted away from the worker and his social relationship, and that production, money and profit become ends of economic activity. One needs to maintain a sense of satisfaction, self-direction and achievement.

Equipment

Obtaining or building equipment (for reeling, spinning or weaving), will present challenges. Apart from (where it is possible) encouraging traditional weavers to share their skills and knowledge of local weaving equipment, Africa should certainly look to the Asian countries that have long histories of rural silk weaving. A great deal can be learnt from them and adapted to African conditions.

Designs of reeling machines, spinning wheels and looms must be decided according to the project, what type of fabric is to be produced, etc. I feel that it will be essential for Africa to develop her own styles and designs i.e. products with a distinct "African" flavour. and not to try to emulate the silk fabrics being produced in the East.

Weavers must be taught and encouraged to develop their own ethnic designs, styles and colours. The more ethnic and African the better. The easier the cloth is recognized as being "African" the easier it will be to market as "African silk." Obviously the acceptance and marketability of the fabric will determine the eventual sustainability of a project.

One point that must be remembered is that Africa will always face an uphill struggle, trying to break into the international silk market. What we need to do is create an African silk. I may be wrong in this, so I will leave the marketing side of things to the experts. Looms do not vary greatly in essential detail, but may vary greatly in size, design and sophistication. The main technical requirement of a loom is to provide the correct tension and means of dividing the warps into alternate sets of leaves. A shedding device allows the weaver to pass wefts through crossed and uncrossed warps, instead of laboriously threading the weft in and out the warps.

The simplest form of loom is the horizontal or floor loom. This is the ideal loom for rural conditions as all the materials needed for its construction are available in any village. The quality of fabric woven on this type of loom can be seen from Lamba, woven by rural people in Madagascar on the floor of their homes.

Backstrap looms are used in many cultures around the world and in Africa. These looms are used to weave narrow strips of cloth which are sewn together to form the finished fabric "Kenti cloth."

Various "European" loom types have developed through the ages and are commercially available (upright, counter-march and flying-shuttle). There are also various loom designs being used in Asian silk producing countries. It will be necessary to look at all of these and decide which will be more acceptable, affordable and serviceable.

Tsinini Silk Farm is the only commercial silk farm in South Africa. Originally started as a government research project in 1981, it was privatised in 1994. In order to make the farm a viable business, the first decision taken by the new

owners was to 'open the farm to tourism. Guided tours are conducted daily. Organised educational school tours and visiting tourists are actively encouraged to visit the farm, where they are shown the intricate methods of silk farming.

In 1998 it was decided by the Directors of Tsinini to open a showroom and weavery to promote the silk farm, weave fabric from the silk produced on the farm and market this in the showroom. The weavery employs 10 local women who have been taught to hand-spin and weave fabric from cocoons produced on the farm by *Bombyx mori*. A small quantity of wild silk from *Gonometa postica* and *G. rufobrunnea* are also processed, spun and woven into fabric

One of the first decisions taken when the weavery opened, was on the structure and type of cloth we should weave. As most peoples concept of silk is the fine eastern silks. We wanted to get away from this and weave a fabric with more body and texture, something we could call an African silk

It was decided that, rather than use the traditional method of reeling the silk and weaving sheer fabric, we would remove the pupae from the cocoon de-gum them in an alkaline solution and hand-spin a coarse textured yarn in the same manner as is used for wool and cotton. This way, one is able to spin various qualities of yarn that will weave fabrics of varying texture. We weave our own fabrics that are used in the manufacture of various products that are for sale in the showroom. e.g. ladies jackets, waistcoats, shirts, cushion covers, throws, scarves and table cloths. The weavery is an integral part of the showroom, where all products produced in the weavery are on sale.

Tourists are encouraged to walk through the weavery, where one of the team of ladies explains and shows the methods of reeling silk and hand-spinning of the yarn. There is a short video showing continuously, on silk farming and weaving at Tsinini, for those tourists and visitors that are interested. Tourists are able to watch the spinners and weavers at work. Encouraging tourists to walk through the weavery, gives them a better understanding, awareness and appreciation of the products for sale in the showroom

Within months of having opened the weavery, we were producing fabric for one of the top couturier's in the country who designed and showed a range of African silk garments that were sold under the label "Silk de Afrique. This was our first venture into the world of "high fashion".

There have been numerous enquiries from people wanting to market our products in boutiques and shops around the country. Unfortunately, at this stage

production volumes preclude us from looking at these potential markets, although it is good to know that a demand has been created, and there is still untapped potential.

The directors of Tsinini have started a programme to get local farmers interested in silk farming. Due to financial constraints, and no government or NGO funding, it has been an uphill battle. The interest is there and the people are keen, but there is no money within a small privately owned company like Tsinini to foster such developments.

Wild silk

This industry poses many different challenges. I know that I was to deal with just the post production challenges, but I feel that there are a number of questions that need to be answered before getting onto that, such as:

(a) What form of exploitation will take place?
(b) Where will this take place?
(c) Who will collect the cocoons?
(d) Who will manage the resource?
(e) How will the cocoons be transported and to where?
(f) How will they be stored?
(g) Who is going to pay for them and what price?
(h) What is the availability and sustainability?

These are all questions that have to be resolved and structures put in place before the spinners and weavers can even begin to operate.

I am often told when discussing projects of this nature that, "this is Africa", "things like this do not work in Africa". "Introducing people to something alien is one thing and getting them to adopt it is another". I feel that if it is approached correctly in the African spirit, it will be accepted and can work. People just need to see the benefits.

Rural people must first be shown the complete process from the collection of cocoons, the de-gumming process, the carding and hand-spinning through to the weaving. They must literally be shown the conversion of cocoon to cloth, the ease of producing and the value of the finished product. Only then can those who are interested be taught.

As I have mentioned before, if there is a history of weaving in the area and there are traditional weavers in the area or region, they must be encouraged to get involved or help.

Sanyan cloth in Nigeria is a combination of cotton and *Anaphe* silk. *Anaphe* and *Epanaphe* silk in Nigeria have been woven into velvet, plush fabrics, neckties, umbrellas and even balloons. *Anaphe* species are known to be exploited in other African countries such as Uganda, DRC. Togo and neighbouring countries.

One attempt at commercial exploitation of wild silk, *Gonometa rufobrunnea* (Aurivillius) Lasiocampadea was in north-eastern Botswana in 1985/86. It failed for various reasons amongst which was the fact that management did not abide by the programme laid down by the company's directors. They erected a factory costing more than the value of cocoons collected. However, it is very important to note that at the same time as this company (Shashe Silk [Pty] Ltd) was getting the local population to collect the cocoons for them, they ostensibly fostered a local peasant production programme through local charitable institutions (missionaries, etc.). This they did by making top quality fibre available at cost. According to one of the directors, these endeavours never yielded much. The probable reason was that it would not have been in interest of Shashe Silks to show the collectors the method of de-gumming. However, I feel that in order to get the support and co-operation of the people, it is essential that they know and are able to do the complete process themselves. "Give a man a fish and feed him for a day, teach him to fish and you feed him for life" Certainly, while Shashe Silk was in operation and using the local population to collect cocoons for them, 13,800 families benefited. Since the demise of the company these same people, had they been taught the whole process, would still be able to generate an income from the cocoons for themselves.

Conclusion

In conclusion, I would like to say that I do not think or imagine that every spinner and weaver will be a success and go on to be rich and famous. There will be those that will attain these heights, but if they can just learn a life skill and earn a reasonable income from it, the project can be deemed a success.

9. CONSERVATION OF INDIAN TROPICAL WILD TASAR SILKMOTHS AND ITS FARMING PROSPECTS

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Abstract: Conservation of natural or wild animals is a serious global concern since various species are in the process of extinction and some species are already extinct. Wild tasar silkmoth is a productive insect contributing tasar silk. Indian tasar fauna comprises of eight *Antheraea* species and 44 ecoraces. Compared to all the varieties of commercial silk like eri, mulberry and muga, tasar is very unique since the quantum of silk fibre per cocoon is the highest in India. India embraces all the four varieties of natural silk fauna, but tasar has attracted the attention of farmers, rearers, villagers, economists, biologists and sericologists in particular, since it produces a high amount of silk against a low investment and infrastructural facilities. India ranks second in tasar silk production in the world and Orissa occupies second position in India. Furthermore, modal variety (a particular ecorace), confined to Similipal Biosphere Reserve (Mayurbhanj District, Orissa, India), is absolutely eye-catching, as these cocoons are toughest, having the highest amount of silk fibre per cocoon in the world. The characteristics of this modal ecorace is univoltism, tetramoulting and polyphagous habit in wild state. Other significant commercial traits are higher fecundity, cocoon weight and silk yield. Owing to its better quality and quantity of silk fibre, it has become popular worldwide.

Introduction

Wild sericulture is a labour intensive agro-based cottage industry, which can provide employment to millions of people living in remote rural areas close to the forest. The world trend in silk production and consumption is quite

favourable. The demand is increasing and the production in major silk producing countries like China, Japan, Brazil is gradually diminishing due to several reasons such as diversification, affluence, high cost of labour, rampant collection of cocoon, deforestation and unscientific practice. Wild silkmoth conservation and utilisation, enhance the productivity and economic returns for small scale land users, particularly the target women groups. Silkworm farming provides the economic basis for community development, suitable for increasing participation of women in cash economy.. Hence, the farming of these wild species needs to be adopted as an insect-based enterprise by rural communities for the integration of biodiversity conservation with the economic development of the rural people and especially women. This can be a means of diversifying their economic base and therefore, encourage them to participate in the current world efforts to promulgate conservation-based development.

Wild silk production can provide a strong incentive for rural communities to adopt sound land management practices as an adjunct to subsistence agriculture. This would promote conservation of natural ecosystem and wild silkmoth habitat, in the face of growing human population. Wild silkmoth farming facilitates the access of women to natural resources, technology and income generation. Development of production system in the wild to conserve the genetic diversity and production of wild silkmoth species in different ecology, is highly desirable. The effort may help alleviate poverty, improve the human condition and preserve the nature grown biological systems on which all life depends. Since India has tremendous scope and opportunity to promote wild tasar silk culture, due attention should be given for its conservation to bring about sustainable development in this new millennium.

Natural animal silk is a fibre produced by certain arthropods as building material for cocoons and webs, especially by the larva of a silkworm moth, mainly of "fibroin" coated with "sericin" formed by the hardening of a liquid emitted from spinning-glands or silk gland (located in the body and opening at silkworm's mouth, but in spiders on the abdomen). In fact, the source or reservoir of silk is the silk gland from which silk is spun. Usually silk insects are of two types, depending on their rearing performance, such as: (i) wild silkmoth and (ii) domesticated silkmoth (mulberry). Silkmoth grown in natural forest with wild eco-geographical condition are termed as "wild silkmoths", like tasar. Now some wild silkmoths have been partially domesticated for which wild moths are termed as "semi-domesticated" or "semi-wild silkmoths". Wild silk has a tremendous market potential in the world market, but the global wild silk production is only 7%, whereas global silk demand is growing annually by 2-3%.

China's dominant role as the world's largest supplier of both raw material and finished silk products remains unchanged. India's position in international market is temporarily slightly deteriorated, but its domestic market remains buoyant. Activities encouraging or imposing the use of environment friendly (eco-friendly) textiles and garments in western countries continue to be a matter of concern, especially among suppliers in developing countries. Recently, the European Union has introduced eco-labelling criteria for T-shirts and bed linen and the intention is to create similar criteria for the entire textile sector. While the existing eco-label schemes are so far not mandatory, silk suppliers will have to monitor future developments so that they are ready when the time comes. Each country feels the urgent need for silk promotion, but solving this problem appears to be herculean. One of the important reasons is the need to burnish the image of silk, somewhat tarnished after the surge in the trade in cheap sand-washed silk products. It is ironic that producers of various other products such as cigarettes, cosmetics, competing textiles and the airlines service sector, use the word silk to describe the best features, of their products, while silk producers and processors remain more or less silent. Another concern, namely that of the availability of reliable and accurate statistical information, remains unresolved. Systematic collection, processing and dissemination of data, both quantitative and qualitative, would greatly enhance the global silk development efforts of everybody concerned — producers, converters and traders alike.

Silk is produced by the poor, but is the product for the rich. Silk and silk products have always been associated with luxury and have traditionally been expensive. The rearing of silkworms continue to be extremely labour intensive and time consuming. However, the perception of sericulture as a profitable venture is encouraging in countries with available labour, suitable climate and vast stretch of land to start sericulture activities. Unlike cotton and wool, which are typical export commodities and often processed in other countries, silk has traditionally been processed and consumed in the producing countries. Silk is mainly used as raw material for luxury products. Today, however, silk goods have attracted a new consumer group, a young generation of consumers with more money to spend, partly because the number of women employed has increased dramatically during the last two decades. Another reason for the interest in silk, is the general rise in demand for natural fibres, brought about by the ongoing environmental movement.

Natural silk has value, but the introduction of sand-washed silk in the early 1980s democratised the trade and brought silk within the reach of most

consumers in the West. However, the low-cost goods did not live up to the traditional image of silk as a quality product. In the aftermath of that fashion wave, silk now has to compete with other textiles for a place in the international market. Nevertheless, growing demand for ready-made articles in silk, continues to encourage manufacturers in developing countries to try to penetrate markets in the West. Silk is highly preferred for garments, ready-made garments, fabrics for interior decoration and other products such as neckties, scarves, cushion covers and other items for the home, because of its lustre, longevity and smoothness. Silk has value and in future will have demand as the "queen of textiles" or "queen fibre" of nature.

Silk scenario of the world

Various types of fibres such as cotton, synthetics, cellulose, wool and silk are in use worldwide; silk production is quite significant (Table 9.1). The share of silk in world production of all textile fibres in 1996 remained unchanged from its 1992 level of about 0.2%. While mulberry silk production has admittedly been steadily rising, silk will never be available in large quantities and international supplies will, no doubt, remain limited in future. While world production of raw silk rose by more than 100% between 1978 and 1993, it dropped by 20% from 1,000,000 tons in 1993 to 80,000 in 1996 (Table 9.2). The rank of China and India as first and second largest producers remain unchanged. As in Japan, silk production in the Republic of Korea continues to decline, largely because of industrialisation. Japan remains the world's largest market for silk products and its imports of silk products continue to rise. China has become Japan's largest supplier of manufactured silk goods (Table 9.3). The bulk of the silk woven in China comes from powerlooms; production in Thailand and India is largely done in handlooms. All weaving in Brazil and the Republic of Korea is carried out on powerlooms. The use of powerloom is expanding; this is particularly so in India where the increasing domestic demand for sarees is justifying the increased use of this type of loom. Traditionally, more than 90% of the world market for silk garments was geared to women's wear. Silk products for men were in the past limited to shirts, neckties, handkerchiefs, socks and underwear. The situation has changed significantly in the West; as a direct result of the marketing of sand-washed silk.

Table 9.1: World production of textile fibres, by quantity, 1975-1995 (in thousands of tons)

Year	Cotton	Synthetics	Cellulosic Fibres	Wool	Silk	Total
1975	11,809	7,346	2,955	1,502	49	23,665
1980	13,981	10,476	3,242	1,608	55	29,372
1985	17,540	12,515	2,999	1,673	59	34,786
1989	18,800	16,000	3,200	2,000	67	40,067
1991	20,830	16,440	2,860	1,940	75	42,145
1992	17,990	17,200	2,720	1,730	88	39,728
1995	19,200	20,200	3,000	1,600	100	44,100

Source: UNSD/ITC Comtrade Database System, 1995

China is today's largest supplier of raw silk to the international market. India, by contrast, has become the world's largest importer of raw silk. Per capita consumption of silk in Europe has traditionally been highest in Switzerland, followed by Germany and the United Kingdom. Japan has the highest per capita consumption of silk in the world. Although consumption has fallen in recent years, principally because of a drop in demand for kimonos, Japan's position is likely to remain unchanged as demand rises for other silk products. Hongkong (China) and China taken together, are today the world's largest converters of silk fabrics. Nearly 60% of the silk garments produced in Hongkong is sent to the United States; the balance is exported to various European countries. Hongkong is the second highest exporter of silk blouses to Germany and India and imports raw silk from China, Brazil and Vietnam, reached between 7000 and 8000 tons in 1996. China's overall domination of the international silk trade is expected to continue for years to come despite the growing number of aspiring silk producers, such as Bolivia, Columbia, Cote' d'Ivoire, Israel, the Islamic Republic of Iran, Peru, Sri Lanka, Turkey and Uganda.

Apart from that, France, Germany, Italy, Switzerland and the United Kingdom are Europe's leading converters of silk, Germany is by far Europe's leading market for textiles and clothing, including silk products. It has also become

one of the world's most competitive markets in the sector (Table 9.4). Italy has over the years been the world's largest importer of waste silk, which is spun into yarn for the production of knitwear. With per capita consumption about a third of that in Germany, Sweden continues to have the lowest consumption rate in Europe. Brazil is the world's third largest silk producer after China and India. China is the world's largest producer of "tussah", a type of wild silk. Production of this silk, now reaching about 1000 tons annually, takes place mainly in northern province of Liaoning. The output of China amounts to 59,000 tons of mulberry silk and 1000 tons of "tussah" in 1996.

India is the only country in the world to produce all the commercially known varieties of silk — mulberry, tasar (both tropical and temperate) eri and muga. It ranks second to China as a mulberry silk producer and accounts for about 17% of world's production of raw silk. It is also the second largest producer of "tasar" silk, again after China. It monopolizes production of the golden-yellow muga silk. Various categories of people, like cocoon producer, reeler, twister, weaver and trader are involved in sericulture (Table 9.5). India has a large domestic market for silk goods and only 15% of production is exported (Table 9.6). About 85% of the silk goods sold on the domestic market consist of traditional items such as sarees, saree-blouses and dhotis. India's exports consist exclusively of sarees, dress fabrics, ready-made garments and made-up articles for interior decoration (e.g. bed spreads, cushion covers, curtains). In 1995-1996, garments were the second best single category of exports (26%) after dress fabrics (39%) (Table 9.6). The table indicates that India's export trade is highly concentrated, with the 10 leading buyers taking 74 % of its total trade in the product categories covered.

Table 9.2: World production of raw mulberry silk , by country/area and by quantity, 1938-1996 (in tons)

Producer	1938	1978	1985	1989	1991	1992	1993	1996
Total	56,500	49,360	58,914	66,978	76,761	88,749	100,175	82,660
China	4,855	19,000	32,000	40,000	48,500	60,570	71,845	59,000
India	690	3,475	7,029	10,000	12,000	13,000	14,000	13,000
Japan	43,150	15,960	9,582	6,078	5,527	5,100	4,254	2,250
CIS[a/]	1,900	3,240	3,999	4,000	4,000	4,000	4,000[b]	2,600[b]
Brazil	35	1,250	1,458	1,900	2,034	2,296	2,326	2,360
Others	4,045	2,200	2,748	3,100	4,000	3,783	3,750[b]	3,500[b]

[a] Commonwealth of Independent States
[b] Estimate

Source: Silk Review, 5th Edition, ITC, Geneva, 1977

Table 9.3. Japan — imports of manufactured silk products from China by quantity and value 1993-1995

Quantity (Q): '000 pieces
Value (V): $ '000

Item	1993		1994		1995	
	Q	V	Q	V	Q	V
Total	19,070	264,970	29,482	352,168	31,460	371,261
Kimonos	2,028	27,967	2,897	44,972	2,987	38,110
Accessories	2,943	8,140	4,682	12,903	4,035	9,777
Women's blouses	4,211	51,788	6,129	66,405	4,987	57,628
Women's Coats	980	33,996	1,169	27,496	854	20,869
Men's Shirts	1,035	14,211	2,308	25,496	2,879	30,550
Men's Coats	771	19,236	810	16,475	520	10,740
Women's Sweaters	687	14,003	1,424	26,482	2,003	31,696
Women's T-Shirts	1,296	9,227	2,072	13,770	2,616	18,612
Women's Blazers	719	20,923	658	17,110	718	16,887

Source: Japan Textiles Importers Association

Table 9.5. India — percentage distribution of proceeds from sales of soft silk fabrics by category of worker (percentage of total)

Serial No.	Category of work	Weight of fabric (gram per metre)		
		40	50	60
1.	Cocoon producer	51.5	54.6	56.8
2.	Reeler	6.2	6.6	6.8
3.	Twister	8.2	8.7	9.1
4.	Weaver	14.5	12.3	10.7
5.	Trader	19.5	17.8	16.6
Total		**100.0**	**100.0**	**100.0**

Source: Silk review, a survey of international trends in production and trade, 5th Edition, ITC, Geneva, 1977.

Sericigenous Flora and Fauna

The natural silk is broadly classified into two types: (a) silk of plant origin and (b) animal origin. The natural silk of plant origin is obtained from silk cotton tree and floss-silk tree. The natural silk of animal origin is broadly of two types — mulberry and non-mulberry. Mulberry silkmoth is a domesticated type, whereas non-mulberry is universally known as "forest" or "wild-type", which is also found in semi-domesticated form. Further, the non-mulberry variety of silk is classified as insect and non-insect type. Insect type of silk is named as Eri, Muga, Anaphe, Fagara, Coan and Tasar. Non- insect : mussel and spider silk are obtained from mollusca and spider, respectively. Insect type of silk is again classified as commercial and non-commercial. Eri, muga, tasar, anaphe, fagara and coan are commercial type of insect silk, whereas non-commercial types of silk is obtained from the weaver ants and green lacewing fly. The silk obtained from spider and mussels are non-commercial types (Fig. 9.2 and Table 9.7). Silk of different nature are available, such as mulberry and non-mulberry, insect and non-insect and commercial and non-commercial varieties (Fig. 9.3).

(a) Silk cotton fibre

Kapok or silk cotton fibre, is known as *Ceiba pentandra* (Bombacaceae), Sveta salmali, Safed simal, Schwetsimal, Salmali, Ilavum, Buraga, Illavi etc. It is from different parts of South Asian countires, i.e. India, Burma, Sri Lanka, Malaya, Java, Indo-China and one of the utilised textile yielding fibres. There is immense potential for this fibre if it is blended with all natural and man-made fibres. Thereby, it possesses a wide range of its utilisation in the textile and other industries. It can be used wherever lightness, moisture, resistance and floating qualities are needed, such as in insulating tanks, for lining aviation suits, in manufacture of life belts, gloves, handling dry ice, surgical dressing and sound proof rooms, etc. This fibre is obtained from the seed pod of a tree. The fibre is made up of unicellular hair occurring in the seed pods that constitute the fruit of the tree. It grows on the inner wall of the pod. The fibre is smooth, cylindrical, hollow, thin-walled and frequently bends over itself. Owing to the smoothness of the fibre, it may be mixed with cotton, wool and spun into yarn. It is resilient, light, elastic, short and silky. It has low thermal conductivity and high ability to absorb sound. It contains highly lignified cellulose.

(b) Floss silk tree

Floss silk tree, *Chorisia speciosa* is a thorny flowering tree of the Family, Bombacacaea. It is native to South America, but cultivated as an ornamental in other regions. It grows to a height of about 15 m (50 feet). The unique feature of this large tree is that the entire trunk along with its stem is covered with thorns. It is a flowering tree, bearing large pink coloured flowers. These flowers yield a vegetable silk used in upholstery (furnishing with stuffing).

(c) Mulberry silk

It is the master silk, widely cultivated in the globe. It is produced by the mulberry silk moth *Bombyx mori,* which is monophagous, i.e. feeding on the leaves of single food plant. It is univoltine in the temperate region and multivoltine in tropical region and highly economic, since the production rate is high with minimum expenditure.

(d) Eri silk

The white or brick red eri silk, also known as "endi" or "errand", is produced by *Philosamia ricini* Bioduval. This is a domesticated multivoltine silkworm. The hill tract, the valley of Brahmaputra and rich forest of north eastern India,

which is charaterised by heavy rainfall and humidity, are entirely suitable for sericulture. So sericulture is widespread in Assam and practised on small scale in Bihar, West Bengal, Manipur, Orissa and Tripura. It mainly feeds upon the leaves of caster oil plant, *Ricinus communis*.

Table 9.6: India — distribution of silk exports, by major market and product, 1995/1996 (in lakhs rupees)

Market	Fabrics	Scarves	Saris	Garments	Carpets	Total
Total	**30,675**	**6,572**	**6,677**	**20,578**	**9,273**	**79,337**
United States	7,005	124	693	15,210	1,190	25,593
Germany	3,409	3,581	53	1,184	3,223	14,173
United Kingdom	4,282	192	911	1,852	608	8,611
United Arab Emirates	845	298	1,807	166	82	3,479
France	1,692	210	11	157	816	2,364
Italy	1,671	97	--	245	108	2,559
Canada	1,024	48	515	646	129	2,464
Netherlands	91	761	--	21	150	2,306
Hong Kong, China	1,701	246	--	31	45	2,160
Singapore	286	30	1,444	38	76	1,950

Source: Indian Silk Export Promotion Council, Bombay

Table 9.7: Silk variety, host plant and distribution of silk

SI. No.	Types of silk	Scientific name of the silk insect/plant	Common name of host plant	Distribution of silk
1.	Silk cotton fibre	*Ceiba pentandra*		India, Burma, Sri Lanka, Java
2.	Floss-silk tree	*Chorisia speciosa*		South America
3.	Mulberry	*Bombyx mori*	Mulberry	Japan, Korea, USSR, China, France, Spain, Italy, Iran, Thailand, Bangladesh
4.	Eri	*Philosamia ricini Boisd.*	Caster, kesseru, simul, alu, papita, payam, maharuk	Assam, Bihar, West Bengal Manipu, Tripura
5.	Muga	*Antharaea assamensis* WW	Som, Scalu, Chapa, Mejankori, Bhomlati	Assam
6.	Anaphe	*Anaphe moloneyi* Druce, *A. panda* Boisduval	Borkoli and others	Southern and Central Africa
7.	Fagara	Attacus atlas L.	Polyphagous Sudan	Indo-Australian region, China
8.	Coan	*Pachypasa otus* D.	Pine, ash, oak, juniper	S. Italy, Greece, Turkey,cypress Rumania

Table 9.7. Contd.

SI. No.	Types of silk	Scientific name of the silk insect/plant	Common name of host plant	Distribution of silk
9.	Mussel	*Pinna squamosa*	-	Italy
10.	Spider	*Nephila madagascarensis Miranda*	-	New Guinea, Paupa, North Queensland
11.	Weaver ant	*Oecophylla longinoda O. smaragadina*	-	Tropical Africa, Eastern Asia
12.	Green lace wing fly	*Chrysopa carnea Osmylus fulvicephalus*	-	-
13.	Tasar (Tropical)	*Antheraea mylitta* Drury A. *paphia* Linn.	Sal, Asan, Arjuna	India
14.	Tasar (Temperate)	*A. yamamai*, A. proylei jolly *A. pernyi* Guerin	Oak	Japan, India, China

(e) Muga silk

It is the golden yellow silk produced by a semi-domesticated multivoltine species *Antheraea assamensis.* Muga culture is exclusively the monopoly of Assam State of India and pride of world. Larva of muga feeds upon mejankori leaves, *Litsea citrate.* So muga silk is known as "mejankori silk", which is attractive due to its durability, lustre and creamy white shaded fibre. It is also known as "Indian golden yellow silk".

(f) Anaphe silk

This type of silk is produced by the anaphe silkworm which has various species like *A.moloneyi* Druce, *A. panda* Boisduval, *A. reticulata* Walker, *A. ambrizia* Butter, *A. carteri* Walsingham, *A. venata* Bulter, and *A. infracta* Walsingham. The silk is distributed in southern and central Africa. The fabric is elastic and stronger than that of mulberry silk.

(g) Fagara silk

It is produced by the giant silkmoth, viz *Attacus atlas* L. and few other related species or races inhabiting India, Australia, China and Sudan. The fagara cocoons are light brown in colour and of less importance, since the silk is not commercially exploitable.

(h) Coan Silk

Coan silk fibre is secreted by the larva of *Pachypasa otus* D. These larvae are found in Mediterranean biogeographic region. This is a polyphagous insect feeding on pine, ash, cypress, juniper and oak. The cocoons are white in colour.

(i) Mussel silk

It belongs to the non insect category which is obtained from a particular mollusca, *Pinna squamosa.* The fibre is called "byssus thread", brown in colour, strong in nature and helps the animal to anchor itself to a rock or any surface of the habitat. The byssus is combed and then spun into silk, popularly known as "fish wool". Its production is largely confined to Toronto and Italy.

(j) Spider silk

It also belongs to non-insect category. Spider silk is soft and fine and is spun by arachnids, like *Nephila madagascarrensis*, *Miranda* and *Eperia*. This silk fibre is reeled out 4 to 5 times a month from the spinning tubes located at the fourth and fifth abdominal segments of the spider body. Spider silk is not used in the textile industry, because of the high cost of production. However, durability and resistance to extremes of temperature and humidity make it indispensable for cross hair in optical instrument.

(k) Weaver ant silk

Weaver ants are tiny animals living in colonies which consist of as many as 5 million female workers, progeny of a single enormous queen. The common species of weaver ants are *Oecophylla longinoda* and *O. smaragdina*. The *O. longinoda* is the yellow tree ant of tropical Africa, whereas *O. smaragdina* is the red ant of south eastern Asia. The nests are made of leaves folded together to form tight tent-like compartments. The leaves are held in place by scams of silk spun by larva. It comes from the larval gland, opening just below their mouth (Mohanty and Mathur, 1997).

(l) Green lacewing fly silk

Green lacewing fly is an insect of the Order Neuroptera. The important species are *Chrysopa cornea* and *Osmylus fulvicephalus*. The larvae live in wet moss and undergo complete metamorphosis. They are predatory, feeding largely on aphids. When fully grown, each spins a cocoon of white silk, given out from a spinneret, which is at the hind end of the body and not on the head as in the silk spinning caterpillar. The cocoons are usually attached to the leaves or barks (Burton and Burton, 1990).

(m) Tasar silk

Tasar silk is another insect variety of silk secreted by *Antheraea* species of tasar moth. The term tasar has been derived from a Sanskrit word "Trasara", meaning shuttle. It is also termed "tussah", "tusara". In India it is regarded as a symbol of tribal culture as it is mostly cultivated by the tribal people. Tasar insects are polyphagous, feeding on both primary and secondary food plants. *Antheraea* comprises of more species than any other genus of sericigenous insects. Thirty-eight species have been recorded. Besides, there are over fifty forms/variants/abberrants/races. Four species of genus *Antheraea* are used for

commercial production. Those are *A. mylitta* (India), *A. proylei* (India), *A. pernyi* (China and USSR) and *A. yamamai* (Japan). Tasar silk is cultivated in dense, humid tropical forest of eastern, middle and southern India. Tropical tasar worms feed on the leaves of *Terminalia arjuna*, *T. tomentosa* and *Shorea robusta*. The Indian tropical tasar silk insects are found in wild and semi-domesticated condition. *A. mylitta* Drury is a semi-domesticated species and *A. paphia* is a wild variety. The second type of tasar is temperate tasar silk, which is largely confined to the northeast provinces. The production by temperate tasar silk moth is *Antheraea pernyi*. However, non-mulberry silk is not only distributed in India, but also in other parts of the world (Fig. 9.4).

Use of Silk

Today man has made a herculean progress in various fields of science and technology. This exploitation is attempted exclusively for pleasure and comfort. Sericulture has attracted special attention due to rising internal demand and its export potential. Silk is used in various ways (Table 9.8). Mulberry silk is highly economical since the production rate is high against a minimum expenditure. It is used in the textile and for the preparation of other silk goods. Eri silk fibre is used for the making of "chaddars". The popular items made from muga silk are "dhoti", "chaddar", "chapkan", "pugree" and "mekhala. Fagara and coan silk are not commercially exploitable. Tasar silk is used for the preparation of saree, chadda and various types of garments. Spider silk is used in optical instruments.

Table 9.8: Use(s) of different types of silk fibres

SI. No.	Types of silk fibre	Uses(s)
1.	Silk cotton fibre	Insulating tanks, for lining aviation suits, in manufacture of life belts, gloves handling dry ice, surgical dressing and sound proof room
2.	Floss-silk tree	Upholstery (furnishing with stuffing)
3.	Mulberry	Used in textile and making of silk goods
4.	Eri	Making of scarves (chaddar)
5.	Muga	Making of dhoti, chaddar, chapkan, prugree and mekhala
6.	Anaphe	Used in velvet and plush
7.	Fagara	Commercially not important
8.	Coan	In ancient time this silk was used to make the crimson-dyed apparel worn by the dignitaries of Rome
9.	Mussel	Help the animals (mollusca) to anchor itself to the substratum
10.	Spider	Used in optical instrument
11.	Weaver ant	The nests are made of leaves folded together to form tight tent-like compartments. The leaves are held in place by scams of silk spun by larva
12.	Green lace wing fly	Used for making cocoon, which are attached to the leaves or bark
13.	Tasar	Making of saree, chaddar, dress material etc

Indian Tropical Wild Tasar Silkmoth

India is proud of producing wild silk and occupies second position in the production in the world. Tropical tasar (Sanskrit - *trasara* meaning shuttle) silk is obtained from the cocoons spun by two species of silkmoth, i.e. semi-domesticated, *Antheraea mylitta* Drury and the wild type, *Antheraea paphia* Linnaeus. The former includes two ecoraces, such as trivoltine "sukinda" and bivoltine "daba", whereas the latter includes three ecoraces, i.e. the univoltine "modal", the bivoltine "nalia" and the trivoltine, "bogei". The distribution of the stated ecoraces is specific to ecogeographical and ecoclimatological status. Tropical tasar is restricted in the forest belt of central and southern plateau. The wild tasar, *A. paphia* is found in the forest of Similipal Biosphere Reserve in the State of Orissa, which is hilly and undulating with diverse meteorology and ecology. At the highest altitude (601-1000m ASL), voltinism is unique and with the decrease of altitude (301-600m ASL) and (50-300m ASL), voltinism increases. Indian tropical tasar silkmoth is distributed mainly in the central plateau covering the states of Bihar, Madhya Pradesh, Orissa, West Bengal, Maharashtra, Rajasthan and to little extent in eastern and western hilly tracts, covering the States of Andhra Pradesh and Karnataka (Fig. 9.5). Thus, the species is distributed to a wide range of geographical area between 12 to 30° North latitude and 72 to 96° East longitude, having diversified eco-meteorological condition. This condition promotes a diverse gene pool of *Antheraea* species having 44 ecoraces in India. The entire rearing process is carried out in planned host plant area (Fig. 9.6).

Tropical tasar silkmoth is holometabolous, tetramoulter and polyphagous in nature. Larvae, after emerging from the eggs, start feeding on the leaves of the host plants. There are about a dozen of primary host plants and 40 secondary host plants. In Orissa, three principal species of tasar food plants are used by the tasar larvae. They are *Terminalia alata* or *T. tomentosa*, arjuna (*Terminalia arjuna*) and sal (*Shorea robusta*) (Fig. 9.7). These trees are distributed not only in all the districts of Orissa, but also in most parts of the tasar rearing belt of India. Usually Sukinda, Boei and Daba ecoraces feed on *T. alata* and *T.arjuna,* whereas Nalia and Modal ecoraces grown completely wild, feed on *S. robusta.*

After four moults, the larva attains fifth instar when the caterpillar starts spinning tasar silk cocoon around itself by secreting liquid silk from the silk gland. When the caterpillar covers its body completely by silk secretion, the stage is known as pupa. During this stage several changes take place inside the shell (metamorphosis) and the moth emerges out from the shell. In this way the life cycle shows four distinct stages like egg, larva (Fig. 9.8), pupa (Figs. 9.9-12)

and image (Fig. 9.13). The life cycle of all the ecoraces begins with the onset of rain. In univoltine race, life cycle is repeated only once in a year during rainy season (July-August). In bivoltine race, it is repeated twice in a year, i.e. during rainy (July-August) season and autumn (September-October) season and in trivoltine race, it is thrice in a year, i.e. rain (July-August), autumn (September-October) and winter (November-December) season.

Out of four distinctive stages, the rearers target is at the pupa, from which a single continuous silk fibre is obtained. The unique feature of the cocoons of *Antheraea mylitta* and *Antheraea paphia*, is the presence of a very strong and stout peduncle with a loop, which in fact, protects the diapausing pupa inside the cocoon from strong wind. Moreover, higher survival success in adverse climatic condition, higher silk yield, fecundity, cocoon weight and silk ratio, are characteristics of these cocoons. Modal ecorace produces the highest silk yield per cocoon in the world. However, after harvest, most women are involved in reeling of fibres from cocoon (Fig. 9.14). Further, the additional value of wild silk are: scarcity value, superior character, natural colour and healthy material.

Conservation of Indian Tasar Silkmoth

Potentially, tasar culture in India is very healthy and sound, because of the abundance of nature grown food plants in the forest, skilled tribal areas and suitable eco-climatic condition, both for tasar flora and fauna. It has been observed that in India, production of tasar cocoons slowed down within the last 25 years. Tribal life and culture is highly associated with the jungle and tasar culture. Moreover, owing to salubrious climate of Orissa, trivoltine tasar culture is practised very comfortably throughout the year. Thus, the forest offers a congenial platform for the tasar culture.

The total forest area of the world in 1900 was nearly 7000 mha. By 1975 it was reduced to 2890 mha and if this continues, by 2000 AD, it would be merely 2370 mha. The major reduction will be tropics and subtropics (40.2%) and 0.6% in temperate areas. The tropic rain forest was originally 1000 mha in 1900 and was reduced to 940 mha by 1975. Maximum reduction has been estimated in Indian Burma and Sri Lanka. The rate of destruction of forest is thus alarming in developing countries like India. Tropical forests occupy only 7% of the land surface area and have a bewildering biological diversity. Merciless clearing of forests is at the rate of 6 to 8 mha per year. By the end of 2000 AD, about 10% of the existing species would cease to exist, amounting to a loss of 25,000 plant species (Desmukh, 1986). In India, we have only 0.97%

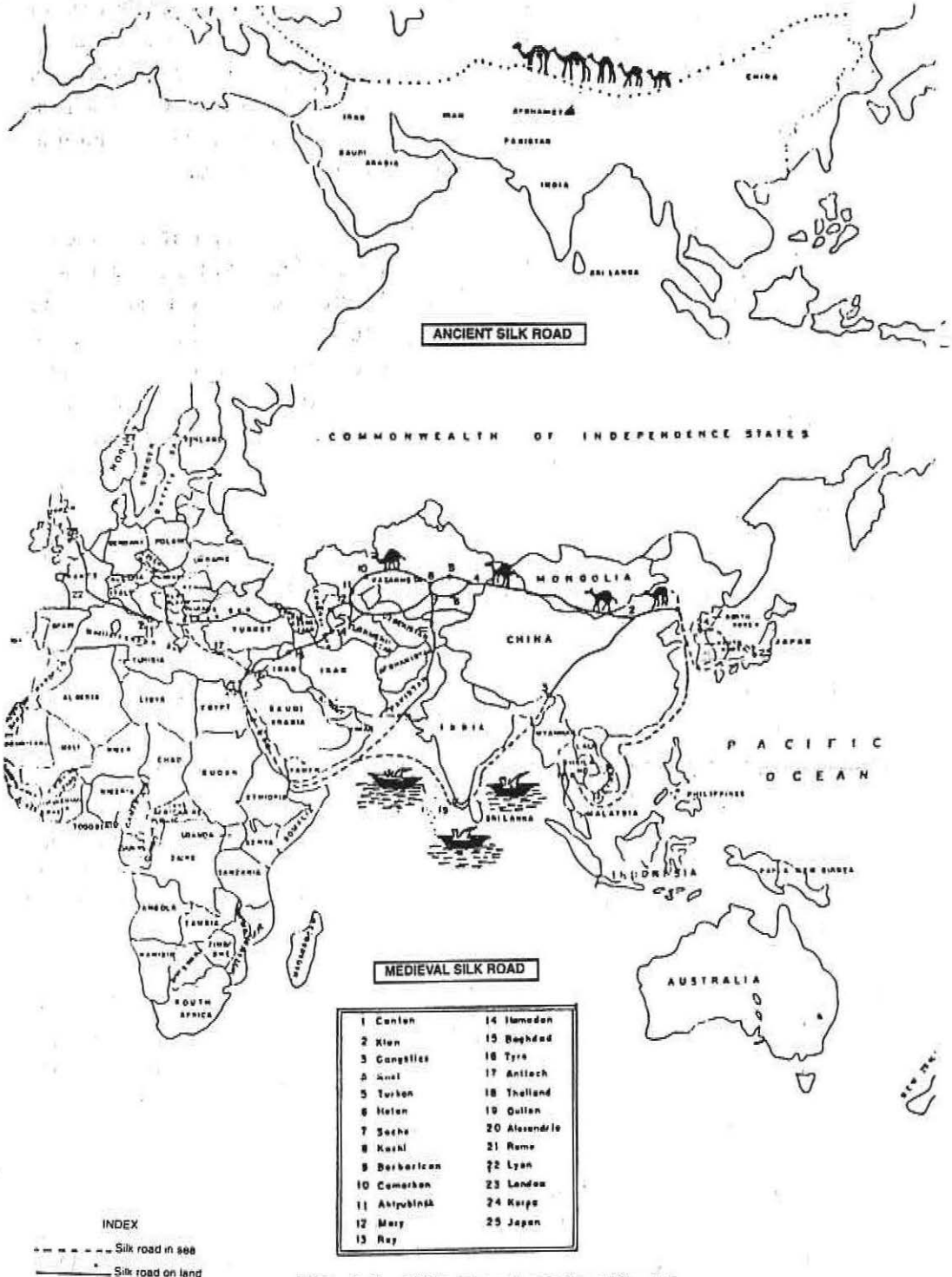

Fig. 9.1. Silk-Road of the World

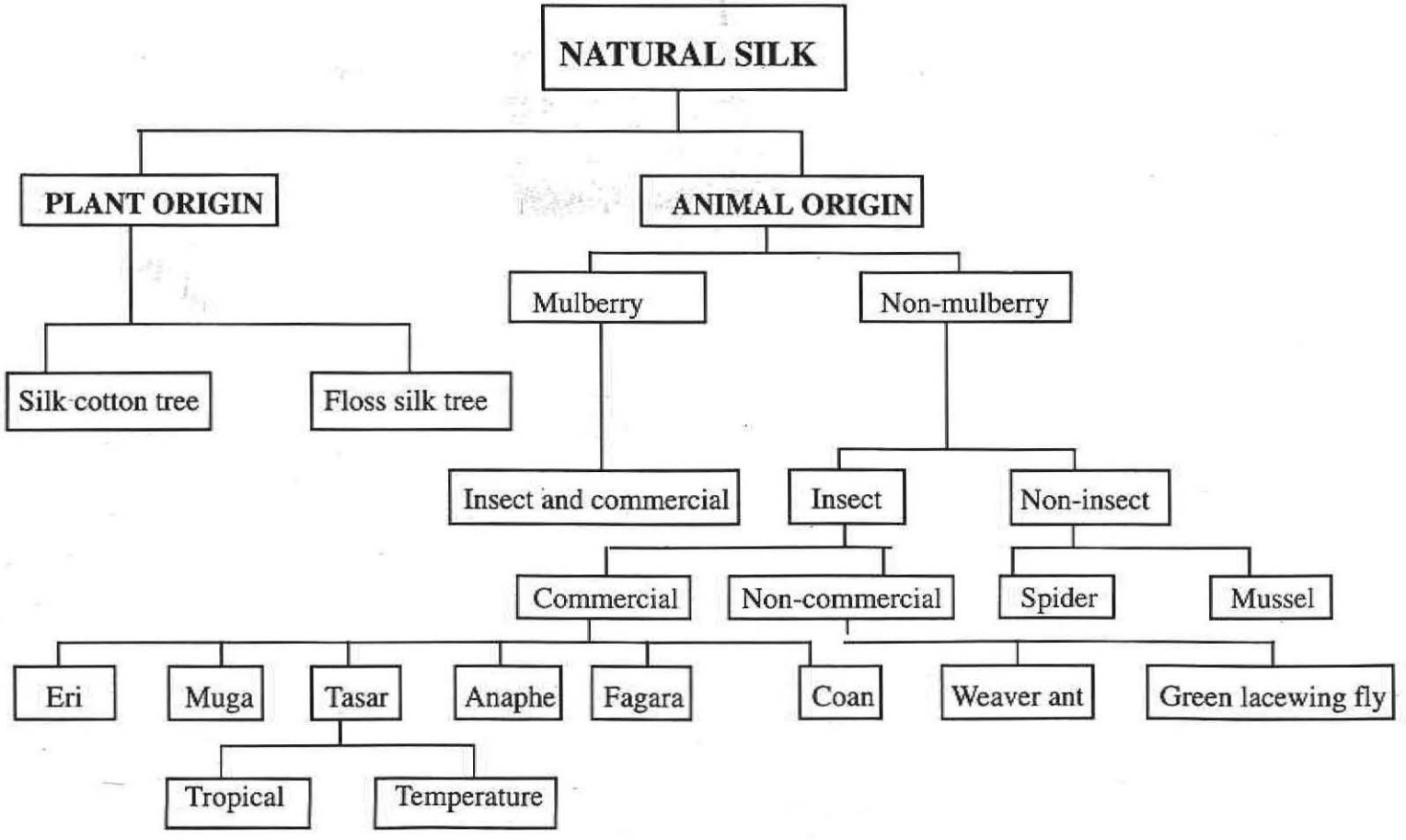

Fig. 9.2. Schematic classification of silk

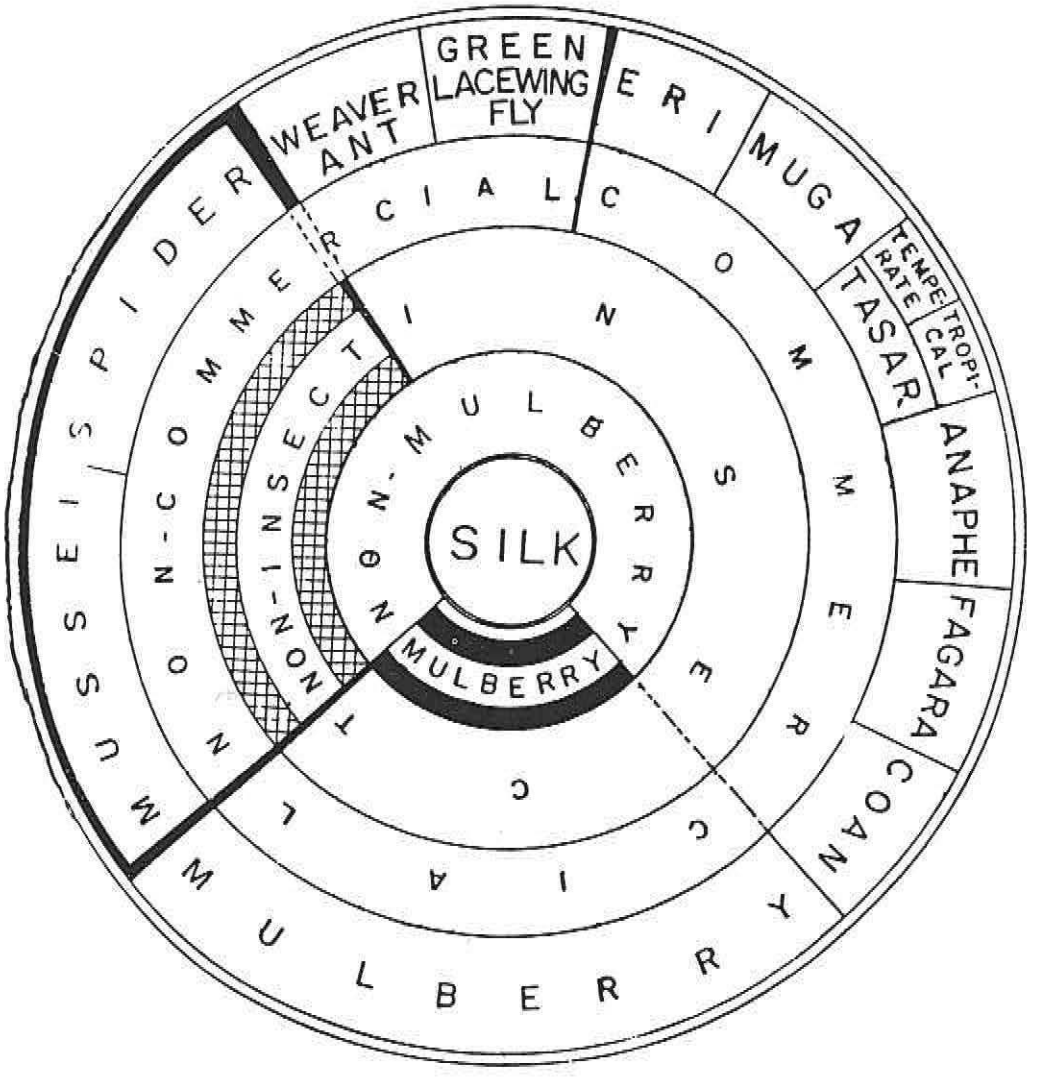

Fig.9.3 Varieties of silk in animals world

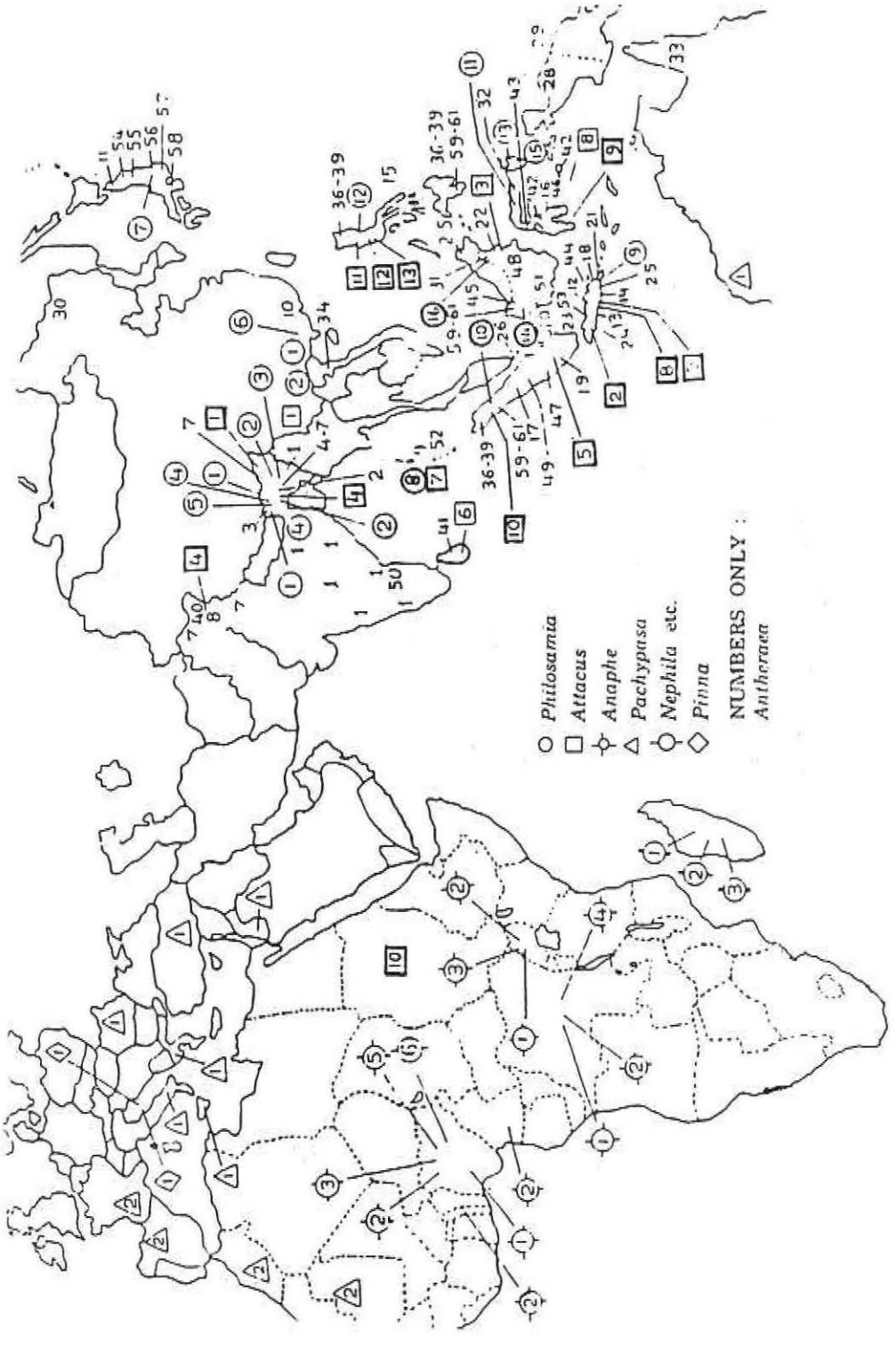

Fig. 9.4 Global distribution of non-mulberry silk fauna

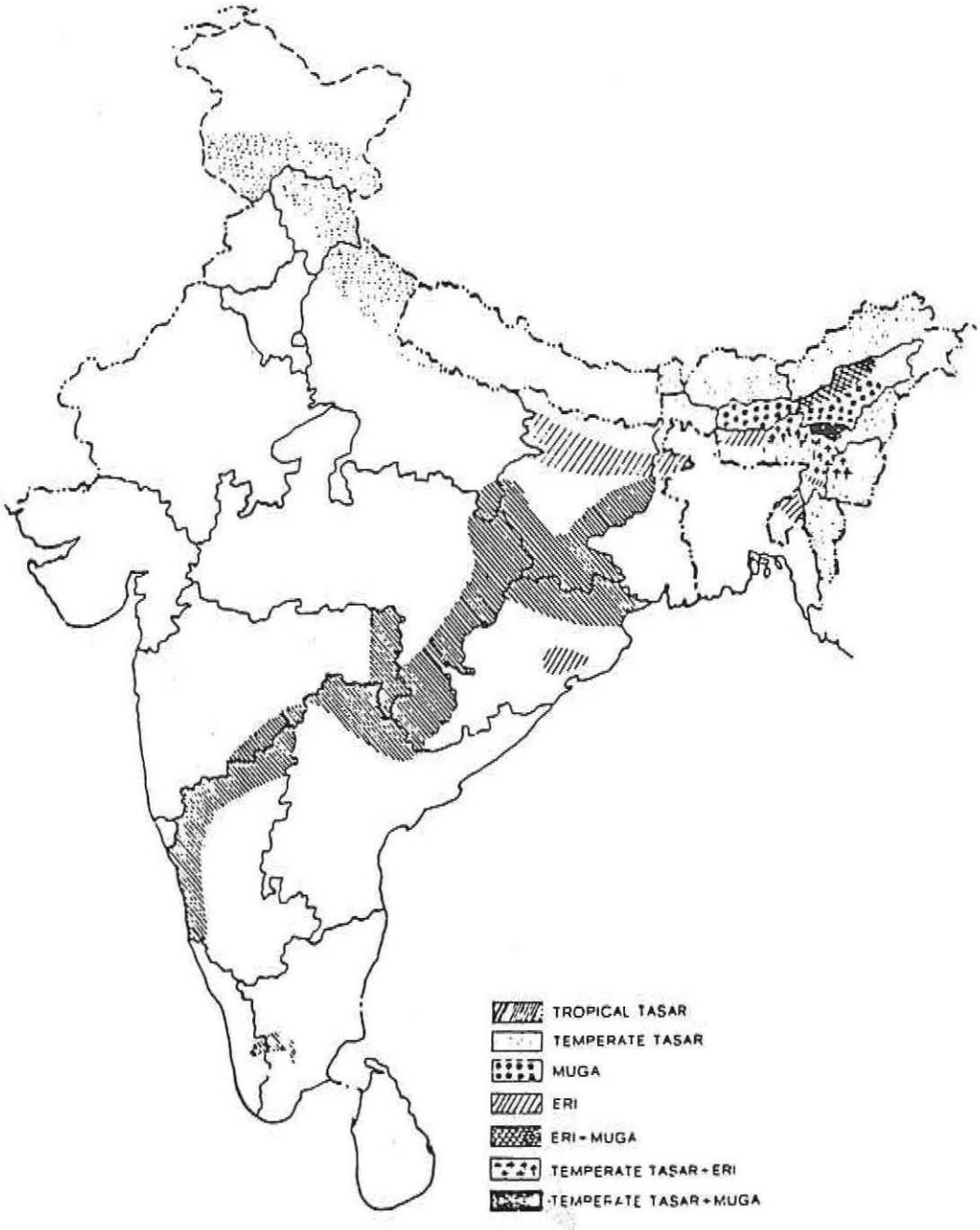

Fig. 9.5 Territorial spread of non-mulberry sericulture in India

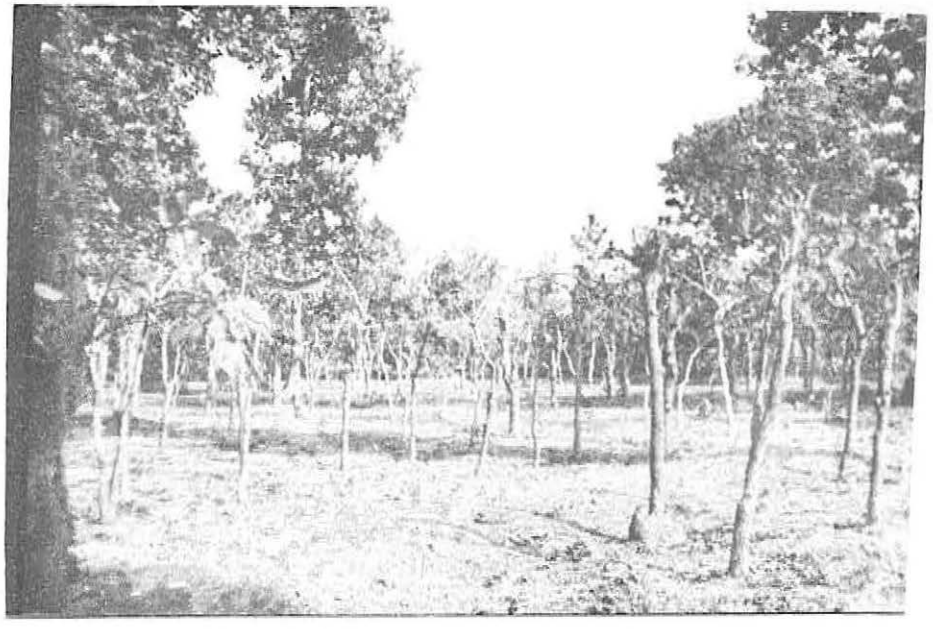

Fig. 9.6 Rearing forest of tasar larva

Fig 9.7. Host plant leaves of arjuna, asan and sal

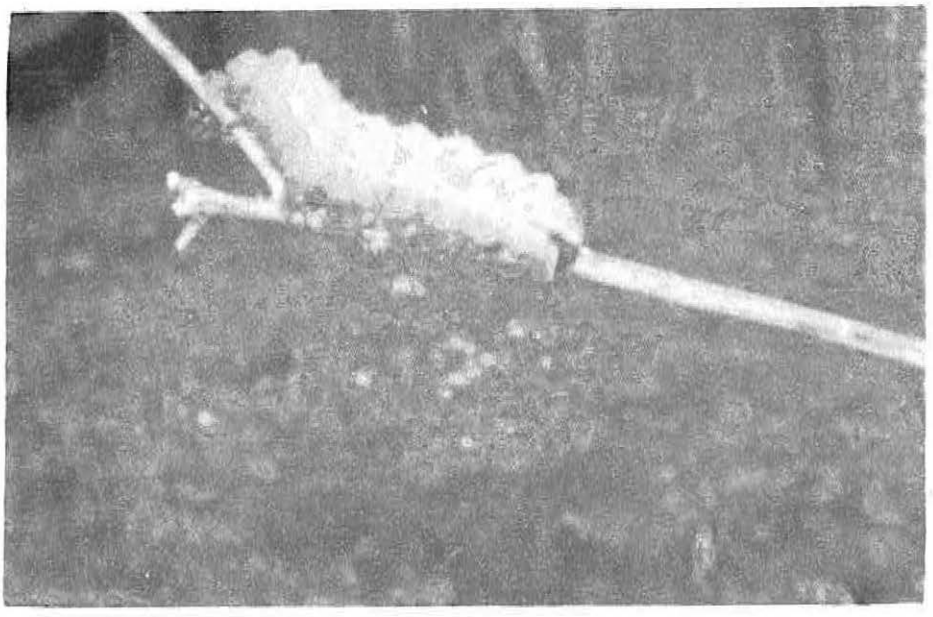

Fig. 9.8. Fifth instar larva about to sprin

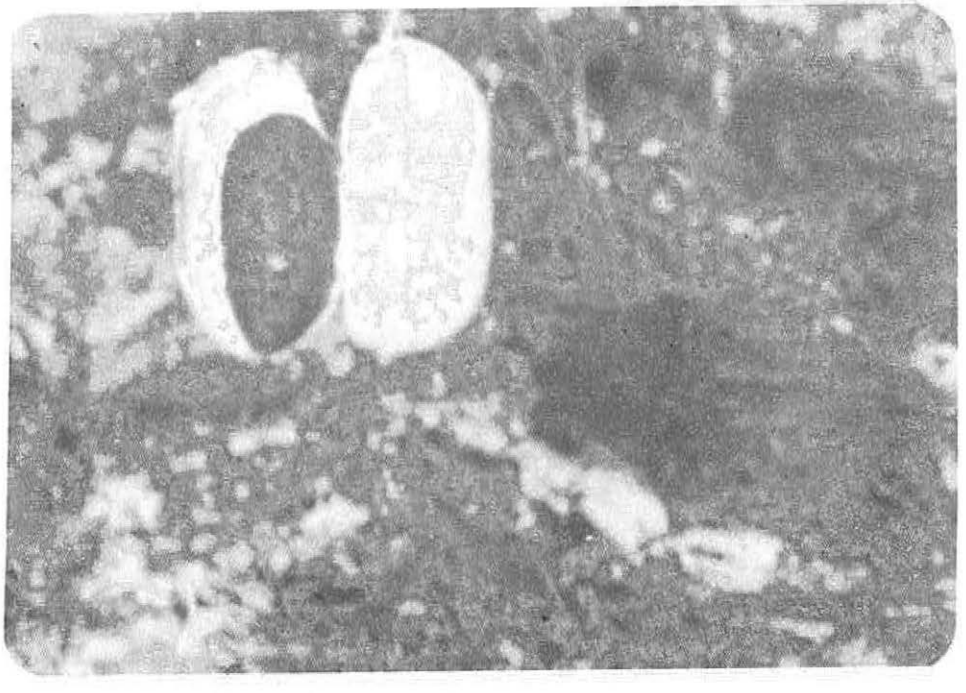

Fig. 9.9. Pupa inside tasar cocoon (tasar cocoon cut open)

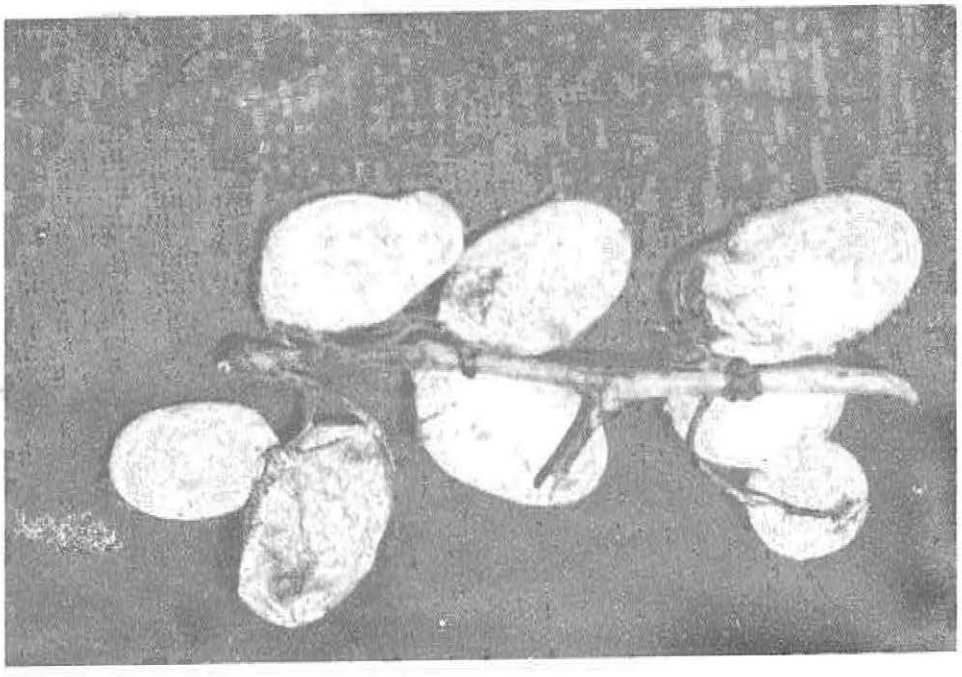

Fig. 9.10. Tasar cocoons on a twig of arjuna host plant

Fig. 9.11. Garlanding of cocoons in the reaaring forest for preservation

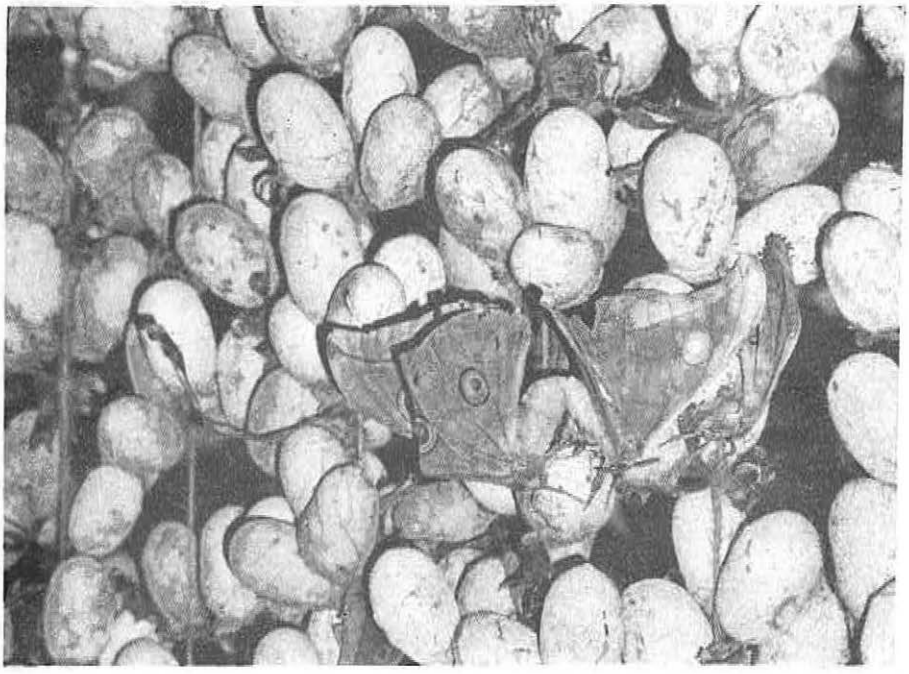

Fig. 9.12. Mating of adult tasar silkmoth in grainage during gardanding stage

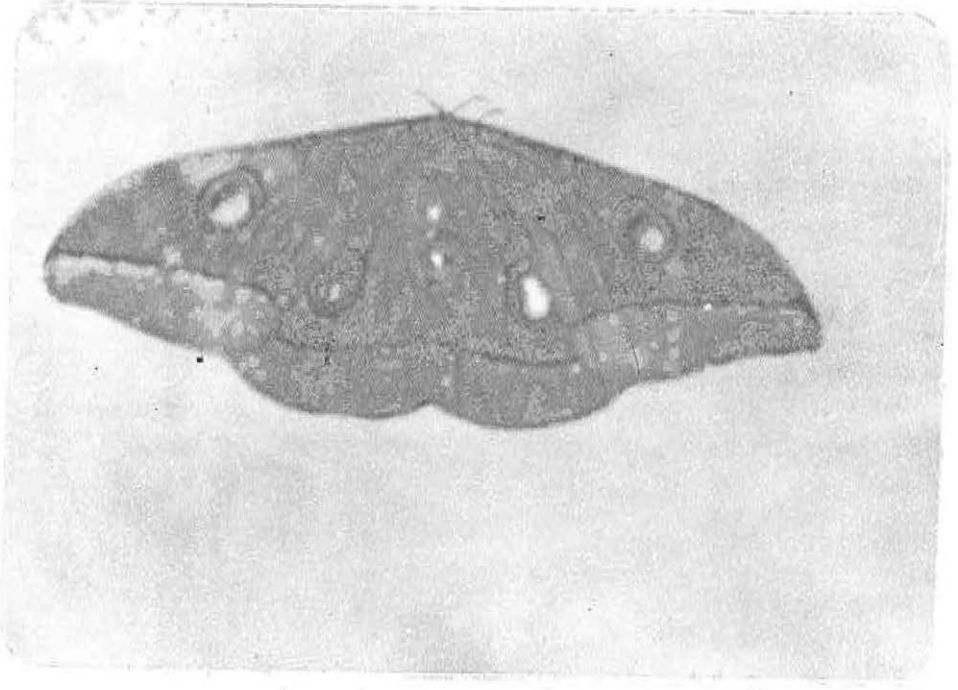

Fig. 9.13. Adult tasar silkmoth after emergence from cocoon

Fig. 9.14. Tasar silk reeling by tribal women

of the country's land area under National Parks, which corresponds to a mere 4.9% of the forest area of the country. While we should have 33% of the total land area of the country under forest for ecological reasons, we actually have only 21% now under forest cover. Out of this inadequate forest area, we have a large chunk of degraded forest area (Economic Survey of India, 1995-1996). There is tremendous pressure for diversion of more forest areas for non-forest purposes, which has prompted Government of India to enact the Forest Conservation Act, 1980.

Conservation is the most efficient and beneficial utilisation of natural resources, It is chiefly concerned with the management of natural resources of the earth, taking into consideration their proper use, preservation and protection from destructive influence and misuse. Precisely, conservation is the national use of the environment to provide high quality living standards for mankind. The important objectives of conservation are as follows:

(a) To maintain the essential ecological process and the life support systems which have air, water, land, flora and fauna as the important elements.

(b) To preserve biological diversity (i.e both genetic and ecological). Ecological diversity indicates the richness of the species, e.g. India is gifted by nature with about 45,000 species of plants and more than 65,000 species of animals.

(c) To ensure sustainable utilisation of species and ecosystem. Sustainable utilisation means proper and planned utilisation of natural resources, so that a continuous yield of useful minerals, plants and animals may be obtained.

(d) To bring out stability, sustainability and productivity.

Preservation of forests is more important than conservation, since forest area are priceless ecological resources, protecting land and water resources, controlling floods, checking wind erosion, storing and cycling nutrients and providing habitats for wildlife denizens. Finally, it constitutes a rich stock of valuable genetic resources and a common heritage of mankind. Since tasar flora and species are just two sides of a coin, tasar fauna can only exist only when tasar host plants survive. Therefore, conservation of tasar fauna needs first the preservation of tasar flora of the forest. However, conservation cause for the three "Cs" — communication, cooperation and coordination and discouraging of the three "Es" of extinction - ego, envy and elitism as a powerful weapon for conservation of tasar biodiversity.

The following suggestions may be taken into consideration for better farming in future:

(a) Attention needs to be given to the preservation of tasar forest and natural habitat.

(b) Over-exploitation needs to be checked and controlled.

(c) Introduction of proposals by introducing non-indigenous species of wild silkmoth need to be discouraged

(d) Strategies are essential for conservation of gene pool of sericigenous fauna and protection of Intellectual Property Rights (IPR) of the country, needs to be looked into seriously

(e) Attempt to be made to evolve suitable *in situ* conservation model for the depleted ecorace.

(f) Introduction of a brief chapter on sericigenous flora and fauna in science subject, for the students of school level, is highly essential to generate conservation awareness from the beginning of the academic career.

(g) Ecofriendly approach of cultivation need to be emphasized through demonstration to the rearers.

(h) Launching of research-based conservation project through non-governmental organisations (NGOs) and local government, may be made for effective preservation and target oriented result.

(i) It is also desirable to furnish scientific and systematic technologoy packages developed through the basic research for rural community.

(j) Research and Development (R&D) support to the rearers need to be provided regularly as training and extension services.

Tasar silk culture and sustainable development

In situ conservation of tasar biological diversity ensures perennial income generation and sustainable use of the forest. Thus, it offers a healthy environment for the development and growth of the forest and arrests the migration of people from the clearing site. Development of the forest develops the production quantum and this in turn facilitates the tribal economy. This crystal clear development is the "development of harmony with nature". Economically, sustainable development means sustainability of resources in process, in production and consumption. Ecologically sustainable development refers to sustainability of the carrying capacity of the earth. The indicators of loss of sustainability are land degradation, loss of biodiversity, degradation of water level, degradation of forest resources and depletion of ozone layer. Sustainability may be restored by "triple **R**" formula, i.e. reduction (reduction of pollution, wastage and consumption), recycling and reuse. Sustainability provides:

(i) continued support of human life
(ii) long-term maintenance of the stock of biological resources and the productivity of agricultural system
(iii) stable human population
(iv) limited growth economies
(v) emphasis on small scale and self reliance
(vi) continued quality in the environment and ecosystem.

Therefore, sustainable utilisation, i.e., systematic, proper and planned use of the natural resources, are essentially desirable. This leads to proper eco-development by which ecological and species loss could be arrested. On the other hand, human beings as the largest predator group of nature could yield useful natural resources continuously for their development. So for sustainable development and equilibrium, sustainable utilisation and eco-development as two sides of a coin need to be strengthened. Further, on keeping up the sustainable development, the "**4H**" approach, human health, animal health, plant health and environmental health can be restored. Wild silkmoth farming, one of the pivotal aspects for sustainable development, can be adapted as an insect-based enterprise by rural communities for the integration of biodiversity conservation with the economic development of the rural people and especially women. This can be a means of diversifying their economic base and therefore,

encourage them to participate in the current world efforts to promulgate conservation-based development. Again for all round sericultural development, due stress should be given to the application of "**4M**s". Viz men, material, machine and management appropriately to the corresponding components of wild tasar culture, eg. Users groups as men, silkworm breeds material, reeling-spinning device as machine and the required managerial skill as management, need to be laid towards enhancing quality linked production.

The new millennium is, therefore, beckoning us not only to find satisfactory solution within the framework of our culture to the problems of poverty, overpopulation, disease and unemployment, but also adjust ourselves to the rhythm of the new world by strengthening the wild sericulture.

So, Progress = Better sericulture
Better sericulture = Better return
Better return = Better quality of life.

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10. SERICULTURE IN CHINA

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History and Present Situation of Sericulture in the World

China is the home of silk industry dating back to at least 5000 years ago, according to the records of ancient books and silk articles unearthed by the archaeologists. Silk was produced only in China, because of severe restrictions on the transfer of sericulture technology. The fabulous silk was firstly carried to Korea by the 12th century BC. Moreover, its secrets were spread to the world through "silk road". Thus, silk industry has been established in the globe. Up to now no other fabrics can match its luxury, lustre and elegance and silk is still extolled as "the queen of textiles".

Looking back to its development in the world, the sericulture posed its glorious years and also suffered setbacks. The leading silk-producing areas/countries have been changed several times for recent hundreds of years. In the 1920s to 1930s, the world silk yield reached 50-70 thousand tons. In 1950s-1960s, it decreased to only 30 thousand tons. After 1970s, sericulture was restored and developed. In 1992, the raw silk yield set a record of 84000 tons in the world. It is forecast that sericulture development trends will be kept in the future years.

Sericulture is a labour-intensive industry which includes mulberry cultivation, silkworm rearing and silk reeling and weaving. Sericulture development depends upon the factors of society such as economy, war or peace, natural resources, science and technology, consuming market and so on. In history, Italy, France and Japan made a great contribution to the world in modern science and technology of sericulture. Since mid 1970s, sericulture has been developed fast in developing countries. Now China and India become the leading silk producing countries. In 1992, China shared 63% of total raw silk production in the world. India shared 16.1%, Japan 6.3%, CIA 5.1%, Brazil 2.8%, Thailand 1.9%, North Korea 1.7%, South Korea 1.1%. These countries produced 98% of the world silk. In addition, many developing countries are trying to develop sericulture

in their own countries. However, the sericulture distribution in the world should have few changes in the coming years.

At present, silk occupied only 0.17% of total textile fibres in the world. The silk production focuses on a few countries. However, the countries related with silk cover all around the world, can be separated into 3 groups as follows:

(a) Silk-producing countries such as China, India and Brazil , are major suppliers of silk in the world.

(b) Silk - consuming countries, such as USA, Australia and many European countries, are pure silk-importing countries.

(c) Silk-processing: consuming countries, such as Italy, Japan, France, Germany, Switzerland and UK, import silk, process it, and then export or consume it. In recent years, raw silk sale is weakening, but the silk is selling well in the international market. It is predicted that silk consumption will be increased with the world economy recovery and the alleviation of regional conflicts. Without doubt, sericulture is a developing industry in tropical and sub-tropi cal areas. Major silkworms belong to multivoltines, producing low grade silk, conflicting with international market and high demand for high quality silk.

Experiences for developing sericulture in China

China is a large cocoon and silk producing and exporting country in the world. Its sericulture industry was fluctuating before 1950s. In 1931, the cocoon output reached 220,800 tons, one of the highest in the records. In 1949, the total cocoon output fell to only 30.9 thousand tons. During 1950-1955, the cocoon production increased slowly. Since the 1970s, sericulture has developed fast. In 1970, China mulberry cocoon output surpassed Japan and became the first cocoon-producing country in the world in 1980, surpassing the national historical record year, 1931. In 1993, national cocoon output was more than 750,000 tons, the share percentage of the world totals in cocoon and silk production. Raw silk and silk fabric export was 74, 57, 85 and 50%, respectively; to date more than 1.2 million hectares of farmland are under mulberry cultivation; every year 24 million cases of eggs are distributed to 20 million house holdings in 1300 counties of 28 provinces, out of 30 provinces. Nationwide, there are more than 1000 silk enterprises, which possess 2.4 million silk reeling machines and more than one million workers are engaged in silk enterprises. At the same time, an education and research system of sericulture has been established.

Based on the sericulture development history and successful experiences in China, more care should be taken as follows:

(a) *Construction of the bases for producing high yield and quality cocoon and silk.*

With a vast territory, China is located in tropical, sub-tropical, warm-temperate, temperate and cold zone areas, where 70% of the areas are favourable for mulberry growing and silkworm rearing. However, China has more than 11 hundred million people, 22% of the world total population, and only 6% farmland out of the world total; the natural resources per capita is less. Based on this situation, the sericulture base should be established under the following conditions:

(i) The climate must be suitable for both mulberry trees and silkworms, especially water supply must meet the needs.

(ii) The bases should be focused on certain areas — Sichuan, Jiangsu and Zhenjiang Provinces, which are located in Yangtze River Valley, produce more than 70% of total cocoons in China. Mulberry trees are planted not only by hectare, but also in the hedges of villages, channels, fields and roads. The ratio of field-planted and scattered mulberry is about 2:1 in China.

(iii) The bases should have rich manpower and the cocoon price can compete with other cash crops.

(iv) Making the cocoon production, silk reeling and weaving of silk garments, a coordinated process. If the base is to produce only cocoons, the less money will be earned and sericulture may fail to compete with other industry.

(b) *Setting up an effective extension system and spread scientific and technological knowledge among sericulture farmers.*

At present, besides one national sericulture research institute (Zhenjiang), there are 22 provincial sericulture institutes and 10 departments of sericulture in related agricultural universities. A hierarchy extension system has been established in levels of Central Government Province County township village. The researches based on production demands and practical techniques are given more attention. The major research works in China are described as follows:

(i) 2540 mulberry germplasm resources have been collected, sorted and preserved; among them 40 varieties have been selected and extended. In important sericulture areas, the improved varieties of mulberry are popularly used. Furthermore, use of Fl seeds of mulberry has made a breakthrough.

(ii) Multi-methods for reproducing mulberry sampling have been utilised, so as to meet the needs. At the same time, a dense planting, early harvesting and high yielding mulberry cultivation technological system has been extended, which has enabled cocoon yield per hectare to increase by 1500kg, even 2000-3000kg.

(iii) A system of silkworm egg breeding, identification reproduction, quality control and distribution has been established. In the recent 40 years, 60 pairs of F1 eggs have been extended and the silkworm lines have been changed 4 times at a large scale. At present, cocoon weight, and shell percentage and single silk length for spring rearing can hit 2.1-2.2 g, 25% and 1400m, respectively; for summer, and autumn rearing is about 1.6-1.7 g, 22-23%, 1200m, respectively.

(iv) Ratio of silkworm rearing for spring, summer and autumn, has been increased from 70: 30 in the 1950s to 45:55 after 1980s. The new rearing technologies such as cooperatively rearing young-age worms, feeding young-age worms few times, simply rearing grown-age silkworms, spreading good mounting frames, applying insect hormones to regulate worm growth and development, have been popularly used. This will raise sericulture productivity and save manpower and provide human resources, giving farmer an opportunity to do other farming activities.

(v) A comprehensive system for disease and pest control of mulberry and silkworm has been established. The cocoon crop-loss caused by diseases and pests, sharply decreased from 30% in 1950s to only 8% today.

(c) Making a decision to promote sericulture development

In order to avoid fluctuation of sericulture production and promote sericulture development in China, we should make sericulture development laws, rules and policies. The fields should cover the silkworm egg breeding, identification,

reproduction, quality control production and distribution as follows:

- certification and management of silkworm disinfectants and mulberry insecticides
- operating rules for silkworm rearing and price ratios of cocoon
- raw silk grading
- silk fabrics awards for new scientific and technological achievements
- patents and copyright reservation

Promotion of Silk Production and Consumption by International Co-operation

Silk is one of the oldest textiles. It has gone through the rigorous trials of man-made fibres, the changes of silk-producing countries and economic crisis! However, it is fashioned by the dress disgners in the world. With the help of scientific and technological progress, silk varieties vary with the demands of different consumption levels. In order to promote silk consumption and production success, the persons concerned with silk must cooperate to resolve the following problems:

(a) Maintaining stable sources of good quality cocoon and silk

The following is the analysis:

(i) China is the largest silk-producing and exporting country. With the economy boom, silk domestic sales will be increased and silk export will be shifted from raw materials manufactured silk.

(ii) Indian silk production and export increased very fast. At the same time, it imports some silk to meet the high silk demands in the domestic market.

(iii) Brazil and Vietnam are developing sericulture to export silk to the world market.

(iv) Japan and the Republic of Korea cannot stop the reduction trends of their own silk production.

(v) Many tropical and sub-tropical countries are willing to develop sericulture, but it will take a certain time to export quality silk.

(v) Sources of raw silk trends to come from different countries and the silk consumption still concentrate on developed countries, such as USA, Japan and West Europe.

Therefore, considering the situation, the international societies should encourage tropical and sub-tropical countries to develop sericulture. On the other hand, it

is very important to support China, India and Brazil to obtain stable sources of silk, especially more than 4A grade of silk. On the contrary, if silk production and quality decrease in the three countries, it affects not only silk suppliers, but also consumers in the world.

(b) Developing new varieties of silk goods to satisfy different consumer taste.

Silk cost is very high and its consumption is limited to the richest for their luxury garments, ties and other high class silk products, because sericulture demands high labour and the silk processing takes a long time. However, new markets for silk consumption can be found to meet varied strata demands with development of science and technology. To promote the global silk consumption, the following policies can be made:

(i) Developing high grade silk goods, represents one person's economic position, educational level and personality. Hence, it is very important to create a famous trademark, bring up great silk dress designers, pay more attention to the design, produce a few high-class products by increasing varieties of colours and sizes, so as to meet the needs.

(ii) Popularising silk goods in recent years, through technological development, in the new silk varieties such as sand-washed silk fabric, silk knits and blended silk. Normal consumers have been able to purchase silk goods. Hence, it is important to develop new low price silk goods to tap low to middle class consumers of silk.

(iii) Developing the traditional and native costumes, because every nationality has its own custom and traditional costume, such as Japanese kimono, Indian sarees, Chinese cheongsam and Arabic robe and scarf.

(iv) Diversifying silk goods consumption in different areas since generally, the silk is narrowly used as garment material. With the economic and technological development, it can be widely used in accessories such as ties, scarves, purses, decorative boxes, umbrellas, hand bags, gloves, handkerchiefs and silk flowers; house furnishings, such as pure silk hangings, wall coverings, table cloths; publishing, such as covers of books and albums. Silk is also extensively used in computer, medical, aviation and military industries.

It is expected that the average silk consumption can be over 20 g per person annually, if these strategies are implimented:

(a) *Enhancing international cooperation and exchange on a mutually beneficial basis to promote both the development of silk production and scientific techniques.*

Since cocoon and silk have to enter into circulation through consumption by the market as trade goods, they must follow the laws of value and economy to take part in the market competition, The suitable ones will be kept and the unsuitable will be discarded. Tracing the rise and fall of sericulture in Italy, France, Japan and South Korea, can ensure that the manpower becomes less and the value of labour rises with the development of economy, thus resulting in the abandonment of sericulture. The governments have taken different measures to protect sericulture production in their countries. However, they cannot maintain their glorious sericulture industry. Such a situation also exists in Zhujiang Delta of China. The historic experience and reality admonish us if sericulture industry is founded on the basis of intensive labour and without close relation with the lives of the common people, hence, its social position is weak.

The present sericultural production and science and technology are mainly facing three challenges:

(i) The challenge from the other industrial circles in which the higher economic profit per unit area and manpower can be obtained.
(ii) The challenge from the modern productive techniques and innovation to the old, complex and low efficiency management and administration.
(iii) The challenge from the improved artificial fibre to the defects of natural silk, such as easily wrinkling, turning yellow and expensive. So, we colleagues from sericulture must face the reality and never avoid problems. Meanwhile, we can enhance the international cooperation and carry out the studies on new techniques applied in sericulture, actively. We must impel the scientific research on sericulture to meet the development of modern science and technology and also impel the change of cocoon production from intensive labours to intensive techniques.

(b) *Pushing sericulture production and consumption and the science and technology together, to apply high yield, good quality,.low cost products, to satisfy the new requirements of the 2lst century:*

(i) Increasing cocoon and silk output per unit mulberry area is carried out through breeding and extending new mulberry and silkworm races,

which have properties in high yield, good quality and resistance to diseases; simplifying worm rearing techniques and popularising silkworm disease and pest control technology.

(ii) Increasing silk-quality. In international market, high grade silk is limited, but low grade silk sales are withdrawn in temperate silk producing countries, such as Japan
(iii) cocoon, pupa, and waste silk.

(c) Managing sericulture to optimum production to obtain more economic benefits.
(d) Developing new silk varieties, to overcome the silk drawbacks, especially the silk turning yellowish, deteriorating and shrinking.
(e) Strengthening silk processing, especially silk dyeing and finishing to raise value-added silk goods.
(f) Strengthening basic research in sericulture

Japan has played an important role in sericultural science and technology in the world, because a lot of resources, including capital and manpower are invested into sericulture in Japan. That is why Japanese silk dominated the international market for a long time and even now, Japanese silk means good quality silk. Nowadays, any sericulture technological breakthrough depends on the progress of basic researches such as silkworm gene analysis, molecular breeding, sex-control led silk protein structure analysis and its expression; regulation of internal secretion system in the growth and development of silkworm; silkworm nutrients and their physiological significance; production of foreign genes by using of silkworm as host; gene structure and parthenogenesis of silkworm viruses. Obviously, it is impossible to accomplish this work by parthenogenesis, relying on only sericulture scientists in the world or scientific and technological abilities in one country. Hence, it is necessary to enhance cooperation with scientists in the varied scientific disciplines such as sericulture, biology, biochemistry, and physiology, to create the rennaissance of silk in the world.

(g) Coordinating sericulture management and promoting transfer of technology.

Nowadays, many developing countries are interested in sericulture industry, which is a long-term capital return project and needs the comprehensive technologies. Therefore, it is important to raise labour qualifications, strengthen systemic management, set up an effective extension system and spread the transfer of technology.

transfer of technology.

(i) Strengthening systemic management of sericulture i.e. balancing production capabilities of mulberry, cocoon, silk, silk fabric and silk products.

(ii) Setting up a hierarchy extension system from central government to provincial, county, township and even village level.

(iii) Preventing mulberry and silkworm germplasm resources, making a set of rules of mulberry and silkworm varieties, breeding, certification and reproduction, so as to supply disease-free and high quality mulberry and silkworm varieties, which are basic to sericulture.

(iv) Organisation of research and education should serve for mass produc tion. Information, education, demonstration and field visits are used to speedup transfer of new technology.

SESSION II

MODERNISING HONEYBEE FARMING

11. PROSPECTS OF WILD SILK FARMING AND ECONOMIC IMPORTANCE OF BEEKEEPING IN SWAZILAND

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Abstract: The country profiles, silkworm species and honeybee ecotype occurring in Swaziland are outlined. The indigenous host trees for silkworm species occurring in the country are also mentioned. Utilisation of silk and honeybee products by Swazi people is outlined. Potential for sericulture and apiculture exist in the country and these commercial insects should be kept and reared at the research station for continuous supply of these products.

Country Profile

Swaziland is a land-locked country with an area of 17,363 km^2, bordered at three sides by the Republic of South Africa (RSA) and Mozambique to the East. The 1994 census estimated the population to be about 850,000, with a growth rate of 3.2 per cent per annum.

There are four distinct agro-ecological zones from West to East respectively: the Highveld, Middleveld, Lowveld and the Lubombo mountains. These ecological zones represent different topographies, climatic conditions, natural habitat and agricultural production systems.

Climate and agroecological zones

The Highveld has a moist subtropical climate with an average temperature of 16°C, 1000 -1500 mm rainfall per year and an altitude of 900 -1800 m.a.s.l. The Middleveld and Lubombo have a warmer subtropical climate with an average temperature of 19°C, 750 -1000 mm rainfall per year and an altitude of 450 -900 m.a.s.l. The climate of the Lowveld is dry subtropical with an average temperature of 22°C, 500 -700 mm rainfall per year and an altitude of 150 -450 m.a.s.l.

There are two distinct seasons in all the agroecological regions in Swaziland, the wet summer and dry winter. Almost four times as much rain falls in summer (October-March) than in winter (April -September), in all regions.

Conservation and Utilisation of Commercial Insects in Swaziland

Silk farming

Both wild and domesticated mulberry species do occur in Swaziland and silk produced by silkworms has never been harvested on these tree species. Sericulture has never been practised before in Swaziland. However, two silkworm species occur in the country, the *Agerma* and *Anaphe* spp. The *Agerma* species is mainly found eating leaves of "Umtfombotsi" *Spirostachys africana* and Marula, *Sclerocarya caffra,* particularly in the dry Middleveld and Lowveld regions. Traditional harvesting of silk produced by silk worms in these regions takes place from October to March. Women harvest silk from these two tree species and make rattles, "Emafahlawane", which is some attire used by women during festive ceremonies. Pontential buyers of these rattles are local women who wear them during festive periods. A pair of these rattles costs an equivalent of US$ 3.50. These products fetch high prices just before traditional ceremonies like "Incwala", "Umhlanga" reed dance and National Independence Day, take place. The audience enjoy the sound coming from "Emafahlawane" during traditional dancing. These silk products are sold at most local markets in the country.

Anaphe spp., "Tindlandlaweni" are mainly found on the leaves and branches of "Umhlanhlatsi" tree, particularly in the Highveld and Middleveld regions. A group of larvae come together and produce a sizeable strong silk material like a nest. But silk is by no means the only commodity spun from these indiginous tree species. In fact, these versatile trees can offer a variety of products that increase peoples' income; for example, women brew traditional beer from Marula fruits. The bark and roots possess medicinal value for cure of stomach ache and certain livestock sicknesses. Most people in the Lowveld region use wooden poles from *Spirostachys africana* to build houses.

Bee-keeping farming

Swaziland beekeeping industry is still at its infancy and the government, aided by foreign donors is working hard to develop it, by providing farmers with improved hives and the necessary skills for successful beekeeping. An apiculture

specialist is placed at Gesawu Farmers' Traning Centre in the Hhohho region, to train farmers on beekeeping aspects, to produce and sell beehives and bee products to consumers. *Apis mellifera scutellata* is the major bee species used. There are about 2800 beekeepers spread across the country. The minimum is 5 hives per person and the maximum is about 200 hives per beekeeper. Beekeepers are on individual basis, associations and communities. Each of the four agroecological regions has one or more of beekeeping associations, showing a marked increase periodically. Similarly, each district has a community of beekeeping. There is Nzongomane at Shiselweni district, Ngwazini in Manzini, Tikhuba in Lubombo and Luhumaneni in Hhohho district.

There are two main harvest periods, namely, summer and spring harvest. However, harvesting times of honey are usually determined by rainfall distribution. Average yield of honey is 15 litres per harvest. The Highveld region harvests 3-4 times per year, Middleveld 3 times per year and the Lowveld only twice per year.

Utilisation

There are three products that come from honeybees:

(i) Honey is mainly used for home consumption and market purposes. Supermakets are potential buyers of this product in the country. Comb honey sells for US$ 6.00 per kg, and liquid honey for US$ 5.50.

(ii) Beeswax sells for US$ 6.00 per kg and this product is used for making candle sticks, Vaseline and polish are still home-based in Swaziland.

(iii) Propolis sells for US$ 5.00 and has some medicinal properties. It is used as an antibiotic elsewhere.

There is an extension beekeeping programme going on, encouraging the growing of communal woodlots, particularly *Eucalyptus* , for bees to get nector in Swaziland. The programme stresses the availability of water supply and fruit tree orchards for pollination.

Pests and diseases

Only three insect pest species have been identified so far, the white-banded wasp, wax moth, *Galleria* sp. and the large honeybeetle. Critical research will definitely reveal more pests and diseases of honeybees in future.

Conclusion

The potential of developing income generating using project commercial insects is feasible in Swaziland. There are indigenous tree species which serve as main hosts for silkworm species. Most of the resources are to be utilised to meet the economic demands of the country. Lack of infrastructure may require some additional funds to get some of these projects underway. The Institute of Agricultural Research at Malkerns should provide opportunities for research and development for the university students and the public at large, by hosting these commercial Insects.

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12. THE GROWTH OF KENYA'S BEEKEEPING INDUSTRY

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Introduction

Beekeeping in Kenya is a traditional art started time immemorial with log, basket, bark or pot hives playing an important role in the production of honey. Out of 42 tribes, the most prominent in this activity are Kambas, Kalenjin, Meru, Maasai, Turkana, Kikuyu and Boran in that order of merit.

Kenya's territorial boundaries measure 640,000 sq km, of which about 80% consist of arid and semi-arid lands. Apiculutral activity is a major occupation in the area and the vegetation found provides a lot of bee flora, particularly the abundant *Acacia* spp. The national production potential currently stands at 60-100,000 metric tonnes of honey, but only about 10% of this is realised to date, mainly from:

(a) 1.1. million traditional hives
(b) 120,000 Kenya top bar hives
(c) 5-10,000 Langstroth hives and others.

The government in collaboration with Canadian International Development Agency (CIDA), embarked on development of beekeeping industry in 1971, after an appraisal study that ascertained the viability of a project to enhance apicultural production.

Development Components

Various areas to improve production in terms of quality and quantity, were incorporated in development of beekeeping industry between 1971 to 1984:

(a) Establishment of beekeeping section in the agricultural sector.
(b) Higher training of personnel and internal training of staff on beekeeping for effective extension.

(c) Research on bee races in Kenya, equipment development, bee behaviour, floral identification and mapping, were carried out.
(d) Establishment of equipment production centre, demonstration centres and the National Beekeeping Station.
(e) Marketing strategies and refineries were established with over 100 groups/cooperatives formed throughout the country.
(f) Setting of quality standards of bee equipment and product, specifically Kenya top bar hive and honey, respectively.
(g) Establishment of Kenya Beekeepers Association.

Extension

Having trained staff, their distribution to the field for extension was effected, to transfer the technology developed. Training of staff in the agricultural sector was carried out and to farmers through field visits and demonstrations. The training of artisans (private and public) for production of protective clothing, hives and its accessories, continued

Liberalisation of beekeeping industry

From 1991, the government started liberalising the agricultural sector to facilitate demand driven participation of all stakeholders. As a result, a number of NGOs, individuals, institutions and other organisations entered in the development of the industry. The notable ones include ICIPE, Baraka Agricultural College, Honey Care International, GTZ, Oxfam (K), Action Aid, SITE, Farm Africa, SAIDIA, Universities, etc. Out of all these, only ICIPE is involved in apicultural research.

The government included beekeeping in the syllabi of primary and secondary schools and colleges. This has boosted the transfer of beekeeping management information.

Lately, the government has mostly concentrated on provision of advisory and regulatory services through training and quality control. A programme is being considered where extension services may be offered on a demand driven approach.

Current contraints in beekeeping industry in Kenya:

(a) Low adoption of technology by farmers due to socio-economic factors

(b) Liberalisation of the sector has led to various organisations/stakeholders without a common network
(c) Pesticides/chemicals that kill bees are left unchecked due to lack of knowledge by users
(d) Low/poor managerial skills in cooperative marketing bodies
(e) Variation of production technologies that do not harmonise on quality and socio-economic factors
(f) Ignorance or inadequate knowledge on quality control and cheating on processors, traders and consumers
(g) Environmental degradation e.g. felling trees, fires, cultivation, etc
(h) Low research priority for better management and production technologies of African bees
(i) Lack of credit and poor land tenure systems
(j) Poor marketing structure

Future plans and recommendations

(a) Need for both national and regional networking of stakeholders
(b) Research could be prioritised to address issues of African bee aggressiveness and hive appropriateness
(c) Intensification of training and extension through exhibitions, shows, demonstrations and field days
(d) Credit facilities and development of better viable marketing strategies
(e) Consumer/producer quality information provision
(f) Development of appropriate technologies targeting the African bee, place and beekeeper

The government is in the process of developing policies and guidelines for promoting the industry.

13. QUEEN BEE REARING AND ROYAL JELLY PRODUCTION SYSTEM IN CHINA

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Abstract: In China, all commercial apiaries rear their own queenbees and most apiaries produce royal jelly. Yield of royal jelly per colony, depends on the season, nectar plants, feed supply in hive, bee races or strains, colony strength, quantity of queen cells and the place of royal jelly-frame in hive.

Introduction

There are more than 7 million bee colonies in hives in China, accounting for 13% of the world's total. The total honey production is about 200,000 tonnes per year, making about 20% of the world's total. Output of royal jelly, bee pollen and bee wax totalled 1000 and 3000 tonnes each year, respectively. These made China the number one producer of bee products in the world. Every year, China exports 60,000 - 80,000 tonnes of honey, accounting for 25% of the world's trade volume; it also exports 300 - 400 tonnes of royal jelly, more than 90% of the world's trade volume.

Beekeeping in China has three objectives as follows: to manage bee colonies very meticulously; through migratory beekeeping, commercial apiaries and small scale queen-rearing.

Commercial Apiaries are Small Scale Queen-rearing Apiaries

In north China, the commercial apiaries mainly produce honey in the lower middle valley of Yangtze River, which is the biggest river in China. In the central part of China, some of the commercial apiaries produce royal jelly, and some both honey and royal jelly, but all of the apiaries in China rear their own queens. These queens are used in artificial swarming to increase the quantity of the colonies in the apiary, replacing older and low-ovipositing queens to improve the reproductivity of colonies, organising double queen colonies and replenishing queens when lost in the colonies.

In general, sedentary beekeepers rear their own queens in the period:

(a) Best for the first main nectar flow in spring to artificial swarming
(b) In the last main nectar flow in autumn to replace older or poor queens

The colonies forage 5 to 6 main nectar sources or more throughout the year. The queens lay more eggs and easily age than sedentary apiaries, hence there is need to rear their own queens in the main nectar flow.

The Essential Conditions for Producing Royal Jelly

Producing royal jellly is seasonal work, with the following essential conditions:

(a) Strong colonies: It is necessary that there are more than 8 combs of bees in the colony. In China, we call 2500 bees one comb of bees, because for langstroth frame, two sides of a comb can hold about 2500 bees one by one. In this colony, the proportion of bees of different age must be proper, and there are brood combs with different age (egg combs, young larvae combs, older larvae combs, and capping brood combs), and the colony must be healthy.
(b) Full feed: It needs nectar sources, especially pollen (protein feed).
(c) Suitable air temperature: When the air temperature is higher than 15°C, beekeepers can produce royal jelly. The suitable air temperature is 20 - 30° C.
(d) Satisfactory tools for producing royal jelly: The tools are as follows: frames of producing royal jelly, strips of queen cell cups, grafting tools, tweezers, blades, royal jelly extractors (or pieces of bamboo), bottles for holding royal jelly, sterilized gauze, alcohol, etc.
(e) Skilled beekeepers: It needs skilled beekeepers who can organize the colonies to produce royal jelly, quickly graft very young larvae and fetch out royal jelly from queen cells.

The main factors that influence the quantity and quality of royal jelly

(a) **Bee strains.** The different bee races and strains have different capability of secreting royal jelly and accepting queen cells, in which the very young larvae are grafted. In European bee races, *ligustica* has a higher capability of secreting royal jelly and accepting queen cells than that of *carnica, mellifera* and *causica.* In *ligustica*, the different strains differ in royal jelly secretion and green cup acceptance.

(b) **Strength of the colony and the right age nurse bees.** The strength of the colony influences the quantity and quality of the royal jelly. In strong colony, there are more nurse bees which have higher capability of secreting royal jelly and accepting queen cells. So, strong colony can produce higher amounts of quality royal jelly. The nurse bees are 10-20 days old.

(c) **Age of grafted larvae.** Experiments show that when the larvae in the queen cells were 90 - 96 hr old, the most royal jelly was accumulated in the queen cells. When fetching royal jelly after 48 hr (2 days), 48 hr old (2 days old) larvae should be grafted. Besides, the age of grafted larvae need to be almost the same.

(d) **Number of the queen cells.** The royal jelly output of a colony depends on the strength of the colony. If the colony is very strong, more queen cells can be put in and if the colony is not so strong, less queen cells ought to be put in.

(e) **The position of royal jelly frame in the colony.** The larvae can stimulate pharyngeal gland and mandibular gland of worker bees to secret royal jelly, so larvae combs need to be placed both sides or one side of the royal jelly frame.

(f) **Feed.** The situation of feed supply of the colony has important influence or the output of royal jelly. If there are honey and pollen sources, the output of royal jelly will be very high.

(g) **Air temperature.** Air temperature obviously influences the output of royal jelly. In summer, if the low temperature is higher than 17^{o} C, the royal jelly from the centre part of the frame is less than that of cells at the sides of the frame. In autumn, if the high temperature is less than 15^{o} C, the royal jelly from the centre part of the frame is more than that of cells at the sides of the frame.

Procedure of producing royal jelly

(a) **Organzing colonies for production.**The colony to produce royal jelly should have eight combs of bees (about 20,000 bees) at least. Enough feed is provided in the combs. Separate the brood nest and super by a queen excluder (in super, there is no queen and in the brood nest, there is the queen). In the nest hive, from the two sides and centre, there are honey and pollen combs, capped brood and empty combs. In the super hive, from two sides to the centre, there are honey and pollen combs, capped brood and young larvae combs and the royal jelly frame.

(b) **Preparing right age larvae.** To improve grafting efficiency, larvae of the right age are required. Five days before grafting, confine the queen on an empty comb. Leave for 2 or 3 days, so that the beekeeper can get the right age larvae.

(c) **Grafting.** Before grafting, the new queen cell cups, which have not been used for producing royal jelly before need to be put into a colony and cleaned by worker bees. It takes 1 or 2 hr to clean the bee wax queen cell cups, and more than 24 hr to clean the plastic queen cell cups. The grafting tool with a spring, which is made in China, is very useful. The frames of royal jelly with grafted larvae should be put into the colonies producing royal jelly in time and placed between two young larvae combs or young larvae and pollen combs.

(d) **Extracting royal jelly.** Generally, royal jelly is fetched from queen cells 70 - 72 hr (about 3 days) after grafting. Tools for extracting royal jelly and bottles for holding royal jelly are sterilized in 75 % alcohol. Before extracting royal jelly, the protruding part of the queen cells should be cut down with a blade, the larvae picked with tweezers and then royal jelly extracted from the queen cells and put into the bottles.

(e) **Filter and cold storage.** Extracted royal jelly should be promptly filtered with the 100 - 120 mesh net and stored in a low-temperature refrigerator with a temperature of under 18° C.

Measures for improving the quantity and quality of royal jelly

(a) Selecting and keeping high-yield royal jelly bee strains. In China, we have some high yield royal jelly bee strains. They can produce more royal jelly than that of normal strains. In the last 5 years, we have bred a new bee strain, which is called HuangShan No.1. The strain is the best for producing royal jelly, compared with other *ligustica* strains. The colony royal jelly and honey production of Huang Shan No. 1 are about 2 times and 30% higher than those of normal *ligustica* strains, respectively. On average, one strong colony of Huang Shan No. 1, produces 80 g of royal jelly every 3 days and can produce more than 6 kg of royal jelly a year.

(b) Using double-queen colonies. In double-queen colony, there are two queens to oviposit, so the colony develops more rapidly and remains strong.

(c) Keeping full feed and stimulative feeding. The very important activity is to keep the feed (honey and pollen) full in the colonies producing royal jelly. If there are not enough nectar sources, the colonies must be fed with syrup and pollen until the feed in the hives is enough, and then conduct stimulative feeding. If there are pollen sources, there only should be stimulative feeding with 200-500 g of syrup, 2 times every 3 days.

14. DISEASE CONSTRAINTS IN NORTH AFRICAN COUNTRIES HONEY BEEKEEPING INDUSTRY

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Abstract: Honey beekeeping in North Africa (Libya, Tunisia, Algeria and Morocco), was known since thousands of years BC. Modern beekeeping industry was introduced to the region only in mid this century. The honeybee races that exist in these countries arre *Apis mellifera ligustica*, *A. m. carnica*. *A. m. saharensis* and *A. m. intermissa*. These races vary in morphology and behaviour. It is difficult to establish the limit of the geographical area they occupy. Traditional beekeeping still occupies a considerable space in beekeeping industry in the region, 75% in Morocco, 37% in Tunisia and 14% in Algeria. Honey beekeeping in these countries faces a number of constraints, which adversely affect honey production and bee management, such as unfavourable weather conditions decreasing vegetation cover and slow dissemination of improved apiculture technology in the area. The most important of these constraints are pests and diseases. These in decreasing order are, *Varroa jacobsoni*, American foul brood, European foul brood, *Nosema* disease, chalk brood and acarine disease. Other pests found to attack honeybee in the region, are, *Merops apraster*, *Galleria mellonella*, *Achroia grisella*, ants and salamanders. Pests and disease control is similar in all countries using a number of pesticides in combination with good apiary management. Losses due to pest and disease are considerable in honey production, reaching up to 100% in some neglected apiaries.

Introduction

Man has known honey since 15000 years BC as indicated in a number of archaeological excavation and studies in Spain and Egypt. Ancient Egyptian know honeybeekeeping since 4000 years BC. Honey beekeeping gradually developed from pipe hives and straw steps, to the modern methods we know today. World beekeeping has achieved an important step forward since introduction of Langstroth and Dudant hives and discovering the bee space, moveable frames and introduction of the foundation wax in 1852. The introduction of the honey extractors in 1865 in addition to the continuous improvement of other honeybeekeeping tools, has largely contributed to the development of today's honeybeekeeping.

In North African countries (Tunisia, Libya, Algeria and Morocco), honeybeekeeping was known for thousands of years. However, it was not until the middle of this century that the modern beekeeping technology found its way in these countries, mainly where traditional beekeeping were largely dominant. Honey beekeeping in the region still exists 14% in Algeria, 37% in Tunisia and 75% in Morocco, except in Libya, where traditional beekeeping is non-existent.

The honeybee races existent are Apis *mellifera ligustica* and *A.m. carnica* (Libya), *A. m. intermissa* and *A.m saharensis* (Morocco) and *A.m. intermissa* (Tunisia). Where the diversity of races are represented in morphology and behaviour, it is difficult to establish the limit of the geographical areas they originally occupied. Intermediate forms exist where hybridisation has occurred between races, e. g. *A.m. intermissa* known as the punic or tellian bees present in the coastal belt of North Africa from Morocco through Algeria, Tunisia to Libya and also in Malta and the Canaries. Honey production was estimated at 4000 tons in Libya (1998). Honey beehives were estimated at 700,000 in Algeria, 150,000 in Tunisia, 350,000 in Morocco and 77,000 hives in Libya (Table 14.1).

Honey beekeeping specialists need to be increased in number to meet the emphasis and targets set to improve this industry in the region, e.g. in Morocco 5833, Algeria 35,000 and Tunisia 7,500.

Apiculture is a rural family venture in North African countries, and does not significantly interfere with normal farming activities. It provides an additional source of food, while simultaneously introducing rural industrialisation trade, by creating a demand for local manufactured equipment. It can ensure the

long term preservation of honeybee races in North African countries, while providing economic benefits to the local communities. Apiculture in the region has potential as an income generating activity for the semi-arid and arid regions.

Honey bee races in the North African countries

There are four widely spread honeybee races in the region (Table 2). A.*m intermissa* exists in the four countries, *A. m. Saharensis* in Morocco and Algeria, *A.m. ligustica* an Italian race was introduced to the western part of Libya and *A. m. carnica* was introduced to the eastern part of Libya from Bulgaria and Eastern Europe. Mixed races occur in the area and it is difficult to find pure races to establish a geographical limit for any of these races. The Australian bee introduced in western in Libya , resulted in mixing between the two races. Distinction between the races became difficult due to mixed races and bee movement between countries. This is reflected in increasing aggressiveness of races, more susceptibility to diseases and pests and decrease of honey production. Strengthening of queen rearing stations existing and establishing new ones to maintain race purity and minimize race mixing is essential.

Table 14.1: Honey bee races in North African countries

Race	Country
Apis mellifera intermissa	Tunisia, Algeria, Morocco, Libya
Apis mellifera saharensis	Morocco, Algeria
Apis mellifera ligustica (Italian race)	Libya (western part)
Apis mellifera carnica (originally from East Europe)	Libya (eastern part)
Hybrid races	All countries of the region

Traditional and modern honeybeekeeping

In the North African countries, traditional honey beekeeping still occupies an important share in this kind of industry, especially in Morocco (Table 14.2). Modern beekeeping was introduced in the region since the early days of the

colonial era. However, traditional beekeeping is the easiest way and does not cost much, compared with the modern methods. Despite low production, small beekeepers tend not to spend money in establishing a modern apiary. In Libya traditional beekeeping was replaced about 40 years ago by modern beekeeping.

Table 14.2: Number of modern and traditional beehives in North African countries

Country	Modern bee hives	Traditional bee hives	Total
Libya	77,000		77,000
Tunisia	110,000	40,000	150,000
Algeria	600,000	100,000	700,000
Morocco	70,000	280,000	350,000

In the North African countries (Libya, Tunisia, Algeria and Morocco), as in other countries of the world, beekeeping industry suffers considerable losses due to pests and diseases. A number of important pests and diseases were recorded to infect honeybee in the region. In North Africa, being semi-arid and arid zone of the world, the honeybee diseases and pests are varied in vigour and the losses they cause, in comparison with other areas of the world, such as tropical Africa, Asia and Europe, where temperature and humidity are an important factor in spreading of certain diseases and pests.

Pests and diseases

(a) American foul brood *Bacillus* is the most important brood disease spread to all apiaries in the region (Table 14.3). However, it differs in severity from one country to another.

(b) European foul brood *Bacillus alevi* and *Streptococcus pluton*, spreads in all areas of honey beekeeping in the area (Table 14.3). It is more severe in Morocco, followed by Algeria and Tunisia and to a lesser extent in Libya.

(c) Sac brood disease is a viral disease spread mainly in Libya and Tunisia (Table 14.3). It affects workers and drone larvae. It is a minor brood disease in the region and it could be controlled by enforcement of the hives and changing of the aging queens.

(d) Chalk brood is caused by fungi, *Aspergillus flavus, A. nidulans* and *Ascosphaera apis* and spread mainly in Libya and Tunisia (Table 14.3) and could be spreading to the other countries of the region. It is a serious disease that affects the colonies heavily and causes considerable losses. In case of heavy infection, all infected combs must be removed, hives cleaned and fumigated and the queens replaced.

(e) Acarine disease caused by *Acarapis wood* mite, has spread in all countries in the region (Table 14.4), but varies in its severity from one country to another, infects the respiratory system of the bee workers and the drones and queens

(f) *Nosema* disease caused by *Nosema apis* affects bees in all countries of the region (Table 14.4) to a different extent by affecting the digestive system of the bees.

(g) Amoebae disease caused by *Malpighamoeba mellficae*; spread mainly in Libya and Morocco (Table 14.4) and affects the digestive system in the mature bees, with no known cure.

(h) Paralysis disease caused by polyhedral virus affects bees in warm and hot climatic areas and is reported only in Libya (Table 14.3) with no known cure.

Pests

(a) Varroa mite *Varroa jaocobsoni.* This disease has spreads to all countries in the North African region as number one pest of honeybee in Morocco, Algeria and Libya and to a less extent in Tunisia (Table 14.4). It affects hives, causing considerable losses in bees and honey production and could destroy the entire colony in the hive in 2-3 years. Pesticides and repellents, used such as tobacco and thymus smoke, are used.

(b) Birds. The most important is *Meropes apistre* (bee-eater). It is a migratory bird, which arrives to the South Mediterranean west coast in March for nesting. It attacks bee hives vigorously, causing losses in colonies up to 70% in some apiaries. The pest is the most serious on honeybees in the region (Table 14.4). Research work shows that when protection nets are used to control the bird, losses dropped from 70 to 30%. When nets and weakly feeding bees are used, losses dropped to almost 0%.

(c) Wasps. Attack adult bees and more seriously in summer time, but exist nearly all year round. They are more serious in Morocco and to a lesser extent in Libya and Tunisia; no information is available from Algeria (Table 14.4).

(d) The large wax moth, *Galleria mellonella L* has spread in all North African countries. It is a destructive pest affecting combs, eggs and larvae. The most damaging life cycle stage of the moth is the larvae.

(e) The small wax moth, *Achornia grisella* For. has spread to all countries in the region, but to a lesser extent in comparison with the large wax moth (Table 4). It affects combs, bee eggs and larva.

(f) Other pests such as ants, lizards, toads, snakes, spiders, bee louse (*Braula ocecaanla*), attack honeybee, but their impact is not economically important compared to that caused by the pests and diseases. The only record of their effect was that from Libya and Tunisia (Table 14.4).

Means of control of pests and diseases of honeybee in the region

Two types of pest and disease control of honeybee in North African countries:

(a) Chemicals are pesticides used in each country for control of pests (Table 14.5) e.g. Apistan (Libya, Algeria, Tunisia and Morocco). Bivarol and Folbex, Apitol, Ametraz, Formic Acid (Libya) Antivorra (Tunisia) and Ametraz (Libya, Algeria and Morocco). Chemicals are used for control of bacterial diseases such as American foul brood and European foul brood. The only two chemicals used are Neoterramycin (Tunisia) and Tetracycline (Algeria). Bee keepers prefer to burn the infected hives, to eliminate the diseases and prevent its spread. No information is available on use of chemicals to control fungal disease, of honeybee such as chald brood in the North African countries.

(b) Natural substance such as tobacco and thymus smoke as repellent.

The most important constraints facing beekeeping industry in the North African countries can be summarised as follows:

(a) Severe summer drought adversely affects vegetation cover, especially the flowering plants. Adverse weather condition prevents bees from flying a long distance.
(b) Severe cold and strong winds during winter, cause death to a large number of colonies.
(c) Aggressiveness of some races limits spreading of beekeeping.
(d) Spreading of a large number of pests and diseases leading to death of a large number of bee colonies.

Table 14.3: The most important diseases affecting honeybee in North African countries scored from 1-10 according to its importance

Diseases	Casual Agent	Libya	Tunisia	Algeria	Morocco
American foul brood	*Bacillus* larvae	1	2	2	3
European foul brood	*Bacillus alevi, Streptococcus pluton*	7	3	-	2
Chalk brood	*Aspergillus* spp., *A. Nidulans*	7	-	-	-
Stone brood	*Ascophaera apis*	3	4	-	-
Sac brood	Viral disease	4	6	-	-
Nosema	*Nosema apis*	8	5	3	4
Acarine	*Acarapis wood*	9	-	-	4
Amoeba	*Malpighamoeba mellificae*	10	-	-	6
Paralysis	Polyhedral virus	6	-	-	-

- Information not available.

Table 14.4: The most important pests of honeybee in North African countries scored from 1-5 according to importance

Pests	Causal agent	Libya	Tunisia	Algeria	Morocco
Varroa mite	*Varroa Jacobsoni* Oud.	2	4	1	1
Large wax moth	*Galleria mellonella* L.	2	1	1	3
Small wax moth	*Achronia grisella* Fbr.	3	2	-	4
Birds	*Merops apiaster*	1	2	2	2
Wasps	*Philanihus Abdel Kader* Luc.	4	4	4	1
Others	Different	5	5	5	-

- Information not available

Table 14.5. Chemical used in controlling of honey pests

Chemical pesticides	Country			
	Libya	Algeria	Tunisia	Morocco
Apistan	X	-	-	-
Bivarol	X	X	X	X
Folbex	X	-	-	-
Anti varrao	-	-	X	-
Apitol	X	-	X	X
Ametraz	X	-	-	-
Formic acid	X	-	-	-
Marvik	X	-	-	-

Table 14.6: Chemicals used to control Bacterial diseases in honeybee in the North African countries

Chemical used	Country			
	Libya	Tunisia	Algeria	Morocco
Neoterramycin				
Tetramycin	-	+	+	

(e) Shortage in extension service in beekeeping
(f) Shortage in qualified experienced persons in the field of beekeeping.
(g) Overcrowded beekeeping areas.
(h) Use of highly toxic agricultural pesticides causing death to a large number of bees.
(i) Lack of some essential pesticides in time, needed for controlling of pests and diseases.
(j) Difficulties in obtaining pure queens with desirable characters, due to some technical and management measure.
(k) Contaminating of imported foundation wax, which could act as source of infection with some dangerous diseases.
(l) Laboratories specialized for disease diagnosis suffer from lack of trained personnel and equipment.
(m) Shortage of training courses for beekeepers on the most modern and suitable methods of beekeeping.

All these factors when combined together could contribute largely to the deterioration of beekeeping industry in the region.

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15. DEVELOPPEMENT DE L'APICULTURE AU SENEGAL

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Abstract: Dés l'accession du Sénégal à l'indépendance, les autorités administratives et techniques du pays se sont intéressées à la promotion de l'Apiculture à travers notamment différents Plans de Développement Economique et Social.

C'est ainsi que, dans le cadre del la coopération multilatérale, des experts des paays amis au Sénégal, ont-ils eu à collaborer avec les techniciens et praticiens sénégalais pour concevoir, définir les contours d'une apiculture moderne et dynamique devant accuper une place déterminante dans l'économie nationale.

De 1962 à 1971, des missions d'études ont séjourné au Sénégal et ont permis à l'encadrement local de prendre en charge le devenir de la filière apicole.

Conscient du rôle prépondérant que joue celle-ci dans la lutte contre la pauvreté, le sous-emploi et exode rural, le Gouvernement du Sénégal à mis en place les Projets de Relance et d'Appiu à l'Apiculture dans le cadre de son Programme Triennal d'Investissements Publics (PTIP).

Les objectifs generaux suivants ont ete fixes:

(a) modernisation de l'Apiculture nationale
(b) augmentation des revnus des apiculteurs
(c) frein a l'exode rural
(d) action sur l'environnement

En ce qui concern les objectifs specifiquees, nous avons fixe les objectifs suivants:

(a) rehabilittation des centres apicoles primaires et secondaires
(b) reimplantation de ruches de demonstration
(c) sensibilisation, formation et organisation des producteurs
(d) acquistion d'equipments et de facteurs de production
(e) identification et assainissement dees circuits de commercialisation des produits de la ruche
(f) controle de la qualite des miels et cires

Les results obtenus de ces projets peuvent se resumer ainsi qu'ils ssont:

(g) les exploitants apicoles sont passes de 20.000 a 35.000 personnes
(h) 30.000 ruches ameliorees modernes et 200.000 ruches traditionnelles
(i) 42 ruchers de demonstration implantes
(j) 15 centres de traitement du miel fonctionnels
(k) 110 GIE d'apicultuers constitues
(l) 4.000 apicultueurs formes
(m) la production moyenne de miel et de cire est passe respectivement de 10 a 15 kg et de 7 a 9 kg par ruche et par an
(n) le prix du kg de miel et de cire est passe respectivement de 800 F a 2.000 - 2.500 F et de 500 a 1.500 F
(o) les productions de miels et de cires (1993-2000) sont passes de 161,5 a 550 tonnes pour le miel et de 65 a 150 tonnes la cire (estimees), de 40 tonnes a 100 tonnes (miel) et de 7 a 13 tonnes (cires) controlees)

La situation actualle dee la filiere apicole, fait apparaitre l'intervention de nombreux projets d'encadrement d'ONG et d'association et de societes.

Introduction

L'apiculture sénégalaise est arrivée à un tournant décisif de son histoire.

En effet après environ 30 ans d'efforts des groupements de producteurs et des pouvoirs publics, pour moderniser l'apiculture traditionnelle et rompre avec les pratiques ancestrales dégradantes pour l'environnement, par l'introduction de nouvelles techniques, l'organisation structurelle des groupements, l'appui à

la commercialisation des productions; tout ceci avec la collaboration de partenaires multilatéraux et d'Organisations non gouverne mentales nationales ou étrangères, il s'avère très opportun de susciter une large concertation sur le sujet pour faire le point et dégager les nouvelles perspectives.

Le cadre idéal pour une telle concertation passe nécessairement par l'organisation soit d'un séminaire national sur l'apiculture, soit de journées d'études, selon la formule que notre réunion d'aujourd'hui aura retenue.

Situation Actuelle de L'apiculture

La pratique apicole connaît au Sénégal un véritable engouement de la part des apiculteurs, des opérateurs économiques qu'ils soient nationaux ou étrangers qui y ont vu un créneau porteur, que de la part des organisations non gouvernementales qui apportent un soutien multiforme aux groupements de producteurs.

Le soutien de l'Etat à l'essor de l'apiculture au Sénégal est bien entendu de loin le plus conséquent par le biais de différents projets d'encadrement du monde rural.

Toutefois malgré tous les efforts consentis, l'apiculture semble marquer le pas. Ce qui est à mon avis essentiellement dû à l'absence d'un cadre national de concertation, pour définir une politique cohérente et coordonnée applicable sur toute l'étendue du pays.

En effet la multiplicité des intervenants fait que souvent les modèles de ruches vulgarisées sont très diversifiées.

Les différents intervenants sont:

(a) les projets d'encadrement
(b) les O.N.G
(c) les G.I. E
(d) les associations de producteurs
(e) les apiculteurs individuels
(f) les dioulas

(1) Les Projets d'encadrement

Les projets d'encadrement apicole sont les suivants:

(a) le Projet relance de l'apiculture (PRA)
(b) le Projet des Petits Projets ruraux (PPPR)
(c) le Projet de développement rural en Basse-Casamance (DERBAC)
(d) le Projet Intégré de Moyenne-Casamance (PRIMOCA)
(e) le Projet Gonakié de Saint-Louis (PROWALO)
(f) le Projet de foresterie rurale de Dabo à Kolda;

(i) Le Projet relance de l'apiculture a assuré de 1988 à 1995 la formation des formateurs, l'encadrement et l'organisation des producteurs,la réhabilitation des infrastructures des centres apicoles ainsi que leur équipement en matériel de bureau et d'exploitation.

Le Projet assure également l'expertise technique pour les projets ayant initié un volet apicole dans leur zone d'emprise.

(ii) Le Projet des petits projets ruraux a financé des sous-projets d'apiculture à Bignona et Kolda avec la construction de centres de traitement des productions et 1' équipement des apiculteurs.

Ce projet a connu quelques difficultés dues à la suspension de son financement ce qui a entraîné l'arrêt de ses activités apicoles depuis le 19 Août 1992.

Mais le projet a subi une mutation avec la modification de son cadre institutionnel qui lui permettra de redémarrer ses activités sous le nom d'Association sénégalaise pour la promotion des petits projets de développement à la base (ASPRODEB), qui va s'appuyer sur une Agence d'exécution de projets (AGEP).

(iii) Le DERBAC apporte un appui important aux groupements de producteurs apicoles de la région de Ziguinchor dans le domaine organisationnel et la formation.

(iv) Le PRIRNOCA a mis en place trois centres de traitement et encadre avec l'aide du chef decentre de Kolda, les organisations suivantes comprenant des apiculteurs:

- La Fédération communautaire des agro-pasteurs de Sansamba (FECAPS)

- L'Association de lutte contre l'exode rural (ASSOLUCER)

- L'Association africaine de la jeunesse agricole et culturelle/Comité de lutte pour la fin de la faim (AAJAC/COLUFIFA)

e) Le PROWALO encadre des jeunes formés dans le cadre des reboisements communautaires et qui y intégrent l'apiculture.

- A.C.D.I. : Bureau d'Appui à la Coopération Canadienne, 44 Boulevard de la République

- Volontaires du Corps de la Paix (Madame PEIROTES), (823.71.78

f) Le Projet de foresterie rurale de Dabo a financé l'équipement des groupements d'apiculteurs de Thiaféna.

(2) LES ORGANTSATIONS NON GOUVERNEMENTALES

Le P.S.S.A. / FAO Vietnamiens
Les ONG sont les suivantes:

(a) l'Association française des volontaires du progrès (AFVP)

(b) le Centre de relations Internationales entre Agriculteurs pour le Développement (CRIAD)

(c) Médecine - Développement - Solidarité

(d) la GTZ

(e) l'Association Arradon Tiers-Monde

(f) Maisons Familiales Rurales

(i) L'AFVP avait encadré de 1983 à 1989 l'Association des groupements apicoles du département de Kédougou (AGADEK), qu'elle a ensuite entièrement responsabilisé.

(ii) Le CRIAD encadre l'Association des apiculteurs Araf/Caritas de Keur Babou Diouf depuis 1993 (FATICK).

(iii) Médecine . Développement. Solidarité fiance des apiculteurs de Toubacouta encadrés par le chef de centre de Karang.

(iv) La GTZ finance les apiculteurs de la Sous-Préfecture de Tanaff encadrés par le chef de centre de Kolda.

(v) L'Association Arradon Tiers-Monde apporte depuis 1989 son appui au Projet relance de l'apiculture dans l'organisation annuelle d'un séminaire de formation apicole à Bignona, en envoyant des apiculteurs Français du Morbihan.

(3) Les groupements d'interet economique

Le Sénégal compte 110 groupements d'Intérêt economiques d'apiculture dont 26 GIE formels et 84 GIE informels. Ces GIE sont soit des GIE de production, soit des GIE de commercialisation.

(4) Les associations de producteurs

Les Associations de producteurs sont:

(a) la Fédération des Agro-pasteurs du Fouladou qui compte des Groupements d'apiculteurs, opère dans la Sous-Préfecture de Tanaff.

(b) la FECAPS qui compte également des groupements d'apiculteurs opère dans la Sous-Préfecture de Djibabouya.

(c) l'ASSOLUCER opère dans la Sous-Préfecture de Diendé.

(d) l'AAJAC/COLUFIFA opère elle dans la Sous-Préfecture de Bounkiling.

(e) l'AGADEK qui regroupe les groupements de Salémata, Kédougou, Bagnon, Bandafassi et Fongolimbi.

(f) le Comité National d'Intiatives pour la Promotion des Apiculteurs du Sénégal(Conipas), dont le siège est à Grand Yoff.

(5) Les apiculteurs individuels

Il s'agit essentiellement de personnes ayant des exploitations d'agrumes ou faisant de la culture maraîchère et qui privilégient donc la pollinisation sur les autres spéculations apicoles. Ils se trouvent presque tous dans la zone des Niayes.

(6) Les vendeurs de miel ou dioulas

Il importe ici de diligenter une étude ou de convoquer une assemblée générale de cette catégorie socio-professionnelle pour procéder à un recensement plus ou moins exhaustif et réfléchir sur les meilleurs moyens de les organiser. En effet la commercialisation des produits de la ruche reste à ce jour le domaine le moins bien cerné, alors que l'on note depuis quelques années un grand remue ménage d'opérateurs économiques qui s'intéressent à la filière.

Au Sénégal près de 35 000 personnes tirent des revenus de l'apiculture, soit par l'exploitation de quelques 3 000 ruches à cadres, 200 000 ruches traditionnelles, ou en faisant la cueillette du miel de près d'un million de colonies sauvages.

Il faut signaler qu'en matière de commercialisation, la Sté d'Exploitation des Ressources Animales du Sénégal (Seras), a joué et continue de jouer un grand rôle.

Un meilleur contrôle des flux commerciaux des productions apicoles permettrait de régler le problème de disponibilité en statistiques fiables.

Nous pouvons ainsi constater qu'en raison du nombre important d'intervenants, il est urgent de trouver le moyen le plus adéquat d'assurer une coordination des différentes actions et une meilleure impulsion de la politique apicole de notre pays.

Les Perspectives d'avenir

Les perspectives pour un avenir florissant de l'apiculture existent dans les pays en développement en général et au Sénégal en particulier, en raison l'augmentation régulière depuis 1975 des importations de miels dans le monde avec un accroissement en quantité d'environ 75% et d'environ 88% en valeur, passant de 150 000 tonnes (soit 133 millions de dollars) à 262 000 tonnes (soit 250 millions de dollars).

Cette accroissement de la demande mondiale en miels intervient à une période où on note une prolifération accrue de l'abeille tueuse d'Amérique du Nord (un hybride issu du croisement de l'abeille locale avec une abeille africaine), qui est en train de décourager la pratique apicole dans cette zone et également par l'extension de la varoise qui décime les colonies d'abeilles en Occident et en Asie.

Tout ceci bien considéré doit amener le Sénégal et l'Afrique à se positionner en vue de devenir des exportateurs potentiels de miels de qualité, d'autant que notre continent est encore épargné par les maladies infectieuses et parasitaires des abeilles qui sont traitées à l'aide de pesticides, dont les résidus se retrouvent dans les produits.

Donc nous pouvons proposer des miels diététiques et même exotiques aux pays membres de la CNUCED, dans le cadre des accords du GATT Si nous parvenons à l'auto-suffisance.

Mais à mon avis, pour que le Sénégal mette tous les atouts dans sa manche pour relever le défi, il faudrait qu'il soit organiser un séminaire national ou des journées d'études, où tous les acteurs de la filière seraient en conclave en vue de baliser la voie.

(1) Semlnairf national ou journees d'etudes

Si notre réunion retient le principe d'une de ces deux formules, il nous faudra débattre de ses modalités d'organisation à savoir:

(a) définir le thème et les sous-thèmes
- choisir les animateurs
- présenter les activités des différents projets

(b) définir la durée et la date

(c) choisir le lieu

(d) déterminer les conditions d'organisation matérielle

- choix du comité d'organisation
- Types de manifestations connexes (expositions-ventes,excursions)

(e) définir les modalités de financement du budget

(f) cibler les bailleurs:

(i) Etat (DIREL et Projets)
(ii) ONG
(iii) Fondations
(iv) les Groupements d'Intérêt Economique
(v) les sociétés
(vi) les bonnes volontés

(g) penser à l'édition d'une plaquette publicitaire

(2) Association des apiculteurs du Senegal

La création d'une telle association qui regroupe toutes les organisations d'apiculteurs, les techniciens apicoles ainsi que les apiculteurs individuels, s'inspire de ce qui se fait actuèllement dans le monde, en vue d'une conformation à une pratique couramment admise de n'exclure personne à même d'apporter sa contribution au développement du secteur.

La réunion devra entendre les représentants des diverses associations, afin de tirer profit de leurs expériences, avant de mettre sur pied un comité chargé de la rédaction des statuts de l'association nationale, qui pourrait voir le jour à l'occasion du séminaire pour lui donner toute la solennité requise.

Nul doute que la réussite de l'organisation du séminaire et la création d'une association nationale ouvriront de très heureuses perspectives à l'apiculture sénégalaise.

(3) Cooperation Nord-Sud et Sud-Sud

L'association nationale des apiculteurs du Sénégal pourra adhérer à la Fédération Internationale des Associations d'Apiculture (APIMONDIA) et à l'Association des Apiculteurs de l'Afrique de L'Ouest.

1/ APIMONDIA dont le siège est à Rome en Italie regroupe près de 160 pays car se sont les pays qui adhérent à cette organisation par le biais de leurs associations nationales. Elle a pour principal objectif de promouvoir et de développer l'apiculture dans les pays membres. Elle célébrera le centenaire de sa création à l'occasion de son 35é Congrès, qui doit avoir lieu en septembre prochain à Anvers en Belgique.

2/ L'Association des Apiculteurs de l'Afrique de l'Ouest a son siège à Cotonou au Bénin. Elle a été créee en 1991 à Banjul à l'issue du 1er Séminaire sous-régional sur la recherche et le développement de l'apiculture en Afrique de l'Ouest. Le 2ème a eu lieu à Accra au Ghana en 1993 et le 3ème à Parakou au Bénin en 1995.

Le Sénégal aura l'insigne honneur d'organiser le 4é Séminaire sous-régional sur la recherche et le développement de l'apiculture en Afrique de l'Ouest, en décembre 1998

Le Sénégal à l'instar d'autres pays de la sous-région qui doivent créer leurs associations nationales, est membre de cette association pour avoir déjà paniciper aux deux derniers séminaires et pour avoir été coopté dans le Comité Exécutif.

Cette Association vise également à promouvoir et à développer l'apiculture dans les pays membres en favorisant les échanges Sud-Sud.

Les pays membres de l'A.A.A.O sont au nombre de quinze (15) à savoir:

Le Cameroun, le Nigéria, le Niger, le Bénin, le Togo, le Ghana, le Burkina Faso, le Mali, la Côte d'Ivoire, le Libéria, la Sierra Léone, la Guinée, la Guinée Bissau, la Gambie, le Sénégal.

16. APICULTURE DEVELOPMENT IN TUNISIA AND ITS FUTURE OUTLOOK

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Abstract: The apicultural sector in Tunisia has undergone a considerable evolution during the last 20 years. Indeed, the number of modern bee hives has risen from 6,000 in 1975 up to 110,000 in 1990 (according to last statistics), against 100,000 and 41,500 traditional bee hives, respectively. The annual production has also risen from 250 tons in 1975 to 1400 tons in 1990; yet such a production is still poor.

But for the government's efforts to enhance the production in this sector, prospects still fall short of world standards. Indeed, the country's 9th plan, extending from 1996-2001, intends to achieve 205,350 modern bee hives and 51,050 traditional ones. All in all, the total production will attain 3874 tonnes with a minimum of 387 g. consumed yearly by each inhabitant. However, the climatic conditions (super semi-arid) in Tunisia limit the availability of pollen and nectar sources (trees and foliage)for bees. In addition the genetic pure lines of bees is a major handicap to the development of the apicultural sector.

However, with increased research within this sector as well as creation of cooperatives to after few new producers and to overseeand develop the quality of production, there is hope for a brighter future for the apiculture sector in Tunisia. Measures will be taken to introduce and adapt new species of foliage and flowers to renovate sources of nectar.

Background Information About Tunisia

Location

Situated in the North of the African continent, Tunisia is bordered by:

(a) The Mediterranean from the north and the east
(b) Algeria from the west
(c) Libya from the south

Surface area

162.155km^2

Coast

1298 km long

Demography

According to the 1994 statistics, Tunisia has 8,785,711 inhabitants among whom 61% are urban and 39% rural population.

Estimated in 1997 at 9.2 millions, there are 54.1 inhabitants per km^2

Climate

It is Mediterranean type of climate in the north and along the coasts, semi-arid and arid inland in the south (Table 16.1).

Precipitations are irregular and concentrated mainly in the cold season (75% of the annual total). The geographic distribution of the precipitations shows that three quarters of the surface of the Tunisian territory is bioclimatically semi-arid, arid and sahara. Temperatures vary from one region to another with the following averages; December 11.4 °C and July 29.3 °C. Investing in the irrigation sector represents the most important portion in the agricultural investments at 37.4% (according to the 9th plan which started in 1996 and expires in 2001).

The government has opted for a strategy that expires in 2001, which aims at mobilizing all the hydraulic resources the country can provide, such as dams, mountainous lakes and underground drilling.

Table 16.1. Climate types and rainfall patterns in Tunisia

Bioclimatic Storey	Rainfall
Humid and sub-humid	>600 mm
Superior semi-arid	>400 mm
Inferior semi-arid	>200 mm
Arid	>50 mm
Sahara	<50 mm

Agriculture

The share of the agricultural sector and fishing in the Gross Domestic Product (GDP), varies. During the last three years, its contribution to the economy has been as follows.

(a) GDP = 15%
(b) active population = 22%
(c) exploitation of the country's fortunes = 12%

Tunisia's main agricultural products, for export are olive oil, citrus, dates and wine. Aware of the importance of the agricultural sector in our country, the government adopted a strategy from 1987 to 1998, with the aim of securing exclusive food security. Some good results have been achieved in that the covering rates reached 77% during the said decade, compared to 49% during theprevious decade, 1977-1987. The sum of the food scale has improved.

Starting from 1997, some measures have been taken to enhance the breeding sector, which comes after the hydraulic sector, in the distribution of investment in agriculture as far as the 9th plan is concerned (1996-2001). These measures give importance to breeding. Apiculture has succeeded in improving the income of small scale farmers. The objective expected beyond this tendency is the achievement of self-sufficiency and development of new products.

Distribution of resources

The productive pastoral resources, forest and agriculture, extend 10.474 million acres, which is 64% out of the total surface. This surface is divided as in Table 16.2.

Table 16.2. Acreage of land use in Tunisia.

Land use	Acreage
Natural forest	386.000
Renovated forest	515.000
Forest course	194.000
Alfatieres layers	740.000
Natural course	2.500.000
Collective course	1.369.000, with a vegetal recovery is less than 25%
Agricultural plots	4.774.000
Hydraulic and humid Zones	393.000
Built lands	180.000

Source: Results of the First National Pastoral Inventory in Tunisia, published in 1995.

History

Apiculture in Tunisia is a very old practice. Indeed, "Ifrikya", which would later give its name to the African continent, used to be charaterised by the mildness of its climate and the richness of its flora. These two elements made it not only tome's storehouse, but also its honey tank. The French colonization and the Second World War changed profoundly the physical aspect of Tunisia. This resulted in the fall of the number of bees, and the dispersion of beekeepers.

After a half century of decline, we witness today the apiculture sector regaining its strength, which it should not have lost. From the beginning of the sixties the ministry of agriculture launched the first actions that aim to promote the apicultural sector. That was carried out by encouraging a modern and more productive apiculture, that would be able to play a more important role in the economy of agricultural exploitation. Apiculture used to be basically traditional, but with the great changes in the physical aspect of this sector during the

eigthties, we attend today to more modern and intensive apiculture with 80%. Yet, to attain international standards in the future other efforts are required.

The Honey-Plant Potential

The floral heritage in Tunisia is composed of the following plant species: 2200 vegetation species, 307 rare plants, 99 very rare plants and 7 species which exist are found only in Tunisia (Table 16.3). With the strategy of reforestation that started since 1990 and covered more that 33,000 acres each year, it reached a success rate of between 70 and 75% has been attained.

This resulted in the improvement during these years of the vegetation cover of the forested area in the following way: 1956 (4%), 1987 (7%), 1990 (9%), 1996 (10%) and 1999(11%). Proclaimed on 4th November 1999 on the occasion of the tree festivities, during which 10 million trees were planted with an average of one tree per one inhabitant (Ministry of Agriculture).

The honey-plant potential in Tunisia is rich and varied. The main resources are arbocultural rather than forest ones, which may bring a fortune to beekeepers, especially in rainy seasons. Yet, these resources degrade from north to south (Table 16.3).

In rainy years, the spontaneous vegetation cover constitutes itself as another source of nectar and pollen, particularly in spring. This cover is basically made of grass-like plants: *Caraway*, leguminous plants, such as Lucern (*Medicago sativa*) and trefoil; Cactus, Harmala (*Peganum harmala* may be found only in Tunisia and helps produce an aromatic honey of very good quality) Sunflower and *Zizyphus lotus.* Other species are found in different regions of the country, which are apiculturaly important, such as the *Retama ream* and garden ornamental plants.

Development of the Apicultural Sector in Tunisia

Agriculture in Tunisia is charaterised by the co-existence of two sectors:

(a) A traditional sector, which has gradually lost its place during the last years and

(b) a modern sector, which is growing, given the encouraging measures and its profitability.

Table 16.3. The calendar of the principal plant/honey-plant species

Identity of the species	Location	Surface: acres 1984	Surface Acres 1996	Honey-plant potential	Blossoming time time
Citrus, e.g. the orange *Citrus sinensis*, the mandarine, *citrus reticulate* the *citron: citrus limon*	North: Cap-Bon (85%)	14.130	16.138 (1998)	V.I.	March
	North, Jendouba, Bezerta and Zaghouan (15%)				April
Eucalyptus: e.g. - *Camal dulensis, Gonphis phocephala,*	North-West, sejnene,Cap-Bon, Kelibia	1500	28.536	V.I.	Jul., Aug.
Euc.Maculate	Bon (85%)Fahs,	1996		1	Sept., Oct.
Euc.Leuoxylon,	Zaghouan			1	
Euc. Territecorcis,				1	May, Jun.,
Euc.Wanda,				1	Jan., Feb.,
Euc.Albens,				1	Mar., Oct.,
Euc.Astaingens,				1	Nov., Dec.,
Euc.medinis,				1	Sep., Oct.,
Euc.accedens,					Jan., Feb.,
Auc.Acodocylyx,				1	Mar.
Euc.vinimalis,				1	May., Jun.,
				1	Jun., Feb.,
				1	Apr., May
				I	Jun., Jul.,

Table 16.3 Contd.

Identity of the species	Location	Surface: acres 1984	Surface Acres 1996	Honey-plant potential	Blossoming time time
					Aug.
					June, Jul.,
					Jul., Aug.,
					Jun., Jul.
Rosemary *Romarius officimalis*	North			I	Sept., Oct.,
	Centre			I	Nov. Dec.
					Jan., Feb.
Thyme: *Thymus Thymus algeriensis, Thymus capitatus, Thymus hirtus, Thymus cerpillum and Thymus vulgaris*	North Nabel Zaghouan			I	June
Briar *Erica arboria, Erica multiflora, Erica scoparia,*	North			I	Oct., Nov.,
Myrtle Myrtus	North			L.I	June

Table 16.3 Contd.

Identity of the species	Location	Surface: acres 1984	Surface Acres 1996	Honey-plant potential	Blossoming time time
Myrtus communis *Myrtus odorata*					
Marribun *Marribun alysson* *Marribun dersti* *Marribun supinum* *Marribum vulgare* *Kairouan* *Siliana*	Centre Kairouan Siliana			I	May, June
Almond tree *Prumus amygdalus*	South-east, and centre, and south Sfax and Sidi Bouzid	275,000	276,000	V.I.	Dec., Jan., Feb., Mar.,
Apricot tree	Centre Sahel (coast)	11,000	15,000	L.I.	Jun., Feb., Mar., Apr
Peach tree: *Prumus percica*	North Centre Sahel	10,000	35,000	V.I.	Jun.,Feb

Table 16.3 Contd.

Identity of the species	Location	Surface: acres 1984	Surface Acres 1996	Honey-plant potential	Blossoming time time
Plum tree: *Pyrus*	North Centre Sahel	3,450	8,000	L.I.	Jan
Pear tree: *Pyrus*	North-eaat	-	28,000	L.I.	Mar., Apr.
Apple tree: *Malus pumila*	Centre North	-	14,000	L.I.	Jan., Feb., March

V.I = very important
I = Important
L.I = less important

Table I = important
V.I. = very important

Source GIAF: The Ministry of Agriculture

Traditional breeding systems

Tunisian traditional beehive, known among people as "jebba", is a cylinder 1.2 to 1.5 m long and 0.2 to 0.3 m in diameter. Beehives are made of different materials, at different regions as follows:

(a) *In the North (forested area), barks of cork-oak, which is a good insulator as follows:*

(i) Centre: branches of lentisque, olives, tamarisk and other flexible timber and then a layer of clay and cowpat make the exterior plaster
(ii) The Sahel (the coast) and the centre south: plaster
(iii) The South: trunks of old palm-trees with a hollow, but enclosed in extremities with plaster or clay

(b) *Beehives are protected from rain, humidity and predators:*

(i) At the bottom, a bed of dry stones,or woods
(ii) At the top and extremities, a thick layer of clay makes the exterior plaster and helps protect beehives from bad weather.

(c) *Traditional sector is charactrised by:*

(i) Good quality and important production of good quality beeswax.
(ii) Very low investing costs.
(iii) Difficult access to hives, which limits the beekeeper's interventions to look after his bees.
(iv) Low production rates of honey: 3 to 5 kg of honey produced annually per hive.
Swarming is not controlled because it is natural and spontaneous and weakens the colonies.
(v) The unstable nature of apiculture. In some years bees migrate, and swarms return during favourable years.

The primitive apiculture is adapted to local conditions. Indeed, it permits the exploitation of the floral resources that are insufficient for a modern (box-like) hive. Traditional apiculture remains interesting given the efforts it requires and the less sophisticated technique easily provided by agriculturists and countrymen, who given these facts, improve and diversify their revenues. It represents a reservoir of bees wax and swarm supplies, which help feed the

modern apiculture. As a result of the introduction of some improvements on the breeding techniques, this type of apiculture will help the valorization of the fair and weak "honey plant" potentialities in several regions of the country.

Modern breeding systems

Langstroth beehives are widely adopted by Tunisian beekeepers given new developments and the encouragement made by the Tunisian government. Modern apiculture, is based on the migratory apiaries and the usage of the so-called pastoral beehives. Thus, rosemary and other species of little importance consolidate the profitability of such projects. Modern apiculture is more productive, because it requires:

(a) high investment cost
(b) good management
(c) good and efficient exploitation of "honey-plant" resources

Modern apiculture is intensive and is almost exclusively restricted to producing honey. Very few have attempted the production of pollen and royal jelly. The other products are, for the moment, ignored by Tunisian beekeepers.

The development of bee number

The traditional sector dominated the scene until the end of the 1960s (Table 16.4). Since the early eighties, however, apiculture witnessed the conversion to box-like hives (modern hives). Thanks to the government's encouragement, aiming at the promotion of apiculture. This was feasible by carrying out an intensive apicultural breeding that was able to valorize better the floral potential. In the mid-1980s, bee breeding in Tunisia had a radical change in terms of its structure, a process that has been accentuated during the nineties (Tables16. 4 and 16.5). This change resulted in:

(a) an important decline and fall of the number in the traditional sector
(b) an important booming and rise of number in the modern sector.

The modern apiculture increased from 51% in 1981 to 60% in 1986, out of the total production. The traditional sector fell, notwithstanding its relative importance, during the last years, because of:

(a) the spread of the *Varroa* epidemic that was difficult to control in traditional hives

(b) the take over from old beekeepers
(c) the impact of years of drought . There have been 4 years of drought (1988-1989) and 1994-1995) during the last two decades (1980-1999);1988 was the hardest, particularly on apiculture. Together with drought, which did not spare any region of the country, we should mention the devastating effects of anti-desert locust treatments. Both had severe effects on bees living in "Djebeh".

The growth rates in the modern sector reached 12% per year from 1975 to 1990 and 5.5% per year from 1991 to 1989.

The traditional sector has to co-exist with the modern one, given its advantages in regions with few plant resources. It is useful as a swarm and bees wax supply. The latter, i.e. bees wax, became a strategic material for the Tunisian apiculture. To face the development of modern apiculture, the government resorted to importation.

The development of honey production

The intensification of efforts in the apicultural sector in Tunisia has led to the growth of honey production (Table 16.6).

Honey consumption per inhabitant per year has plainly improved, yet it remains far from satisfying the needs. Compared to other nations, honey consumption rates in Tunisia are still lower than the world standards, as the following statistics yield. Honey consumption per inhabitant during the nineties:

(a) Austria: 1882 g of honey per inhabitant each year
(b) Germany: 1492 g of honey per inhabitant each year
(c) Tunisia: 175 g of honey per inhabitant each year

Nevertheless, Tunisia has never imported nor exported honey. Compared to Austria and Germany, honey in Tunisia is still considered a luxurious food. Its average retail price ranges from 10 to 15 TD, which is equivalent US$ 10 to 15 per kg. This shows that honey production is still insufficient and may be due to by high costs of bee wax and imported treatments.

The growth of brute bees wax (Table 16.7) could not meet the local needs. This situation compelled resorting to importation, since 1980 until 1996 given:

Table 16.4. Number appraisal and development

Year	1975 appraisal	1990		1998		2001 Estimates of nineth plan
Modern beehives	6,000	Estimates 75,000	Statistics 110,000	Estimates 154,000	Statistics 140,000	205,000
Traditional beehives	100,000	49,000	41,500	44,000	30,000	51,000

Table 16.5. The number of beehives:Estimates of the 9th plan (1996-2001)

Year	1996	1997	1998	1999	2000	2001
Box-like hive	127,500	140,250	154,275	169,700	186,670	205,350
Traditional hive	40,000	420,000	44,100	46,300	48,620	51,050

Table 16.6. Development of honey production and consumption in Tunisia:

Years	1975	1990	1998	2001 (estimates)
Honey production (tons)	250	1400	2900	3874
Honey consumption (g)	45	175	300	387

(a) the development of modern apiculture and initiation of new projects
(b) the decline of the traditional sector
(c) collection circuits are interrupted and collectors are no longer interested.

Table 16.7: The growth of brute bee wax production: appraisal and estimates

1998	1975	1990		1998		2001
Brute bee wax	Appraisal	Appraisal	Estimates	Appraisal	Estimates	Estimates
Production (tons)	68	54	52	57	68	87

The quantities of bee imported to meet the country's needs during the last decade are as follows (in tons):

1990 27,500
1991 35,000
1993 20,000
1996 5,000

As part of the restructuring of public enterprises programme, the private sector will take charge of provisions in this sector.

Development of Apiculture in Tunisia

(i) Apiculture in Tunisia has long been ignored, It is only after the 1970s, when this type of activity started to occupy the place it should have in the Tunisian agriculture. Indeed, apiculture is an agricultural activity that is particularly appropriate to developing countries, since it does not require large investment.

In rural areas, apiculture can play a very important social and economical role, in that it provides significant additional income for some, while it is a decent source of income for others. Aware of the importance of the apicultural sector, the government decided since 1975 to encourage apicultural development. To carry out its projects, Tunisia approached UNDP and FAO for financial help. Moreover, the breeding and pasturage office took charge of this mission until the apiculture project became a reality.

Right at the start, this project stressed the urgency of founding group structures to this sector. Indeed, three apicultural stations were created:

(a) Mraissa apicultural station (Soliman)
(b) Sidi Fradj queen breeding and fertile queen production (Tunis)
(c) Some apicultural equipment producing centre (Tunis), which produces*Beehives and accessories
(d) One for all purpose metallic articles
(e) One wax
(f) One for wafer-like wax

Afterwards, a government research centre was constructed and equipped and the necessary staff recruited. Generally, the efforts made by the government for apicultural development have been in the following sectors:

(a) The government encouragement for the promotion of apiculture

Preoccupied by encouraging investment relative to the apicultural sector, the government provided through "Fond special due developpement de l'agricuture (FOSDA)", i.e. Special Fund of Agricultural Development (SFAD) and "l'agence de promotion des investissements agricoles (APIA)", Agency for the Promotion of Agricultural Investments (APAI), facilities to pomote apiculture.

(b) Training

Within the FAO-UNDP project, the training of senior and junior officers and production assistants were a preliminary objective in order to realize the apicultural promotion programme. Emphasis was laid on the training of beekeepers and technicians working in pilot production and demonstration stations.

Moreover, given the combined efforts of the Ministry of Agriculture and the National Education Ministry, apicultural training was co-opted in the curriculum of primary, professional and secondary education and in university-level agricultural schools. Some hundreds of primary school teachers participated in intensive courses, followed by practical workshops in apiculture. They have actively initiated their pupils to the rational exploitation of bees. Twenty among them attended intensive specialized training courses in apiculture and were then posted to 18 primary schools equipped with apicultural material from UNICEF.

This was carried out within the programme of opening the primary school on its environment. Seven professional, agricultural training centres (in Tunisia, called CFPA), were founded with the aim of training agricultural assistants. These centres did not exclude apiculture from the curriculum. Two CFPA (El Alia in Bezerta) and Takelsa in the Cap-Bon, known by their highly-qualified staff and modern equipment, look after the training of assistants specialising in apiculture, who, after a one year theoretical and practical training session, attended a 6 to 8-month training-course in different beehives. The total number of graduated specialized assistants from these two CFPA, is 301. The Soukra Young Girls Agricultural School sends at least two pupils each year for a 10 months training course in apiculture. Apiculutre is also taught at the university level in agronomy schools. Also, seminars were held by the apicultural project in collaboration with different boards of the ministry of agriculture, in order to make officers, assistants and those responsible for extension, sentisitised.

The FAO-UNDP project organized refresher courses and trips for exchange of ideas and experiences and also sent the technical staff of the project abroad.

(c) Extension and technical assistance to beekeepers

Though many efforts have been made in training,and many beekeepers were not concerned. The extension of new apicultural techniques required other types of intervention such as the organisation of open days and mass media usage. The extension in the Cattle and Breeding Office (CBO) is organized each year all over the country, reaching more than 1000 people interested in beekeepers. Audio-visual methods are widely used in meetings, for a better understanding of apiculture and its advantages. Radio, television and newspapers have been efficient methods in the publicity of apiculture. Visiting trips to modern beehives were organized for the benefit of farmers, to encourage them in practising apiculture. As for the technical assistance, consultants from the Cattle and Breeding Office (CBO) in Tunisia, provide framers with professional advice and technical support, either in breeding or in their struggle against bee diseases. In this framework, it is important to mention the noticeable actions led by the Association of Development and Rural Animation (ASDARA), i.e. Association de Developpement et l'animation rurale (ASDER). Likewise the PAM, PDR and PDRI projects, implement the introduction of modern apicultural techniques to poor and deprived famers.

(d) Supply to the sector

The development of modern apiculture has made it necessary from the outset that biological materials (swarms and queens) and breeding equipment (hives and accessories), be put at the promoters' disposal. To respond to these needs, three stations were created in 1975 by the CBO:

(a) The Apicultural Station El Mraissa
(b) The Queen Breeding Station in Sidi Fradj
(c) The Sourkara Equipment Manufacturing Centre

The Mraissa Apicultural Station, which keeps 800 bee colonies, works towards achieving practical training for 10 to 15people each year. The production is 300 to 600 swarms each year and 15 to 18 tons of honey are sold directly to consumers.

In this way, the quantity of swarms produced is intended to be sold to the growing number of promoters. Natural swarm-collection campaigns have been tried by the apicultural project started by the CBO in areas densely populated with traditional beehives. Unfortunately, the success of this enterprise is low, given the quality of swarms proposed, the costly accessibility fees and the difficulty of access. In 1983, a purchasing operation of traditional hives with a view to decanting them was difficult to realise. Moreover, the Soukra apicultural equipment manufacturing centre, produces 2000 to 25,000 complete hives each year, secondary exploitation materials and 10 to 12 tons of foundation wax.

Such a production proved to be insufficient in face of the demand, which compelled the commercial directory to the CBO to subcontract the manufacturing of this material. The local market used to provide sufficient quantities of brute wax for the Soukra centre, but, due to the exceptional heat of the summers of 1982 and 1983, respectively, that seriously damaged the crops in traditional hives, the quantities of brute bee wax were so lo. Hence, importation was urgently required. In conclusion, supply to this sector could be executed suitably, only if all the efforts are combined. Beekeepers who possess important hives should be sensitised and motivated to collect the maximum number of natural swarms of good quality, and to recover and treat the wax.

(e) Scientific research

Before the creation of the Sidi Fradj Apicultural Research Centre, work in this domain was non-existent. The objective of the Centre is to lead research of practical nature, offering solutions to many problems, mainly those affecting apiculture in Tunisia. Yet, the beginning of these projects was very difficult. The task was hard to achieve since it involved recruitment of young officers without any knowledge in apiculture, who were later initiated to its relevant problems and trained afterwards in the apicultural research. Thanks to FAO, some of the needed equipment was provided.

The rest was provided by the Tunisian government and even if some difficulties remain unresolved, pathology, biology and chemistry laboratories have been functional. The pathology laboratory of apiculture concentrated its efforts in the following directions:

(a) It has secured the examination of specimens or broods sent or brought by beekeepers, so as to set up the necessary diagnosis and prescribe adequate treatments.
(b) It has organized, in collaboration with the health services of the animal productiondirectory, campaigns of *Varroa* treating. This directory also provides, the chemical used to treat this parasite (pheothazine) for free.

(c) It has carried out essays that aim at looking for other chemicals, able to replace effectively the classical phenothiazine.

(d) Has also focused on been the centre of our researcher in the false ringworm, a classical enemy of bees.

In biology, the equipment is modest, the biometric study of bees in Tunisia has started and will be followed in the future by an electrophoretic study. This research will help us determine the bee population in Tunisia.

Obtaining fertile queens, in periods other than the one extending from April to May, is still a serious handicap in apiculture, Experiments were done in the biology laboratory in order to alleviate it, Generally speaking, the bee biology in Tunisia and the evolution of colonies during the seasons, have been the subject matter of research. Meanwhile, the chemistry laboratory is to be completely furnished to determine the purity degree of brute. The main objectives of this domain has been on the one hand the establishment of Tunisian honey standards and on the other hand, determine levels of pesticides in the apicultural products such as bees and wax.

Tunisian Project Development

After the execution of the FAO-UNDP project for the development of apiculture in Tunisia in 1985, the CBO secured the continuity of these efforts for developing the apicultural sector with its different facets (training, extension, research and supply.

Training

(a) Seminars on apiculture were organized for organisations technicians, agricultural services and CFPA and CFRA teachers. Initial courses in apiculture were given to those interested in the creation of hives. The institutes of agronomy, university education and some primary schools, were interested. Lectures and seminars were illustrated by film projections (mute and sound) and overhead projection films. The realizations are shown in Table 16.8.

Table 16.8. Lectures and Seminars

Year	1987	1988	1989	1990	1991
Nature of training Lectures and seminars:					
• Number of participants	102	56	63	69	79
• Number of days	33	245	10	214	188

The practical training courses were in the CBO centres and by CFPA, extension experts, teachers and people from the private sector (Table16. 9).

Table 16.9: Practical training

Year	1987	1988	1989	1990	1991
Nature of training Training courses:					
• Number of trainees	41	09	12	40	60
• Number of days	2695	1480	923	1500	2500

(b) Extension and assistance

News and apicultural training days were organised for farmers, technicians, veterinarians and teachers (Table 16.10 and 16.11).

Table 16.10: Training for farmers

Year	1987	1988	1989	1990	1991
Nature of training					
• Number of trainees	30	24	38	40	60
• Number of days	1500	700	1000	1000	1000

This action is in particular interest to the beginners in beekeeping. Yet, in most cases, experimencted beekeepers who often face technical difficulties, consult the CBO technicians.

Table 16.11: Training

Year	1987	1988	1989	1990	1991
Nature of training:					
• Number of modern beehives	18922	21692	26241	30000	35000
• Number of "Jebbah" concerned	9184	9558	12977	15000	20000
• Number of beekeepers concerned	2700	3065	2105	3000	3500

(c) Broadcasting on radio and television programmes

From time to time, the television (channel 7) and the national and regional radio channels broadcast some programmes about bee diseases and beekeeping techniques.

Supplying the sector

CBO went on the a limited period, supplying this sector mainly with locally manufactured and imported apicultural equipment. Need of wafer-like wax are rising, but the local production is insufficient to satisfy them, forcing the BPO to importation. This did not last for a long time, because some measures in the framework of restructuring of public enterprises were adopted in 1993 to reorient the economy.

Indeed, in this new orientation, the CBO was free of any commitment. Thus, supplying the sector with apiculture is confided to private promoters who were well-prepared and have learnt through CBO, a valuable experience in line manufacturing. The CBO's role nowadays is restricted to only implementing the development of this sector through extension and technical assistance.

Supervising social projects

New economic tendencies are envisaged by the present policies in the mainstream of developing the agricultural activities for the creation of micro-projects as sources of income for deprived rural families. The CBO in collaboration with regional agricultural services and regional councils have taken charge of this noble task by supervising the projects.

(a) The national solidarity fund 26-26

The national solidarity fund 26-26 is a fund created by the government to intervene in deprived areas of the country, known as "shadow-zone", and this is by the creation of small social projects that are sources of income for rural families. This fund also intervenes in the electricity and water supply for rural areas and the construction of primary and nursery schools.

The fund benefited from citizens living in Tunisia or those residing abroad by means of donations 26-26 projects for apiculture, are assisted and supervised by the CBO all over the country (Table 16.12).

Table 16.12. Projects by CBO

Number of Zones	Number of benefactors supervised	Number of hives concerned	Number of supervision visits
87	1344	13109	348

(b) Projects of the Tunisian Union of Social Solidarity (TUSS) (Table 13)

According to the convention of cooperation established between the TUSS and the CBO (Table 16.13), the relative interventions of supervising of apicultural projects all over the country are to be assumed by the CBO technicians either from the headquarters or regional councils.

Table 16.13: Supervision of TUSS projects by CBO (1998)

Number of Zones	Number of benefactors supervised	Number of hives concerned	Number of supervision visits
12	162	1371	191

(c) The project of rural integration development programme (PRIDP) (Table 16.14)

Apicultural projects started by PIRDP are also technically supervised by experts from CBO

Table 16.14. Supervising of PRIDP projects by CBO (1998)

Number of Zones	Number of benefactors supervised	Number of hives concerned	Number of supervision visits
57	1450	15401	214

(d) The national project for the promotion of family Apiculture (Table 16.15)

Within the 9th plan of the economic development that started in 1996 to expire in 2001, there was the creation of a project called "the national project for the promotion of family apiculture". As its name implies, its main objective is the promotion of family beekeeping, in order to improve the rural family standards and above all provide work for women.

Table 16.15: The contribution of the Tunisian ban of solidarity(TBS) in financing social projects

Number of Zones	Number of benefactors supervised	Number of hives concerned	Number of supervision visits
10	100	1181	24

The tunisian ban of solidarity is a very important new creation, for the financing of micro-projects and consolidation of the already established projects. This financial institution grants credit 10,000 to a maximum dinars with an interest rate lower than 5%. Some apicultural projects which were launched by TUSS and 26-26, have already been financed by the TBS.

Prospects

Apiculture in Tunisia had a noticeable rise, in that honey production and consumption have improved; yet self-sufficiency is still far from being secured. Moreover, other apicultural products (royal jelly, pollen.) are for the moment ignored by Tunisian beekeepers. Development actions must be followed to achieve desirable objectives. Next to the expected national projects, another project named "The regional programme for the distribution of improved apicultural technologies in North Africa", will be beneficial to the apicultural sector in Tunisia.

The project objectives

The importance of apiculture in Tunisia and the potentialities provided for this type of breeding, either at the traditional level or at the level of existing potentialities, will be implemented through several actions to promote this sector and improve its productivity. Indeed the International Fund of Agricultural Development (IFAD), in collaboration with the International Centre of Insect Physiology and Ecology (ICIPE) look forward to starting a three year period régional programme for the transfer of apicultural hi-tech in the four countries of Africa (Tunisia, Algeria, Morocco and Libya)

The objectives of the project are:

(a) Installing of queen breeding stations
(b) Starting research in queens' production by natural and artificial insemination (using local African races)
(c) Improving research infrastructure for diagnosis of the major domestic bee diseases
(d) Establishing a quality control laboratory for the analysis of honey and other hive products.
(e) Conducting demonstration activities for the technical training of beekeepers and improving their institutional capacities.

The implementation of the apicultural hi-tech transfer project will have the following advantages:

(a) The installing of queen breeding stations will constitute a source of income for beekeepers and help the country save money
(b) The creation of quality control laboratory for the analysis of honey, will enhance beekeepers to produce good quality honey for exportation
(c) The creation of the project will contribute to growth of honey production of good quality and the improvement of rural life standards
(d) The wise treatment of bees disease and the health aspect, which are basic objectives, will certainly positively affect the improvement of bee productivity.

Project justification

Tunisia has at its disposal very important honey plant resources; citrus, eucalyptus, thyme, rosemary, fruit trees of different species, etc. It also has a climate, particularly favourable for bee breeding, especially in rainy years. The number of modern hives according to the 9th plan (1996-2001), is estimated to rise from 125,500 in 1996 to 205,350 in 2001. Honey production will rise from 2025 tons in 1996 to 3874 tons in 2001.

It is crucial that we should improve the performance of this sector and give it the place it should hold to face up to the complicated challenge of the Maghrebin apiculture. In resolving the problems of apiculture in this region, ICIPE and IFAD look forward to finding proper methods that will improve the functioning of industry on the level of the transfer of technology, rather than on the level of apicultural pathology.

Implementation

(a) Personnel

To help carry out the objectives delimited by the regional programme of apicultural hi-tech transfer, all the efforts, those of Tunisian technicians and foreign experts, should be combined, to succeed in the actions envisaged. Tunisia can play a preponderant role in the realization of the various aspects of this project.

(b) Materials

To achieve all the objectives underlined by this programme different breeding stations should have the necessary equipment at their disposal. This equipment will mainly be provided by IFAD. The equipment at Mraissa station should be reviewed.

(c) Finance and investment

The necessary investment fees to carry out the actions programmed in the regional programme for the apicultural hi-tech transfer in North Africa, will be financed by IFAD and the nations mentioned (IFAD contribution and national contribution).

The actions are as follows:

Section 1: Queen breeding and selection
Section 2: Honey quality analysis
Section 3: Bee diseases
Section 4: Coordination, data analysis and reports
Section 5: Beekeepers' training and technology transfer

(d) Suggestions

To secure a better future for the Tunisian apiculture, several means and actions must be implemented, among them:

i) Scientific research which remains the foundation for a durable development should essentially focus on:

- The genetic improvement of breeds and this is possible only by selecting the most productive colonies and the best queens to constitute supply of improved breeds.
- The study of bee-plant relations in order to improve the interaction.
- The most productive and adapted honey-plant to the climatic conditions of the country, must be introduced or intensified, particularly in irrigated areas such as the leguminous plants (Lucerne and trefoil). These plants represent an important supply of nectar, given the dependency of apiculture in Tunisia on climatic conditions (precipitation).
- In order to overcome this deficit in the honey plant pollen relations in nearly the whole country, from the end of August to November, we must think and intensify or introduce forest species or arbocultural ones, blossoming during this period, and hence, adapt to our climate.
- Looking forward to finding the most adequate swarming methods of our bees.
- Health control and the struggle against the principal bee diseases.

(ii) Training of officers: training is necessary and useful in any kind of breeding

(iii) Extension: we should intensify and combine efforts to demonstrate the most profitable apicultural techniques all over the country

(iv) Organising the profession: we notice that beekeepers are not organised efficiently in the 9^{th} plan opted for the creation of regional associations of beekeepers and special cooperatives

(v) Preserving forest patrimony by wise exploitation and the creation of paths to facilitate accessibility

(vi) Fiscal encouragement by lowering taxes on imported chemicals

(vii) Promoting the sector of the transforming industry of apicultural product.

17. OPTIMAL APICULTURE TECHNOLOGY FOR RURAL FARMING COMMUNITIES IN NORTHERN ETHIOPIA: RESEARCH PHASE, WITH FARMER PARTICIPATION

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Abstract: Promotion of apiculture as an income-generating activity for farmers in the Tigrai Region is a top-priority of the Tigrai Bureau of Agriculture and Natural Resources (TBoANR). Before implementing large scale introduction of improved apiculture technology, the TBoANR, with technical backup by the Permaculture and Parasitology Institute (PPI), is comparing the long-term income generation potential of several types of bee hives with the aim of singling out the most optimal technology promotion. In July 1999, 24 farmers were each provided with three types of moveable frame box hives, and 12 were also provided with top bar mud hives; all farmers provided one of their own traditional hives for comparison. One of the modern box hives being tested is Langstroth-type polyurethane hive with great potential for Africa. Hands-on training and workshop for beneficiary farmers and other community members will be included in the research programme. Results from the first 5 months of the 2 year project, will be presented, including initial assessment of technologies by both farmers and researchers, and preliminary results of floral and pest/disease survey.

Introduction

Ethiopia has an estimated 7 million bee hives, most of them traditional. The average honey yield from one of these hives is 5 - 8 kg per year, so yearly production can be estimated at 35,000 - 56,000 tons. Honey export is negligible, (about 1 ton in 1997), with most production (80-90%) domestically consumed as honey wine. A small amount of honey (about 6.5 tons per year) is imported for the table and food industry.

The country, however, is the fourth largest exporter of beeswax in the world. Due to the industry, which buys crushed honey combs from farmers, much wax waste is generated, which is bought by middlemen traders and sold to a handful of exporting companies in Addis Ababa. The wax is purified and exported mostly to Japan, the United States, Germany and Italy. Between 1995 and 1998, over 1,800 tonnes were exported, bringing revenue of about US$5.4 million. The rural beekeepers, who give wax as they sell their honey to the industry, benefit little from this trade.

Modern beekeeping was introduced to Ethiopia in the 1960s at what is currently the Holeta Bee Research and Training Centre (HBRTC), the only apicultural research facility in the country. Numerous attempts have been made to bring modern apiculture technology to the rural communities, with mixed success. The constraints also include lack of training and back-up capacity, costly and scarce equipment, lack of credit systems for farmers, poor product quality, and lack of marketing strategies to allow maximum benefit for smallholder rural beekeepers.

Improved beekeeping has recently been incorporated as a strategic component for poverty alleviation in some regions of the country, including the northern Tigrai Region. A model programme for technology testing and adaptation, training for bee hive management and associated industries and marketing, has been developed for Tigrai in 1999 and is already under way. A collaborative effort was set up between the Tigrai Bureau of Agriculture and Natural Resources (TBoANR), which is the implementing agency and the Permaculture and Parasitoloty Institute (PPI) (an international non-governmental organisation, which provides the technical back-up with other collaborators). Funding is provided by the Ethiopian Social Rehabilitation and Development Fund (ESRDF), a governmental agency that channels aid funds from international donors.

The overall programme is composed of separately-funded projects, of which the first is under way in Tigrai. The following is a list of the projects and their objectives:

Project 1: Production-Oriented Strategic Research and Adaptation:

(a) To design an optimal bee hive that can be locally produced
(b) To test and refine the technology in the rural community with farmer participation
(c) To improve the quality and yield of bee hive products

Project II: Training and Capacity Building:

(a) To facilitate adaptation and transfer of improved apicultural technolo gies to the farming communities at the local level
(b) To develop sustainable apiculture extension package

Project III: Training for Establishment of Local Industries:

(a) To train groups in the production of locally-made adapted bee hives, beekeeping accessories, and value-added products
(b) Provide local capacity to process and package bee hive products

Project IV: Market Research:

(a) To determine the extent of domestic and foreign demand for Ethiopian bee hive products
(b) To establish marketing strategies for rural communities

Project V: Background and planned activities:

Like other regional agriculture bureaux in Ethiopia, the TBoANR has implemented an admirable extension system that reaches rural communities through a hierachy of regional Bureau staff that culminates in the Development Agents (DAs), who live within the communities and assist them with all aspects of agriculture, including beekeeping.

Two years ago, the TBoANR began introducing modern hives (Zander) to farmers on a 3-year credit basis (now being shortened to 2 years). A few centrifugal honey extractors, wax-casting moulds and accessories, have also been made available in district and community agriculture offices. Protective clothing was provided to extension agents or farmers, hindering the introduction process. The TBoNAR plans to greatly increase promotion of modern beekeeping to rural farmers in the future.

Before embarking on a large-scale modern hive distribution programme, however, the TBoNAR planned to test several technologies to choose the best one to promote. Together with PPI, it is testing and comparing the performance and adptability of the standard wooden Langstroth hive, a polyurethen hive modelled after the Langstroth, a wooden Dadant hive with a shallow super, and intermediate nul hive modelled after the top bar hive. All are being compared with the locally-used form of traditional hive. Testing is done with

farmer participation in home compounds or private bee yards, to provide maximum exposure to all technologies and to facilitate information feed-back to researchers.

In addition, information on floral resources, pests and diseases, yearly colony cycles, bee races and behaviour, etc, are being gathered to provide background information necessary for good bee management in the research areas, while the techniques will act as models for information-gathering in other parts of the region.

Planned Research Activities

(a) Hive comparison using cost/benefit analyses, acceptability and sustainability
(b) Hive adaptation to local conditions and development of low-cost, appropriate technologies
(c) Demonstration and training
(d) Floral calendar development for nectar and pollen sources
(e) Bee race identification and correlation with behaviour
(f) Description of seasonal cycles of swarming and migration
(g) Disease and pest surveys and treatments
(h) Studies of the income potential for bee hive products other than honey, wax, propolis, pollen, royal jelly, queens
(i) Studies of potential crops for honey and pollination of crops
(j) Queen rearing
(k) Processing and packaging of honey and wax

One of each high-altitude and mid-altitude sites were chosen by the TBoNAR for apicultural research (Table17.1). Within each site, 2 sub-locations (representing separate communities), about 15 km apart, were chosen. In each sub-location, 6 farmers were picked by the TBoNAR with community recommendation to assist with research in their own bee yards. A total of 24 farmers among the 4 sub-locations were involved. These farmers who are receiving equipment and training, are hereafter called "beneficiaries".

A split-plot design is being used to compare the efficacy of the five types of hives. Hive construction and assembly: Polyurethane hives were built in Addis Ababa by the International Centre of Insect Physiology and Ecology (ICIPE), using an imported mould and materials. Wood for box hives was cut in Addis Ababa and the hives were assembled at the Rural Technology Promotion Centre

Table 17.1. Experimental split-plot design of hive deployment in the Tigrai Apiculture Research Project

Altitude	Wereda	Tabia (location)	No. of beeyards (farmers)	Hives at each beeyard	Total hives per t'abia
High: (ca. 2,200 to 2,600 m)	Atsibiwomberta	Hayelom	6	Polyurethane 1	6
				Langstroth 1	6
				Dadant 1	6
				Mud 1	6
				Traditional 1	6
					30
		Barka/ Adisebeha	6	Polyurethane 1	6
				Langstroth 1	6
				Dadant 1	6
				Mud 1	6
				Traditional 1	6
					30

Table 17.1. Contd.

Altitude	Wereda	Tabia (location)	No. of beeyards (farmers)	Hives at each beeyard	Total hives per t'abia
Middle (ca. 1,800 to 2,000 m)	Ahfarom	Mai Suru	6	Polyurethane 1	6
				Langstroth 1	6
				Dadant 1	6
				Mud 1*	6
				Traditional 1	6
					24
		Adi Zata	6	Polyurethane 1	6
				Langstroth 1	6
				Dadant 1	6
				Mud 1*	6
				Traditional 1	6
					24
Total	**2**	**4**	**24**	**5**	**108**

* Mud hives were not completed in time for year 1, but will be deployed in year 2.

in Mekele. Intermediate mud hives were made by three trained farmers in Hayelon and assembled at the bee yards of 12 beneficiaries in Atsibiwomberta Wereda. In Ahfarom, only one trained mud hive builder was identified at the start of the project (another has recently been found), who failed to complete the hives in time; these hives will therefore be deployed for the next honey flow season in 2000.

Equipment and accessories were provided to beneficiaries and DAs. Each beneficiary received a polyurethane box hive, a wooden Langstroth box hive, a wooden Dadant box hive, 25 wooden top bars for the intermediate mud hive, two poles for hive stands, a veil, beekeeping suit, bee brush, gloves, boots, a smoker and water sprayer. During harvest, farmers also receive clean plastic buckets with lids. DAs were equipped with protective clothing.

Colony acquisition: Committees were formed at each Wereda to locate and buy strong bee colonies of local origin. The committees consisted of members of the TBoANR, chairman and economic advisor, beneficiaries and PPI. Funds were tranferred from PPI to the local TBoANR offices and disbursed through them. The colonies were bought and transported during the last 2 weeks of July. Each beneficiary provided his or her own active traditional hive for comparative purposes. Colonies that absconded were replaced in most cases. Most colonies were bought at bee markets.

Colony transfers: Colonies were transferred from traditional to modern box hives between 26 July and 6 August and to intermediate mud hives, between 23 August and 3 September.

Hive Comparison and Management

The hives:

(1) The polyurethane box (PU) hive was developed by Dr. Kalus Wallner of the University of Hohenheim, Germany, and is being tested for the first time in Africa; it is modelled after the Langstroth hive. Its advantages include durability (the first models are 20 years old and still in excellent condition), low weight, good insulating properties, no termite or fungal rot attacks and no dependency on wood which is scarce and expensive in Ethiopia, due to massive deforestration.

(2) The Langstroth box (LA) hive is made of wood and is the most widely used box hive in the world; the one used in this research had fixed rather than a removable bottom and is therefore, modified Langstroth hive.

(3) The Dadant box (DA) hive is also made of wood; the model being tested has a shallow super and removeable bottom

(4) The mud (MU) hive is intermediate between the traditional and modern hives in that it uses movable frames (wooden top bars), but no wax foundations, so that the bees must build their own combs. It is made of locally available termite mound clay, mixed with straw.

(5) The traditional (TR) hives used in the research areas are horizontal cylinders, mostly made from dung, with some mud and straw . A few are made of hollow logs or bark. The hives for sale in Atsibiwomberta are large enough to be used also for honey production,while the hives sold in Ahfarom are about half as large and used strictly for sale. After they are bought, the Ahfarom hives are attached to larger dung cylinders to provide room for honey storage by bees.

The dimensions of the hives under test are provided in Table 17.2. Relative cost of materials and labour for building each type of hive, and relative management effort, will be provided when more information is available.

Hive management

Monitoring of modern hives began 1 to 2 weeks after colony transfer and continued on a bi-weekly basis. Initially, management consisted of checking for absconding, pollen foraging, pests and diseases and counting of the number of frames in the box hives that were covered by bees (i.e. active frames with brood). As the colonies grew and became more aggressive, monitoring was limited to external observation of activity, because opening the hives was too disruptive to the lives of the farmers and their neighbours. As harvesting season neared, hives were opened after dark by PPI staff at the request of the farmers, to check if they were ready for harvest. The mud (MU) hives were monitored on a monthly basis and included checks for absconding, pollen foraging, pests and diseases and number of combs. Traditional (TR) hives were monitored for absconding and pollen foraging, but management was left to the farmers.

Table 17.2. Dimension of the experimental bee hives and their maximum potential comb surface area

	Internal hive dimension (m)			Frame dimensions (m)			Maximum, comb surface area (sq m)		
Hive type	Length	Width	Height	Volume (cu m)	No. of frames per chamber	Centre to centre distance	Length (internal)	Width (internal)	Box	Whole hive
Polyurethane	0.44	0.38	0.24	0.038	10	0.034-0.037	0.40	0.20	1.60	3.20
Langstroth	0.47	0.38	0.25	0.044	9	0.038-0.042	0.42	0.19	1.40	2.80
Dadant-brood box	0.49	0.37	0.24	0.042	10	0.034-0.038	0.43	0.20	1.70+	-
Dadant - super	"	"	0.16	0.027	10	"	0.43	0.12	0.98=	2.68
Mud	0.67	37-17	0.24	0.048	21-23	0.032-0.034	0.15-0.36	0.23	2.68-2.80	2.68 -2.80
Traditional dung cylinders	Length (mean)	Diam. (mean)	-	(Mean)	-	-	-	Radius	-	-
Atsibiwomberta	0.67	0.26	-	0.036	Ca. 19 combs	Theoretical 0.032	-	0.15	1.34	1.34
Ahfarom*	0.38	0.24	-	0.017	Ca. 10 combs	Theoretical 0.032	-	0.14	1.34	0.62

* Traditional Ahfarom hive data refer only to small hives used for colony sales.

Progress and Results

Some absconding occurred after colony transfer (Table 17.3), but the overall percentage was low (8% of modern and MU hives).

Table 17.3: Absconding rates of transferred colonies

Hive types*	Location (Wereda)	No. hives transferred	No. absconded (%)	Possible cause
PU	Atsibiwomberta	12	1 (8%)	Queen absent or not
PU	Ahfarom	12	0	
LA	Atsibiwomberta	12	1 (8%)	Weak colony without brood
LA	Ahfarom	12	0	
DA	Atsibiwomberta	12	1 (8%)	Paint not dry
DA	Ahfarom	12	2 (17%)	Paint not dry
MU	Atsibiwomberta	12	2 (17%)	New swarm without brood; virgin queen with clipped wings
MU	Ahfarom	0		
TR	Atsibiwomberta	12	0	
TR	Ahfarom	12	0	

- PU = Polyurethane box; LA = Langstroth; DA = Dadant; MU = Mud (intermediate); TR= Traditional.

One DA hive in Atsibiwomberta suffered heavy mortality of workers during the first week after transfer, possibly due to a toxic effect from the paint, which was still not completely dry.

The data comparison of colony progress in brood boxes of modern hives have not been analysed, but colony growth appeared to be slower in the DA hives than in the PU and LA. However, the DA hives were inadvertently painted with a slow-drying paint that was still sticky during colony transfer, which probably contributed to their poorer perfomance. At this date, three of these hives remained too weak to super, while all other modern hives had already superred. Also, colony growth appeared to be slower in Ahfarom than in Atsibiwomberta during the first month after transfer, after which it caught up. Ahfarom hives are filling with honey at a lower rate than Atsibiwomberta hives and will therefore, be harvested later.

The TR hives cannot be easily monitored, but their management system was compared with the other hives and systems. They are therefore left undisturbed in accordance with traditional management until the farmer harvests them. On the other hand, MU hives were stocked with a variable number of brood combs when colonies were transferred into them. In early November, the number of combs in each hive ranged from 6 to 20 (mean + sd = 11.8 + 4.7, n = 8), showing a high degree of variability in progress.

Supers and queen excluders were added to modern hives when most or all of the brood box frames were covered by bees. In many cases, these activities were carried out by the farmers according to PPI demonstration and instructions. To date, all active modern hives are superred, except 2 DA hives in Atsibiwombeta and 1 DA hive in Ahfarom. Some hives in Atsibiwomberta were harvested early in October, to provide some preliminary information on yield comparison among the hive types (Table 17.4). The main harvest in all the sites will occur in November and December.

Table 17.4. Early honey yields from experimental hives in Atsibiwomberta in early October*.

Hive type**	Number harvested	Honey yield (kg) Range	Mean	Total yield (kg)
PU	6	5.0 - 15.0	10.0	60.0
LA	5	5.0 - 12.0	7.8	39.0
DA	5	5.0 - 12.0	8.9	44.5
MU	0	0	0	0
TR	3	5.5 - 8.0	7.1	28.5

* The major honey harvest is expected to begin in late November.

** PU = polyurethane; LA = Langstroth; DA = Dadant; MU = Mud; TR = traditional.

The early harvest data are insufficient for any comparison, but there is an indication that the modern hives will produce higher yields than the traditional hives.

An estimate of total production from the active experimental hives in year 1 is made, based on the productivity of the early harvest (Table 17.4). If the MU hives provide a conservative estimate of 8 kg of honey, total production from all active experimental hives (including modern, mud and traditional) in 1999, will be about 1.07 tonnes, with a mean of about 48 kg per beneficiary in Atsibiwomberta and 41 kg in Ahfarom. The yield is expected to increase drastically in year 2 after the colonies gain strength and the initial problems are overcome.

Appropriate technology testing

Smooth wax foundation

The standard foundations require the use of an imported wax-casting mold, costing US$875. Alternatives are therefore being tested.

A low-cost, low technology smooth wax foundation made with a wooden mold that any farmer can make, has shown mixed results. During colony transfer, about 3-5 brood combs were transferred from the traditional hives to frames in the modern hives. Half of the remaining frames in the brood box were supplied with smooth and half with standard embossed wax foundations, in alternating sequence. The first 10 smooth frames examined (in 4 hives), all had been rejected by the bees, with built combs, off the wooden top of the frames, completely bypassing the foundation. A few smooth frames were later found with normal comb development, and interestingly, a few embossed foundations were also rejected. Consultation with the HBRTC, which is rigorously testing the smooth wax foundation, has provided hope for its ultimate success. The supers were provided with embossed foundations only because of the poor initial result of the smooth foundation.

Queen excluder

Ethiopia does not produce queen excluders, and imported ones are sold for about US$12 each. A search for low cost, domestically produced materials that could act as queen excluder was made. An industrial wire mesh (ca US$ 1.40 per excluder), was found in Addis Ababa and appeared to be effective in trial tests there. A similar mesh has been found in the Mekele market, and

preliminary tests with 8 queen bees in the research sites showed promising results. Queens were held in the palm of a hand and tried in vain to pass through the mesh held over the hand, while workers passed with ease. Based on these preliminary results, queen excluders were cut from the wire mesh for all box hives. Recent examination of some of the hives, however, showed a high degree (26%) of failure of this excluder so far (Fig 17.1), and further examination may reveal an even higher failure rate. The failure can be attributed to the non-uniformity of the mesh, which is therefore difficult to cut straight, in addition to having some larger openings. The construction of the PU hive makes it expecially vulnerable, because the edges of the excluder are exposed to the bees and must therefore fit perfectly.

Modification of the wire mesh, including aluminium sheeting around the edges and more careful choice as to the uniformity of sections, will be tested. However, other venues will be pursued more rigorously. Some inquiries have already been made with Ethiopia plastics and fibreglass companies that have promise for future production of relatively low cost, effective, domestically fabricated queen excluders.

Floral calendar

A list of flora used as honeybee forage within 2 km of the bee year is presented (Table 17.5). Species are determined to be useful to bees through observation, but ultimately the list will be refined to include pollen and/or nectar species. The list is not complete and several species have yet to be identified to species level and flowering phenology will be supplied later.

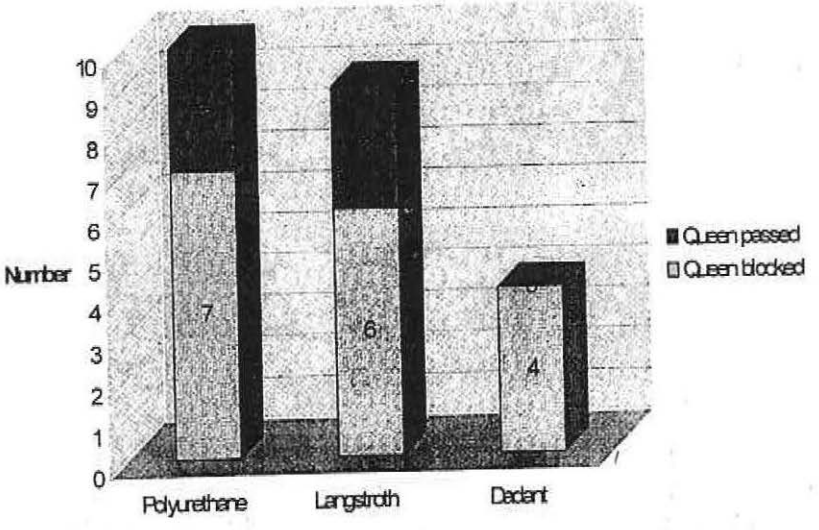

Fig 17.1. Efficiency of the experimental queen excluder among examined hives (n=23)

Table 17.5. Flowers used as honeybee forage in Atsibiwomberta and Ahfarom (July-October)

Species	Atsibiwomberta	Ahfarom
Wild species and planted perennials:		
Agave americana	x	
Becium filamentosum	x	x
Opuntia ficus-indica	x	
Rumex nervosus	x	x
Argemone mexicana	x	x
Acacia lahai		x
Asaligna	x	x
Trifolium rueppellianum	?	x
Brassica spp.	x	x
Eucalyptus globulus	x	x
Bidens spp. *complex*	x	x
"Grbia" (Labiatae)	x	x
Seasonal crops:		
Linum sp.	x	x
Lens sp.	x	x
Pisum sp.	x	x
Vicia faba	x	x
Seasonal planted bee forage:		
Helianthus annuus	x	x
Vicia? Cracca	x	x

Plant collection and identification

Several common bee forage species and others with similar habits, have been collected and pressed beginning in August for a reference collection. Identification is made by use of keys provided in *The Flora of Ethiopia.* Since *The Flora of Ethiopia* is still incomplete, species not yet treated in the keys will be identified by the National Herbarium, Addis Ababa University. A photographic (slide) record is also being made of bee forage species.

Disease and pest survey

Diseases

Some adult bee mortality was reported in late October and early November from modern hives by 5 beneficiaries in Atsibiwomberta. Living and/or freshly dead bees have been collected from these hives and preserved in 70% ethanol for analysis by the regional Veterinary Laboratory of the TBoANR. There is no indication of significant die-off in these diseased hives.

Pests

Potential pests have been collected from hives and preserved. These include:

(a) Nitidulid beetles possibly *Aeethena tumida,* a predator of bee larvae
(b) Tachinid flies, possibly *Rondanioestrus apivorus,* a parasitoid
(c) Pseudoscorpions, possibly *Ellingenius fulleri,* a predator which may actually be beneficial by preying on bee pests
(d) Ant species

In addition, mites have been occassionally observed on adult workers, but not yet collected. Death's head hawk moths, which take nectar from the combs, have been captured by farmers in Atsibiwomberta, but the specimens were too poor to preserve. None of these potential pests have appeared in large enough numbers to be of concern.

Bee race identification

Preliminary work on bee races have been limited to observations of queen and colony colour at the time of colony transfer. Colonies usually consisted of both red individuals and black individuals, although the red individuals varied in the extent of reddish colour. The colonies were described as mostly red or black. In the high altitude site, Atsibiwomberta (AT), colonies with predominantly red individuals (56%), were somewhat more numerous than colonies with predominantly black individuals (44%), whereas in the mid-altitude site, Ahfarom (AH), most colonies were predominantly black (84%) (Fig. 17.2). The site difference is highly significant (Chi-square, corrected [1 degree freedom] = 14.55, $p<0.001$). This finding is contrary to descriptions of known honeybee races in East Africa, where the high altitude race is said to tbe *Apis mellifera monticola,* which is described as large and black, whereas the lower-altitude race *A.m. scutellata,* is smaller and redder. There is a strong

possibility that the Tigrai bees in the research sites are of the smaller *scutellata* race, but that the Ahfarom populations represent an extreme in colour form.

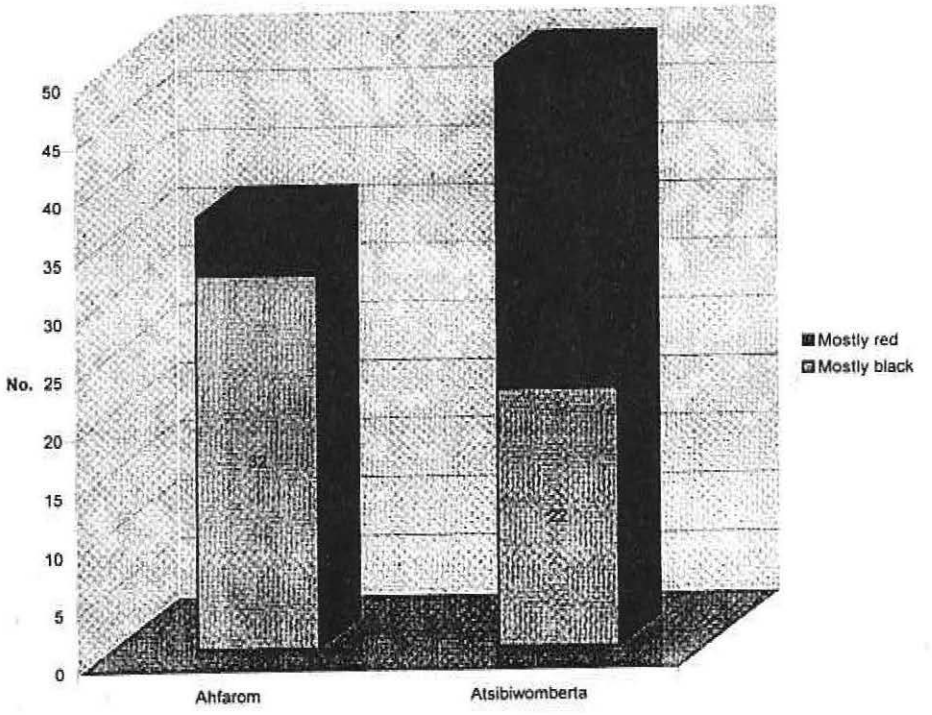

Fig. 17.2. Distribution of colony colour at Atsibiwomberta and Ahfarom

Queens were usually all red or black, although one was mixed in colour. Red queens predominated in Atsibiwomberta (61%) and black queens predominated in Ahfarom (65%).

As expected, there was a strong relationship between the colour of the queen and her colony. Colonies with predominantly black individuals usually had black queens, while predominantly red colonies usually had red queens (Fig. 17.3.). The relationship is highly significant (chi-square, corrected [1 degree freedom] = 15.86, $p<0.001$).

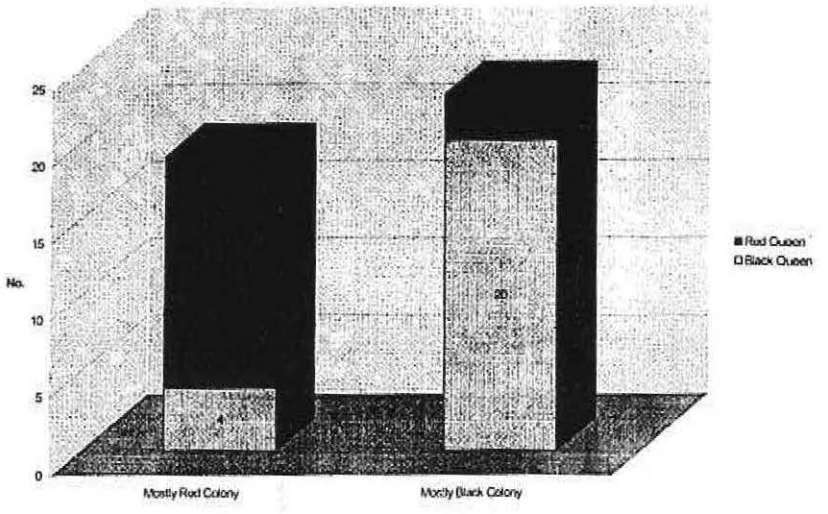

Fig. 17.3: Relationship between queen and colony colour.

Demonstration and training

Demonstration: The beneficiaries were encouraged to attend demonstrations during colony transfer, hive monitoring, superring and harvesting. Most have attended all of these activities and many have also assisted PPI staff at the homes of other beneficiaries. Most of the beneficiaries and/or their wives and children have been trained in the application of wax foundations onto frames and in superring hives, including the placement of queen excluders. All will be trained in honey extraction using a centrifugal extractor.

Training: A 2-day orientation course outlining the research project, modern bee management, bee biology, hive product extraction and use, and bee flora, was provided by PPI at each of the 4 sub-locations for the 6 resident beneficiaries and up to 10 of their neighbours. A total of 60 farmers attended.

TBoANR staff: Due to time constraints and late acquisition of protective clothing, most TBoANR staff have not been able to attend many PPI field activities so far, with the exception of a very active DA in Ahforam. However, protective clothing has now been supplied and detailed plans of PPI activity, are being forwarded to the wereda and t'abia offices through the regional TBoANR office, to encourage participation by local staff. Five DAs particiapted in the 2-day farmers' training course. In addition, 2 bee-yard guards for a TBoANR replication and demonstration site and 1 zonal staff member from Mekele, participated in 1-day training course provided by PPI.

TBoANR replication and demonstration site: The TBoANR and PPI chose a nursery site at Elala (north Mekele), as their site for replication of the field work and for demonstration of modern and intermediate beekeeping techniques. The TBoANR built shelters and provided colonies and a Zander hive, while PPI provided the Pu, LLa and DA hives, and performed the colony transfers. The TBoANR will monitor the replication hives. In addition, PPI is testing two fibreglass hives on the site.

Socio-economic and apiculture questionnaires: Two questionnaires were created by PPI and the TBoANR, one for rural beekeeping and the other for rural families that do not keep bees. These will be further information on apicultural practices, activities and perceptions and on the socio-economic status of a cross-section of the communities. The questionnaires were translated into tigrigna by the TBoANR and will be administered by its staff (supervisors) in January 2000 and again at the the end of the research project. Sixty-four families, equally divided among the communities at each of the 4 sub-locations, will be questioned. Half will be beekeepers and half non-beekeepers.

Conclusion

(a) A total of 108 experimental hives of 5 types have been deployed.
(b) The hive comparison has not progressed far enough to draw conclusions, but absconding rates appear to be equal among all hive types so far, and honey yields appear to be higher in modern box hives than in the traditional hives.
(c) Low-cost alternatives for expensive queen excluders, require more research; a low cost industrial mesh made in Ethiopia, is suitable for use as a queen excluder.
(d) A low cost method for production of smooth wax foundations by farmers, showed mixed results and will be tested further.
(e) So far, 18 species or genera of important bee resource plants have been identified in the research sites.
(f) No significant pests and diseases have been recognized so far.
(g) Queen and colony colour differ significantly between the high and middle altitude sites: the higher altitude colonies contain more red bees, while the middle altitude colonies contain more black bees.
(h) Demonstration and training has been extended to the 24 beneficiaries and to an additional 36 community members and 8 Agriculture Bureau staff.

18. AN APPROACH TO BEEKEEPING IN THE NEW MILLENNIUM — A VIEW FROM INTERNATIONAL BEE RESEARCH ASSOCIATION (IBRA)

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Abstract: Beekeepers need to think beyond their experiences in order to create successful strategies for the development of their craft in the next millennium. Some examples of development in the past show how experience can be applied to the future. It also tries to foresee some of the challenges that lie ahead and looks at how we need to prepare to meet them

Throughout, it stresses the need to share knowledge in order to promote understanding. Communities and those directly involved with the bees need to be well-informed. Access to information is vital, but it is esential that the information available is of the highest quality and proven scientific value.

Well informed beekeepers can become the educators in their communities by setting an example of how management skills and applied learning can bring better results and increased income

Background

It is sometimes said that beekeeping in Africa is at its infancy. Yet, the history of honey hunting and traditional beekeeping in Africa is probably as old as anywhere in the world. Therefore, it is necessary to ask why progress has differed in this continent which has not seen or was late to discover the developments found in other parts of the world. To do this, it may be easier to turn the question around and see how the main stream of beekeeping has developed and to ask whether that type of development is the right one to apply to the African model.

Keeping bees in log hives is still common practice in Kenya and has always been the traditional method of beekeeping. This applied wherever man had bees. The log hives in Europe tended to be vertical, whereas in Africa they are horizontal, but the practice was much the same. The next step was to replicate those hives by creating a home for the bees, still with fixed combs, in a wattle cylinder, clay pot, straw skep or wooden box. This was roughly the point that European/North American beekeeping had reached in the middle of the last century.

The year 1851, marks the beginning of modern beekeeping. In that year, Rev. Lorenzo Lorraine Langstroth bought 2 colonies of bees in box hives. Undoubtedly, Langstroth was an intuitive beekeeper, but he did not rely on just his own wits and resources. From the start, he read the works of others for he had obtained various books on apiculture, in particular Huber's *Letters* and Edward Bevan's *The Honey Bee* (1838). It was after reading these that he modified his hive to create the bee space and the moveable frames. This type of resourcefulness can be summed up in an equation: Progress = Intuition + Practical Experience + Information (Accumulated Knowledge)

Langstroth's discovery was a big step forward, but true progress requires something else — the sharing of knowledge. Langstroth published his theories and reported on the practical outcome. The result was that other beekeepers took up his ideas and developed some of their own. By 1861 moveable frame hives were common in the USA and by 1862 they had been introduced in England and within a decade were common all round Europe. Other ideas, each to some extent dependent on what had gone before, came thick and fast:

(a) 1857 Johannes Mehring in Germany produced a machine for making wax foundation.
(b) 1865 Huruschka in Austria came up with the centrifugal extractor.
(c) 1865 Collin in France developed the queen excluder and others in other places were coming up with similar ideas. The smoker, the bee escape, all own their origins to this golden age of invention. It was also a golden age for the printed word and saw a proliferation of bee journals. Many nations trace the first issues of their journals back to this period. It was a time of initiative, design and communication.

As Samuel Johnson wrote in the 18th Century: Knowledge is of two kinds. We know a subject ourselves or we know where we can find information upon it. (Johnson, 1775). This is all history. What is it to do with Africa and the new millennium? Take this quotation: "The chief cause of the depressed state of

bee culture in general is not to be traced to any want of attention to the subject. It is to be found rather in inadequate knowledge..." ABJ January 1861, Vol.1 No. 1.

Africa today? Actually it was written 138 years ago, but there are many who would agree with the sentiments expressed.

Future of Beekeeping

Daily beekeepers are developing ideas and coming to grips with problems that have a major effect on their livelihoods or their supplementary source of income. There are too, those who spurn the accumulated knowledge of the years and ignore the discoveries of others. These people, sadly just perpetuate bad habits or work slavishly to reinvent the wheel.

The good and forward thinking beekeeper, will always be prepared. This requires access to information which is not based on hearsay or anecdote, but is accurate and scientifically proven. Above all, it must be presented in a way that makes sense to the practitioner.

Is there such a crystal clear source where one can drink of such pure knowledge?

Libraries, books, journals, the internet, associations, meetings, radios, video shows, exhibitions and demonstrations, all give refreshment to those who thirst after knowledge. IBRA too is an important source. It has, for over 50 years collected, collated, added value and disseminated information by a variety of methods — journals, books, conferences and increasingly by the internet. So we gather the experiences of others gleaned over the years in the laboratory, the apiary or both wipe the slate clean and start afresh? No! That is the most certain way of throwing the baby out with the bath water.

The start must come from the traditional methods — it must use practical experience and local knowledge, which are then enhanced by education and information. It starts by making many more people aware of the importance of bees. Then instead of killing the bees with fire and smoke, a small amount of cool smoke is used to subdue the bees, the brood nest is left intact and some food is left. This means that, providing there is some forage and water, the bees are less likely to abscond and beekeeping has begun.

The next stage is to choose the most suitable and, just as important, the most affordable type of hives, and to consider appropriate sites for their location.

This means looking at top bar hives of wood, brick hives, Langstroth type hives and so on. However, superimposing a system developed in another part of the world is not necessarily the best way forward. Superimposing a system and expecting people to operate it when they do not fully understand what is involved, is a sure path to failure. The purpose of beekeeping here is to tame or at least control the African bee and to increase its revenue earning capacity. That can only be done if the technology is appropriate to both the bee and the beekeeper.

There is a lot to learn, but there is much information available that enables short cuts to be taken along the route of progress. A top bar hive will hopefully create a home for bees, where they will be more inclined to produce more honey than they do in a log hive. Similarly, a Langstroth will be more conducive to the production of honey than a top bar hive, but each hive costs more than the previous one. So, the cost has to be offset against the sale of production, in order to calculate one that gives the most profit. Then the top bar offers more opportunity for beeswax collection and beeswax may be easier to market, have a higher demand and fetch a higher price than honey.

Thus, we see that beekeeping is market driven and success in the new millennium will come to those who think beyond their own experiences, who try to understand the market and the conditions it imposes on them, their production, quality control and marketing methods. We are looking at a global market which is driven by what the consumer demands. What are those demands you ask or at least you should be asking? The consumer will demand a pure product, consistently of the highest quality and a reliable and steady supply.

We are going into an age which will see even more ways of testing the purity and quality of a product. Thus, ensuring that the consumer gets what she or he wants. Those producers that fail to reach these high standards will not find a market for their product.

There will also be increasing demand for bees to pollinate the crops needed to feed an ever increasing population. This will require more mobility in beekeeping with the need to move the hives to different crops at different times. Moving bees spreads disease and so beekeepers will have to combat epidemics of bee diseases, probably already present, but only in isolated pockets, due to the more static nature of traditional beekeeping at present. Hence, be prepared for the rampant spread of problems at present unknown in your part of the world. A prime example of this is varroa which is new to Africa, but is spreading with extraordinary speed.

In addition, there are probably further unknown afflictions waiting to take the stage. Ways to treat these afflictions will be developed — science will find answers. However, some of those answers may in themselves cause problems by affecting or endangering the purity of the products of the hive. Let us not be blinkered by the possibilities offered by bees and bee products. Cow's milk can be made into snooker balls, so who knows what uses honey, beeswax or bee venom could be put to. It would only take one medical or scientific breakthrough with one of these products to vastly affect the demand, then the whole market changes and ultimately the methods by which the bees are managed could be affected, so as to concentrate on the production of that particular hive product.

IBRA cannot foretell the future, but it will continue to preserve data and make that information available. Sharing knowledge and increasing understanding must be the way ahead into the new millennium.

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19. IDENTIFICATION OF MAJOR POLLEN SOURCE HONEY PLANTS IN THE CENTRAL HIGHLANDS OF ETHIOPIA: CASE STUDY AROUND HOLETA BEE RESEARCH CENTRE

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Abstract: To determine the major pollen source of the study area, pollen traps having 16.5% pollen trapping efficiency, were fitted on the entrance of two colonies in Langstroth hives for 2 years. Pollen pellets were trapped and collected from honeybees and sorted by colour after being dried and examined under the microscope, to identify the origin of pollen source plants. As a result, 29 honey plant species and 7 botanical unidentified honey plants were identified as source of pollen of the study area. *Guzoita* spp., *Brassica napus*, *Bidens* spp.and *Plantago lanceolatum*, are the major pollen sources of spring (September-November) and provided pollen for honeybees for 41, 69, 53 and 64 days, respectively. *Vernonia* spp., *Plantago lanceolatum* and *Heliminthothea echioides* are the chief pollen source of the period December-February and supplied pollen for honeybees for 40, 75, and 42 days. *Plantago lanceolatum*, *Pinus* spp. and *Eucalyptus* spp. are the leading pollen source in both autumn (March-May) and winter (June-August). Moreover, *Plantago lanceolatum* contributed about 27% of the mean annual pollen, collected by honeybees for about 280 days in a year. Ample pollen was collected during spring and autumn compared to the remaining seasons.

Introduction

The production of honey, bees wax and other hive products depends on honey plants from which honeybees obtain nectar and pollen as their main food. These food sources provide all their nutritional requirements. Nectar provides heat and energy for honeybees and is used for making honey.

Pollen provides protein, vitamins, minerals, fatty substance and other nutrients, needed by larvae and nurse bees that feed larvae. Fresh pollen is 100% effective in stimulating the development of the hypopharyngeal glands that produce royal jelly in worker bees (Haydak 1961). Without pollen or an adequate substitute, colonies do not rear broods that replace the old bees (Haydak 1973a). The older bees can rear brood without consuming pollen, but they do this at the expense of their body. However, the amount of brood produced is rather small (Haydak 1973b). A single colony requires about 30 kg pollen each year. The rearing of a single bee from a period of hatching until emerging, requires 3.21 mg of nitrogen, which would amount to an average of 145 mg of pollen (Alfonus, 1933). The normal development and growth of colonies is hampered by an insufficient pollen supply (Maurizio, 1960; Lovell, 1963). To correct this condition, beekeepers should feed their colonies with either a pollen supplement or substitute. Hence, the presence of honey plants that provide pollen is very important for the existence, colony strength, production and productivity of the honeybee colony. Therefore, identification of pollen source honey plants at each season of the year is of paramount importance for beekeepers to strengthen their colonies and effectively use the resource.

Attempt has been made to identify honey plant species growing around Holeta for the last 4 years. Accordingly, about 136 plant species have been identified as honey plants (Amssalu 1997). However the potential of these honey plants as source of pollen was not exhaustively determined. Therefore, in this study an attempt was made to determine pollen source honey plants at each season of the year.

Objective

The major objective of this study is to:

(a) identify major pollen source honey plant species at each season of the year
(b) determine the length of days these plant species provide pollen for honeybees
(c) create awareness to grow, protect and conserve pollen rich plant species

Materials and Method

Two medium-sized honeybee colonies in Langstroth hives were placed at a distance 1.5 km apart in the compound of Holeta Bee Research Centre. Pollen traps having 16.5% pollen trapping efficiency, were fitted on the entrance of

each colony for trapping pollen loads for 2 years (24 Oct 1992-23 Oct 1994). The trapped pollen pellets were collected two times daily (at 1200 hours and 1800 hours) throughout the study period and allowed to dry overnight at room temperature. These collected pollen pellets were sorted by colour and the fractions weighed and recorded. Samples of pollen grains were taken from the representative pellets of each colour, washed in ether and mounted in glycerin jelly on a microscope slide, to identify pollen source honey plant species under the microscope. Some pellets were also mounted fresh to verify the homogeneity of colour fraction. To verify the identification, pollen samples were collected from flowers of honey plant species found in the study area. Pollen that could not be botanically identified were categorized as "unidentified".

Results and Discussion

The area is located on the western part of the Ethiopian Rift Valley system, particularly in the Awash River basin at 30' N Latitude and 38^0 30' E Longitude, 45 km West of Addis Ababa on the way to Wellega . It consists of a section of central highlands having a slopping topography with slight variations in elevation, comprising of some scattered hills and mountains between altitudes ranging from 2250-2500 m above sea level. The area has three types of soils, Mellisols (reddish heavy clay), Vertisols (dark to very dark grey to greyish brown heavy clays) and Nitosols (reddish brown siltty clay). The vegetation around Holeta is charaterised by bushland, numerous herbaceous flora, scattered trees and cultivated eucalyptus that deserve special attention. Moreover, cultivated oil crops, horticultural crops and others are also common to the area.

Land utilisation of Wolmera Wereda includes settlement, grazing land, cultivated land and forest wasteland, at the rate of 124, 9614, 23152, 7040 and 1090 ha., respectively (WAO, 1985). The annual mean temperature of the area is 14^0C, with May as the hottest month with mean highest temperature of 23.8^0C and December the coldest month with average lowest temp. of 1.7^0C. The annual mean rainfall is 89.5mm with an average relative humidity of 58 %. About 29 pollen source honey plant species were determined and 7 groups were not botanically identified and categorised as unidentified over the study period. The highest proportion of pollen was collected during autumn (March-May) and spring (Sept.-Nov.). Summer (Dec.-Feb.) and winter season (June-August), are the periods in which least proportion of pollen was collected (Fig.19.1)

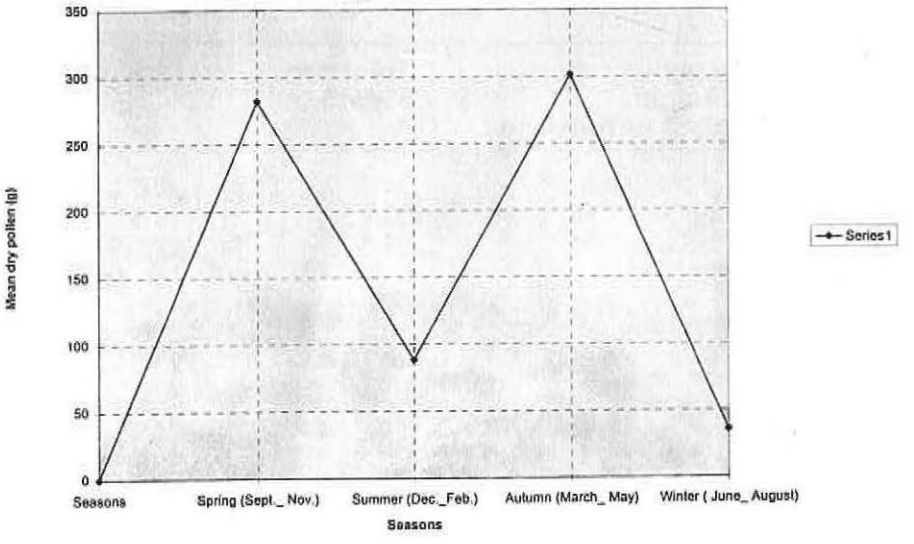

Fig. 19.1. Mean seasonal pollen collection by honeybees during the study period

Spring (Sept. - Nov.)

The number of pollen source honey plants identified during spring are the highest (22 plant species and 3 unidentified groups) of all seasons (Fig.19.2). This may be due to the fact that it is a period in which many natural and cultivated plants bloom. However, the amount of pollen collected during spring is less than autumn season. This indicates that the number of honey plant species does not govern the yield of pollen, but the potential and abundance of the individual plant species and the preference of honeybees to forage, determines it.

Guzoita spp., *Brassica napus, Bidens* spp. and *Plantago lanceolatum* are the major pollen source honey plants of the seasons, contributing 29.3, 24.4, 17 and 10% of the seasons' pollen collection, respectively. Moreover more than 80 % of the seasons' pollen was contributed by these honey plant species, which supply pollen for honeybees for 41, 69 53 and 64 days, respectively (Fig. 19.2)

Table 19.1. Mean pollen collected by honeybees at each month of the study period

Months	Mean pollen collected Dry Weight		Total per Month	Proportion (%)
	Morning	Afternoon		
Sept.	45.4	29.1	74.5	10.5
October	97.7	77.8	175.5	24.8
November	22.8	9	31.8	4.5
December	7	2.4	9.4	1.3
January	39	21	60	8.5
February	13.8	5	18.8	2.7
March	126	41.4	167.4	23.7
April	45.9	20	65.9	9.3
May	53.5	14.8	68.3	9.6
June	22.5	7.8	30.3	4.3
July	3.3	1	4.3	0.6
August	0.8	0.5	1.3	0.2
Total	477.4	229.8	707.5	105
Proportion (%)	67.5	32.5		100

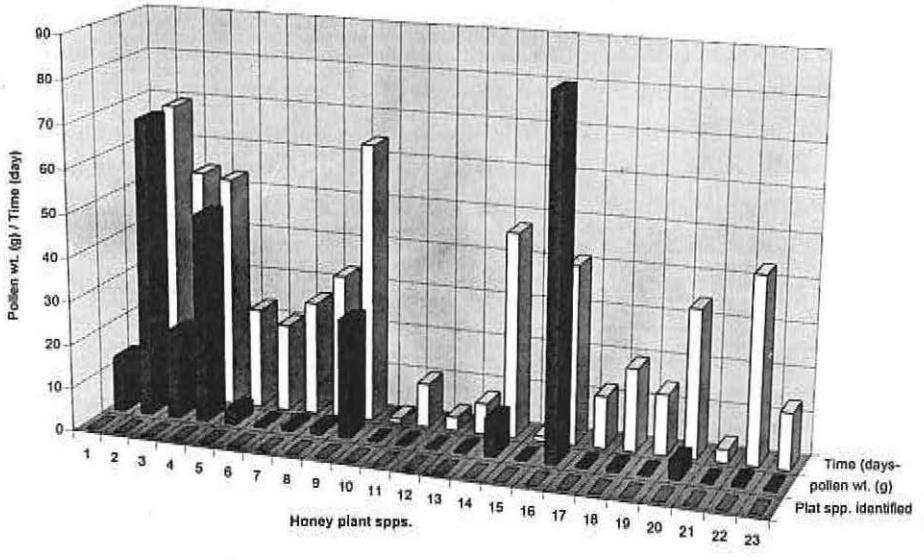

Fig. 19.2. Mean pollen collected and length of time and individual plant supply pollen during spring season

1. *Cynopis barbata*
2. *Brassica napus*
3. *Trifolium* spp.
4. *Bidens spp.*
5. *icia faba*
6. *Ocimum sanctum*
7. *Pisum sativum*
8. *Rumex baquarti*
9. *Plantago laceolatum*
10. *Heliantus annus*
11. *Linum ustatssium*
12. *Rosa abyssinica*
13. *Rhomnus prilods*
14. *Eucalyptus spp.*
15. *Cucurpita pepo*
16. *Guzoita spp.*
17 *Geranum spp.*
18 *Caylusea abyssinica*
19 *Hypoestes spp.*
20 *Acacia spp.*
21 *Vernonia spp.*
22 *Echnopis spp.*
23 Unidentified

Summer (Dec.-Feb.)

Summer season is a period in which scarcity of pollen was observed in the study area next to winter season. Only 12.5% of annual pollen collected (Fig. 19.1) was gathered by honeybees during this season.

Vernonia spp., *Plantago lanceolatum* and *Helminthothae echioides,* supplied about 82% of the season's pollen and hence they are the major pollen source of the period. They supplied more than 33, 29, and 20% of pollen collected over the whole period, respectively. Pollen of *Vernonia* spp. was collected by honeybees for a total of 40 days (3, 29,8 days in Dec., Jan. and Feb., respectively). and *Plantago lanceolatum* for about 75 days (28 in Dec., 27 in Jan. and 20 days in Feb.). *Helmithothea echioides* provided its pollen for honeybees for 42 days in the season (8,29 and 5 days in Dec., Jan. and Feb.), respectively (Fig.19.2 andTable 19.3)

Autumn (March - May)

More than 42 % of pollen for the year was collected during this season, but the number of honey plant species (10 honey plant species and 2 unidentified groups), offering pollen for honeybees, were less than that of spring seasons.

Plantago lanceolatum, Pinus spp. and *Eucalyptus* spp., were the major pollen sources of the seasons. *Plantago lanceolatum* supplied more than 40% of pollen of the season for about 87 days of the period. It also remained an important pollen source over the whole season of the year. It contributed about 27% of the year's pollen collection for 280 days (Table 19.3). *Pinus* spp. (Needle tree), contributed 21.6% of the season's pollen collection for 73 days and *Eucalyptus* spp. contributed 16.6% of the seasons pollen for 47 days (Fig. 19.4)

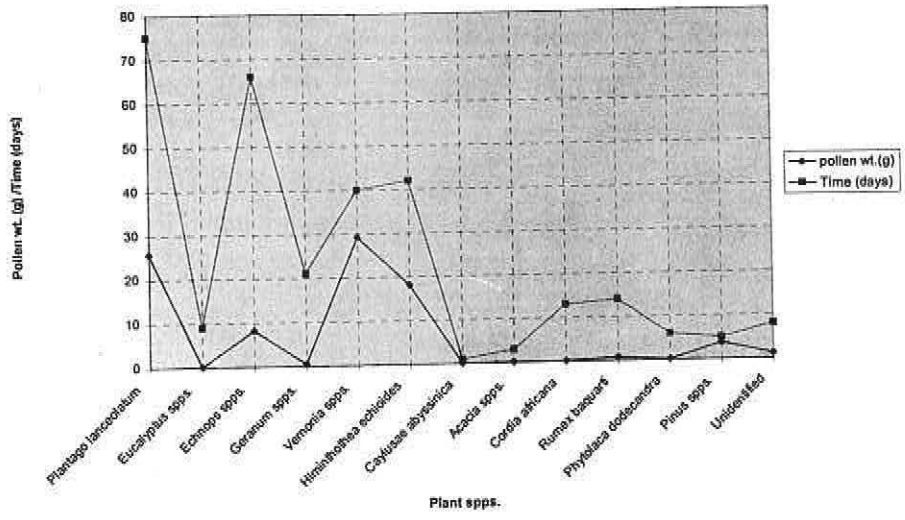

Fig. 19.3. Mean pollen collected and the period pollen supplied during summer season

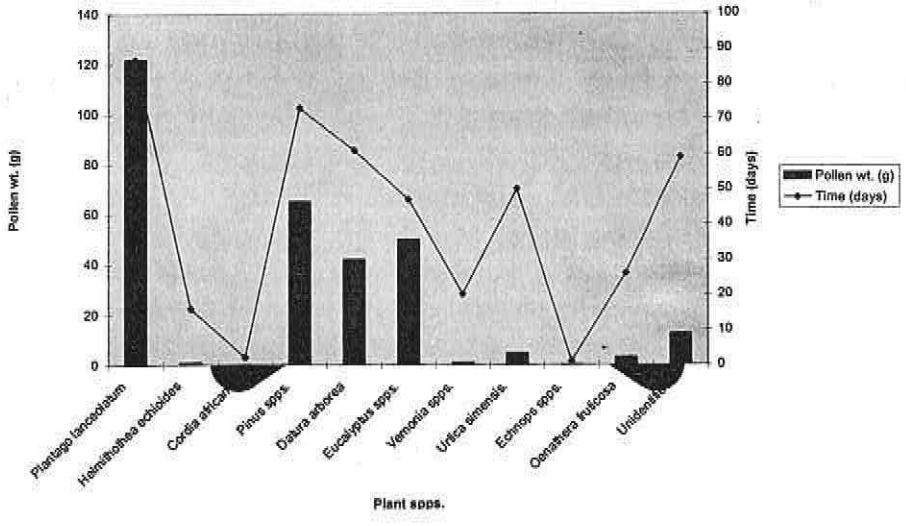

Fig. 19.4. Mean pollen collected and the period an individual plant supplies pollen during autumn season

Winter (June - August)

Only 5% of the total pollen trapped over the whole study period was collected during this season. This indicates that this season is highly scarce in pollen yielding honey plant species. *Plantago lanceolatum* provided more than 61% of pollen in 54 days of the period and remain an important pollen source over the whole season. *Eucalyptus* and *Pinus* spp. (needle tree) were second and third important pollen sources of the season, respectively (Fig. 19.5).

The amount of pollen varies from month to month, but pollen collection was observed in each month of the year. The highest amount of pollen was collected during October and March. Moreover, more than 67% of the year's pollen collection was observed during morning time (0700 to 1200 hours), while the rest (32.5), was collected during the afternoon (1300-1800 hours) (Table 1). This may be because the morning time is more wet or humid than the afternoon, and hence, it is favourable time for bees to collect and pack pollen grains into pollen basket and bring home.

From all identified honey plants and unidentified groups, *Plantago lanceolatum, Guzoita* spp., *Pinus* spp., *Brassica napus*, *Eucalyptus* spp.and *Bidens* spp. are found to be the dominant pollen source honey plants of the study area. They contributed 74.43% of the annual pollen collected by honeybees. As compared to honey plant resources of the area, only a few of the pollen source honey plant species were identified. This is due to the fact that the study area encompasses not more than 2 km radius from the Holeta bee research centre . Hence, further study is important to investigate the pollen source honey plant of Holeta area. Moreover, research is needed to determine nutritional value of pollen grains of the identified pollen source honey plants.

Acknowledgments

I wish to thank Enani Beshawored and Hadas G. Mariam for their unreserved assistance in collection of pollen from honey plants grown around the study area to verify identification and conducting of laboratory work during identification of pollen source honey plant species.

Table 19.2. Number of days honeybees collected pollen from the identified pollen source honey plants at each month of the year

Months	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Total days
Plant spp.													
Brassica napus	30	30	9	-	-	-	-	-	-	-	-	4	73
Bidens spp.	23	30	-	-	-	-	-	-	-	-	-	-	53
Trifolium spp.	24	30	-	-	-	-	-	-	-	-	-	-	54
Cynotis barbata	30	-	-	-	-	-	-	-	-	-	-	2	32
Plantago lanceolatum	5	29	30	28	27	20	30	28	29	30	20	4	280
Ociumum sanctum	6	14	-	-	-	-	-	-	-	-	-	-	20
Vicia vaba	23	-	-	-	-	-	-	-	-	-	-	-	23
Picum sativum	13	13	-	-	-	-	-	-	-	-	-	-	26
Rumex baquarti	21	0	12	0	8	6	-	-	-	-	-	-	47
Linum vistatissa	1	9	-	-	-	-	-	-	-	-	-	-	10
Heliantus annus	1	-	-	-	-	-	-	-	-	-	-	-	1
Rosa abyssinca	3	-	-	-	-	-	-	-	-	-	-	-	3
Rhamnus prilods	7	-	-	-	-	-	-	-	-	-	-	2	9
Eucalyptus spp.	0	18	29	9	0	0	0	17	30	30	19	3	202
Guzoita spp.	0	23	18	-	-	-	-	-	-	-	-	-	41
Echnops spp.	0	15	28	27	29	10	1	-	-	-	-	-	110
Acacia spp.	0	9	25	6	-	-	-	-	-	-	-	-	40
Caylusea abssinca	0	0	19	3	-	-	-	-	-	-	-	-	22
Geranium spp.	0	0	12	21	-	-	-	-	-	-	-	-	33

Table 19.2. Contd.

Months	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Total days
Vernonia spp.	-	-	3	3	29	8	0	13	7	-	-	-	63
Hypoetes spp.	-	-	14	-	-	-	-	-	-	-	-	-	14
Phytolaca dodecandra	-	-	-	-	-	6	-	-	-	-	-	-	6
Pinus spp.	-	-	-	-	-	5	30	27	16	15	-	-	93
Urtica Simensis	-	-	-	-	-	-	-	21	29	-	-	-	50
Oenathera fruticosa	-	-	-	-	-	-	-	-	26	19	-	-	45
Datura arborea	-	-	-	-	-	-	19	16	24	6	6	-	71
Hypoestes spp.	-	-	14	-	-	-	-	-	-	-	-	-	14
Cordia africana	-	-	-	-	7	6	2	-	-	-	-	-	15
Cucurpita pepo	1	-	-	-	-	-	-	-	-	-	-	-	1
Un identified	4	6	3	2	3	3	13	28	18	24	-	-	104

Table 19.3. Mean annual pollen collected and period pollen supplied

Seasons/	Spring		Summer		Autumn		Winter		Total	
Plant spp.	Pwt(g)	Day	Pwt(g)	Day	Pwt(g)	Day	Pwt(g)	Day	Pwt(g)	Day
Brassica napus	69	69	-	-	-	-	1	4	70	73
Bidens spp.	48	53	-	-	-	-	-	-	48	53
Trifolium spp.	20	54	-	-	-	-	-	-	20	54
Cynotis barbata	13	30	-	-	-	-	0.1	2	13.1	32
Plantago lanceolatum	27	64	26	75	122	87	21	54	196	280
Ociumum sanctum	0.5	20	-	-	-	-	-	-	0.5	20
Vicia faba	3	23	-	-	-	-	-	-	3	23
Picum sativum	1	26	-	-	-	-	-	-	1	26
Rumex baquarti	1	33	1	14	-	-	-	-	2	47
Linum vistatissa	0.2	10	-	-	-	-	-	-	0.1	10
Heliantus annus	0.1	1	-	-	-	-	-	-	0.1	1
Rosa abyssinca	0.1	3	-	-	-	-	-	-	0.1	3
Rhamnus prilods	0.3	7	-	-	-	-	0.2	2	0.5	9
Eucalyptus spp.	9	47	0.1	9	50	47	6	52	65.1	202
Guzoita spp.	82	41	-	-	-	-	-	-	82	41
Echnops.	1	43	8	66	0.1	1	-	-	9.1	110
Acacia spp.	4	34	0.2	6	-	-	-	-	4.2	40
Caylusea absinca	1	19	0.1	3	-	-	-	-	1.1	22

Table 19.3. contd.

Seasons/	Spring		Summer		Autumn		Winter		Total	
Plant spp.	Pwt(g)	Day	Pwt(g)	Day	Pwt(g)	Day	Pwt(g)	Day	Pwt(g)	Day
Gernium spp.	0.4	12	0.5	21	-	-	-	-	0.9	33
Vernonia spp.	0.1	3	29	40	1	20	-	-	30.1	63
Hypoestes spp.	0.3	14	-	-	-	-	-	-	0.3	14
Phytolaca dodecandra	-	-	0.2	6	-	-	-	-	0.2	6
Pinus spp.	-	-	4	5	65	73	4	15	73	93
Urtica Simensis	-	-	-	-	5	50	-	-	5	50
Oenathera fruticosa	-	-	-	-	3	26	0.4	19	3.4	45
Datura arborea	-	-	-	-	42	59	1	12	43	71
Helminthothea echioids	-	-	18	42	1	15	-	-	19	57
Cordia africana			0.2	13	0.1	2	-	-	0.3	15
Unidentified	0.4	13	1	8	13	59	2	24	16.4	104

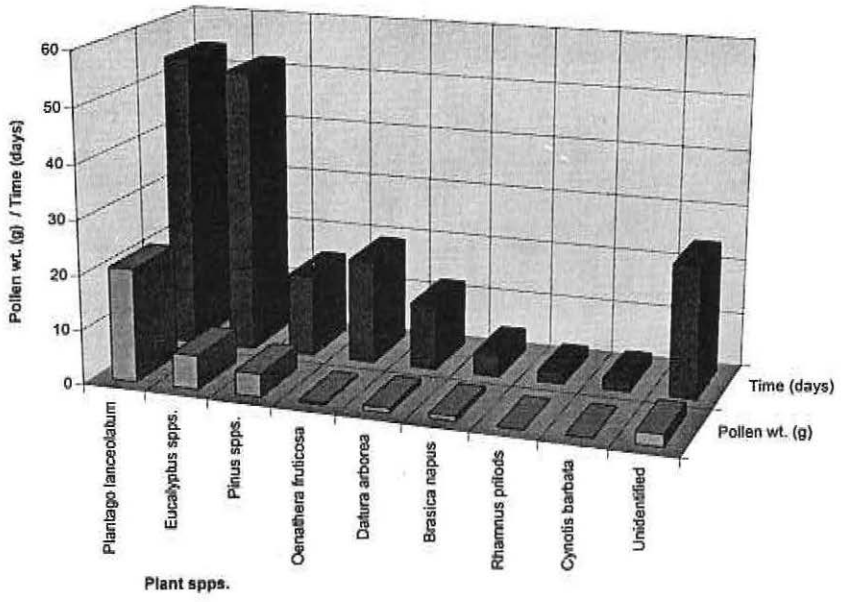

Fig.19. 5. Mean pollen collected and the period an individual plant supplies pollen during winter season.

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20. FLORA OF ZANZIBAR FOR COMMERCIAL INSECTS PRODUCTS

Zanzibar Experience in Beekeeping and Biological Resources Conservation

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Abstract: Zanzibar Island, which was separated from the East African coast, some 15,000 years ago, has flora of a kind that harbours and provide, a pleasant habitat for honeybees, and produces high quality honey for local use and trading. Beekeeping is a traditional activity in Zanzibar. In recent years, beekeeping efforts have been taken up by enhancing community awareness. Along side with the use of local hives, modern methods of beekeeping were introduced, aimed at boosting honey production for income generation. Beekeeping has a major role in conservation of biological resources and its potentiality serves both socio-economic and ecological purposes. Honey produced from cloves buds and mangroves fetches good market within the country and outside. There are several potential tree species in the family Leguminoceae, Papilionaceae Caesalpinaceae, Rutaceae and Combretaceae in the East Coast thickets of Zanzibar, that can be put to beekeeping practices and conservation.

This paper intends to explain Zanzibar's experience in beekeeping practices and conservation of biological resources, with special emphasis on community involvement.

Introduction

Locations and Climate

Zanzibar is part of the United Republic of Tanzania. It consists of two major Islands, Unguja and Pemba, situated within the Indian Ocean and lies 4 and 6.5^0s. The two main Islands are 40 and 60 km off the coast of mainland Tanzania, respectively.

Zanzibar experiences tropical Maritime climate with temperatures ranging between 17 and 40^{0}C. The two distinct wet seasons are "Masika" the long rain season and "Vuli" from October to December. Zanzibar is always green, because of adequate rainfall, hence its one time name "the green Islands". January and February are driest months of the year (ZLTFP, 1997).

Soils

The soil in the Island can be classified in two major categories, the deep, rich, fertile soil in which most permanent agriculture takes place and the coral rag soil charaterised by a thin layer of soil. Deep soils occupy western sides and coral rag soil occupy the eastern side cover, about 55% of Unguja and 15% of Pemba, where most beekeeping activities exist (ZLTFP, 1997). A century ago, most Zanzibar coral rag areas were covered with dense evergreen bush and the natural coastal forest. These forests are a very important source of fuelwood construction poles, agriculture and beekeeping activities.

Beekeeping Practices

Coral rag

The rocky calcareous soil of eastern Zanzibar is called coral rag soil. The thickets cover some 98,329 ha. (37%) of the country land (Ali, 1997), with more than 200 species for beekeeping in families.

The best area where most beekeeping activities are done is covered with semi-deciduous to evergreen bush, natural coastal thicket and forest, dominated several potential tree species in the families of leguminaceae, Papilionaceae, Caesalpinaceae, Rutaceae, Combretaceae and other families, which are important in beekeeping. Apart from these trees, there are so many types of herbs and grasses that serve the same purpose.

The list of potential species for beekeeping in coral rag forest include: *Tamarindus indica, Afzelia quanzensis, Casuarina equisetifolia, Rapanea melanophloes, Polyspharia parvifolia, Polysphaeria parvifolia, Mytenus mossambicenis, Annona senegalensis, Vitex* spp. *Dalbegia vacciniflora, Senna petasiana, Citrus* spp. and *Terminalia* spp.

Mangrove swamps

Out of 265,292 ha. of Zanzibar Island, mangroves occupy some 19,000 ha. This of course forms an important habitat for bees and beekeeping. Mangroves are a special class of natural forest and the most important source of floral for beekeping in Zanzibar. Mangrove provide high quality of honey, construction poles, excellent fuelwood and act as shield against waves and help the sedimentary stability of the coast. Mangrove ecosystem provide important fish breeding in Zanzibar. Most mangroves yield a good amount of nectar and pollen.

Beekeepers position hives in mangrove forest in such a way that during high tides, water would not reach the hives. Mangrove forests produce more honey compared to coral rag, because many species flower during honey flow in the period, Dec - Feb. The colour of honey is dark with a little bitter taste, because of *Xylocarpus granatum*, which produce bitter fruits used as medicine for stomach pains. Mangrove honey fetches good price in local markets.

The important mangrove species. for beekeeping in Zanzibar are *Avicennia marina, Rhizophora mucronata, Soneratia alba, Lumnitzera racemosa, Ceriops tagal, Bruguieral littoralis, Xylocarpus granatun* and *Xylocarpus molucensis.*

Deep soil agriculture land

While coral rag thickets comprise of 37% of Zanzibar land, agriculture land forms 9.4% of some 251,084 ha. The most important species of trees (in priority) include coconuts, cloves and mangoes. Thus, the tree crop combination in traditional mixed cropping of Zanzibar, provide wide space and chances for apiculture. Beekeeping is not so much practised in deep soil areas, because of the agricultural area and people's settlement, due to population growth rates, which result in pressure for land.

The list of trees, which produce good flora in deep soil agriculture areas are *Augenia chrysophylus, Azadirachta indica, Citrus* spp., *Cocos nucifera, Eucalyptus* spp, *Tamarindus indica, Mussa* spp., *Psidium guajava*, and *Mangifera indica* . Natural and plantation forests cover an area of about 9000 ha. while wood vegetation covers 19,733 ha. (7.4%) of Zanzibar land. In Pemba Island, beekeeping activities are done in deep soil areas, because of clove trees, *Eugenia chrysophylus* , with a good source of nectar from clove buds, during clove harvesting period.

Beekeeping efforts

Is a traditional practice in the Island. However, in 1980, modern methods of beehives were introduced all over the Island. The village afforestation programme includes beekeeping. More than 250 individuals and 100 groups of mainly women, were trained in beekeeping. Currently, most have lost interest, while few are in the process.

In a few villages where beekeeping is practised, it proved that those who keep bees love trees and are unwilling to clear their forest lands. This to a very large extent encourages the conservationists in the Island and thus, recognises that, a combination of beekeeping and conservation forest patches, has great role in biodiversity conservation.

Pilot villages

Eight villages surrounding Jozani forest are intended to be pilot villages in beekeeping and conservation practices. This effort is intended to be started, once funds become available. While Jozani and other villages in Zanzibar, are looking for an alternative income generation, beekeeping seems to be one among the priority areas.

Constraints to Beekeeping Activities in Zanzibar

Deforestation

Deforestation increases in relation to population due to bad farming practices, tourism industries and need for fuel and construction materials. This is a problem towards beekeping in Zanzibar. This leads to disappearance of suitable flora species for Apiculture.

Bad farming practices include cutting for shifting cultivation with lower fallow period and monoculture. Tourism as a current leading economic activity in Zanzibar, causes major consequences to coastal forest where many hotels were built after clear cutting of the forest. Annual forest fires are among causes of forest depletion. Demand for fuel wood and construction poles for domestic uses are one among the issues affecting the activities.

Why beekeepers lost interest

(a) Few experts: Only 2 experts in beekeeping compared to more than 60 foresters in village aforestation programmes.
(b) Fear to bees: traditionally, beekeeping is a man's activity in the Island. Women have interest, but they do fear. Thus, in absent of man's help, they neglect the hives.
(c) Poor marketing: The most reliable market of Zanzibar honey are Arabian State; Western States markets are difficult to penetrate as the quality of honey produced is poor, due to local processing and harvesting techniques.

Measures to encounter the problems

The responsibility for promoting beekeeping in Zanzibar was in the hands of the Commission of Natural Resources. Efforts to conserve natural resources and their flora and fauna has focused, not only on apiculture, but also on general biodiversity conservation.

The following are taken into account:

(a) Conservation education, which creates awareness to the community for better conservation of natural resources.
(b) To find other alternative income-generating activities such as hand crafts, seaweed farming and oil production, as an alternative to environmental damaging activities.
(c) Formation of village conservation committees for controlling of natural resources,where rules and regulations are set by the communities themselves.

Conclusion

It is estimated that the Island has some 234,903 ha., about 97% of the country land available for beekeeping practice, in combination with biodiversity conservation.

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21. THE ROLE OF WILD BEES IN THE POLLINATION OF THE EGGPLANT, *SOLANUM MELONGENA* L

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Abstract: The ecosystem services provided by wild bees to crop pollination were investigated in 1998-1999 in the Nguruman area of southwestern Kenya: The study area is a dry forest dissection, an arid rangeland. It is presently being brought into cultivation for the production of export vegetables, and as a result, the forest is rapidly being cleared and planted. Research objectives have been to document the role of wild pollinators to the crops, and to identify key resources, which permit their persistence, even under development.

Initial floral manipulations revealed that, although the 2 eggplant varieties (the Early Long Purple and the Black Beauty) studied were self-compatible, fruit set was not possible unless an efficient pollinator effected pollination. A total of 10 bee species were observed visiting the eggplant blossoms, but only 2, *Xylocopa senior* and *Lassioglossum* spp. visited the eggplant blossoms at a great frequency. Pollinator effectiveness tests were carried out using Spears (1983) procedure. *Xylocopa senior* turned out to be the most effective pollinator of both eggplant varieties. The honeybee, *Apis mellifera*, and the other bees did not visit the eggplant blossoms frequently enough, to be used in the study.

The use of wild habitat, adjacent to farmland by key pollinators, was also studied. Key floral resources and habitat use were documented.

Plant Pollination

There is a growing recognition, worldwide, that pollination is a service provided by nature, which we tend to take for granted, and often do little to encourage, until we start to lose it. Two thirds of all flowering plants depend on animals, largely insects, for pollination. It is probably the evolution of the role of pollinators that has permitted flowering plants to take over the world. While plants cannot move, pollinators can, and they permit reproduction between scattered individuals. When insects are particularly faithful to plant species, this ensures that a small number of individuals will be able to reproduce and biological diversity can be greater than without animal intermediaries.

A good example of this native to Kenya and many other places, is cycads. Cycads may at first look like palms, but they are not at all related. In fact, cycads are a plant that evolved over 200 million years ago and flourished at the same time as the dinosaurs. Cycads tend to be very limited in their distribution and under considerable threat. Cycads are gymnosperms, which means they produce seeds, but no flowers. The seeds develop within the cones on female plants; cones on male plants only produce pollen. The pollen must then be carried from the male plant to the female plant, probably by a beetle. Coning is very unpredictable among cycads, and it is already a rare chance that the male and female will cone at the same time. The insect pollinator must be available, and the seed requires up to a year and a half to ripen. Given all this, it is estimated that one cycad seed has a chance of surviving one in ten thousand!

Pollination is a service that is key to agriculture as well. Insect pollinators are essential for many fruit and vegetable crops, and the demand for pollinators grows as agricultural productivity grows. Unfortunately, by developing larger and larger fields and landscapes for agriculture, we also remove the habitat that may be needed by pollinators.

Pollinators have real commercial values, but this is not always appreciated. Consider the oil palm plantations of Malaysia. Until the early 1980s the pollination of millions of oil palm trees in Malaysia was done by human hand, an inefficient and expensive way of perfomring the task. Then the plantation owners asked themselves how the oil palm got itself pollinated in its native habitats of West Africa's forests. Researchers discovered, in Cameroon and Nigeria, that the job was very efficiently done by a tiny weevil. Stocks of the weevil were carried back to Malaysia where they were released into the plantations. As the weevil only ate oil palm pollen, and both came from West

Africa, there were no ecological complications. The pollination is now entirely accomplished by the weevil, with savings that already amounted to US$150 million per year in the early 1980s. It is not clear why we do not have a more recent evaluation of the value of this polllinator service provided by West Africa to Asia.

Estimation of Value of Pollinator Services

Studies on pollination have almost always shown that we should not rely on a single pollinator species. The more different kinds of pollinators the better for many crops. For example, with cucurbits such as watermelon, the size of the fruit is directly linked to the number of pollinator visits. Moreover, certain pollinators may fly when it is only warm and sunny, such as most bees, while others, such as hawkmoths may fly in cooler and cloudier weather. It has become apparent that the provision of pollinator services involves far more wild species and habitat types than have been considered in most discussions of agriculture's dependence on biodiversity.

To illustrate this range of diversity in pollinators, we have depicted the key pollinators of horticultural crops and tree crops grown in Africa. As can be seen, bees figure very importantly in horticultural crops; a wider diversity of pollinators are important among tree crops. FAO has recently published information on potential yield losses of crops, with loss of pollinators, which we present here for key African horticultural and treecrops.

Remarkably, little is known about pollinators, in general. Virtually nothing is known about the effectiveness of pollinators of wild species, and really suprising, little of crop plants. When pollinators drop out of a system, because there are usually many species which fulfill similar roles, the losses may be very subtle and unnoticed at first. When they do start to take effect, loss or reduced seed set is the first most obvious impact, and increased inbreeding within a crop or population. The primary threats to pollinators are habitat alteration, leading to loss of breeding sites, fragmentation and pesticides.

We have focused our initial pollination work in the Nguruman horticultural area, which is an area under fairly recent agricultural development. The farms are located on a Maasai group ranch, which is actually a very arid site, in general. As a result of rivers coming off the escarpment, two riverine acacia forests occur at the base of the escarpment, and one has been demarcated into individual plots, which either have been or will be cleared of forest and planted to horticultural crops. A rudimentary system of irrigation from the rivers

provides water to grow vegetables all the year round. The Maasai have adopted farming, though not always by themselves. In many cases, the land parcels are leased to Kikuyus and others from outside. They grow Asian vegetables almost exclusively for the export market, and do not consume what they grow. They apply pesticides about once a week, and use quite a high level of pesticides, although no fertilizer as yet, as the land is still quite fertile.

Manipulation of the pollination of eggplant

Five treatments were done on two eggplant varieties (Early Long Purple and the Black Beauty) to ascertain the extent to which insufficient pollination can limit the crops yield. These treatments tested the crop yield when the flowers were:

(a) Open-pollinated (allowed unrestricted visitation by the pollinators)
(b) Self-pollinated (bagged to exclude both wind and pollinators)
(c) Hand-pollinated with pollen from the same flowers
(d) Cross-pollinated with pollen from flowers of other plants
(e) Wind-pollinated (caged to exclude pollinators, but allow wind action)

A randomized block design was used. The plot was divided into five blocks, each measuring 10sq m. Different treatments were then randomly assigned to the blocks.

Results

An ANOVA was performed to compare the effects of each treatment on the number of seeds set in fruits of both eggplants. The seed set resulting from the various treatments were significantly different ($p < 0.0001$, Fig. 21.1).

The hand- and open-pollination treatments resulted in higher seed and fruit set. Only one fruit was set in the wind pollination treatments done in the Black Beauty variety, while no fruit was set in the Early Long Purple.

Buzz pollination of the eggplant

Solanum spp. bear flowers whose anthers dehisce by pores. The abundant pollen can only be removed through these small orifices, and bees have learnt to expel and efficiently harvest pollen from these flowers by vibrating their bodies while in contact with the stamen, effecting a process termed "buzz pollination". This mode of pollination is called buzz pollination, because of the audible buzz component of bee behaviour as they visit flowers.

The pollinators alight on the corollas and coil on the anther cones, grasping the stamens tightly with their mandibles, while their wings are held stationery over their abdomen and thorax. They then contract their large indirect flight muscles and transmit vibrations throughout their bodies.

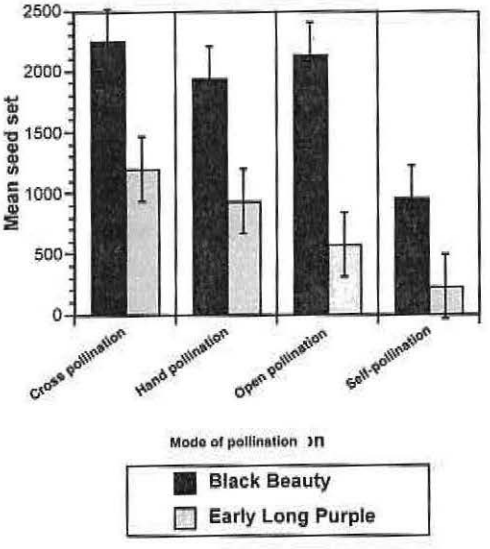

Fig. 21.1. Mode of pollination

The body parts such as the thorax, abdomen, and legs that are in direct contact with the anthers, vibrate very rapidly at a frequency of between 40 and 2000 Hz, (Buchman, 1983), immediately causing the anthers, locules and sometimes the entire flower to vibrate with the same frequency as the thorax of the buzzing bee. This vibration, functions to loosen the locule-contained pollen, producing strong pollen grain locule interaction that results in rapid expulsion of most of the pollen from the anther apices within a few seconds. Not all bees can "buzz pollinate"; specifically carpenter bees and other anthphorids and megachilids do so very successfully, while honeybees simply cannot. It is common to see honeybees investigating eggplant flowers, perhaps picking up a bit of pollen, which has been "buzzed' out by a prior pollinator and taking off in great frustration.

Since eggplant flowers produce no floral nectar as a reward to the pollinator, and have abundant pollen, it has been hypothesised that their pollen chemistry might be different from other plants, without anther pores and not requiring vibrational pollination (Buchmann, 1983). The pollen of buzz pollinated flowers has been determined to be more nutritious than that from other flowers, and specifically higher in protein content. Nonetheless, bees which pollinate eggplant will need to also have a source of nectar nearby.

Many of the organisms visiting a population of flowering plants, are not pollinating agents, but are pollen and nectar "thieves" that do not benefit the plants. Before any meaningful investigations into pollen-pollinator systems can be undertaken, it is imperative to determine the importance of a visiting species to the plant population under investigation. A measure of pollinator effectiveness is needed.

Direct measurements of effectiveness are measures of seed set by a plant population in response to pollinator visits. Direct measures are commonly used in agricultural research (Alderz, 1966; Tepedino, 1981). Spears (1983) used this method in measuring the pollinator effectiveness of the pollinators of *Ipomea trichocarpa.*

There are three parameters used to determine pollinator effectiveness (PE) for a visiting species *(i)*, namely: Z = mean number of seed set per flower by a plant population in the absence of pollinator visits. U = mean number of seeds set per flower by a plant population with unrestrained visitation. This technique assumes that flowers with unrestrained visitation will average greater than a single visit during the life of the flower. P *(i)* = mean number of seeds set per flower by a plant population receiving a single visit from species *(i)*. With these parameters, PE for each species can be calculated as:

$$PE = \frac{P_i - Z}{U - Z}$$

i.e., the proportion of unrestrained seed set caused by a single visit of species *(i)* , corrected by the amount of seed set when no visitation occurs (Spears, 1983).

Young flower buds were bagged a day before they opened to exclude pollinators. On the second day after the flower had opened, the bags were removed and the flowers allowed only a single visit by a known pollinator species. The flower was then bagged again until withered. Bee species, 14 were observed visiting the eggplant blossoms, but only two species — *Xylocopa senior* (Anthophoridae, Hymenoptera) and *Nomia* sp. (Halictidae, Hymenoptera), were frequent enough to be used in the pollination efficiency tests.

Xylocopa senior had a higher pollinator efficiency than *Nomia* sp. in both eggplant varieties (Table 21.1). The 2 bee species also had a high pollination efficiency in the Early Long Purple variety than in the Black Beauty variety (Fig. 21.2).

Table 21.1. The pollination efficiency of *Xylocopa senior* and *Nomia* sp.

Bee species	Early long purple	Black beauty
Xylocopa senior	5.15	2.197
Nomia spp.	2.615	1.722

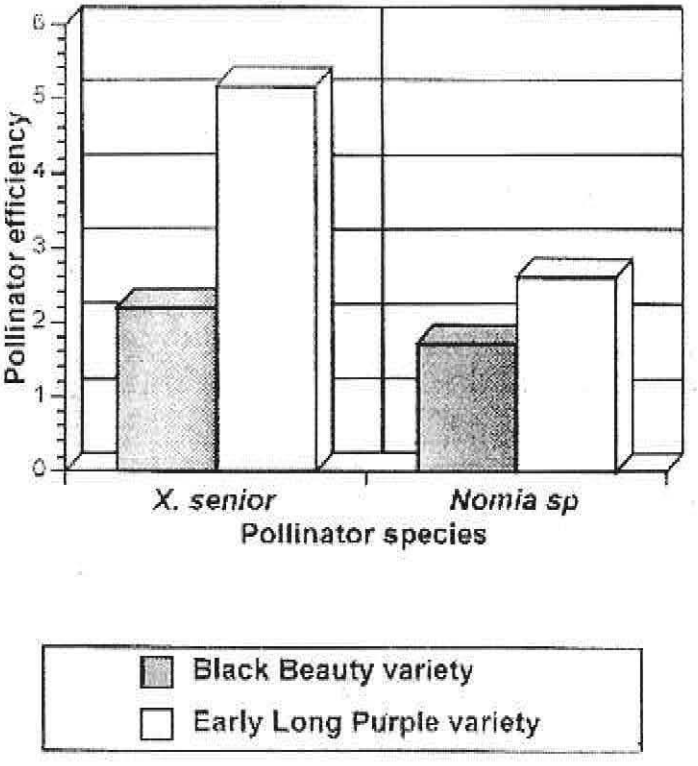

Fig. 21.2. Pollinator species

From this, *X. senior* is the most efficient pollinator and that Early long purple variety, in particular, shows a marked response to pollinator treatment.

Why do pollinators need to persist in an ecosystem?
(a) Foraging resources, in and off season
(b) Water
(c) Nesting sites

Selection of foraging resources

All bees are attracted to flowers by colour, odour or the nectar and pollen rewards they offer. Bees can discriminate between those plants that produce higher rewards and those that are less rewarding. Much of the literature on forage resources and pollination, concentrates on this kind of interaction between the crop and other flowering plants, as this discrimination can cause pollination problems, when a crop is grown in an area where more rewarding wild flowers may be in bloom. We are looking at the other side, the fact that pollinators of eggplant will need to get their nectar from other flowers, and make use of other resources at other times of the year, when eggplant flowers may not be available, in order to persist.

We looked first at all the flowers in the wild habitat and at their visitation rates. Labiates such as Leucus, and Acanthaceae such as *Justicia* are highly favoured.

We compared pollinator visitation to the wild flowers and eggplant flowers. It appears that the key pollinator of eggplant, visits other floral resources earlier in the morning. Eggplant is then visited in mid-morning, and as temperatures rise, the other floral resources are visited again, possibly for nectar and liquid resources that are not provided by eggplant.

Then we looked at where those flowers occur. The most important floral resources occur abundantly in farmland as ruderal weeds, and in the grassy swale area. Looking at this data alone, one might suggest that *Acacia tortilis* forest, which is being cleared to bring more land into cultivation, is not a very important resource from the standpoint of pollination.

However, when we looked at temporal and spatial changes in the broader wild habitat, by means of a 5-km long transect, which was surveyed every month for 6 months, we see that at one key time of the year in February, pollinators preferentially chose the woodland habitat. This is a time at the end of the dry season, when floral resources are scarce.

Our conclusion is that the resource which may be the most critical may not be the most obvious. It may be resources that are used only for a brief period, but without it, pollinators may not be able to persist in the ecosystem. The last two resource requirements are:

(a) Water
(b) Nesting sites

Water is not currently a problem, though it could be, if irrigation water was channelled.

Nesting sites, however, are more complex. Carpenter bees, as their name implies, nest in wood, but not in extremely hard Acacia wood. This means, they must find wood in the vicinity of farmland — a rarer commodity as demand for fuelwood increases.

Nomia and other halictines nest in the ground. They need fairly disturbed soil with a fair amount of sand intermixed. They are semi-social and may have up to 500 nests per sq. m. Once they start nesting in a place, it may be a good idea to conserve that site, as they are not easily moved or uprooted. Farmers in the US manage Nomia bees for alfalfa seed production, with imported playgrounds of sand and loam, to encourage nesting.

In any case, this is not yet an issue in Kenya. The point is, the service which others are paying good sums of money for, is still provided free of charge in Kenya. Keeping it "free" will require sensitive development, and the conservation of wild habitat in and among horticultural crops. The farmer we work with in Nguruman understands this well, but we will seek means to convey this message to other farmers as well, as the message is fairly simple, but the consequences fairly severe.

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22. PROSPECTS FOR IMPROVING CROP PRODUCTION WITH HONEY BEES

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Abstract: One-third of the world's crops are pollinated by insects, mostly by bees. Although there are ca. 25,000 species of bees, the most widely distributed species and the most widely used for crop pollination is the honeybee, A*pis mellifera*. A recent review of the role of honeybee in crop production in Europe listed 264 species of crop plant from 60 plant families grown. Out of these, nothing is known of the pollination requirements of a third of the species, but of the remainder, 84% depend on or benefit from pollination by honeybees. The contribution of the honeybee to the pollination of only 30 of these crops was estimated to be US$ 4250 million. Crop production is global and crops are no longer grown solely in their country of origin, but often far from it and away from native pollinators. Most of the crops grown in Europe are also grown in Africa. Strategic research is needed to assess whether pollination is limiting crop yields and to ensure that their pollination requirements are being met. Sustainable crop production to meet the food requirements of a growing population, pollinator conservation and conservation of the biodiversity of fauna and flora in Africa are interdependent. Research approaches to meet this aim will be discussed.

Workshop Theme

This Second International Workshop on *"The Conservation and Utilisation of Commercial Insects"* at The International Centre of Insect Physiology and Ecology (ICIPE), focuses on the implementation of modern apicultural technologies suitable for Africa. It has brought together experts from Africa,

Asia, Europe and USA to discuss the complementarity of their apicultural research and development programmes with those of ICIPE. As a pollination ecologist, I will focus, in my paper, on the role of bees in crop production in Europe, on my own bee and pollination research and development programme at Rothamsted, and then discuss the relevance of these to crop pollination in Africa.

Population Density and Agriculture in Europe

Population density and agriculture exert major pressures on land use in Europe. The 15 member states of the European Union (EU) have a population of *ca.* 332 million and a land area of 324 million hectares. About 44% is utilised agricultural area and 33% is woodland; much of the non-cultivated land is also man-managed. Eastward enlargement of the EU is expected to increase the population by 100 million and expand the agricultural area by 50%. The agriculture is diverse and intensive, supplying a variety of high quality food and other products for its multi-cultural population.

Which crops need pollinators?

Crop production in Europe is highly dependent on pollination by insects. At least 264 crop species from 60 plant families are grown in the EU. Nothing has been published about the pollination requirements of a third of these species, but of the remainder, 84% depend on, or benefit from, insect pollination (Williams, 1994, 1999a).

Which insects pollinate crops?

The botanical diversity of the morphology, the degree of self-compatibility and the sexuality of the flowers of the crops grown in Europe requires a diversity of insect vectors for efficient pollination (Corbet *et al.* 1991a, b; Williams, 1994, 1996). The flowers of most outdoor crops are visited by an assemblage of insects. This typically includes the honeybee, several species of bumble bee, a few species of solitary bee, and, on the more open flowers, various species of flies, beetles, butterflies, or thrips. Some beetles pollinate cucurbits and oilseeds, butterflies pollinate blackberry, clovers and tobacco, while some flies are used commercially to pollinate protected crops of onion, chive, carrot, strawberry and blackberry. However, on the basis of abundance and foraging behaviour, bees are the most important pollinators. Honey bees and bumble bees usually outnumber all other pollinators on crops, although the relative proportions of each vary with crop, its location, season, time of day and pollination management practice.

The honeybee

The native European honeybee, *Apis mellifera* is undoubtedly the insect species that contributes most to crop pollination in Europe (Williams, 1994). There are estimated to be *ca.* 7.5M honeybee colonies managed by *ca.* 500,000 beekeepers in the EU, so the honeybee is abundant and readily available. It is the only pollinator available for supplementary pollination of field and outdoor fruit crops. As a generalist feeder, it visits and pollinates most of the crops grown, yet on a single foraging trip, it is highly constant to species, making it a reliable cross-pollinator, although not necessarily the most efficient one for all crops.

Bumble bees

Bumble bees are also important pollinators in Europe, and particularly so in the more northerly latitudes where the weather is too cool for honeybees (Osborne and Williams, 1996, 1999b). They are efficient pollinators of crops wherever they are sufficiently abundant, but their distribution and abundance have declined in recent decades. They are generalists with a broad flower choice, but species differ in tongue length and hence flower preferences. Long-tongued species, such as *Bombus hortorum* and *B. pascuorum* are important pollinators of crops with deep corollas, such as field bean and red clover. They are better pollinators than honeybees of solanaceous and ericaceous crops because of their ability to buzz-pollinate. Following the development of methods for the continuous rearing of bumble bees in the late 1980s, the use of bumble bees, *Bombus terrestris* for the managed pollination of protected fruit (e.g. aubergine, blueberry, melon, raspberry, red currant, strawberry, sweet pepper and tomato) and seed (e.g. carrot, cauliflower and brussels sprout) crops, has grown dramatically. Their potential for the pollination of some high value outdoor field crops (e.g. almond, apple, blueberry, cherry, cranberry, peach, pear and plum), is being assessed.

Solitary bees

The contribution of several hundred species of native solitary bees in the pollination of field crops is less well understood (Williams, 1996). Solitary bees are rarely as numerous on crops as the honey and bumble bees and their abundance is restricted by the proximity of suitable nesting sites. Nevertheless, some species of *Andrena, Osmia* and *Anthophora* can make a useful contribution to early flowering fruit when other bees are scarce and species of *Megachile* are important pollinators of legumes. Associated with their short flying season

and seasonality is a synchronisation of their foraging activity to a limited number of plant species that flower at that time and have accessible pollen and nectar. Most have short tongues (*Prosopis, Colletes, Andrena, Halictus, Sphecodes*), whereas others (e.g. *Anthophora*), have tongues longer than that of the honeybee. Particular species of solitary bee can be especially useful pollinators of particular crops; the alfalfa leaf-cutting bee, *Megachile rotundata* is used on a small scale for the pollination of lucerne and white clover. Management methods are also being investigated for a few species of stem-nesting *Osmia* and *Megachile*, for use in the pollination of selected orchard and soft fruits, field legume and seed crops (Williams, 1996).

Economics of Crop Pollination by Bees

Despite the inherent difficulties, attempts have been made to ascribe an economic value to the pollination service provided by bees.

Worldwide

Estimates of the value of the honeybee to crop pollination have been made in Canada (Jay, 1990; Winston and Scott, 1984), the European Union (Borneck and Bricout, 1984; Borneck and Merle, 1989), Hungary (Benedek, 1985), New Zealand (Matheson and Schader, 1987), USA (Levin, 1983, 1984; Robinson et al., 1989 a and b; Southwick and Southwick, 1989 and 1992) and the USSR (Soldatov, 1976). The economic value of the honeybee as a crop pollinator has been shown to greatly exceed its value as a producer of honey, wax and other hive products. The economic value of the bumble bee pollination of glasshouse crops in Europe, has also been estimated (van Doorn, 1993).

Assessments of the value of bees to crop pollination have used a variety of methods. Some authors have considered the market value of all, or of some of the insect-pollinated crops grown; others only that portion of production attributable to honeybees. Some have included the value of crops grown from seed, derived from bee-pollinated plants, the legume crops and livestock products dependent on them, or even those legumes that fix nitrogen and thereby reduce nitrate fertilizer requirements. However, there is insufficient information on the pollination requirements of crops, on the benefits to be derived from bee pollination, or, on the proportion of pollinators that are honeybees, to allow such estimates to be made with great accuracy.

Europe

An economic evaluation of the contribution of bee pollination to the production of 30 insect-pollinated crops in Europe was published more than a decade ago (Borneck and Bricout, 1984). These authors attributed to each crop a value, "the coefficient of incidence", based on its dependence on insect pollination and attributed 85% of insect pollination to honeybees. They calculated that the crops had a combined annual market value of *ca.* US$65,000M, that insect pollination contributed US$5,000M and pollination by honeybees contributed US$ 4,250M. There is need to update this evaluation and include more of the 177 crops grown in the EU that benefit from bee pollination.

UK

At least 39 insect-pollinated crops are grown in the UK for their fruit or seed, and a further 32 need insects for propagative seed production (Williams et al.,. 1993; Williams, 1994). The honeybee plays a dominant role in their pollination, being the only managed pollinator available for field and outdoor fruit crops. However, commercially reared B. *terrestris* are used for the managed pollination of almost all tomato (total area *ca.* 350 ha), pepper and aubergine crops grown in glasshouses and polythene tunnels. The estimated value of honey and bumble bees as pollinators of major selected UK crops for which market statistics are available, is *ca.* $260M for outdoor crops (rape, beans, tree and soft fruit) and *ca.* US$ 45M for glasshouse crops (tomatoes and sweet peppers) (Carreck and Williams, 1998). There are few data from which to estimate proportions of pollination, attributable to different bees in the UK. However, if 80% of the insect pollination of outside crops is attributed to honeybees following accepted evaluations in other countries, the estimated value of honeybee pollination of these selected crops in the UK amounts to ca. US$ 200M. Honey production by the estimated 200,000 honeybee colonies owned by the estimated 35,000 beekeepers in the UK is about 4000t per annum, valued at approximately US$ 24M. Based on the conservative estimate of Crane (1990), that bees wax production is approximately 1.5 % of honey production, UK production is *ca.* 60t per annum, which has a market value of US$ 180K. Adding the value of honey and bees wax to that of pollination, the total annual value of honeybees can be estimated to be US$ 230M. Using the estimate of 200,000 colonies, the annual value of each honeybee colony to the UK economy, therefore, exceeds US$ 1000.

Beekeepers and Crop Pollination

Agriculture and apiculture are interdependent and beekeepers have an essential role to play in ensuring crop pollination (Williams et al., 1991; Williams, 1993). Agriculture provides flowering crop plants, from which bees can collect nectar and pollen and, in return, bees pollinate the crop flowers they visit. In the UK, surveys of bee forage plants and beekeeper practice have been conducted to investigate aspects of this interdependence (Williams et al., 1993; Carreck et al. 1997). Beekeepers reported 70 different plant species to be important nectar sources. The dominant honey flow came from oilseed rape (27-49% of records), followed by lime, tree fruit (apple, pear, plum, cherry) and blackberry (10-21% of records). Heather, clover, field bean, sycamore, chestnut, hawthorn, rosebay willow herb, ivy, balsam and dandelion were reported in 1-8% of records (Williams et al., 1993); other species were of less widespread importance. In UK, therefore, bees collect nectar from a wide range of both crop and native plants. Beekeepers move their colonies to a variety (up to 30) of different insect-pollinated crops, to supplement locally available pollinators, at the request of growers and for a pollination fee. The crops included field crops, tree fruit, soft fruit, seed crops, and glasshouse crops (Carreck et al., 1997).

Varroa, beekeeping and pollination

The varroa mite, *Varroa jacobsoni*, which entered Germany in 1977, had invaded Greece, Italy, France and Holland by 1992, and continues to spread and devastate honeybee populations on mainland Europe. It was discovered in the UK in 1992. Since then, varroa has spread throughout Britain and in 1998, was reported from Ireland. Beekeepers are increasingly unable to meet the demand from growers for honeybee colonies for pollination (Bee Farmers Association, pers. comm.). There is concern that honeybee stocks are now insufficient in number and inappropriately distributed to meet the pollination needs of the UK.

Loss of pollinators and causes for decline

Concerns about the impact of the diminishing European bee fauna on crop and wild flower pollination, caused Scientific and Technical Options Assessment (STOA), European Parliament, to commission a review to examine the impact of changes in land use and beekeeping practice on pollination.

The STOA (Corbet et al., 1991b) documents report serious regional losses of bumble bee species, marked decreases in the number of managed honeybees and the listing of numerous species of solitary bee in National Red Data Books. It recognises that: (a) the distribution and abundance of bees depends largely on the availability of a seasonal succession of forage flowers and nest sites, (b) fragmentation and destruction of semi-natural habitats, particularly open biotypes such as garique, heaths, unimproved grassland and undisturbed areas of farmland, are a cause of the decline of wild bee populations and of reduced food supply for honeybees, and (c) intensively cultivated arable land is an inhospitable environment for bees (Osborne et al., 1991). It warns that the impact of inadequate populations of pollinators will be far reaching: 'If bee-pollinated flowers do not set seed, the integrity of Europe's remaining semi-natural vegetation will be destroyed ....." This in turn will deprive many other herbivorous or seed-eating insects, birds and small mammals, of their host plants and/or food, with consequent further loss of species diversity. Crops dependent on pollination by bees will give decreased yields and may no longer be grown profitably. Their loss will cause further depletion of nectar resources for the remaining bees. This vicious circle, resulting from the mutual interdependence of bee-pollinated plant and pollinator, makes the future survival of both, inextricably linked. It concludes that appropriate agricultural and environmental policies and co-ordinated research and development programmes, are needed urgently to ensure adequate pollination of bee-pollinated crops and wild flowers in the European Union.

Land management for bees

Arable farmland, with its mosaic of cultivated fields and uncropped areas (woodland, hedges, banks and waysides), provides a fragmented habitat for bees. Cultivation for crop production, particularly in cereal-dominated arable areas, usually decreases the amount of land available for food plants and increases the distances that bees have to fly to collect food. The relative proportion of these resources and their spatial arrangement within the farmland mosaic, is important for the success of bee colonies. The spatial scale of bee flights is also important for the pollination of both crop and wild plants within this fragmented habitat. If a crop is inadequately pollinated, it will not give optimum seed yields; if a wild plant becomes isolated from its pollinator, it will not survive. The dynamics of the flights of bees between patches of forage and within and between the plants of a patch, affect seed production potential, outcrossing rates, genetic diversity and the survival of plants in agricultural habitats.

The development of land management strategies favourable to bees to ensure efficient pollination of our entomophilous plants, requires more knowledge about their nectar and pollen requirements, spatial and temporal foraging dynamics and how this affects pollen flow within agro-ecosystems. The cues bees use to find the essential resources they need from their habitat, are also poorly understood. These are some of the overall aims of our pollination ecology research programme at Rothamsted.

Enhancing farmland for bees

Farmland can be enhanced as a habitat for insect pollinators, by growing plants to provide the nectar and pollen that they require for food. Non-cropped areas can be sown either to annual plant species for rotational management perennials. Conservation headlands can be managed to avoid killing useful forage plants for pollinators (Williams and Carreck, 1994).

Phacelia tanacetifolia (phacelia), an annual plant species native to N. America, is widely grown as a catch crop or for green manure in Germany and Eastern Europe. It has long been recognised as a valuable food plant for bees. Williams and Christian (1991) evaluated it for bees in the UK. They showed that, with its high floral density, long flowering time and abundant production of nectar and pollen, this plant was highly attractive to eight species of bumble bee and the honeybee. Sown sequentially from May to July, flowers were available from early July until December. It established easily with minimal seedbed preparation, out-competed weeds from a range of seed rates, and volunteers were easily controlled with broad-leaved herbicides.

Commercial annual seed mixtures, developed in Germany (Tübingen Mixture) and the Netherlands (Ascot Linde SN) to provide a long succession of flowers for a greater diversity of insect pollinators, were evaluated in the UK by Carreck and Williams (1997). The mixtures were visited by 14 species of Hymenoptera, 14 species of syrphid Diptera and six species of Lepidoptera. The mixtures contained 12 and 5 plant species, respectively, but phacelia was the dominant species to establish, flower and attract insects in both mixtures and the other plants contributed little to flower density or insect diversity. When planted at the recommended times, peak flowering occurred when other major forage sources such as oilseed rape, field beans and limes were in flower. The composition of these commercially available annual mixtures was, therefore, considered to be inappropriate for UK conditions and requirements. Further annual mixtures containing only six plant species: borage, buckwheat, cornflower, mallow, marigold and phacelia in varying proportions, have since

been evaluated, as have perennial field margin strips sown to a commercially available "Diverse grass and wildflower mixture", a "Wild bird mixture" (both recommended for use to encourage biodiversity on farmland and not as specific food for bees), or allowed to regenerate naturally (Carreck and Williams, 1999). Both annual and perennial mixtures established well and attracted a diversity of insects to their flowers. Some plant species were more attractive to particular insects than others. Flower mixtures were more specific to particular pollinators, but could be designed by inclusion of species, particularly attractive to and/or nutritious for them.

Flower mixtures could be made even more valuable, if more was known about the nutritional requirements of bees, such as, which amino acids are essential and whether they benefit from a mixed diet of different types of nectar and/or pollen. This is the subject of a new research project at Rothamsted.

The foraging ranges of bees

To investigate the foraging ranges of bees, we pioneered the use of harmonic radar, to track the foraging flights of bees in arable farmland (Riley et al., 1996; Osborne et al., 1997). The radar was developed by the Radar Unit, Natural Resources Unit, Greenwich University, to track the flights of tsetse flies in Africa. Each bee to be tracked is fitted with a diode/dipole device, which absorbs energy from the incoming radar signal and re-radiates it at a harmonic of its frequency, back to the receiving radar dish. This eliminates the need for a battery on the insect. The radar receiver is tuned to the harmonic frequency, thereby eliminating reflections from ground features so that the track of the tagged bee is clearly visible on the conventional radar screen, as it flies across the landscape. The current maximum detection range of the tags is 700 m, allowing coverage within a 1.4 km diameter circle centred on the radar. This technique has enabled new information to be obtained about the foraging flights of bumble bees (Osborne et al. 1999), the orientation flights of honeybees (Capaldi et al., 1999), and about how bees compensate for cross-wind on their flight paths (Riley et al., 1999).

Foraging patch loyalty of bees

The spatial pattern of foraging behaviour of bees during a foraging trip and on successive trips, has implications for pollen flow. To investigate within patch loyalty of bees, a habitat fragmentation experiment, set up originally on Rothamsted Farm in 1989, was used to investigate the movement and population dynamics of selected parasitoids and predators in a patchy environment. This

consists of a field of barley into which are sown patches of semi-natural vegetation of two different sizes arranged in a regular symetrical pattern devised by bio-mathematicians; a hedgerow provides a field boundary on one side. The seed mix of the patches contained four of each of species of grass and broad-leaved perennials, including knapweed, *Centaurea nigra*, which is visited by *Bombus lapidarius*. Mark-reobservation techniques are being used to study the movement of *B. lapidarius* between the patches.

Pollen and gene flow mediated by bees

1. Using isoenzyme genetic markers in white clover

The development of isoenzyme genetic markers in white clover, has opened new possibilities for research into how bee movements on different spatial scales mediate pollen and gene flow in arable ecosystems. Quantifying pollen flow from a particular source has presented practical problems in the past, because pollen bears no obvious indication of parentage, but these new markers allow us to monitor its movement with precision.

Five fixed isoenzyme selections within the white clover, *Trifolium repens* cultivar S100, are being used to investigate pollen and gene flow within and between plants, in discrete and fragmented populations. Flow is monitored by determining the paternity of seedlings by starch gel electrophoresis for gluco-phospho-isomerase (Michaelson-Yeates et al., 1997). Foraging intensity to a particular inflorescence, is controlled by bagging it to prevent visitation and then unbagging it to allow single or multiple visits at known time intervals. Intra- and inter-plant foraging behaviour following individual bees and loyalty to patch, is monitored by mark-reobservation techniques. Different planting arrangements of the five isoenzyme selections are being used to determine:

(a) the relative amounts of self- and cross- pollen transferred by bees

(b) the genetic diversity of pollen carried by bees when foraging in a genetically mixed discrete plant population (Williams et al., 1997)

(c) rates of outcrossing between adjacent patches and patches placed on the habitat fragmentation experiment in an array, such that any outcrossed seed will indicate the distances over which foraging bees carry marked pollen

(d) the effects on seed production of multiple successive visits after inter vals of time

(e) outcrossing rates between fragmented patches of differing sizes

(f) pollen carryover to flowers visited in succession.

2. *Using GM herbicide-tolerant oilseed rape*

Risk assessment of genetically-modified (GM) crops, necessitates quantification of the risk of the spread of pollen from these crops to other non-GM crops and their weedy relatives. This year was the first with large field-scale experimental plantings of GM herbicide-tolerant oilseed rape crops in UK and one trial was located at Rothamsted. A research programme was initiated to investigate the role of bees in mediating pollen flow from this crop. A transect of honeybee colonies was set up across Rothamsted Estate at different distances from the GM crop. Each colony was fitted with a dye dispenser so that outgoing bees could be marked and their foraging areas located in the various crops on the Estate and also with a pollen trap to collect incoming pollen. This is now being analysed using PCR techniques to determine its content of GM pollen.

Foraging cues

Floral cues important to foraging bees, such as those from pollen, are the focus of increased research effort at Rothamsted. A newly-constructed state-of-the-art bee flight room enables observations of bee behaviour to be made in controlled environment and conditions, where lighting, temperature and humidity are optimised for bee flight (Poppy and Williams, 1999). The role of visual and olfactory cues is being investigated using sophiscated new technology. An odour-dispensing artificial-flower system is being used to study the learning responses to and preferences for odour and colour cues by free-flying bees. The "proboscis extension reflex" bioassay, facilitates the study of the powers of recognition and discrimination of restrained bees to floral cues.

Prospects for Improving Crop Production with Honeybees in Africa

The prospects for improving crop production with honeybees in Africa are enormous. It is estimated that one-third of the world's crops require pollination by insects to set seeds and fruits and that most of these crops (an estimated 73%) are pollinated by the 25,000 species of bees (McGregor 1976; Roubik, 1995; Buchmann and Nabhan, 1996). This pollination activity is valued world-wide at US$ 65-70 billion. Roubik (1995) lists 1330 economically important plant species grown in tropical countries. Out of these, 221 originate in Africa. Crop production is a global activity and crops are grown far from their country of origin, often without their natural pollinators. Out of the 264 species of crop plants grown in Europe, the majority are bee-pollinated (Williams, 1994)

and are also grown in Africa, albeit under different environmental and socio-economic conditions. In addition, a large number of other crops are grown in Africa, whose pollination requirements are unknown and may be inadequately met, because of lack of spatio-temporal co-incidence between crop and pollinator.

The most widespread and widely used insect pollinator in crop production is the honeybee. However, overdependence on a single species for the pollination of its crops is becoming a major problem for the world's agricultural production. The varroa mite has spread rapidly in Europe and North America with devastating results on honeybee populations. Fruit and vegetable growers are reporting difficulties in hiring honeybee colonies and hence, the resulting poor fruit and seed set of insect-pollinated crops.

Pollinator diversity is an essential resource, here in Africa as elsewhere in the world, and needs to be sustained. There are undoubtedly thousands of different bee species in Africa, many as yet undescribed and with very specialised pollinator relationships with the flora of Africa. Conservation of this biodiversity is important to the future economic development of Africa. Many of these native plants may be our food crops of the future and many of the other pollinators may be essential pollinators of these crops or have certain advantages over the honeybee as commercial crop pollinators.

The International Pollinator Conservation Initiative

The importance of pollinator diversity is at last being recognised internationally. At the second meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity (CBD) in Montreal in 1996, the Brazilian Government proposed establishing a work programme on Agricultural Biological Diversity, which included a proposal for the establishment of an "International Pollinator Conservation Initiative". As a contribution to the development of this programme, the Brazilian Government held an international workshop of pollination experts, in Sao Paulo in 1998. Results and recommendations from this workshop will be presented as a Report to the 5th SBSSTA meeting in January 2000. If they are endorsed by the 5th Conference of the Parties (COP) in May 2000, this initiative is expected to help foster support from international agencies, to enhance further initiatives in all continents on pollinator conservation and sustainable use. Such international action would certainly boost the prospects

for improving crop production worldwide with honeybees and other pollinator species.

Acknowledgements: IACR-Rothamsted receives grant-aided support from the Biotechnological and Biological Sciences Research Council.

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SESSION III

QUALITY CONTROL AND MARKET OPPORTUNITIES FOR COMMERCIAL INSECTS PRODUCTS

23. GLOBAL MARKETS AND MARKETING OF SILK

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Abstract: Silk makes up an insignificant volume of the international textile market (0.2% by weight), but it is a multi-billion dollar industry. Until 1989, silk was a high cost luxury fabric, affordable by only the *haute couture*. In the early 1990's, however, low cost silks from China were introduced into the world market. In particular, sand washed silks made silk products become available to low and middle income customers. By the end of 1999, the world market price for raw silk dropped 50% from its 1989 high. The pace of the market for silk products has been further slowed by the Asian recession, new import quotas in Europe and the U.S. and Gulf War. Today, the price of raw silks has stabilized to about US$ 21-23 per kg. In the future, the silk market will continue to face new competition from synthetic fibres that look and feel like silk, but that are easier to care for. Some solutions to address the drop in the international market, could be a generic campaign to promote silks world-wide, promotion of silks as environmentally friendly products, a capitalisation on new technologies and a repositioning of the image of silk, tarnished by the introduction of lower quality products in the 1990's.

Silk Production

Production of raw silk is concentrated in developing countries, with low labour costs, and in tropical climates that support mulberry and silkworm cultivation. Unfinished silk products are traded in the developing world; countries with developed economies trade primarily in finished and manufactured products. Both silk production and its consumption in major markets are declining.

Some producers believe that the silk trade will rebound in the next 3 years, but only with governmental and financial assistance:

(a) Korea and Uzbekistan have organized a partnership to produce raw silk. The enterprise is heavily subsidised by the Korean government and international financial organisations.
(b) Colombia and the Centre for Technological Development of Silk, are supporting a transition from coffee to silk. Five-hundred farmers are marketing silk cocoons through cocosilk, and the number is expected to increase.
(c) Mexico, Costa Rica, Venezuela, Paraguay, Peru and Ecuador are considering silk production as a means to supplement the falling incomes of their rural populations.

Before investing in new approaches to silk production the types of markets available to small scale silk producers need to be identified. The following factors, however, need to be considered:

(a) Eco-friendly, high quality silks: In US, the typical customer is female, college-educated, professional 30 years old, with children and a minimum annual income of US$30,000.
(b) Silk story: There is a small, but growing market of socially responsible consumers, who will appreciate natural fibre and profits accruing to subsistence farmers.
(c) New material properties: Growing market for comfort clothing (elasticity) and sports clothes (strength).
(d) New silk products: High fashion (e.g, cashmere-silk blends) and cloth coloured with natural dyes (possibly hypoallergenic).

Marketing of Silk

Silk, like other high value agricultural products, could benefit from cooperative marketing. Niche marketing to the environmentally conscious consumers could help revive the silk industry. The following market types exist:

(a) Most important European markets: Great Britain and Germany
(b) Current European markets susceptible for targeting via aggressive marketing: Netherlands, Italy, Denmark and Belgium
(c) Growing markets: Spain, Australia and Switzerland
(d) Future markets: Western-European block and Asia, Singapore, Japan and Malaysia
(e) US market for all organic products is estimated to be US$ 3.7 billion in 1999.

National or international certification (ISO 14000), may be required to support claims of environmental benefits Foxfibre and Stonyfield Farm are eco-friendly companies that have had different business approaches and degrees of success. The success of Foxfibre, Inc. has been limited by lack of integration between the production of raw material and finished products.

(a) Successes include:

(i) Numerous awards for environmentally responsible products
(ii) Naturally coloured cotton that consumers like
(iii) Niche market quantities (small amounts), able to produce cotton
(iv) Initial distribution network

(b) Continuing challenges:

(i) Difficulty in finding domestic spinners
(ii) Fragmentation of production chain (spinning vs dyeing)
(iii) Pre-determined colour preferences
(iv) Globalisation of the market
(v) Lack of government subsidies
(vi) Noncompetitive price
(vii) Market for naturally coloured fabrics is limited to under garments, bridal wear and home furnishings

Stonyfield farm has witnessed explosive growth in its 14 year existence, expanding from regional to international distribution for the following reasons:

(a) Highest quality products available
(b) Unlimited product potential and continuing market
(c) Completely integrated business with farm, product processing and retail
(d) Values-based approach to employee well being and participation
(e) Local school educating people about environmental practices
(f) Interactive marketing including:
    (i) Have-a-cow: educate consumers as to how product is produced
    (ii) Just say Moo: educate consumers to controversial environmental issues linked to product
    (iii) Profits for the planet: 10% of profits donated to organisations and farmers toward advancing sustainable agriculture

New types of markets have expressed interest in the special properties of natural silks. Experience in southern Madagascar from 1993-1996 suggests the premium value of wild silks.

The market for printed textiles is set to grow approximately 2.5% in 2000, tracking world population and the economic recovery in Asia. Digital printing offers the possibility of high profits, from the small volume production of unique fabric designs and finished products as follows:

(a) Recently developed, ink jet, textile printers would allow local artists to design and print fabrics at low cost and volume with high efficiency
  (i) US$ 250K for the printer
  (ii) US$ 2/m^2 for supplies

(b) Companies marketing digital printers include:
  (i) Stork <http://www.storktextile.com/home.htm>
  (ii) Konica <http://www.texart.co.jp/ad/nassenger.html#konica2>
  (iii) Cambridge consultants (in design) <www.camcon.co.uk>.

Non-profit-making organisations offer assistance in production, design and marketing by:

(a) Training artisans to apply indigenous designs and produce finished products
(b) Teaching entrepreneurial skills
(c) Teaching processors how to dye fabrics
(d) Facilitating collaborations with designers
(e) Developing an international market
(f) The future for silks could be bright if we:
  (i) Develop new silks
  (ii) Develop quality control and certification
  (iii) Capture more of the value chain
  (iv) Explore digital printing
  (v) Explore commerce
  (vi) Develop marketing arrangements
(g) Learn from examples like Foxfibre (vertical integration, assure channels to market)

Development of the Textile Industry

The textile industry has gone through a period of rapid expansion that has resulted in a significant drop in the value of silk fabrics:

(a) From 1988-1993 the silk industry expanded rapidly:
  (i) Price of raw silk rose to the tune of US$ 51 per kg in 1989
  (ii) Raw silk production rose by 25,000 tons (60%), outstripping the predicted rise in silk production by 9 years.

(b) China dominates the world market, growing by 16% per year and replaces Japan as the major processor 60% of raw silk products as follows:
  (i) in 1985 made goods equal 3.5% of the value of the Chinese market
  (ii) in 1993 made goods accounting for almost 60% of Chinese silk exports with another 22% in finished fabric
  (iii) Due to "democratization" finished silk became available to middle and lower income groups
  (iv) Silks products for everyday wear
  (v) Consumer perception of silk shifts

(c) In 1991, the "democratization" of the international market caused the price of raw silk to drop by 50% from a high US$ 51 per kg in 1989 to US$ 26 per kg at the end of 1998.
(d) India is second largest world producer of raw silk and the Asian countries continue to be the world's largest consumers.
(e) New and rapidly growing entrants to the market, such as Vietnam, undergo rapid rates of expansion (+29%).
(f) Today the price of silk is roughly US$ 26 per kg.
(g) China remains the dominant producer of raw silk (70% of a total 70,000 tons).
(h) India produces 16% of the world volume of silk products.
(i) Japan is the world's leading silk consumer

24. APPLICATION OF STANDARDS IN THE DEVELOPMENT OF APICULTURE AND SERICULTURE

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Abstract: Standard gives the minimum performance requirements of a product or service (usually referred to as its quality). Quality is the ability to satisfy the needs of a consumer or stakeholder. Standards, therefore, provide an interface, which is responsive to the particular economic and cultural needs of the populace. They serve as the quality reference point, facilitate fair comparison, which is a prerequisite for the promotion of global trade, by removal of technical barriers to trade (TBT) and practical market integration.

Standards are an essential input for any viable and sustainable development. They serve as a means of transfer of technology, increase efficiency and create harmony in the provision of high quality goods and services.

Fully aware of the importance of standardisation, in 1974, the Government of Kenya by Cap 496 Laws of Kenya, created the Kenya Bureau of Standards (KEBS). The Bureau's mission is to enhance Kenya's industrial and commercial competitiveness in the new millennium, through the promotion of metrology (science of measurement), establishment and use of standards, testing and quality management (MSTQ). This is propagated through certification of products, development of management systems and improvement of measurement accuracy.

We are a member of the International Organisation for Standardisation (ISO) and work closely with other standardisation bodies world-wide. KEBS has a well-developed Standards Information Resource Centre (SIRC) and

is also WTO/TBT Enquiry Point and COMESA Focal Point on Measurement, Standards, Testing and Quality Assurance (MSTQ).

In the areas of apiculture and sericulture, the Bureau has already developed standards for honey, beehives, beeswax, neckties and umbrella fabrics (100% silk). Work has already started in standardisation of silk yarn and other silk fabrics. A lot still remains to be done. Our officers monitor through market surveillance and import inspection, the quality of all products covered by Kenya Standards.

The Bureau is committed to render services to researchers and other entreprenuers interested in developing/investing in the areas of apiculture and sericulture, which is bound to contribute to the country's industrialisation process.

The Kenya Bureau of Standards

The Kenya Bureau of Standards (KEBS) was set up in 1974 as a National Standards Body (NSB) in Kenya through an Act of Parliament (Cap 496), with a mandate to undertake and oversee all standardisation activities in the country.

The Bureau's mission is to enhance Kenya's industrial and commercial competitiveness in the next millennium, through the promotion of metrology (science of measurement), establishment and use of standards, testing and quality management (MSTQ). This aims at:

(a) Promoting both local and international trade and
(b) Protecting consumers against sub-standard goods, thus ensuring good health and safety.

KEBS is the national enquiry point for the World Trade Organisation (WTO) on matters related to standardisation and trade. This gives the Bureau the mandate to:

(a) Ensure that technical standards and regulations do not serve as technical barriers to trade

(b) Make available to all Kenyans information on standards and technical regulations from the world over.

Application of Standards in Apiculture and Sericulture

A country can only achieve industrial growth if its manufactured goods are traded freely and are of acceptable quality to consumers, both in the local and international markets. Goods imported into the country must be subjected to the same standards and technical regulations as those applicable to the locally produced goods.

Ladies and Gentlemen, a Standard is a precise and authoritative statement of the criteria necessary to ensure, that material, product or procedure is fit for the purpose for which it is intended. Standards, therefore, give the minimum performance requirements for a product or service, which is referred to as its quality. We have standards for raw materials, manufacture and processing of goods, finished products, handling and packaging, provision of services, quality and environmental management systems.

Standards are used to ascertain, measure or test the quality of goods and services. They can serve as the basic quality reference point when ordering and/or evaluating supply of goods and services. Standards worldwide are developed by technical committees composed of experts, representing various interests such as manufacturers, consumers, researchers and testing organisations, in both the private and public sector.

Inputs in terms of technical expertise and knowledge in the standardisation process, are very crucial if we aim to achieve these at this workshop, i.e. Building African Commercial Insects Farming Industires for the New Millennium. Standards play a key role in the industrialisation process as a means of transfer of technology. They provide the universal language for the exchange of goods and services.

Industrial growth thrives on large and accessible world markets. Our products must be of acceptable quality to consumers in the global international markets. I assure you that, in the liberalised global market we are trading in, any product emanating from the African apiculture or sericulture industry will be subjected to the same quality reference point (standard) as any other and we should strive to invest in quality assurance measures to make our products more competitive.

The Kenya Bureau of Standards is a member of the International Organisation for Standardisation (ISO) and has very close links with other standardisation bodies. We have invested in the development of a world class standards information resource centre (SIRC) and we serve as the World Trade

Organisation (WTO) enquiry point on technical barriers to trade. Currently, the Bureau is the COMESA National Focal Point on measurements, standards, testing and quality assurance. This is a European Union sponsored project aimed at strengthening national bureau of standards in the region.

The Bureau's mission is to spearhead standardisation activities aimed at the growth of our local industries. We wish to facilitate fair comparison of goods and services by the use of standards at the local and international level, thus promoting global trade through removal of technical barriers to trade (TBT) and creating practical market integration.

We at the Kenya Bureau of Standards are ready to work with any organisation that wishes to implement or develop standards in their product development initiatives. We shall give such organisations the necessary assistance through training and technical advice to ensure their goals are achieved. The implementation of standards in our commerce and industry is necessary, if Kenya has to attain the status of a newly industrialised nation by the year 2020. In my capacity as the current ARSO president, I would like to inform you that we are keen to develop and strengthen national bureau of standards in the African region. We have well-funded projects by the European Union and ISO programme for developing countries, which are aimed at the development and strengthening of MSTQ activities in Africa.

Plans are at an advanced stage to start capacity building activities in training scientists and provision of state of the art equipment. The overall goal and interest is to produce quality goods that can trade in international markets. I call upon you to join and support the African Regional Standardisation body (ARSO) and its association organs like the African Regional Accreditation Committee (ARAC). ARAC is the regional accreditation body for certifying all laboratory and quality certification bodies through the African Regional Accreditation Scheme (ARAS), in compliance to ISO Guide on "Compliance Criteria for Accreditation Bodies".

I highly commend the organisers of this workshop and the participants for creating a forum where new industrial investment opportunities will be discussed and possibly created. In the areas of apiculture and sericulture, the bureau has so far developed standards for honey, bees wax, beehives, neckties, and umbrella fabrics (100% silk), methods of test and codes of practice for this industry. We are fully aware that the apiculture and sericulture industry in the African region is not fully developed. There is room for expansion and growth. We must invest to cater for the changing consumer needs, with apiculture and sericulture products becoming more popular.

There is high demand for expansion and investment, especially in honey and silk garment industry for export markets. We must strive to create industries, which add value to our raw products like bees wax, honey and silk yarn and also decrease the production costs. I am sure this investment will save our country/region the need of importation, to create employment and wealth for our people.

Conclusion

Our policy at the Bureau is to establish standards that take care of national, regional and international interests. Standards not only help an industry to thrive and compete, but also guarantee the consumer the expected quality and value for their money. Currently the output of the silk and apiculture industry in Kenya is very low. Undertakings by various organisations have not succeeded to a level that can sustain bulk processing factories, especially for silk processing.

Farmers need to be encouraged to set up more silk and honey production farms, which will ensure adequate output and supply that will trigger the growth and sustenance of the industry in Kenya. This will require collaborative efforts of the various organisations, government and research organisations. Kenya has a great potential of developing these two industries to a very high capacity due to its climatic conditions and readily available market.

The Bureau is ready to support this industry by offering technical advice and consistency on standardisation. Our elaborate testing and metrology laboratories are available for use by industry at reasonable rates.

We have expanded our mandate to inspect all imported and locally manufactured products, to safeguard against unfair competition and create a level playing ground.

As I conclude, I wish to remind you that standards should play a big role in commercial insect farming. Kenya Bureau of Standards is prepared to develop any standards that this sector may require in the future. As the two industries of apiculture and sericulture develop, we have to fully evaluate their impact on the total ecological balance and establish standards to prevent any possible negative consequences.

25. PROSPECTS AND PROBLEMS OF SILK INDUSTRY IN AFRICAN COUNTRIES

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Abstract: Sericulture is a labour intensive agro-based cottage industry, which can provide employment to millions of people living in rural areas. It can be practised under varying agro-climatic conditions with minimum investment and skill. The gestation period to yield is short and many crops can be taken annually. This feature augurs well with the socio-economic conditions of African countries, to pursue sericulture as a tool for generating income and employment for the rural households. The surplus labour, land and ideal climate of this continent can be effectively used to maximise income with minimum investment in a comparatively short span of time.

The world trend in silk production and consumption is also quite favourable. The demand is increasing and the production in major silk producing countries is gradually diminishing, due to a variety of reasons, viz., diversification, affluence, high cost of labour, etc. Hence, African countries have great scope and opportunity to promote sericulture.

However, efforts to introduce and promote sericulture in the African continent have not been very successful and are riddled with many problems. Lack of adequate policy framework, which is suitable and practicable, planning, R & D support, suitable infrastructure, linkages between different segments of the industry, aggressive market promotion and use of local talent, have contributed to the slow pace of development. A continuous and co-ordinated effort will be necessary to sustain and increase the pace of development of sericulture in this continent.

Introduction

Silk is a textile material of limited production. It is a natural material with which humanity has been in love since the dawn of civilisation. Silk being the most exquisite textile fibre continues to enjoy its unique place, seldom challenged by other textile materials. Sericulture, the practice leading to the production of silk, consists of mulberry cultivation, silkworm rearing, silk reeling and weaving. Sericulture, though initially confined to China, has spread to many parts of the world due to certain distinct advantages of the industry. It is a labour intensive cottage industry, which can provide employment to millions of people living in rural areas. One hectare of mulberry can provide employment to about 10-12 persons throughout the year at different stages of its conversion to silk fabrics. The investment needs are low and the gestation period to generate income is very short. It can be practised under varying agro-climatic conditions and 4 to 5 crops can be taken annually under the tropical conditions. The labour involved is light and the practises are simple. Thus, it provides ample opportunity to employ even unskilled women labour. Since silk industry is basically an occupation based on production by masses and not by mass production, it is an ideal tool for rural development. Sericulture can provide opportunities for stable and additional income to landless and marginal farmers.

Global Trends in Silk Production and Consumption

The world production and trend in silk and silk products have undergone radical changes over the last 2 decades, affecting both sources of supply and the nature of demand. Both China and India have overtaken Japan and Korea, respectively, as major producers of raw silk. Their outputs in 1998 at 49,000 and 14,000 tonnes respectively, were far larger than Japan's 1000 tonnes and South Korean 150 tonnes. The decline of sericulture in Japan and Korea is mainly due to industrialisation, high labour cost and reduced land availability for cultivation. These impediments have rendered the silk industry un-economic in these countries and are now net importers of raw silk, to meet the increased domestic requirements. Over the last few years Brazil and Vietnam have also taken steps to increase their production.

The world raw silk production which was at its peak in 1995 at 105,000 tonnes, had declined to 71,700 tonnes in 1998, a decrease of 32% (Table 25.1). This decrease is mainly due to production cut of 36% from 1995 level in Chinese silk production. The silk production in other countries like Brazil, Vietnam, Thailand, etc. have also shown signs of decline after 1995. On the other hand,

the Indian silk industry is slowly, but steadily growing during the past several years, due to its strong domestic market. However, India cannot contribute much to the world silk market, as the growth in domestic demand outspan production.

Table 25.1. Trends in world mulberry raw silk production

	Raw silk production in *Tonnes*							
Country	**1938**	**1970**	**1980**	**1990**	**1995**	**1996**	**1997**	**1998**
China	4850	11124	23485	43800	77900	59000	55000	49400
India	690	2258	4593	10805	12800	12927	14000	14000
Japan	43150	20515	16155	5700	3240	2580	1920	1080
Brazil	30	259	1284	1680	2468	2270	2120	1820
S.Korea	1820	3026	3279	780	346	146	140	140
Others	5920	3818	6704	7320	8284	9600	6420	5280
Total	**56460**	**41000**	**55500**	**70085**	**105038**	**86523**	**79600**	**71720**

Source: DESCO, Zurich

There is a steady growth in silk consumption both in producing and consuming countries. The silk consumption in Japan, USA and Europe, the three major silk consuming countries together, have contributed about 50% of raw silk produced in the world. Judging from the consumption trends, silk demand is growing annually by about 2 to 3%. However, despite the growth in demand and production, the contribution of silk to the world textile fibres is only about 0.2% (Table 25.2). This situation has remained unaltered since the last 3 decades. As already referred, there has been only shifts in production base and the silk has not faced glut in the world market.

Table 25.2. World production of textile fibres

	Production textile fibres in *'000 Tonnes*					
Year	**Cotton**	**Synthetics**	**Cellulosic fibers**	**Wool**	**Silk**	**Total**
1975	11809	7346	2959	1502	49	**23665**
1980	13981	10476	3242	1608	55	**29362**
1985	17540	12515	2999	1673	59	**34786**
1990	18447	15830	2988	1897	70	**39232**
1992	17990	17200	2720	1730	80	**39720**
1995	19200	20200	3000	1600	105	**44105**

Source: ITC Silk Review Report, 1997

Unlike other textile fibres, silk is largely consumed in the silk producing and developing countries, which have the domestic market as their main outlay. India, for example, consumes about 85% of the silk produced in the country (Table 25.3). The export of silk products from the country continues to be directly linked to increase in production and import of raw silk. The latest reports indicate that silk consumption in Japan is reviving and stabilizing. One of the reasons is the surge in interest to western garments and accessories made of silk. Despite the decline in use of kimonos, it continues to absorb about 75% of the silk processed in the country. Recent references from China indicate that, silk consumption is on the upswing, because of improving living standards. Consumption trends in the Republic of Korea appear to be similar to that of Japan.

Table 25.3. Trends in world silk consumption

World silk consumption in Tonnes			
Country	**1982**	**1995-96**	**1997-1998**
Japan	20700	22350	13925
India	3500	15082	16445
China	7500	10000	12000
S.Korea	800	2047	2272
Europe	4530	16015	13363
U.S.A.	5500	24499	23421
Rest of World	10970	13653	11739
Stock variation	-	2555	2796
Total	**53500**	**106201**	**95961**

Source: TDRI Report, 1982, DESCO, Zurich; ITC Silk Review 1997

World Market opportunities for Development of Silk Industry in Africa

The prospects for development of silk industry in Africa is very bright. Silk production in major silk producing countries is steadily declining due to various reasons. Demand for silk fabrics and made-up goods was once restricted to high cost luxury items for a selected clientele at the upper income levels. This

demand has expanded in recent years to include low priced goods within the reach of consumers from the middle income groups. Further, the market for silk items for interior decoration is growing. Germany has been a large market for silk cushion covers. The increasing use of interior decorations is pushing up demand for natural silk. They use silk curtain fabrics and wall coverings, in addition to the usual bedspreads and cushions, to create a total and different look. With the improvement in living standards, the silk consumption in both the silk producing countries viz. China, India, etc. and silk consuming countries, viz. USA, Europe, Japan, etc., is gradually increasing. The global silk demand is growing annually by about 2-3%. With this trend in production and consumption, silk will never be available in larger quantities and international supplies will remain limited in future, unless new production bases are created and nurtured. This world market scenario has thrown open a very good opportunity for the African countries to rapidly increase their silk production. All these developments indicate that the availability of silk in the world silk market, continues to be in limited quantity for a long time.

Prospects of silk industry in African countries

African countries enjoy congenial climate for cultivation of mulberry and rearing of silkworms. The major portion of the continent except the Sahara region and north-eastern desert area, receives annual rainfall 700-3000 mm. The temperature varies between 25-35° C and is fairly stable. There are a good number of rivers flowing across many countries as good source of irrigation. The Congo Basin stretching through the middle of the continent, most of the southern parts, the Nile basin and some of the eastern countries, are suitable for practising sericulture.

Agriculture is the main occupation of the people and contributes 25% to the GDP. About 70% of the total population living in rural areas are mainly dependent on agriculture and allied activities; 75% of the total population fall under the low income group (GNP below US$ 610). The socio-economic conditions, especially in the rural areas, are conducive for practising sericulture as a gainful avocation. Hence, African countries have great prospects and scope for introducing sericulture, if comprehensive and renewed effort to create a new base for silk production is made.

Status of silk industry in African countries

In Africa, attempts to introduce sericulture have been made with considerable external support, but have not resulted into anything significant to global silk

supply. Promising initial steps appear to have been taken in Algeria, Tunisia and Morocco, but are hampered by production of industrially sub-standard qualities of silk. Other countries, viz. Zimbabwe, Zambia, Kenya, Uganda, Nigeria and Botswana, have launched similar efforts, but due to lack of comprehensive and systematic planning, these countries also have not met with much success. In Madagascar, silk industry is affected by low productivity and poor quality of cocoons, though there is good domestic demand. In Egypt, the silk production is affected by the poor quality of leaf harvested from old mulberry trees. The quality and productivity of cocoons are also poor as there is no comprehensive plan to develop sericulture and to introduce modern techniques and practices. In 1995, Uganda undertook a sericulture project aimed to raise income level of small farmers, increase the overall silk production of the country and diversify export. The project sought to produce cocoons for export. Even this initiative is likely to suffer in the long run as there is no effort to organise the vital linkages of seed production and reeling facilities. There is also no organised effort to create and promote domestic and export market as well.

Problems of silk industry

The problems of silk industry in Africa are innumerable and the initiatives are few. The industry lacks direction. From the present scenario as it appears, no serious attempts have been made even to understand the problems. There is no policy framework and planning for comprehensive and integrated development of silk industry in the continent. Sericulture, though identified as an important avocation for rural development and export, appears not to have been integrated with the rural development activities and has hence not received the attention and funds for its planned development.

Even after a decade of introduction of sericulture in the continent, no serious effort has been made to collect the mulberry and silkworm strains and screen their suitability to different agro-climatic conditions. There are problems of crop failures and production of sub-standard cocoons. There is no seed organisation and production system. The seed is still imported from different parts of the world. There are no infrastructure facilities for either seed production or raising of young silkworms. The cocoons are exported and there is no initiative to develop local reeling facilities. The facilities for training of extension workers and farmers are too inadequate. No serious attempts appear to have been made for organising linkage between the different segments of the silk industry and to exploit local weaving talent. Marketing and market promotion seem to have not been attempted. There are large stocks of cocoons unsuitable for export. Above all, there is no apex body/institution for coordinated development of silk industry in Africa.

Conclusion

Sericulture can be successfully introduced only if the industry is properly organised and coordinated. A serious study should be undertaken to identify the problems of the industry and to find solutions. A clear cut sericulture policy should be framed and spelt out taking into consideration the prevailing situation of the region and the priorities. To receive constant attention of the implementing agencies, the silk industry should be integrated with the rural development activity. A serious study should be made to evaluate/develop suitable mulberry and silkworm strains, suited to different agro-climatic conditions. Keeping in mind the socio-economic conditions of the people, the sericulture technology and practices should be introduced. There should be an intensive effort to create awareness and motivate farmers to take up sericulture. Proper facilities should be created to provide intensive training and extension services to the farmers. The requisite linkages of the sector viz. seed production, reeling, etc. must be established and efforts should be made to develop local skill/enterprise in reeling. These 2 linkages are very vital for organised and stable development of the industry.

Forward linkages, like marketing, reeling, weaving, etc. also have to be established along with the other developmental processes. These requirements have to be initially organised, either by Government or the institution responsible for development of silk industry and phased out gradually to private sector, as the industry attains the stabilised production level. Sustained development of the industry, is necessary to dovetail and integrate reeling with traditional domestic weaving. There should be serious effort to organise marketing and market promotion for the silk products. The silk products developed in the region should be branded and promoted, exclusively.

There are distinct advantages in developing local skill in reeling and to establish linkages with domestic weaving sector. The development of silk industry, especially in the tropical region, depending purely on exports, is not very often successful. After the export of cocoons, substantial quantity of lower grade cocoons are left behind. Inspite of best efforts, the situation is likely to persist for a long time. The utilisation of these cocoons, if not planned could render sericulture uneconomical. The local skill in reeling, if developed, will serve the exports and local needs. Similarly, the use of silk yarn in domestic weaving will promote indigenous consumption of silk and a stable market for the producers. Serious effort is also necessary to intensively promote consumption of silk in the domestic market. If 20% of the population living in Africa annually

buy a single scarf each, it can create demand for nearly 5,000 m of silk. If the same quantity is promoted to be bought by the visiting tourists, the demand will be about 10,000 m. If the silk is dovetailed to produce traditional garments, the demand will be much more. Thus, the prospects for promoting silk industry in this continent is good. The prospects will further increase if the sericulture development in this continent is integrated and coordinated to facilitate proper use of resources and market opportunities.

RECOMMENDATIONS

The purpose of the workshop was to enhance the commercial potential and competitiveness of apiculture and sericulture in the next millennium. In order to do this, several general recommendations were made that apply to both specialist fields, while others were made to apply to apiculture and sericulture, specifically.

General recommendations

(a) That ICIPE supports and or seeks support for activities, including research, that add to the body of knowledge in apiculture and sericulture areas.

(b) That ICIPE supports, and/or seeks ways to support the dissemination of this knowledge to end-users, ways by which that body of knowledge can be disseminated and shared in an appropriate form and by all feasible methods, amongst all those who would benefit from it or access to such knowledge and information.

(c) That standards be applied so as to raise the quality of apicultural and sericultural products, so that they are competitive and can take place alongside competitors in world markets,thereby ensuring the success of such micro- economic enterprises that are the very backbone of the African economy.

(d) That another workshop be held in 2 years, giving time for discussion and the construction of practical methods for the development of sericulture and apiculture. This to be facilitated by grouping in the workshop for specialist discussions.

More specialist recommendations were made by the two groups on sericulture and apiculture.

Recommendations for apiculture
(collated by Prof. Ingrid Williams and Richard Jones)

(a) That the workshop had been extremely useful, but needs to be consolidated by providing back-up and information to the delegates involved, so that they do not feel isolated when they return to their posts. We recommend that this be done by ensuring that each

apicultural member of the workshop automatically became a member of IBRA for 2 years, following the workshop. This should be built into the budget at a cost of US$140 per delegate.

(b) That pollination be recognised as a key process in sustainable crop production and biodiversity conservation and that this be underpinned with strategic research, which needs to be encouraged and funded.

(c) That the pollination requirements of crop and native plants be determined.

(d) That pollinator biodiversity be assessed and conserved.

(e) That major nectar and pollen sources for bees be identified, conserved and enhanced by management practices.

(f) That new technologies be developed that are sustainable, wealth creating and build on local traditions and utilise local resources to realise the full potential of beekeeping as an economic activity.

Recommendations for sericulture

(collated by Dr S. Raje Urs)

(a) The workshop has provided a platform to discuss and consolidate the experience and strategies for further development of sericulture in the African Continent. ICIPE can work out a comprehensive strategic plan for introduction and/or expansion of sericulture in different countries and how it could share/disseminate its expertise/experience to facilitate organised development.

(b) That silkworm strains suited to different African countries be screened/ developed and silkworm seed production and distribution system be organised. Similar technologies and practices suited to local conditions and traditions be developed to hasten sericulture development.

(c) That a training and advisory centre be organised to disseminate knowledge and skills.

(d) That reeling requirements and local talents be identified to integrate the reeling with traditional domestic weaving.

(e) That a study team be constituted to identify the problems of sericulture development in African countries and to suggest measures for improvement.

(f) That linkages required for promotion of sericulture be organised and strategy for marketing of silk products be worked out.

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