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The Conservation and Utilization of Commercial Insects

Edited by S.K. Raina, E.N. Kioko and S.W. Mwanycky

PROCEEDINGS OF THE FIRST INTERNATIONAL WORKSHOP ON THE CONSERVATION AND UTILIZATION OF COMMERCIAL INSECTS

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Cover Photograph:

Top: The lunar silkmonth, *Argema mimosae* laying eggs on the leaf of host plant, *Sclerocarya birrea*.

Bottom: African honey bees, *Apis mellifera scutellata* at the entrance of Langstroth hive.

ACKNOWLEDGEMENTS

We are grateful to the International Fund for Agricultural Development (IFAD) for the major research grant to ICIPE to support the First International Workshop on the Commercial Insects for African farmers, to enhance their knowledge base by interacting with the globally renowned sericulture and apiculture experts, through this forum, where farmers had the opportunity to exchange their ideas and constraints. The professional and moral support offered by Dr. Hans Herren, ICIPE Director General is gratefully acknowledged. Drs. Akke Van der Zippe, Johanne Boumgartner and Vitalis Musewe, ICIPE Deputy Director General, Research; Head of Department, Population Ecology Ecosystem Science; and Head of Department, Capacity Building, respectively were a great source of inspiration in the successful organizing of the Workshop. My personal thanks to the Workshop Organizing Committee for contributing their best individually and collectively in making the Workshop a success. Special mention to Esther Kioko, David Kimbu, Vijay Adolkar, Harrison Muiru, and Peter Ngugi for tirelessly working on the Workshop and Proceedings. Excellent video filming and photography by Arun Patel is highly appreciated

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FOREWORD

Dr. Hans R. Herren
Director General, ICIPE

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 as the poverty line, or 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, require small investments, are easy to implement and have a good marketing outlook to assure that whatever capital and training investments are made, will give good returns.

ICIPE has over the last three 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 a solid scientific and capacity building base, established in Africa, near the users. ICIPE has a mandate in promoting insect science for development. The Centre has taken this mandate to its full length, the initiative to create a research; through 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 First International Workshop on the Conservation and Utilization 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 range from full spectrum activities, production to 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, exposing producers to exploitation. It is part of ICIPE's philosophy, to ensure 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 too. 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. To utilize biodiversity will lead to its conservation, this is what is being promoted with the utilization of wild silkmoth, endemic to East and Southern Africa. The utilization of this "natural resource", developed through research, will not only allow for added income, but also for the sustenance of the environment.

I would like to thank the participants to this workshop for their valuable input. I would also like to thank IFAD, for supporting the ICIPE sericulture and apiculture programmes and 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.

SESSION I

a. b. c. d.

Plate 1

Plate 1. Setting of sericulture in East Africa using bivoltine hybrids of *Bombyx mori*: a. the mulberry, *morus alba* plantation; b. disease free egg layings of *B. mori*; c. fith instar silkworms; d. cocoons of *B. mori* on mountage.

A REVIEW OF THE COMMERCIAL INSECTS INNOVATIVE RESEARCH AND TECHNOLOGY DEVELOPMENT IN AFRICA

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Introduction

In Africa, development of sericulture (silkworm rearing) and apiculture (beekeeping) technologies is needed to enhance the income generation potential of small holders. These technologies promote the conservation and utilization of natural resources that are rapidly being depleted. The Commercial Insects Project at the International Centre of Insect Physiology and Ecology (ICIPE), with the support of the International Fund for Agricultural Development (IFAD), is developing innovative sericulture and apiculture technologies focusing on enhancing the productivity and economic returns of small scale land-users in Africa. This project mainly puts emphasis on sustainable utilization and conservation of the natural resources in Africa. The three components: domesticated silkworm rearing for fibre production, conservation and utilization of wild silkmoth species and beekeeping, form the main research spectrum. In this paper, some of the research outputs are outlined. Along the three research components, the project targets to initiate on-site farmer-participatory technology testing and development.

Domesticated Silkworm, *Bombyx mori*

(a) Rearing of Domesticated Silkworm, Bombyx mori

A new domestic silkmoth hybrid which flourishes in the African environment and produces high quality silk has been developed. The hybrid was selected by crossing a number of domestic silkmoth, *Bombyx mori* strains and testing their vigour when grown on the mulberry cultivars available at ICIPE. The silkworm hybrid cross NB18 X NB7 when grown on the mulberry Kanva 2 cultivar, generated the highest silk yield. Other races which are being developed and selected are ICIPE I, ICIPE II, NB_4D_2 Egyptian race, Shuko X Ryuhaku (S X R), Kenshou X Shoku (K X S) from China etc. The field test is being carried out in Nyeri in Kenya. In Uganda the Silk Sector Association is using only K X S race from India and their production has reached 2-3 tonnes per year as compared to Kenya, where production was initiated in 1997 and reached 250 kg; it is expected to rise with time. Tanzania will initiate the production in 1998. About 1kg of raw silk was obtained with approximately 5000 - 6000 green cocoons. All the necessary materials needed to rear the domestic silkworms in the field were constructed using local materials and local labour. The technology was developed in line with the ideas of reputed authors (Jolly, 1987 Ullal and Narasimhanna, 1987).

Major disease problems by nuclear polyhedrosis virus and other diseases was identified. Lime powder therapy with benzoic acid has brought the attack under control.

(b) Screening of Mulberry Cultivars

Seven cultivars of *Morus alba* were screened against the silkworm races ICIPE 1 x ICIPE II, NB7 x NB18, NB4D2, and S x R. Kanva 2 was found to be the most superior in terms of Renditta, thread length and disease resistance. This is followed by Embu and Thailand varieties. Attempts are being made to spread the Kanva 2 variety across East Africa in the farmers' fields. Mulberry plants are subjected to many diseases particularly during the rainy season. Red rust was found to be very common during the rainy season, sometimes attacking the whole field. Preventive measures were established.

(c) Reeling of Bivoltine Silk and Wild Silk Cocoons Established

Reeling and re-reeling units have been installed. Reeling performance of cocoons obtained from the various *Bombyx mori* races was compared. Length of the reeled fibres were determined on a mono-cocoon reeling unit. This helps in the establishment of the best silk fibre producing race for the field release. Out of the four races, ICIPE I, ICIPE II, Egyptian and K X S, the latter has proved to be the best and the average fibre length from a single cocoon was 1120 metres (Fig. 1). However, the least average length of the fibre recovered from ICIPE I was 1009 metres. The renditta performance was also checked for each race (Fig. 2).

(d) Post Cocoon Technology

Post cocoon technology has also been incorporated in the project activities. The cocoons are reeled on bobbins and re-reeled to make skeins which after winding, twisting, doubling and bleaching process are transferred into a warp. The warping constructs a sheet of parallel yarns from the bobbins on a roller drum. The drum is fitted at the rear of the powerloom and the handloom which are already installed and functioning. Weaving, which is the transformation of the yarn into fabric on the power or handloom has been incorporated.

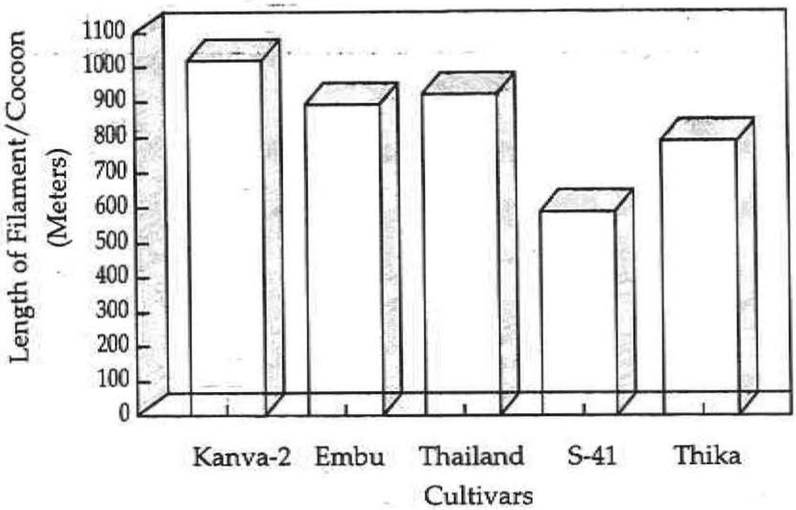


Fig. 1. Filament length of *B. mori* Cocoons (ICIPE I) reared on different cultivars.

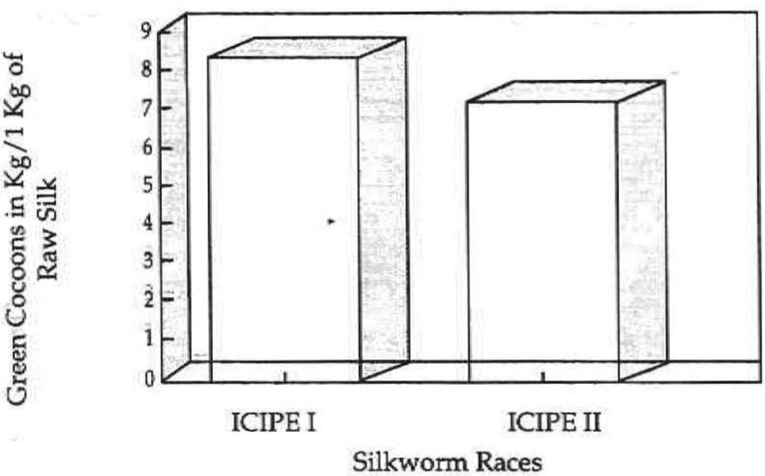


Fig. 2. Comparison of renditta of ICIPE I and ICIPE II.

Wild Silkmoths of Africa

(a) Population Trends of Silkmoth Species Selected for Conservation and Utilization

In Kenya and Uganda, a survey of existing wild silkmoth species was undertaken and two potential species, *Argema mimosae* and *Gonometa* sp. from two Lepidoptera families, Saturniidae and Lasiocampidae, respectively were found, which produce silk of high quality. The larval stages of these species in the field require 30-40 days in *A. mimosae* and 50-70 days in *Gonometa* sp. (Fig 3). Like other species of wild silkmoths (Jolly et al., 1979), they are exposed to attack by predators, parasites and other mortality factors, which result into up to 84% loss of the larvae. Experiments in the field have shown that the high mortality can be significantly reduced by using simple net sleeves to protect the early larval stages. The farmers are required to learn rearing techniques that will decrease silkworm losses and thus increase their productivity. Other institutes and people with interest in wild silkmoths are also involved and are collaborating in enhancing the wild silkmoth research in Africa (Peigler, 1993; Peigler, 1994; Hartland-Rowe, 1992; Chikwenhere, 1992; Akai et al., 1997).

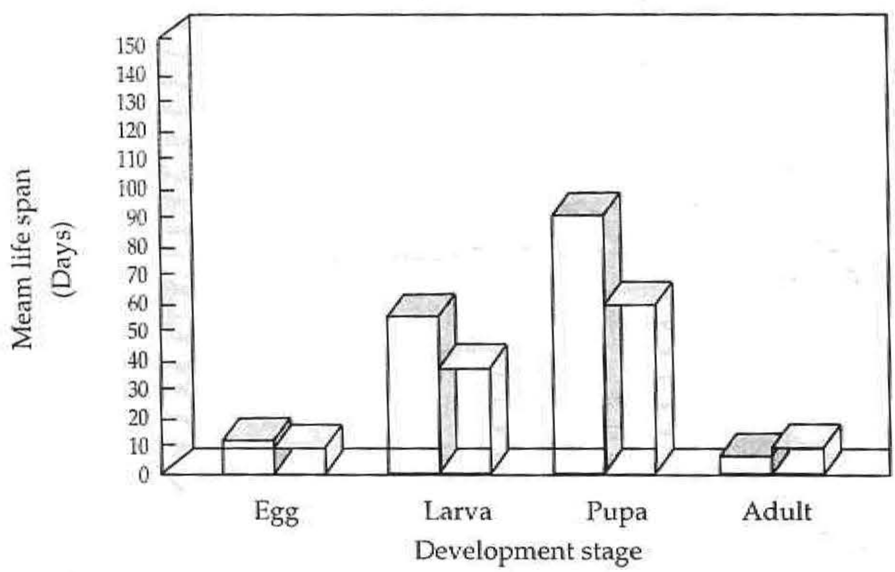


Fig. 3. Life cycle of African wild silkmonths, *Gonometa* sp. and *Argema mimosae*.

(b) Abundance and potential for silk production of silkmoth species in families, Saturniidae and Lasiocampidae across East Africa

Different localities across Kenya, Uganda and Tanzania were sampled for wild silkmoth diversity. Various insect collections in Museums holding East African insects were examined and silk cocoon forming species recorded. Sixty five species were recorded in the two families. This is an indication of a high potential of successful silk production in this region.

(c) Morphological Studies on the Different Stages of the Silkmoths

Scanning electron microscope studies have been carried out to taxonomically characterize the eggs on the basis of specific chorionic structure (Figs.4-7). The cocoon and filament structures are also being studied (Akai et al., 1997).

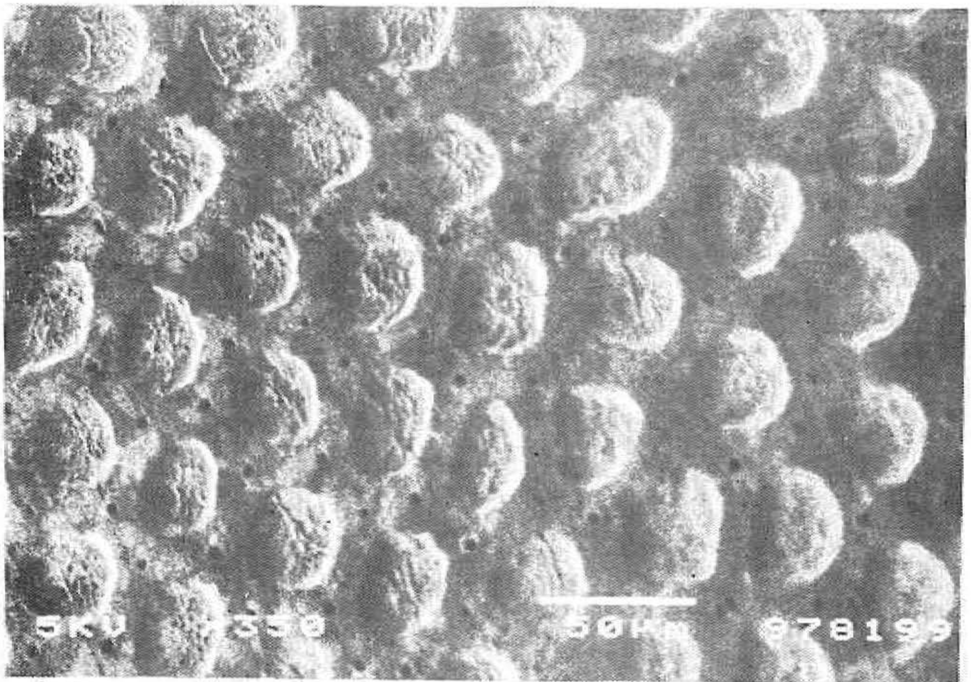


Fig. 4. Chorion surface of *Argema mimosae*

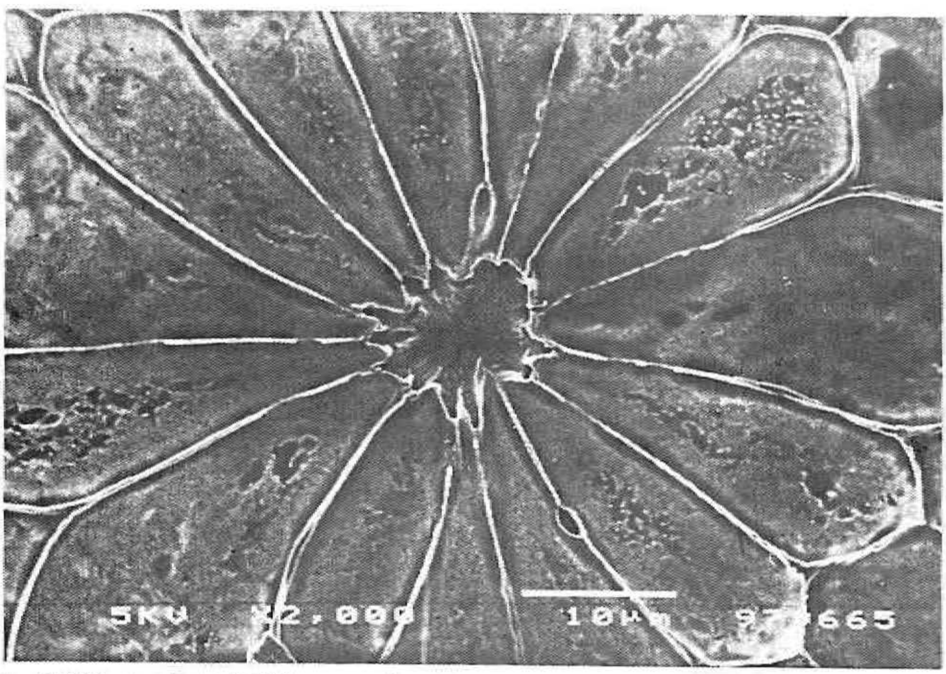


Fig. 5. Micropyle end of *Argema mimosae*

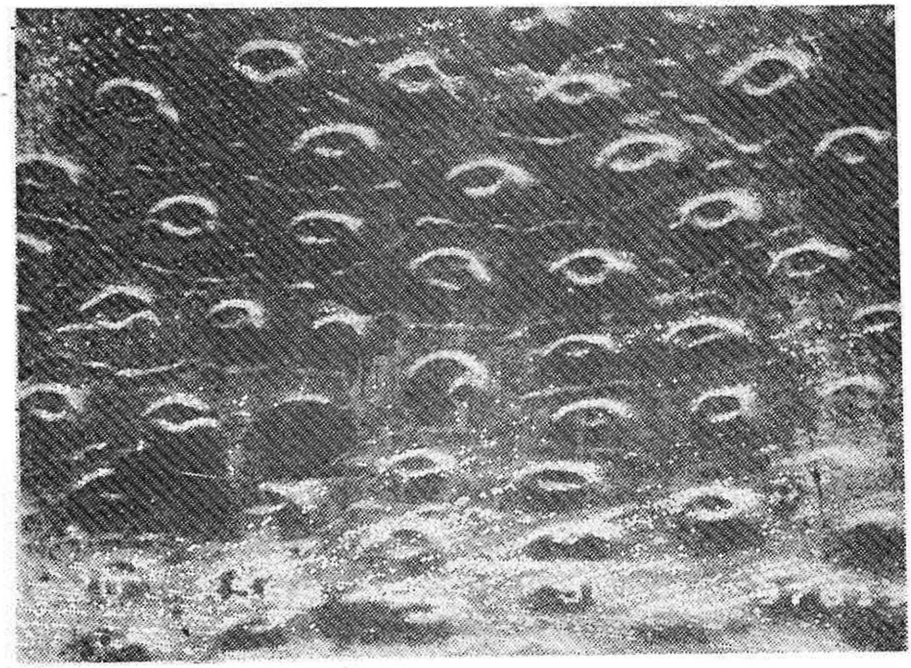


Fig. 6. Chorion surface of *Gonometa* sp.

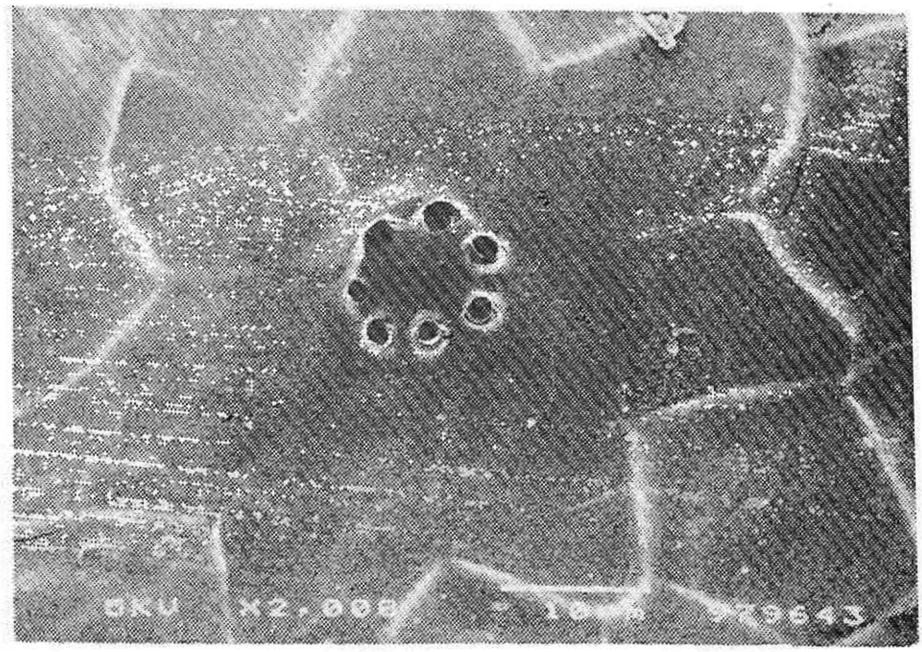


Fig. 7. Micropyle end of *Gonometa* sp.

Apiculture

(a) Floral Calendar

The population dynamics of bees depend on the seasonal flowering. Floral calendars, which catalogue flower type, abundance and month and duration of bloom, are being developed from a variety of beekeeping areas. The calendar indicates the season of nectar flow and needs to be produced in the ecological regions where beekeeping is practiced and honey dearth periods of the regions recorded.

(b) Bee Swarming and Migration

Bee swarming and migration are a major problem to beekeeping in Africa. The main reason being the dearth period and lack of colony splitting knowledge to beekeepers. The swarming and migration routes of East Africa bee races are being explored. The results of morphometric studies of the various pure or hybrid races of the bees in Kenya can be correlated with the swarming pattern of the bees across places from where the samples were collected (Table 1, Fig. 8).

Table 1. Mean value and standard error; F ratio(bottom) of 6 morphological parameters of honeybee, *Apis mellifera* races in 7 different regions of Kenya

Localities altitude(m))	WL	WW	CI (RatioA/B)	LL	PROB	ANTL
Mombasa	47.513D	15.350D	2.439AB	58.050D	28.068C	21.309CD
75	0.134	0.060	0.078	0.188	0.512	0.100
Mwingi	47.884D	15.438D	2.335B	57.675DE	30.584B	21.266CD
650	0.174	0.077	0.079	0.300	0.171	0.125
Kitui	48.000D	15.859C	1.941D	56.963F	31.416A	21.490C
850	0.125	0.056	0.066	0.240	0.170	0.123
Kimana	50.741A	16.694A	2.269BC	60.197B	32.100A	22.894A
1250	0.135	0.063	0.048	0.220	0.294	0.106
Kakamega	51.041A	16.272B	2.078CD	61.056A	32.213A	22.988A
1680	0.198	0.071	0.044	0.267	0.268	0.120
Central	48.853C	16.063C	2.558A	57.391EF	30.175B	21.047D
1950	0.159	0.061	0.068	0.129	0.261	0.056
Kinangop	49.919B	15.931C	2.244BC	58.619C	31.931A	21.894B
3200	0.171	0.114	0.055	0.145	0.136	0.124
F ratio	46.44	21.91	6.89	31.13	19.61	26.40

N.B: Means with the same letter are not significantly different.

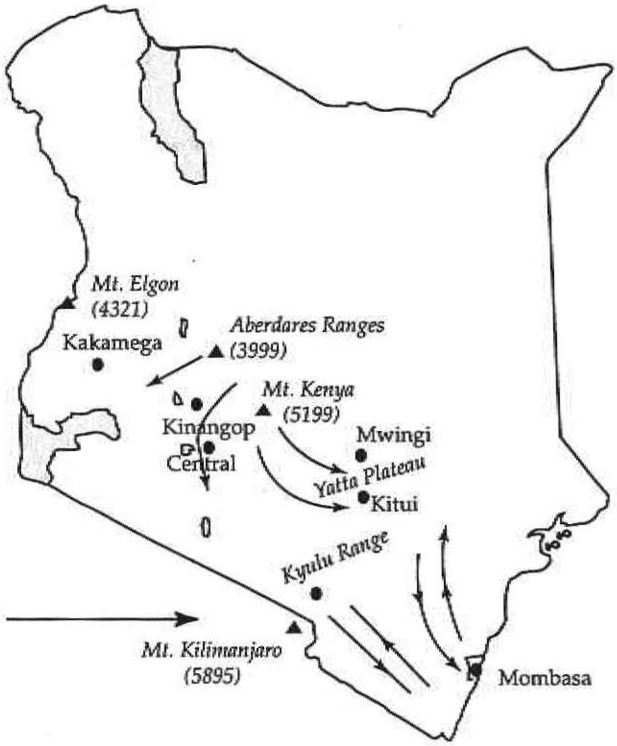


Fig. 8. Swarming and migration pattern of three *Apis mellifera* races in Kenya

(c) Spread of Langstroth Hives

There are two types of hives that are used commonly in beekeeping in Africa. The output from these hives is very low and no hive product other than honey and wax could be produced. To make beekeeping more profitable and sustainable, an innovative hive called the Langstroth hive was introduced in East Africa and its advantages are being compared with the other hives already in use. Queen rearing becomes simplified and colony multiplication easier (Morse, 1994; Morse and Hooper, 1985). Other hive products such as royal jelly, propolis, pollen and bee venom are harvested. The extra products will increase the income of beekeepers and small holders. The beekeepers in Kenya, Uganda, Ethiopia and Tanzania are being encouraged with incentives to try modern beekeeping.

(d) Breeding of African Queen of A. m. scutellata and Artificial Insemination

A major breakthrough in beekeeping was achieved by developing and improving queen-rearing techniques (Morse, 1994). The rearing of queen bees coincides with the onset of rainy seasons in East Africa. Young queens were reared in queenless and queenright colonies. The latter method proved to be more advantageous. The results so far indicate that the peak reception of queen cells was achieved during May to July in both queenless and queenright colonies. Queens were artificially inseminated with specific drones in an attempt to select desirable behavioural traits in the offspring. Ideally, this technology may resolve the behavioural defects of African honeybees (such as aggressiveness and absconding) and may lead to the development of a better breed of bees for both hive products and pollination services.

(e) Royal Jelly and Bee Venom

Royal jelly from bees has been used for centuries for its remarkable health and rejuvinating properties. It is the food fed to the queen larvae by young workers. Two different honey bee races, *A. m. scutellata* and *A. m. monticolla* were compared on the basis of royal jelly production. The preliminary results indicated that *A. m. monticola* is superior in royal jelly production, producing approximately 35% more than *A. m. scutellata*. The cell receptivity and climate suitability for royal jelly production in different races is being assessed.

Bee venom is produced in the bee's venom gland and stored in the venom sac. Bee venom stimulates the heart and the cortico-adrenal glands. It induces cortisone production which makes it possible for the treatment of rheumatic disease, especially arthritis. A simple technique to collect bee venom that does not harm the bees was designed. The milking capacity of different races is being evaluated. Other bee venom devices (Simics, 1995; YaoChin, 1993) are being compared for appropriate optimum production.

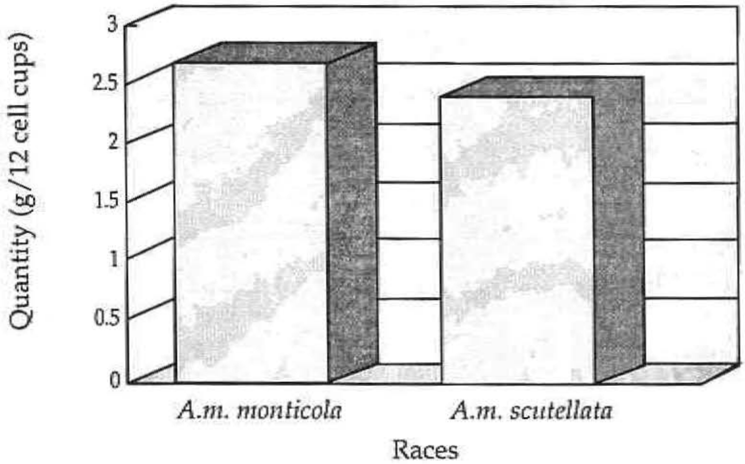


Fig.9. Royal jelly secretion in *A. mellifera* races

(f) Survey on Pest and Diseases in Honey Bee Colonies in East Africa

The African bee industry is in its infant stage of modernization and not much research has been carried out on bee diseases. Samples examined from East

African traditional and Langstroth hives did not reveal any brood and adult bee diseases or mite infestation. However, the wax moth, *Galleria mellonela* has been a major problem to beekeepers in Africa. In our laboratory trials, the use of microbial pesticide, *Bacillus thuriengiensis* (*Bt*), has given results and attempts are being made to test this method of control in infected apiaries. The honey quality after the *Bt* spray will be analysed.

(g) Quality Control and Marketing Design

A laboratory to process and package the honey and bees wax for the market, from both the traditional and Langstroth combs has been established and farmers are being trained in these techniques. The art of candle-making has been introduced for the farmers as a source of additional income. At ICIPE, a quality control laboratory has been established to test the HMF, diastase, sugars pH, prolines invertase and the moisture contents in the honey produced by the beekeepers.

Graphic summaries of results so far obtained for 5 different samples compared to maximum or minimum limits allowed by International Trade Commission are as depicted below.

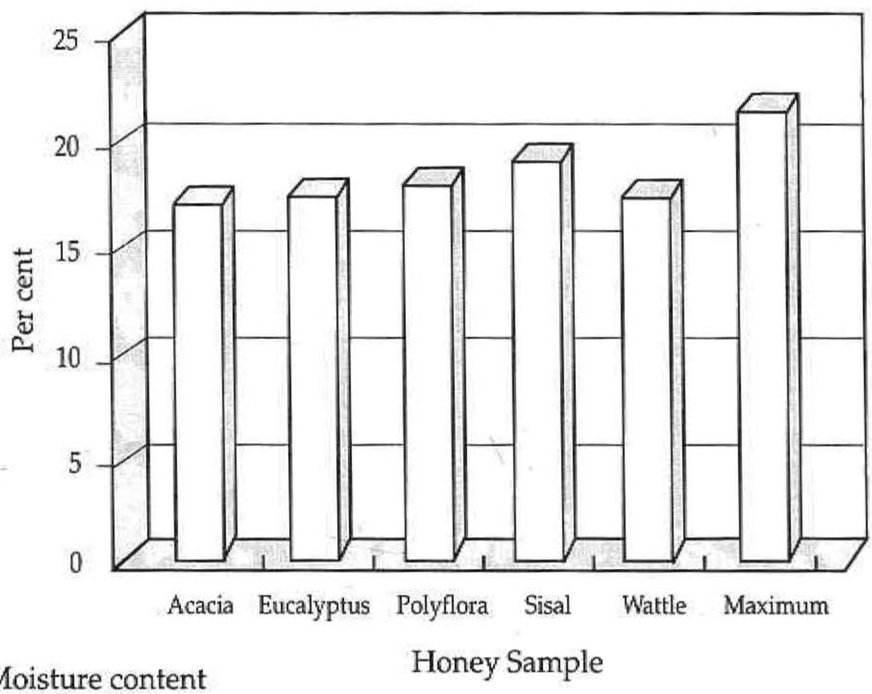
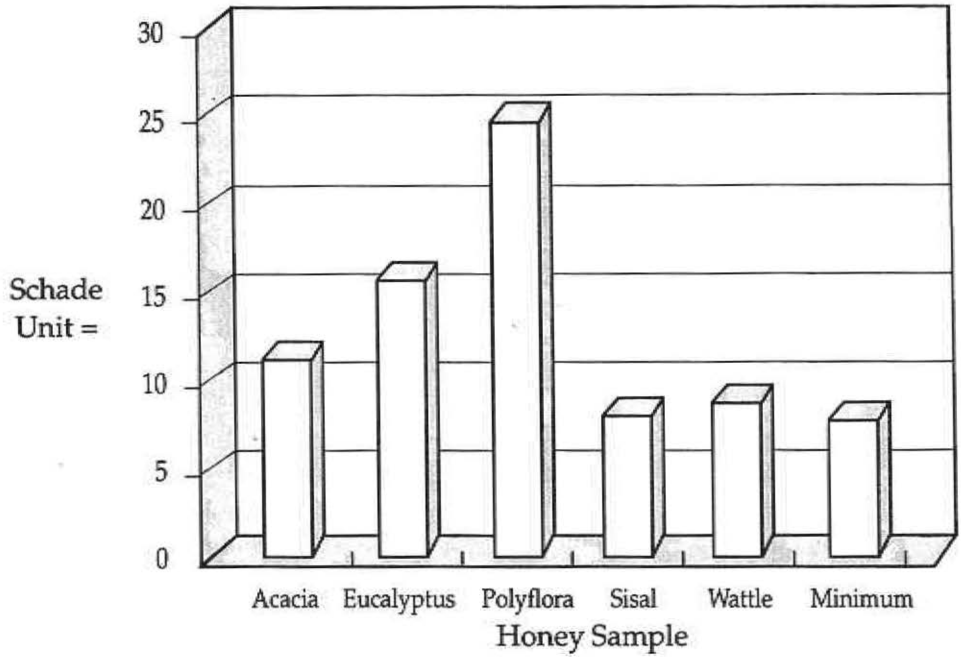


Fig. 1. Moisture content



Schade unit = is the amount of diastase acting on a fixed amount of starch within a fixed amount of time.

Fig. 2. Diastase content

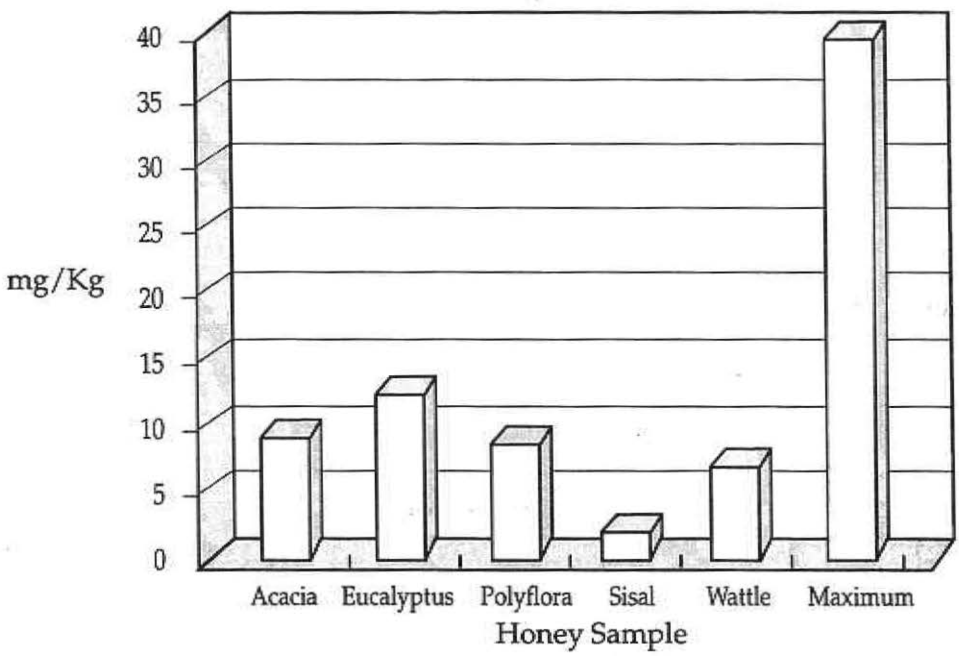


Fig. 3. HMF content

A marketing strategy for the beekeepers of East Africa has been designed and national and international outlets established for the sale of honey and other hive products.

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RECENT ADVANCES IN SERICULTURE AND SERI-BIOTECHNOLOGY IN INDIA

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Abstract

India made more than ten-fold increase from the period of 1960s to 1990s and is second largest producer of silk after China. This increased production of silk per unit area is through the development of new silkworm and mulberry varieties and appropriate practices for rearing and cultivation, protection of mulberry and silkworm against pests and diseases and expansion of sericulture in new areas.

Central Sericultural Research and Training Institute (CSRTI), Mysore developed excellent bivoltine breeds like KA, NB4D2, NB7, NB18, CA2, CC1 and popularised multi x bivoltine hybrids in the field. During the 1990s, new silkworm breeding programmes with emphasis on the higher survival (above 95 %), cocoon shell ratio (above 23 %) and neatness (above 93 %), resulted in the development of new productivity CSR bivoltine hybrids as part of the National Sericulture Project in collaboration with Japan International Co-operation Agency (JICA). These hybrids have been popularised in the field on a large scale.

To overcome the constraints of developing hardy bivoltine silkworms suitable for tropics and with higher silk contents. CSRTI started biotechnological research, especially recombinant DNA technology in order to find out the molecular markers correlated to quantitative traits loci (QTLs) in silkworm. RFLP, RAPD and many satellite probes were used to identify these markers for gene-tagged breeding. Similarly, the molecular basis of disease resistance in silkworm was tested by studying the antibacterial and antiviral protein produced. These proteins were isolated and the amino acid sequencing was done, to enable isolation of genes responsible for controlling the resistance to diseases. A model transgenic system for the transfer of genes has also been developed in collaboration with the European Partners under EC Project. This is applied in Sericulture for the transfer of gene controlling traits of commercial importance.

Introduction

Indian sericulture represents a well-knit agrobased cottage industry. In India, especially in southern states, sericulture has emerged as a minimum investment, but rich dividends industry. This has helped India to emerge as the second largest producer of silk in the 1980s. In more than 60,000 villages, about 6 million people from the poorer society, practice sericulture. One hectare of mulberry plantation generates employment to nearly 13 people annually in mulberry cultivation, silkworm rearing, reeling, weaving, dyeing and trading (Jolly, 1987). Sericulture, being highly land and labour intensive is an ideal activity for small land holders. Sericulture offers regular and frequent source of cash income compared to other agricultural activities. Studies conducted by CSRTI, Mysore during 1995 revealed that 48.3 % of the price (gross value) of Indian silk fabrics produced is received by the cocoon producers, 21.6 % by traders, 11.2 % by weavers, 9.6 % by reelers and 8.1% by twisters (Mattigatti et al., 1996).

India is the only country which produces all commercially known varieties of silk *viz.*, Mulberry, Tasar (both temperate and tropical), Eri and Muga. The non-mulberry silks constitute about 9 % of the national silk production and are concentrated in north-east (Assam) for Eri silk, eastern Deccan for tropical Tasar and north-eastern states for Oak Tasar and Muga. Mulberry silk contributes to over 90 % of the total silk produced in the country (Table 1). Out of the total production of 13,899 MT during 1995 - 1996, Mulberry silk alone accounted for 12,884 MT.

Table 1. Raw silk production by variety (in Tonnes)

Raw silk variety	Production
Mulberry	12,884
Tasar	194
Muga	86
Eri	745

Mulberry Sericulture in the Past

Prior to independence, sericulture in India was considered as a subsidiary occupation of the poor farmers. The industry was characterised by low yielding mulberry varieties which yielded 4 and 15 MT / ha, respectively, under rainfed and irrigated conditions, and low producing silkworm hybrids, predominantly

PM x C. nichi hybrids with 15-20 kg cocoon yield/100 dfls in southern tropics (Datta, 1984). The lack of technological know-how, low productivity of indigenous races, poor renditta (16-20) and frequent crop failures were reasons for the poor returns. In 1947, the silk production was limited to 800 MT with very low productivity (13-14 kg/ha). The silk recovery was only 10-12 % of very poor quality (C grade). In the post independence era with the establishment of the Central Silk Board (CSB), emphasis was laid on development of appropriate technologies for the tropics through its research institutes established during the sixties. Breakthrough in research, especially in the development of new mulberry varieties, silkworm breeds and practices for mulberry cultivation and silkworm rearing, and their adoption in the southern states, helped India to achieve increased silk production. Due to research efforts in the seventies, the mulberry acreage increased from 82,954 ha in 1960s to 155,164 ha in 1980; cocoon production from 19,918 to 55,890 MT and ultimately, the raw silk production increased to 4114 MT, four-fold production compared to 1154 MT in 1960 (Table 2).

Table 2. Improvement in mulberry acreage and silk production during 1980s

Year	Mulberry acreage (ha)	Cocoon production (MT)	Raw silk production (MT)
1960	82,954	19,918	1154
1970	98,571	34,255	1781
1980	155,164	55,890	4114

Recent Advances in Sericulture

Breakthrough in R & D during 1980s, increased silk production was achieved during 1995-1996 to 45 kg/ha (Datta, 1996) as follows:

(a) Mulberry Varieties

The predominant mulberry varieties of traditional sericulture belts are Local and Kanva-2. The local variety yields 15-20 MT/ha under irrigated and 4-5 MT/ha under rainfed conditions of southern tropics. Kanva-2 was recommended during late sixties and is now popular in all sericulture states of the country. This has a yield potential of 30-35 MT/ha/yr. Table 3 gives an account of different mulberry varieties evolved by various institutes of CSB. During 1996, a unique variety V1 was evolved by CSR and TI, Mysore, which yields 70 MT/ha of leaf yield under irrigated conditions and has gained popularity in the southern states.

Table 3. Mulberry varieties recommended for different regions

Sl. no.	Variety / Region	Yield (MT/ha)	
		Irrigated	Rainfed
1.	Local (Southern Tropics)	12 - 20	4 - 5
2.	Kanva 2 (Southern Tropics)	30 - 35	12
3.	MR 2 (Southern Tropics)	25 - 30	–
4.	S 54 (Southern Tropics)	43	–
5.	S 36 (Southern Tropics)	38	–
6.	S 13 (Southern Tropics)	–	10 -12
7.	S 34 (Southern Tropics)	–	15
8.	S 1 (Eastern sub-Tropics)	30	12
9.	TR 10 (Hilly areas of eastern and northern sub-tropics)	25	–
10.	S 1635 (Eastern sun tropics)	40	–
11.	V 1 (Southern Tropics)	70	–

(b) Agronomical Package

In traditional areas, mulberry is cultivated in rows at spacing of 45 x 10 cm. At present, the recommended spacing for mulberry is 60 x 60 cm in the irrigated areas and 90 x 90 cm in rainfed areas, with a fertilizer dosage of 300:120:120 and 100:50:50 NPK kg/ha/yr, respectively. In India, mulberry is propagated mostly through cuttings. Under row system (45 x 10 cm), more cuttings are required resulting in more plants per unit area, but the yield level does not vary significantly with 60 x 60 cm spacing after establishment. Recent findings indicated that paired row system of plantation with a spacing of (90–180) x 60 cm, produces an equivalent amount of leaf as produced under 60 x 60 cm spacing. This type of plantation also provides scope for mechanisation (Ramakant et al., 1997).

(c) Silkworm Breeds

During the 1970s, the farmers were rearing low yielding multivoltine breeds (C.nichi x Pure Mysore) in South India and with the introduction of bivoltines in Karnataka State, the farmers switched over to multi-bivoltine hybrids. Since then, improvement in cocoon quality and yield have taken place as shown in Table 4. As a result of introduction of improved hybrids, the renditta has improved to the present level of 9.2 (Datta, 1996).

Table 4. Average performance of silkworm races and hybrids

Sl. No.	Race/ Hybrid	Yield/10,000 larvae No.	Yield/10,000 larvae Wt. (kg)	SR %	Filament length (m)	Denier
1.	Pure Mysore	8867	9.644	14.20	452	2.20
2.	Nistari	9175	9.375	13.20	462	2.08
3.	PM x C.nichi	7325	8.886	12.07	497	2.32
4.	PM x NB4D2	9141	16.000	17.90	732	2.55
5.	KA	8428	16.602	19.07	828	3.06
6.	NB4D2/NB18	9538	18.317	21.20	972	3.14
7.	KA x NB4D2/ NB18	9383	19.083	20.50	1035	3.00
8.	CSR 2	8994	17.409	24.77	1088	3.17
9.	CSR 5	8230	14.713	24.03	947	3.23
10.	CSR2xCSR5	9705	19.740	24.10	1218	3.08

The CSR breeds exhibit a renditta of 6 and the quality of silk produced is also of international quality (2A-4A grade). Due to superior quality, the cocoons fetch a higher price of Rs 175-200 per kg compared to Rs 130 in case of other hybrids.

(d) Integrated Disease and Pest Management.

Various disease control measures were recommended for mulberry leaf spot, leaf rust, powdery mildew and root knot. Recently, eco-friendly approaches using biocontrol agents were developed for disease control. Integrated pest control has been developed with biocontrol agent as one of the components for the control of mealy bugs causing 'tukra' in mulberry.

"Resham Keet Oushadh", a silkworm bed disinfectant which was developed during the 1980s is very popular in the field for control of silkworm diseases, which account for about 30% loss. In 1996 "Vijetha", a four-in-one bed disinfectant, was developed and it reduces the disease pathogens in the silkworm bed. Apart from controlling the disease incidence, it increases the cocoon yield by about 10 kg per 100 kg (Table 5).

Table 5. Performance of "Vijetha" and "Resham Keet Oushadh" (RKO) in field

Treatment	Cocoon yield per 100 kg
Vijetha	49.67
RKO	45.58
Control	39.84

Biotechnological methods (immunodiagnostic kits, dipsticks) were developed for the detection of young silkworm diseases which are being tested in the field for adoption (Nataraju et al., 1994).

Uzifly, a serious pest of silkworm, is controlled through Integrated Pest Management (IPM) consisting of Uzicide spray, release of biocontrol agents and Uzitrap in a liquid formulation developed in the institute, reducing uzifly infestation by 77% (Kumar et al., 1993).

Advances in Seri-Biotechnology

Rapid developments in biotechnology promise to revolutionise the plant and animal breeding procedures in the near future. The advent of recombinant DNA technology has made it possible to isolate and clone genes from any organism. However, the impact of the powerful and sophisticated approaches of modern biotechnology are just beginning to be felt in sericulture.

Some of the key traits for molecular dissection could be disease resistance, thermotolerance, high productivity (both quality and quantity) and growth rate, which are to be selected during the course of breeding. The first step in this direction is to develop molecular map of the silkworm genome.

(a) Genome Analysis of Mulberry Silkworm Using Molecular Markers

DNA markers like RFLPs, RAPDs, VNTRs have provided unlimited polymorphism to the entire genome. High density saturated molecular maps are being developed for most of the important crop plants and livestock (Patterson et al.,1988; Tanksley and Nelson,1996).

The mulberry silkworm, *Bombyx mori* has 28 linkage groups and the classical genetic linkage map of 217 loci developed so far is based mostly on morphological and a few biochemical markers (Doira, 1992). Most of these are deleterious mutants which have limited value and their number is insufficient for a thorough understanding of the genome. Genome analysis of *Bombyx mori* using molecular markers has been initiated (Shi et al.,1995, Promboon et al.,1995). During 1993, Central Silk Board established a Seribiotech Research Laboratory in Bangalore for conducting research in frontier areas of molecular biology and to harness the benefits of its applications in sericulture (Datta,1995).

RFLP and RAPD analysis was taken up using silkworm strains representing diverse geographic origin and yield potential. DNA of these strains was isolated, purified and digested with specific enzymes, electrophoresed and Southern transferred. The Southern blots were hybridised with MAG transposable element. The results showed high level of DNA polymorphism. To detect RFLP markers closely linked to cocoon parameters, parents showing contrasting attributes have been selected and NILs are being developed. Partial genomic library of 0.5 to 3 kb size has been constructed in plasmids. The recombinant clones are being screened for inserts and low copy clones. Southern blots of DNA from the contrasting parents are being hybridised with the isolated low copy probes which are labelled for detecting RFLP markers for cocoon traits (Datta, 1995). Application of PCR based RAPD and DNA fingerprinting with minisatellite probes has been taken up to study the DNA profiling of silkworm genotypes (Nagaraja and Nagaraju, 1995). Each genotype revealed distinct and unique DNA profile which was specific to diapausing and non-diapausing strains. The study indicated their potential use in understanding genetic relationships and as powerful tools to generate markers that are linked to traits of interest in silkworm.

(b) Understanding Molecular Basis of Resistance to Silkworm Diseases

In India, most of the damage is caused by viral and bacterial diseases, which result in 30 % or even more crop losses. Among the silkworm diseases, the most dreaded one is grasserie caused by BmNPV.

It has been established that the defense reaction in silkworm against BmNPV triggers the production of anti-viral substances in the digestive juice and viral inhibitory factors (VIF) in the haemolymph (Aizawa, 1991). It was also reported that red fluorescent protein (RFP) and alkaline proteases in the gut juice show antiviral activity (Funakoshi and Aizawa, 1989). Work was initiated for the isolation, purification and characterisation of the antiviral proteins in the digestive juice. The protein was purified through Sephadex - G100 column. Three fractions (A, B and C) were collected and pooled. Fraction A had 66 kD, fraction B showed 32 and 35 kD and fraction C contained 28, 32 and 35 kD proteins. Out of these, two bands of 28 and 66 kD were found to show clear anti-viral activity. The N-terminal sequence of the 28 kD protein was found to be Phe-Asp-Leu-Gly-Glu-

Arg-Asp-Val-Val-Phe, and that of 66 kD protein was Glu-Gln-Gly-Ala- Tyr-Arg-Val-Pro-Trp-Phe-Phe-Lys-Ile-Leu (Datta et al., 1997)

Insects do not have immune system that involves antigen-antibody reactions, but have efficient self defense mechanisms like phagocytosis, encapsulation and humoral responses against bacterial infections. The humoral responses mainly involve production of a variety of anti-bacterial substances like cecropins, attacins, defensins, diptericins and lysozymes (Boman and Hultmark, 1987). An induced antibacterial protein was isolated and purified in this institute from the haemolymph of mulberry silkworm infected with *Escherichia coli*. The purified protein was a single polypeptide chain of 16 kD. The 20 N-terminal amino acid sequence of the protein was determined and this sequence showed homology with those of lysozymes reported in other species (Abraham et.al., 1995).

(c) Silkworm as a Model Transgenesis System

A collaborative research endeavour comprising multidisciplinary and multinational teams involving Indian and European laboratories in France, Italy and Belgium has been initiated during 1995. The joint proposal entitled "Molecular genetics of silkworm: Fundamental studies and applications to sericulture" envisages exploitation of silkworm as a model organism to study the molecular aspects of gene expression and development. Further a transgenesis system for the transfer of cloned genes into the germline or somatic cells of silkworm, similar to those available in other insects like *Drosophila* is proposed. As a result, microinjection techniques, electroporation and other methods of direct introduction of DNA into the eggs or early embryos are being worked out (Nagaraju et.al., 1996). Mobile elements like the *Bombyx* retrotransposon mag, vertebrate retroviruses and also the baculovirus BmNPV, which are pathogenic to silkworm, will be exploited for efficient insertion of the injected DNA.

Once the gene transfer methods are perfected, they offer tremendous application in sericulture. They have potential for the germline transfer of genes controlling traits of commercial importance (survival/disease resistance) to the productive bivoltine breeds.

(d) Development of Immunodiagnostic Kit

The silkworm, *B. mori* is susceptible to many diseases caused by pathogens, namely protozoa (*Nosema* sp.), bacteria, fungi and virus (NPV, CPV, IFV), resulting in heavy crop loss. It is assumed that specific monoclonal and polyclonal antibodies raised against various silkworm pathogens and purified antibodies could be employed for detection of these pathogens at very early stage to take up effective control measures. Both monoclonal and polyclonal antibodies which are specific to pebrine spore and nuclear polyhedrosis (NPV) virus have been purified. These antibodies attached with latex beads when mixed with the pebrine or NPV infected haemolymph, give a visible agglutination. Polyclonal antibodies for NPV developed by the institute are being used now for developing "Dip Stick" and "Antibody Capture Assay" for easy and quick diagnosis of those diseases. Antibodies of IFV, DNV 1 and 2 were also developed for detecting these pathogens in the field by immuno diffusion technique (Nataraju et.al., 1994).

(e) Biological Control of Uzifly

The uzifly, *Exorista sorbillans* is a well known endoparasitoid of silkworm, *Bombyx mori* causing considerable loss to the sericulture industry every year. Recently, several parasitoids, *Nesolynx thymus, Dirhinus* sp., *Trichopria sp.* and *Exorista philippinensis* have been noticed to be highly destructive to maggot and pupal stages of uzifly. Uzifly population was brought down considerably (80 %) through an integrated pest management approach by releasing the parasitoid, *Nesolynx thymus* and spraying of uzicide on the silkworm body (4th and 5th stages), where eggs are laid by the fly (Kumar et al., 1993).

(f) Semisynthetic Diet for Young and Late Age Silkworm

A suitable semisynthetic diet for both young and late age silkworm consisting of varying levels of mulberry leaf powder, defatted soybean flour, rice flour, corn starch, cellulose, inorganic salt mixture, vitamin mixture, ascorbic acid, citric acid and carraghenen has been developed. A mass scale rearing under standard rearing conditions with 10 dfls of PM x NB4D2 for each diet of CSRTI and Japanese were brushed along with leaf controls. The larvae were reared on their respective feeds. The results indicate that economic characters of the silkworm reared on artificial diet are comparable to those of the control (the difference being non-significant).

(g) Mulberry Improvement Through Biotechnology

Conventional breeding of mulberry coupled with improved agronomic practices have contributed to the improvement of foliar production, nutritive value and palatability. Many new plant breeding methods are now available through emerging applications of tissue culture. Novel plants have been produced through protoplast fusion and electroporation of desired genes in many plant species.

(i) In Vitro Screening for Tolerance to Specific Stress Conditions

In vitro selection procedures are being widely used to isolate, characterise and select the plants having salt tolerance, disease resistance and herbicide resistance in various crop species. These techniques could be efficient to detect the mulberry genotypes for tolerance to alkalinity, salinity and drought conditions. The studies conducted so far show that mulberry could be multiplied in large scale using tissue culture technique with 90 % survival. *In vitro* screening of the plants under culture indicated that some mulberry accessions can tolerate pH up to 9.4 in alkaline conditions and 4.6 in acidic conditions. It can tolerate 12 to 14 bar (80 g/ PEG) osmotic potential in drought conditions. Large scale screening for specific traits is being carried out.

(ii) Azotobacter Biofertilizer as Supplement for Chemical Nitrogenous Fertilizer

Nitrogen fertilizer is not only a costly input but is also not readily available in time. Hence, a lot of thrust is being given to curtail the requirements of chemical nitrogenous fertilizer through a cheap source of biological nitrogen fixation.

In a field experiment carried out at CSRTI, Mysore and subsequently confirmed at farmers' land, *Azotobacter chroococcum* biofertizer @20 kg/ha/yr was found effective in curtailing the chemical nitrogenous fertilizer input to the extent of 50 % (Das et al.,1994). The leaf yield and other quality parameters, including silkworm rearing, were found at par with that recorded in plots receiving the recommended dose of nitrogen (300 kg ha/yr).

(iii) Development of Suitable Mycorrhizal System for Mulberry Production

Vesicular arbuscular mycorrhizal (VAM) association and its beneficial effects on mulberry for phosphate assimilation and uptake are important areas of research. Curtailment 75% of chemical phosphate manuring by application of VAM has been achieved. Further work on introduction of efficient strains of VAM in established mulberry gardens is under progress (Katiyar et al., 1995).

Impact of Research and Development in Indian Sericulture

The increase in silk production the country achieved during 1970s and 1980s (Table 6) was based on research breakthrough by CSRTI, through popularisation of agronomical practices for mulberry cultivation, development of productive bivoltine silkworm breeds KA, NB7, NB18 and NB4D2, using appropriate rearing technologies and release of Kanva-2 mulberry variety. These new technologies were transferred to the field through joint extension drive by DOS and scientists of CSRTI, Mysore from 1970. There has been a total shift from using multivoltine eggs to multi x bivoltine eggs at commercial level and 80 % of the local variety mulberry gardens are replaced by Kanva - 2 variety and over 2500 acres with new S varieties.

The major impact of research is as follows:

(i) The cocoon production/ha has increased from 293.8 kg/ha/yr to 403.3 kg in1976.

(ii) The raw silk production/ha has increased from 13.9 in 1960 to 47.5 kg in 1995.

(iii) The raw silk % has doubled from 5.8 in 1960 to 10.7 in 1996.

(iv) The overall renditta has come down from 17.2 in 1960 to 9.2 in 1996.

(v) The area under mulberry has increased from 82,954 ha to 288,510 ha during 1960 to 1996

(vi) Export earning which was negligible in the 1960s has reached 9000 million rupees in the 1990s.

Table 6. Mulberry raw silk production and growth rate

Period	Raw silk production (MT)	Annual growth rate (%)
1950 - 1959	960 - 1141	2.1
1960 - 1969	1154 - 1758	5.8
1970 - 1979	1950 - 3979	11.6
1980 - 1989	4193 - 10905	17.8

Overall Economic Benefit

The economic benefit that has been generated through sericulture R & D, mainly as an impact of improvement in productivity, can be computed from the base year 1960. The estimated raw silk production for the increased acreage of 350059 ha (in 1994) in 1960 should be roughly 4867 MT.

Table 7. Improvement in renditta and raw silk %

Factors	1960	1970	1980	1990	Current level
Mulberry cocoon production (MT)	19,918	34,255	55,880	110,433	128,349
Raw silk production (MT)	1154	1781	4114	10905	13913
Renditta	17.2	19.2	13.6	10.1	9.2
Raw silk (%)	5.8	5.2	7.4	9.9	10.7

The actual production of 13,913 MT of raw silk (Table 7), which is 185 % over the estimated production, assuming that productivity has not increased, is contributed by three factors, namely, higher mulberry productivity (49%), cocoon productivity (52%) and cocoon quality improvement (raw silk %, 84%). The total value of all silk products would have been only Rs 1400 crores without the production and productivity increase through research over the years, as against the current actual value of nearly Rs 4000 crores.

Relevance of Technologies for Development of Sericulture in Africa

The agro-climatic condition of Africa, especially East African countries, is tropical with wet and dry seasons. The temperature varies between 18 °C in January to about 25 °C in July. The average rainfall ranges between 958 - 1200 mm, with maximum in April - May. However, in some parts, there is a second wet season in November - December. Thus, the conditions are similar to those of South-East Asian tropical countries practicing sericulture, especially India, Brazil and Thailand.

Sericulture in Africa could be developed by adoption of sericultural technologies already developed in tropical countries like India, especially the rearing of bivoltine silkworm hybrids, silkworm disease management practices such as early disease detection and their prevention production of quality mulberry leaf and cultivation of high yielding mulberry varieties. The 90 people trained at CSR&TI, Mysore on Tropical Sericulture could establish and develop sericulture in other countries.

Once sericulture is introduced and successfully established, it is important to develop the specific regional production base, especially silkworm breed, breed maintenance technology and commercialization of seed production to meet the demands. The knowledge available from a tropical country like India, should be used with appropriate local modifications.

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EFFECTS OF NATURAL AND ARTIFICIAL DIET ON THE LARVAL GROWTH AND COCOON AND SILK QUALITY OF SILKWORM, *BOMBYX MORI L.*

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Introduction

Silk-producing started in China five thousands year ago. It is a traditional exchange-earning industry. Silk-raising industry is an important occupation in Rural areas of many countries. Traditional sericulture is a labour-intensive production, ideally suitable for exploiting the rural plentiful labour resources, providing the needed jobs or additional earnings for the labour or semi-labour (men and women) in rural area. In China, 1980s, when the progress and development of the rural economy, village and town-owned industry developed rapidly, rural labours transferred from farming to industry; meanwhile the pollution from farm chemicals and industry were serious and the damage caused by *Nosema bombysis* was heavy. All these conditions are dangerous to sericulture. It is essential to study artificial diet rearing, to stabilize and develop the Chinese sericulture.

Artificial diet rearing is an up-to-date technology in sericultural industry that changed the traditional pattern of a must to plant first before silkworm rearing. Artificial diet rearing of silkworm has the advantage of saving labour, using field for planting mulberry tree sparingly, reducing the damage caused by environment pollution and silk disease, rearing silkworm in any season, etc.

To enhance the practicality of silkworm artificial diet rearing, we studied the necessary technologies to Chinese conditions.

(i) To lower the artificial diet cost (Table 1)

(ii) To draw up the practical standard of artificial diet rearing for young stage silkworm

(iii) to select and breed the silkworm races that are suitable to artificial diet rearing (Tables 2 and 3, Fig. 1)

Results and Discussion

We compared the effects of mulberry leaf and artificial diet rearing on the larval growth (Tables 4 and 5 and Figs. 2 and 3), cocoon and silk quality of silkworm. The results suggest that setae dispersion of newly hatched larvae and the growth of young stage worm reared by artificial diet are uniform. The grown silkworm is vigorous, large and strong. The cocoon and silk quality of artificially reared silkworm is superior than that reared on mulberry leaf (Table 6) within a certain extent, such as good cocoon rate, percentage of releable cocoon, cocoon filament length, unwinding ratio, length of non-broken cocoon filament and raw silk rate, etc. The study showed that the cocoon of silkworm reared with artificial diet is up to the standard for reeling high grade of raw silk (Tables 7 and 8).

The cocoon and raw silk production of China accounted for large proportion of the world production (Table 9), but we should take into consideration the fact that the sericulture in China (Table 10) in the past took advantage of the population, especially in rural area and that was extensive technology. In pace with steady growth of Chinese economy, especially the development of rural industry, most of the rural labour was transferred to industry; there is an urgent need to enhance the labour-productivity.

As seen in above table, the labour-productivity of sericulture is lower than that of other crops (Table 11). It will be important to study the artificial diet rearing and to extend this technology.

Figure 1. Brief processing technology of artificial diet

Mulberry leaves ——> Boiling ——> Drying 600°C ——> Grinding ——> Sieving

drying in the sun

Material ——> Drying ——> Grinding ——> Sieving

Additives

——> Ingredients ——> Mixing ——> baging ——> boiling or steaming

mixing ——> storing in 5-8°C

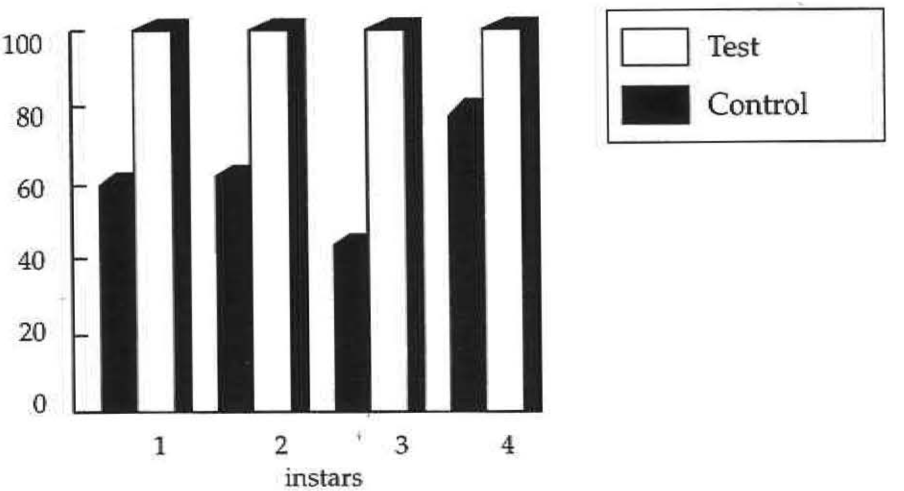

Figure 2. Effect of artificial diet rearing on the larval body weight

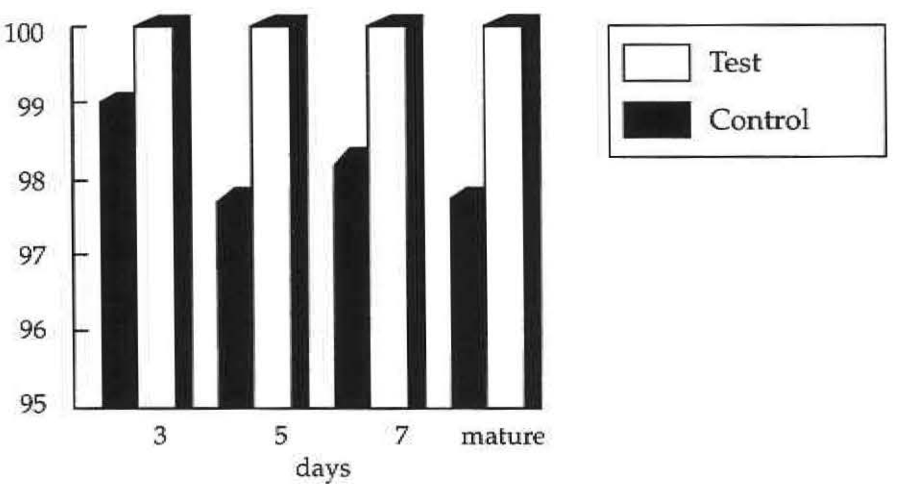

Figure 3. Body weight index of 5th Instar Larval

Table 1. Comparative study of the production cost of silkworm rearing between artificial diet and mulberry leaf

Items	Artificial diet rearing (1-2nd instars)	Leaf rearing (1-2nd instar)
Food	5.9 (yuan)*	3.00(yuan)
Labour	6.50	16.25
Heating	2.50	2.50
Disinfecting	1.50	1.50
Total	16.40	23.25

* 1US$ = 8.3 Yuan).

Table 2: Status of sericulture in the World

	Cocoon (T)	Raw silk(T)
1980	477240	55116.2
1984	535515	55813
1988	615200	59334
1990	731000	70920
1992	864000	86262
1994	972000	97800
1996	952000	90200

T: Metric tonne

Table 3. Ingredient of improved artificial diet requirement

	Instars		
Items	1-2	3-4	5th (g)
mulberry leaves powder	30	28	25
bean cake powder	30	33	40
corn powder	20	23	25
sugar	4	4	4
citric acid	3	3	3
VBp mixture	1	0.5	0.5
Vc	1	0.5	1
inorganic salt	2	–	1.5
caragean(agar)	3	–	–
antiseptics	0.3	0.3	0.5
Total	100.3	100.3	100.0

Table 4. Effect of different diet shape to the setae dispersion rate of newly hatched larvae

Diet shape	1	2	3	Average
Plate	95.50	88.00	100.00	94.50
Slice	90.90	89.40	94.00	91.60
Cylinder	97.00	97.20	83.70	97.60

Table 5. Comparitive performance of the silkworm larvae development

	Larval duration (day: hours)					
	Instars					
Items	1	2	3	4	5	Total
Test	4.2	3.16	4.12	5.15	7.22	25.18
Control	3.10	3.45	4.08	5.14	8.03	24.15

Table 6. Comparison of the silk quality

Item	Artificial diet rearing	Leaf rearing(control)
cocooning rate%	95.42	98.73
rate of dead worm cocoons	11.63	12.15
good cocoon rate%	88.24	87.44
filament length	1345.79	1361.41
length of non-broken filament	894.95	891.8
reliability	66.50	65.46
silk/cocoon	0.4160	0.4175
reeling discount of deflossed cocoons(kg)	230	226
raw silk rate	4357	44.33
filament size(d)	2.559	2.502
cleanliness	95.35	94.14
neatness	91.2	92.57

Table 7. Comparative study on the cocoon production of artificial diet and leaf rearing in rural condition

Rearing type	Rearing quantity (egg boxes)	Cocoon (kg)	Cocoon/box (kg)	Cocoon no. /kg cocoon
1-2nd instars with artificial diet rearing	5	197.5	39.5	500
Leaf rearing (control)	2	82.5	41.1	494

Table 8. Cocoon quality of silkworm reared by artificial diet and mulberry leaves

Rearing type	Fresh shell for 50g cocoon (g)	Dried shell weight(g)	Cocoon weight (g)	Cocoon shell weight(g)	Cocoon shell rate (%)
Artificial diet rearing in young stage	10.83	9.6	2.00	0.44	21.88
Leaf rearing (control)	11.00	9.77	2.03	0.45	22.00

Table 9. Production Percentage of China to the World

	cocoon output(t)			raw silk(T)		
	China	World	%	China	World	%
1981	241500	479370	50.38	26439	52920	49.96
1990	478500	731000	65.46	42973	70920	60.59
1991	511500	733000	69.75	48486	76420	63.45
1992	640000	864000	74.07	56246	86262	66.82
1993	746220	871000	85.67	76470	80415	92.78
1994	776910	972000	29.92	72548	97800	74.07
1995	759836	952000	29.81	64613	90200	71.63

The resources are from: Silk society of China.

t = metrics tonnes

Table 10. The status of sericulture in China

Date	Mulberry Cocoon(ton)	Silk(10,000T)	Fabric (100 million)
1950	33720	–	–
1960	62370	–	–
1970	121500	1.67	4.32
1980	249850	3.54	7.59
1990	478500	5.66	17.12
1991	550541	6.07	24.06
1992	659522	7.33	32.42
1993	7216202	7.65	–
1994	776910	7.25	–
1995	759836	6.46	–

Table 11. Comparative study of economic effect between sericulture and other crops

	production cost		labour		total output value		net profit	
	yuan/mu	index	days/mu	index	yuan/mu	index	yuan/mu	index
grain crops	25.17	100.0	17.4	100.0	65.05	100.0	20.29	100.0
oil crops	22.52	89.5	19.0	109.2	67.75	104.2	24.15	119.0
cotton	47.32	188.0	45.1	259.2	164.37	252.7	67.86	334.5
tobacco	61.62	244.8	62.8	360.9	221.15	340.0	93.78	462.2
fibre crops	39.83	158.2	55.1	316.7	179.51	276.0	81.00	399.2
tea	45.01	178.8	53.6	308.0	156.76	241.0	51.97	256.1
cocoon	98.08	389.7	98.8	567.8	303.48	466.5	101.99	502.7

1 mu=667 square metres
1 yuan=7.2 shilling
1US$=8.3 yuan

SELECTION METHODOLOGY AND ITS EFFICIENCY FOR IMPROVING RESISTANCE TO CPV IN *BOMBYX MORI*

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Introduction

The aims of silkworm breeding for disease resistance are to develop some practical varieties which have both higher resistance and better economic characteristics required by the market. Therefore, the improvement of the resistance of races to cytoplasmic polyhedroses virus (CPV) should first be considered carefully and the economic characteristics should not be lower than those which are normally found in production during the breeding process. The paper presents a preliminary report on the selection methodology and its efficiency for improving resistance to CPV in *Bombyx mori.*

Material and Method

(i) Experimental races: Zhenongl, Dong 34, Dazao.

(ii) Preparation CPV solution:

(a) Higher concentration CP, 10^8 CP/ml was made and kept at 5°C

(b) Just before infection, after adding 0.2 M $Na_2 Co_3$ - $NaHCO_3$ buffer solution to make a dilution of 10^8 CP/ml, the polyhedrosis was opened and the solution was adjusted to pH7.

(c) The higher concentration adjusted CPV solution was diluted into several lower CPV concentrations with distilled water which were used for infection to experimental need,

(d) Oral infection: Each 2ml for 10^5 ,10^4,$1/2x10^5$, $1/4 \times 10^3$,10^3 and 10^2 CPV solutions was spread on the back of a 100 cm^2 piece of mulberry leaf. One leaf piece with CPV solution was fed to each of the 600 larvae at the second instar, just after ecdysis, and the controls were fed the same size pieces of mulberry leaf with distilled water. After the infected mulberry leaves were eaten completely, the larvae were changed to normal feeding until they matured.

(e) Examination of CPV Infected Larvae: Generally, as the infected larvae developed into the 4th and 5th instars, the symptoms were seen in different degrees according to races, infection CPV concentrations and feeding conditions, in the rearing trays. The larvae developed slowly and non - uniformly. The larvae were taken out of the rearing trays and recorded only after they were found to be CPV diseased. The cocoon characteristics were investigated in the normal way.

(f) Resistance Selection: Two infection methods were used. In one, the experimental races were infected with CPV in each generation, successively. In another, the experimental races were infected with CPV in alternate generations. Mass selection was used for experimental races and control and in each generation the sound pupae were kept to cross - breed.

Results

Selective Resistance Efficiency

In spring 1989 and 1990 Dong 34 and Dazao were tested for their resistance after they were infected with CPV for 7 successive generations.

Table 1. Test for CPV select resistance efficiency (sound pupae rate %)

	1989			1990	
Concentration CP/ml	10^5	1/2x10	Concentration (CP/ml)	10^3	$1/2x10^3$
Dong34S	76	84.4	Dong34S_8	68.3	83.7
Dong34CK	64.8	85.2	Dong34CK	44.2	65.4
DaZaoS,	74.6	93.8	DazaoS_8	80.3	88.1
DaZaoCJ	70.8	94.8	DaZaoCK	77.3	88

S7,7 successive generation of CPV selections, Sr, x successive generations of CPV selection

Table 1 shows that after 7-8 successive generations of CPV selections under 10^5 CPV concentration Dong 34 sound pupae rate was 17.3-54.5% higher than the control group, but in the same situation, Dazao sound pupae rate was only 3.9-5.3% higher than that in the control/group. Moreover, under the $1/2 \times 10^5$ concentration selections of 7-8 generations, the resistance improvement for both races was not significant.

Performance Test of Resistance and Cocoon Characteristics

The S_7 larvae of Zhenong1 were selected from larvae which had been infected with CPV for seven successive generations. The S_4N_4 larvae also from Zhenongl, were selected from larvae which had been infected with CPV in alternate generations, 4 generations infected with CPV, 4 generations selected without CPV). After S_7 and S_4N_4 larvae had passed through CPV treatment, it was found that the average proportions of sound pupae were 65 and 61%, respectively. The rate of sound pupae in the S_7 treatment group was only 4% higher than that in the S_4N_4 treatment group.

Table 2. Performance of the cocoon characteristics in S_7 and S_4N_4 of Zhenong1 S_4N_4 of Zhenong 1 (Index)

Season	treatment	10^3 (CP/ml)			$1/2x10^3$(CP/ml)		
		Cocoon weight	Cocoon shell weight	Cocoon shell ratio	Cocoon weight	Cocoon shell weight	Cocoon shell ratio
1987	S_4	88	87	99	97	97	100
Spring	S_4N_3	100	100	100	100	100	100
1988	S_3	91	86	94	95	92	98
Spring	S_2N_3	100	100	100	100	100	100
1989	S5	88	94	96	99	95	96
Spring	S_2N_4	100	100	100	100	100	100
1990	S_1	88	91	103	92	92	101
Spring	S_4N_4	100	100	100	100	100	100
Average		91.5	89.5	98	95.8	94	98.8
		100	100	100	100	100	100

In Table 2 the average cocoon weight index, cocoon shell weight index and shell ratio index in successive CPV treatments were 8.5,10.5 and 2 lower, respectively, under the 10^5 CPV infection concentration, But under $1/2 \times 10^5$ CPV infection concentration, the averages for the above three characteristics were only 4.2, 6, and 1.2, lower, respectively.

CPV Concentrations for Treatments

Table 3. The sound pupae percentage under different concentrations

Concentration (CP/ml)	Spring			Autumn		
	10^5	$1/2x$ 10^3	$1/4x$ 10^3	10^5	10^4	10^3
Dong 34	44.2	55.5	80.2	7.5	5.6	13.3
Zhenong 1	16.5	37.5	71.8	4.5	14	22.2
DaZao	20	52.7	84.2	10.6	14.3	32.3

From Table 3, the CPV 10^5,$1/2x10^5$,and $1/4x10^5$, could be used in spring rearing. In Autumn rearing, the CPV 10^5, and 10^4 concentrations were too high, hence not practical; it was better to use CPV 10^3 or 10^2 concentrations for infection, depending on rearing conditions.

Comparisons of Cocoon Characteristics Between CPV Treatment in each Generation and Control

After cocoon harvesting, first the abnormal cocoons were taken out of trays both in treatments and controls. Only the rate of picking out in the treatments were higher than those in controls. The cocoon characteristics were then investigated as shown in Table 4.

The average indexes of cocoon weight and cocoon shell weight of Zhenong1 treatments were a little lower than those in the control group except the cocoon shell ratio. Both treatments for the Dong 34, and their controls were close to each other in their average indices. All the average indices of the treatments were 1-2 lower for the Dazao than those in their controls.

Conclusion

In resistance selection for CPV, the improvements of resistance vary in different races. The successive CPV selection in each generation could result in a slightly faster increase in resistance, but the alternate CPV selection would improve both resistance and cocoon characteristic. Using higher concentrations can ensure that the sound pupae rate keeps to 20 -30%. The lower concentrations used may result in sound pupae rate of 40-500%, depending on different regions, seasons, rearing conditions, and so on. In order to attain good results, the selection sample size should be sufficiently large.

Table 4. Comparisons of cocoon characteristics in CPV treatments and controls

	Dazao						Dong 34						Zhenong1					
Characteristics	Cocoon weight		Cocoon shell weight		Cocoon shell ratio		Cocoon weight		Cocoon shell weight		Cocoon shell ratio		Cocoon weight		Cocoon shell weight		Cocoon shell ratio	
	T	CK	T	CK	T	CK	T	CK	T	CK	T	CK	T	CK	T	CK	T	CK
1986 spring	96	100	78	100	82	100	100	100	102	100	105	100	103	100	108	100	104	100
1987 spring	100	100	99	100	99	100	91	100	89	100	98	100	89	100	84	100	94	100
1988 spring	98	100	100	100	102	100	89	100	87	100	98	100	89	100	88	100	101	100
1989 spring	102	100	107	100	104	100	105	100	109	100	106	100	100	100	95	100	96	100
1990 spring	101	100	104	100	104	100	108	100	113	100	105	100	87	100	88	100	102	100
Average	99	100	98	100	98	100	99	100	100	100	102	100	94	100	93	100	100	100

T:Treatment

CK:Control

STRATEGY FOR DEVELOPMENT OF GRAINAGE FOR SILKMOTH EGGS IN AFRICAN CONDITION

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Global Trends in Silk Production

Global silk production has undergone drastic changes over the last few decades. There has been shift in production base. Japan and South Korea which were once major players in silk production have shown a steady decline (Table 1). China and India have rapidly increased the production to replace Japan and Korea as major producers of silk. The decline of sericulture in Japan and Korea is mainly attributable to their rapid industrialisation, limited rural manpower, higher wage levels and prohibitive shifts in the cost of sericulture. However, the annual world raw silk production has not increased significantly.

Table 1. Trends in World Mulberry Raw Silk Production *(Tonnes)*

Country	1938	1970	1980	1990	1992	1994	1995	1996 (Provisional)
China	4850	11124	23485	43800	54840	72000	64613	59000
India	690	2258	4593	10805	10658	12550	13450	12884
Japan	43150	20515	16155	5700	5100	3900	3228	2578
Brazil	30	259	1284	1680	2280	2520	2468	2270
S. Korea	1820	3026	3279	780	660	780	643	480
Others	5920	3818	6704	7320	6900	6600	7115	9600
Total	**56460**	**41000**	**55500**	**70085**	**80438**	**98350**	**91517**	**86812**

Source: International Silk Association (ISA), Sericologia (1995, 1996).

Silk being the most exquisite textile fibre continues to enjoy unique place, seldom challenged by other textiles. Judging from the consumption trends, silk demand is growing annually by about 2-3%. In recent years there are signs of decline of sericulture in China (Table 1). Hence, the prospects for development of sericulture lie in the third world countries which have ideal socio-economic conditions and climate for practising sericulture.

Advantages of Sericulture

In the context of global situation, sericulture can be adopted as a tool for alleviating problem of massive rural unemployment and for generating income for the rural population in the third world. The advantages are that sericulture is labour intensive and one hectare can provide employment to about 10-12 persons throughout the year in various activities of sericulture, viz. mulberry cultivation, rearing, reeling, weaving, etc. Mulberry can be cultivated on a variety of soils and 4-5 crops can be conveniently taken under the tropical climatic conditions. The investment required is minimum and the gestation period to generate income is also low. Sericulture can be practised both by small and large scale farmers and the product can be exported. All these advantages augur well for adopting sericulture in the developing countries.

Table 2. World Production of Textile fibres ('000 Tonnes)

Year	Cotton	Synthetics	Cellulosic fibres	Wool	Silk	Total
1975	11809	7346	2959	1502	49	23665
1980	13981	10476	3242	1608	55	29362
1985	17540	12515	2999	1673	59	34786
1989	18800	16000	3200	2000	67	40067
1990	18447	15830	2988	1897	70	39232
1991	20830	16440	2860	1940	75	42145
1992	17990	17200	2720	1730	80	39720

Source: UNSO/ITC Comtrade Database Systems, 1993.

Potential for Sericulture Development in African Countries

African countries enjoy congenial climate for cultivation of mulberry and rearing of silkworms. The soils are suitable and the required labour is also available. The socio-economic conditions, especially in the rural areas are also conducive for practicing sericulture as a gainful agrobased rural cottage industry. As already mentioned, there has been only shifts in production base and the silk has never faced glut in the world market. The silk production in the world is still very small compared to the other natural and man made fibres (Table 2). Its share is only about 0.2%. The demand for silk is growing gradually, but steadily at an average rate of 2-3% per annum. Hence, the African countries have great opportunities and scope for introducing sericulture with comprehensive and renewed effort to create a new base for silk production.

Status of Sericulture in African Countries

In Africa, attempts to introduce sericulture have been made with considerable external support, but have not resulted in major contribution to global supply as yet. 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. The other countries viz. Zimbabwe, Zambia, Kenya, Uganda and Bostwana have launched similar efforts, but due to lack of comprehensive and modernisation effort, these countries also have not met with much success. Some of the major constraints which have hampered sericulture development in these countries are non-availability of egg production facilities and silkworm strains adapted to the region; absence of cocoon processing facilities; lack of applied research base, trained manpower and local training facilities; and absence of intensive extension effort.

Activities of Sericulture

Sericulture mainly involves mulberry cultivation, silkworm rearing, silkworm seed production, silk reeling and weaving. Each activity is intertwined closely with the other. The performance at each stage affects the other. However, when sericulture is introduced, the importance of seed production is usually compromised and this becomes a stumbling block for further progress.

Importance of Seed Quality

Successful sericulture depends mainly on supply of disease free silkworm seed in adequate quantities to the farmers on time. The silkworm seed supplied, should be of disease free and high yielding variety, adaptable to the agro-climatic conditions of the region. Since many crops are raised in a year, the seed quality and timely availability becomes all the more important as the performance of one crop affects the successive crops.

Present Status of Seed Production in African Countries

Many of the African countries that have introduced sericulture during the last decade, suffer for want of good quality seed to sustain sericulture. There is no organised effort to evolve suitable silkworm races adaptable to the respective countries or to develop a sound seed organisation/infrastructure to meet the internal demand for seed. Even decades after introduction of sericulture, the silkworm seed is being imported from other countries. Problems in hatching, performance and timely supply are encountered, but no visible effort to organise seed production has been made in the African countries.

Disadvantages of Import of Seed

The difficulties encountered in import of seed are innumarable. Timely supply is not guaranteed, the cost of seed is high, adaptability is not ensured and even hatchability of the seed is quite often affected by mishandling in transit and replacement takes long. Hence, it is essential that the requirement of seed should be met locally to ensure successful crop and to sustain sericulture.

Seed Organisation

The seed organisation mainly consists of breeding lab for development/ identification of suitable silkworm strains adaptable to local conditions. Seed farms, for organised multiplication of parental silkworm strains for seed. Seed rearers for raising disease free parent seed cocoons in large numbers for hybrid seed preparation, and Seed Production Centres (Grainages) for preparation of disease free commercial hybrid seed to raise cocoons for reeling.

Breeding Laboratory

Availability of silkworm strains adaptable to the local conditions are critical for successful sericulture. The breeding labs collect germplasm from various sources and develop suitable strains. These strains once developed and tested for their adaptability, productivity and quality are authorised for commercial exploitation. Sometimes pure silkworm breeds are also collected from international organisations like International Sericulture Commission and screened for their adaptability and commercial exploitation.

Seed Farms

The authorised breeds are subsequently subjected to further multiplication to increase the availability of seeds for production of hybrid seed. These farms rear silkworm under prescribed conditions following the norms and procedures of selection to ensure the vigour and disease free parent seed cocoons. Depending on the quantum of seed required 2 or 3 stages/tier multiplication is carried out. These stages are called P3, P2 and P1. P3 and P2 centres have qualified technical and skilled personnel and are normally kept under government control to maintain pure and disease free breeds.

Seed Farmers

The P1 seed generated by the P2 farm are distributed and reared by selected, experienced and skiled seed farmers. This practice is adopted as the rearing at this stage is on large scale and cannot be economically done in farms. These seed farmers rear P1 seeds and supply parent seed cocoons to the commercial grainages (Seed Production Centre).

Grainages (Seed Production Centres)

Grainages are organised for preparation of commercial hybrid seeds. These units purchase seed cocoons from the selected seed farmers and process them to prepare the eggs. These institutions are well equipped with facilities for seed preservation, handling of moths, oviposition, examination of moths and processing of eggs.

The seed organisation differs in temperate, sub-tropical and tropical conditions. The number of crop cycles also varies from 2-5 depending on the climatic conditions. In the former, the effort is to generate seeds in bulk quantities in limited crops in specified seasons, whereas in the sub-tropical and tropical conditions due to increased crop cycles, the emphasis is on production of silkworm seed in small quantities spread over several months for continuous availability of seed to suit multiple cropping.

Strategy for Seed Production in African Countries

Sericulture in Africa is spread over many countries. Due to several reasons, significant improvement in silk production has not taken place. The mulberry cultivation and rearing is limited in most of these countries and the demand for seed is also small. It is essential that each country has its own infrastructure for seed, however, due to limitation of fund, infrastructure, trained and skilled manpower, it may be difficult for all the countries to organise seed production. However, with willing co-operation of one or more countries, a seed production base can be created in one of the countries, which has fairly good infrastructure and trained manpower, and seed so produced can be effectively shared by all the countries, until such time the requirement of seed increases and the infrastructure for seed production is developed in other countries. The advantage of centralising the effort initially will help in organising seed production at competitive price.

The seed organisation can be implemented in 4 stages for convenience. This will not only help to produce seed at economical cost, but also organise development of seed infrastructure/base.

First Stage

The initial stage in seed organisation is to establish a breeding laboratory to evolve/screen silkworm races adaptable to the region. This is only a preparatory step for identifying suitable silkworm strains, which after identification are field-tested among several farmers and confirmed further for their adaptability to local conditions.

Second Stage

After suitable silkworm breeds are identified and tested, a seed farm is organised, which will act as composite farm for multiplication of the authorised variety and production of hybrid seeds. During the initial stages of introduction of sericulture, the mulberry acreage is small and the demand for seeds is also less; the seed farm can conveniently produce and supply about 50,000 dfls or 1000 boxes of eggs per annum (minimum average of 400 eggs per disease free egg layings (dfls per annum).

Third Stage

With the increase in mulberry acreage, the demand for seed production also increases. At this stage it will be necessary to organise one more seed farm to increase the rate of seed multiplication and for preparing hybrid seed. These facilities together can handle production of about 2 lakhs hybrid dfls or 4000 boxes of eggs per annum.

Fourth Stage

When the seed demand increases further with the expansion of sericulture, in addition to the above infrastructure, few of the already experienced rearers can be identified for raising seed cocoons, who are generally called seed rearers. This arrangement will be essential for production of large quantity of seed cocoons at fairly reasonable costs. Since the requirement of P3 and P2 seeds are limited, these farms can sustain supply of basic seed to fairly large number of seed farmers. Similarly a seperate seed grainage can also be organised for production of hybrid seed up to 1-1.5 million dfls per annum. The infrastructure needs to be increased and augmented with facilities and manpower.

Conclusion

It is recommended that a breeding laboratory be organised at a suitable location to develop/screen silkworm strains and for imparting training to the scientists in breeding. The programme can be initiated under the supervision of an international expert in silkworm breeding. Simultaneously, effort may also be made to collect and maintain germplasm material required for breeding activities. As a second step, a seed farm and seed production centre may also be organised with facilities for training technicians locally. It will also be advantageous if coordination between African countries is established to facilitate exchange of views, share experience and facilities to further development sericulture in the region.

PRESENT STATUS OF SERICULTURE IN EGYPT AND ITS ECONOMIC IMPORTANCE

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Background

Egypt has produced silk since the early Islamic period, which has contributed to the thriving trade between eastern producer countries of Asia and western consumer countries of Europe. During early 19th century (about 1805), Mohammed Ali, ruler of Egypt at that time, promoted the planting of the sector mulberry trees (over 3 millions). They were cultivated in Nile delta zone on canal banks. Since then, sericulture began in Egypt and about 4820 kg of raw silk were produced. Later, the government found that it was not able to compete favourably with silk industry developed in other countries at that time. The industry declined for years and developed again. In 1920, a private sector factory for spinning and weaving silk fabrics was construed in Damiette (a port on the Mediterranean sea), to facilitate exporting silk garments to the neighbouring countries (Syria and Lebanon). In 1972, the government established the Department for Sericulture to be responsible of all the activities concerning silk. The department imported egg boxes, raised silkworms and reeled its cocoons with the help of a net extension agents to supervise the activity in the rural areas.

Land and Climate

Egypt soil is deep freable and porous with silty and sandy loam in texture that belongs to the alluvial type which is ideal for growth of mulberry plant. The climate in sericultural regions of Nile delta is Mediterranean type. It is warm in spring (the room temperature ranges from 18.5 to 24.5°C and relative humidity about 75%, and the average temperature is approximately 26°C in summer with long photoperiod of about 6hr/day. In winter it reaches 18°C with rare rainfall (about 25 mm). These conditions are suitable for mulberry growth and foliation of leaves starts from the middle of February until the middle of November. The duration of fall of leaves is 3 months in Autumn and Winter. The vegetative period of mulberry allows for more than one rearing season/year if suitable varieties of mulberry and silkworm hybrids are available.

Economic Considerations

Owing to the annual increase of inhabitants and the limited cultivated area in Nile valley and delta, Egypt has been transformed into a labour-surplus economy. The pressure on the limited cultivated land has emphasised the need to increase productivity of an already intensive crop production system and to create more jobs. Some rural governerates already have population densities over 1000 sq km^2. Silk production and processing are considered as small cottage industries and has recently come into prominence as a potential rural based industry. Rearing silkworms is still largely practised in the delta area where the farmers sell the cocoons directly to the private entrepreneurs. A typical family income from sericulture is 300-400 Egyptian pounds (US$ 100-133) representing 10-15% of total agricultural income.

Stages of Sericulture

The basic stages of sericulture encompass mulberry cultivation, commercial silkworm egg production, worm rearing, farm management, disease control, cocoon quality control and raw silk reeling. Every stage requires specific skills, large labour inputs and some investment.

In short, the basic conditions, potential and demand for prosperous industry as a model of agro-industrial activity are present in Egypt.

Mulberry

There are approximately 3 million trees in Egypt in delta region, located along the canals and roadsides, from which an estimated 3000 rearers continue to provide the backbone of Egyptian sericulture. The trees are part of the landscape and are kept for shade and fruit. Farmers do not own these trees and they do not look after them. The leaves are collected in spring for feeding in the spring rearing, but owing to the long photoperiod during summer, it ages rapidly and does not satisfy other rearing seasons. Also, harvesting of these mulberry leaves is very difficult, as it is done by climbing the huge trees and cutting main branches. The varieties are not suitable for both weather or silkworms as they are grown from seedlings. Consequently, it is difficult to rely on the traditional way.

Recently, applied studies have been undertaken by the department to introduce several varieties of mulberry with different specifications for early and late rearing of summer, autumn and spring. They have been examined and selected as the most appropriate for Egyptian environmental conditions. Results of applied studies indicated the high production of fresh leaves and different time sprouting.

Mulberry farms are being established by investors in the private sector in the surroundings of sericulture governarates. They rely on mulberry bushes cultivated in the field (about 7000 bushes/feddan. 1 hectare equals 2.4 feddans) and secure a higher yield of leaves per feddan. In addition, cost of labour is significantly reduced and there is a better control of the rearing season's schedules.

Rearing of Silkworms

Egypt has to import eggs annually as the domestic production cannot satisfy the requirements of rearers. It obtains about 2000 egg boxes from Korea yearly, but the import faces constraints due to confusion with custom's department, which affects the distribution of the shipment to rural zones before the hatching of eggs. Finally, the increase of transportation fees every year results in limited profits for rearers. As the importation of eggs is only for spring season, no summer or autumn cocoon crops are raised in the country.

Recently, the private sector was encouraged by the government to diversity on the agricultural sector and it established a grainage for commercial egg production. It is capable of providing the country with not less than one thousand egg boxes and the production is likely to exceed that. The grainage will enable the smooth supply of eggs all over the year for more crop seasons. It will facilitate the rearing in the governerates at different times according to their weather conditions and mulberry growth.

The average yield of fresh cocoons per box is about 20 kg and of dry cocoons 8 kg/box. Total cocoon production in Egypt is at present 30 tons and that of raw silk 3-4 tons. The low yields are due to inadequate rearing conditions, because farmers use shelves made of reed which are usually suitable for old age worms only. Disinfection of rearing places, equipments, tools and worms had never been conducted in the countryside. Some infectious diseases mainly flacherie were found in the old stages and non-uniform worms were observed in beds. Young stage rearing centres did not exist . The leaves wilted quickly in very dry weather. Atmospheric temperature varies widely between day and night (about 8-10°C difference), with no artificial heating to be used in the countryside when the temperature drops. The sun drying ot cocoons affected the quality of its fibre.

With the help of the extension agents the Sericulture Department planned to improve rearing in the countryside, by following new techniques and introducing modern tools to rearers for better quality and quantity. The mulberry farms though still limited, produced standardized cocoons, in size, weight and reliability. The government built young age co-operative rearing centres countrywide. This will protect worms from disease and will create more than

3 cocoon crops using the same resources of mulberry. Drying equipment imported from Japan is now available for rearers for the drying of cocoons.

Dried cocoons are purchased at auctions held in governerates under the supervision on MOA. The cocoon producers buy their product by volume a tin of 20 litres volume. The purchasers are reelers of middlemen. No grade evaluation of cocoons is considered during the marketing.

Reeling and Spinning

Using the manual reeling machine produces domestic raw silk. Production is consumed locally for weaving hand made silk carpets and rugs. Most of the domestic silk is 50-70 denier type to suit the industry and is lacking the re-reeling process. Recently, additional re-reeling machine part has been manufactured by MOA and added to the manual reeling ones. These parts have improved the quality of the thread to have less percentage of gum and more regularity of thickness.

Multi-end reeling machines had been introduced to Egypt by private sector and co-operative societies. Their numbers are few, and yet enabled the country to reel threads with international specifications, which can give hope for better future of silk in Egypt. It produces 20-21 denier threads twisted as weft for silk carpets. The industry still depends on imported raw silk as warp threads, because the local one does not satisfy the domestic market. Manual reeling dominated by a small number of traditional reelers who have a limited processing capacity due to technical and financial resources, impeded fast marketing of cocoons. The raw material cost of one kg is about US$ 7 which is not high. A team of one skilled reeler and two unskilled workers operating one reeling machine can produce between 1.5-2 kg of raw silk. A reeler yields a net profit of US$ 2 per day. This return is possible despite the availability of cheap imported silk.

Probably the most important factor in the decline in raw silk production was the 1976 closure of Egypt's only automated silk reeling factory. However, the factory had no policy to gradually replace its capital stock, resulting in a need to completely replace the machines at a time when rising maintenance costs had eroded profits. The factory had to close, causing a major disruption in cocoon prices – as private reelers using manual reeling machine only gradually filled the void.

It is worthy mentioning that one of the constraints facing the industry is the absence of mechanical mills for spinning the waste of the fibre. Attempts are done by private sector to install such mills and fill the gap to produce fine spun silk used for silk fabrics.

Women in Sericulture

The typical rural family is made of 4-8 persons related by birth or marriage. The wife usually manages production and assigns tasks among the rest of the family. She with the children feed the worms and clean their beds. She and other family adults reel the cocoons using the manual reeling machine by turning the crank to power the machine or reel the cocoons themselves. In most cases, women do the actual marketing of cocoons in the auction, bargaining with merchants for higher prices.

Most women in Egypt are unemployed in the rural areas and very often perform unpaid agricultural work for their families; their participation in paid work in sericulture is necessary. It is worth noting that silkworm rearing in the country has traditionally been the work of unskilled female labour. Now, the government gives special attention to enhance the work of women already engaged in sericulture and seeks foster the participation of women in other sericultural activities of new mulberry farms. Operations like planting, weeding and leaf harvest are mainly done by rural women. The indoor nature of the activity makes it more convenient to rural households. Similarly in reeling, the role of women is more predominant because of the skill involved. It is true in general that little is known of the dynamics of expenditure decisions of sericulture of peasant households.

Silk Industry

The past decade has been a period of expansion in world consumption of silk products. Silk carpets, cloth and embroidery trimming are Egypt's main silk products. The silk finishing industry is composed of small, entrepreneurial craft shops located in Cairo and various villages throughout the delta and upper Egypt. Demand for these products is great and Egypt's silk manufacturers are becoming increasingly sophisticated and attuned to their markets. Most silk carpets are sold to European buyers, Americans and visitors from the rich Arab states. Silk cloth is sold to a wide range of customers and silk embroidery is often found on high quality galabuya (national costume) for men.

Ironically, while production of finished foods has been expanding, Egypt's production of raw silk has declined resulting in a growing dependence on imported raw silk. The imported silk is usually cheaper than all, but the domestic silk.

The virtual drop of silk carpet sales to Europe in the 80th Century Iran and Afghanistan provided a golden opportunity for the rapid development of the Egyptian silk carpet industry. It grew with noticeable success and profit. This was due to the use of first grade raw material coupled with the skilled weaving. The importing countries are enchanted by the hand-made materials and village crafts. The growth of the local raw silk production could not keep pace with an ever increasing domestic demand. Importation of raw silk grew from 120 tons/ year in 1984 to 250 tons in 1996. The local production increased from 2 to 6 tons during the same period. With the increase of world prices and the need of hard currencies, the silk traders turned to local silk producers and the prices of domestic cocoons and raw silk went up. As a result, the numbers of rearers attracted by the prospect of good income in a short period, grew quickly and the numbers of distributed egg boxes multiplied. This sudden increase created problems in the marketing of cocoons. Local reelers who were the only buyers at that time did not own enough capital to buy the product available in the public auctions. Many of the new rearers who were expecting an immediate reward started doubting the market mechanism. In spite of that, the profit-earning potential of these silk downstream activities is significant.

Dependence on imports raise the cost of both small and large enterprises, limits their growth, and makes them vulnerable to external events. Production and growth of the industry can only be sustained in the long run if the availability of locally produced silkworms eggs and raw silk is assured. One of the main objectives of government policy was the establishment of modern grainage equipment for the production and supply of egg boxes to rearers all over the country. A private sector grainage began production of P1, P2 as a step for P3 and selected hybrids adapted to local environmental conditions. It is important to save foreign currency used for the importation of egg boxes and raw silk. Also domestic eggs will promote multiple rearing sessions/year. It will create not only extra income for jobless and marginal rearers, but will also develop the skills of individuals concerned in the rearing or other activities of sericulture. This will ensure smooth supply of cocoons to reelers all over the year, which result in low inventory cost of raw silk and its final products. It will absorb critical country economics created by the raise of egg prices every year, to avoid the influence of political relations between Egypt and others that can affect importation strategy. The existence of a grainage will in the long run sustain the growth of sericultural industries.

Two main big projects have been implemented in Egypt in the field of sericulture. The first by Ford Foundation in 1981 and the second by the small scale agricultural activities of USAID in 1983. The projects successfully met their objectives, which were to expand and improve the mulberry nursery facilities and to develop the rearing and reeling skills of the target group of rural marginal families, especially households. The extension efforts expanded to train the target groups on weaving of silk carpets and rugs.

In the early 1980s, the Chinese had a protocol agreement with Egypt where silk was imported at a special rate in return to Egyptian rice. This gave a special boost to carpet manufacturers and textile weavers who suddenly found that large profits could be made in weaving of silk. Unfortunately however, the protocol was not renewed in 1984.

Economic Importance

Since thousands of years ago, silk has been treasured as much as diamond and pearl. It is because it has its unique aroma which no man-made fibre can achieve. People all over the world enjoy wearing silk, which is protein fibre produced by the silkworm.

Sericulture is one of the most labour-intensive activities in the world. It involves long chains of interdependent operations that provide income for many people in both agriculture and industry. The basic stages of sericulture include mulberry cultivation, leaf collection, silkworm rearing and cocoon reeling. Every stage requires specific skills, large labour inputs and some investment. In addition, each stage induces concurrent services and processing subsector activities. Raw silk production involves an extensive range of manual and industrial stages of which cloth and carpet weaving are the main core. Silk production is identified as a promising sector for development of rural employment and hard currency earnings.

In Egypt, silk carpet weaving has been a traditional job that one of the villages in Delta zone, Saquia Abou-Shaara has specialised in. Instead of raising sheep, goats or livestock, own looms to weave all kinds of carpets especially the silk ones. Silk carpets are often sent abroad to Japan and Europe at reasonable prices of US$ 1200 / square m. Traders competing with different countries gained good reputation and money. Carpet weaving is a promising export sector if Egyptian designs are developed instead of repeating the old designs and colours of Iran.

Conclusion

Despite the various problems facing silk, it enjoys immense interest and attraction to the public and has certain unique properties to offer; its chemical composition is close to that of human skin and could be one of the healthiest things to wear. What is required now is to start its promotion using modern marketing and advertising techniques. Unfortunately, the condition of the world silk industry in terms of demand and production tends to decline due to:

(i) Low price of raw silk on the international market.

(ii) The production of cocoons and raw silk from the new republics of the former USSR with extremely low prices compared to those from the existing silk producing countries.

(iii) Urbanization.

(iv) The rise of industrialization.

(v) The high production cost of cocoon and silk fibre.

However, it was predicted that the market will recover in the 21st Century if future development will be focused on the effective information system, both in terms of production techniques and market systems, without neglecting high yield and quality of production. The world production of silk is still dominated by China (71-80% and India (14.0%). The tropical African countries have the advantage of favourable socio-economuc characteristics for silk production, like low wages and large rural populations. It may take time for these countries to reach international standards of raw silk qualities, but it is worth trying.

THE ROLE OF UGANDA SILK PRODUCERS IN SERICULTURE DEVELOPMENT IN UGANDA

Musaasizi Jovita
Uganda Silk Producers Association, Uganda

Composition of USPA

Uganda Silk Producers Association (USPA) is a non-governmental organization (NGO). It was formed in 1993 and is composed of two silk companies and individual farmers. One of the founder members is Mr. Gershom Mugenyi. There are about 1000 registered silk farmers, 500 of these rear silkworms on regular basis. Others have only planted mulberry and do not have rearing facilities.

Objectives

The major objective of USPA is to:

(a) co-ordinate the activities of sericulture in Uganda.

(b) Monitor and control the quality of cocoons produced.

(c) Where possible assist silk farmers by providing credit facilities.

Production

Farmers (300) have been assisted to put up rearing houses. Each rearing house has an area of 600 sq ft and can accomodate 2 boxes of silkworms. Each farmer is encouraged to plant at least a one and a half acres of mulberry to feed 40,000 eggs (2 boxes).

Each box of egg yields 30-45 kg	Ushs.
A box of egg costs US$ 13.00	13,000.00
A box of 5 worms cost	18,000.00
1 kg of fresh cocoons costs	2,400.00
Average production/box	35 kg
Yield/cycle	70 kg
Gross payment/cycle 70 x 2400	168,000.00

Cost of worms	18,000.00
Net payment	150,000.00
If he rears 6 cycles/year= 150,000 x 6	Ushs. 900,000.00
If 300 farmers rear 6 cycles a year we would get	
300 x 2	600 boxes
600 x 35 kg x 6	126,000 kg
126 tons per year.	

However, our target is to rear 9 times per year and get 1500 farmers who can rear 2 boxes, nine cycles per year. In addition to rearing houses we provide rearing equipment such as cocoon frames known as Mabushis disinfectants.

We also provide extension services and training to the farmers and provide disease free eggs.

Organization

The association is run by an executive committee headed by the chairman, but the activities of the association are carried out by the implementation unit (IU). This consists of head IU, Credit Manager, SDC co-ordinator, Account Assistant and Secretary.

The silk farmers are encouraged to form corporate bodies (15-20 members) and form what is called silk development centre (SDC). At SDC we expect the farmers to share common facilities e.g. Young age rearing house, mulberry garden, drying facilities and extension services. This is done so that at future date a farmer will be able to sell cocoons to sustain sericulture in Uganda. We concentrate our activities in only 14 districts in East, Central and South-west Uganda.

Source of Funding

We get our funds from member contributions and grants. Our donor has been European Union through Silk Sector Development Project for the period 1995 - 1997, using stabex funds.

Marketing

The buying of cocoons from the farmer is done by silk companies although the association provides crop finance. At first we exported to Japan, but the requirements were beyond our reach and so we had to shut our market somewhere else. In due course we contacted Sanshi Seritech Ltd. which supplies us with silkmoth eggs to link us to any cocoon market. This has been ably done by Mr. C. Subramanyam by linking us to Tata in India and Dr. Kumar in Malaysia.

Constraints

(a) The practice is foreign and hence the need for thorough training and extension services to the farmer.

(b) Mobility of extension workers is difficult on bicycles to monitor and supervise farmers who are widely scattered.

(c) We lack knowledge and skills to utilize the non exportable grade.

(d) Production is still low and so we find it difficult to get a buyer who can tolerate our erratic cocoon shipment.

(e) We lack expertise in some sericulture areas e.g. silkworm pathology.

Prospects

(a) We intend to reel our non exportable cocoons. We are in contact with Mr. C. Subramanyam who is to advise us on how to go about it.

(b) It has come to my knowledge, though not officially, that ICIPE is ready to give us a reeling machine and even train our persons.

(c) We intent to identify a women group who can do weaving, say kikoyi scarfs.

(d) As a long term plan we intend to set up a grainage if the farmers and the demand increase. Meanwhile we have an egg unit whereby we keep our hibernated eggs.

Achievements

(a) Assisted 300 farmers

(b) Established sericulture manuals for farmer use.

(c) Established silk development centres which are the main focus for sustaining sericulture in Uganda.

(d) Harmonized the sericulture activities in Uganda

(e) Established an egg unit, whereby eggs can be obtained on demand.

Together with the Minister of Agriculture, particularly Mr. Mugenyi we have kept the fire of sericulture in Uganda glowing.

SESSION II

IBRA'S ROLE IN PROMOTING BEEKEEPING, SUSTAINABLE ECONOMIC GROWTH AND BIODIVERSITY IN AFRICA

Richard Jones

International Bee Research Association

UK

Human beings have hunted for honey for thousands of years. They have robbed wild bees and destroyed the insects that brought the golden harvest. Sadly, this is still going on today and wild bees often have their habitats destroyed by new farming methods and suffer the ultimate destruction of being smoked out or killed for the short term gain of one honey collection. There is also the practice of honey hunting against established hives of beekeepers, particularly when the hives are situated in out-apiaries. This is destruction, theft and a difficult problem to address.

An answer to these problems must lie in education. Honey hunters need to be educated into beekeepers. Farmers need education to help them understand the necessity to maintain a balance in the environment. Much can be achieved if school children are taught from an early age the value of bees and the need to maintain biodiversity Development is necessary, but keeping the ecological balance is also essential.

There is an all too simplistic equation of, Bees = Honey. This has to be addressed through wider education on the themes of pollination and the value of other hive products.

Starvation is something which is too well known in the world — particularly in Africa. People need to be made aware through education that bees could be a means to combat starvation.

The Scope for Development

There are three primary stages or steps to beekeeping:

(i) To kill bees

The first stage just robs the bees of honey and takes the larval and pupal stages for food. Any bees that survive are doomed without food or a succeeding generation. It is a small, but important step to the next stage.

(ii) To Have Bees

This is where wild swarms are encouraged to settle in pots or bark hives. Combs are built directly onto the container so that honey combs can be removed, while brood remains. However, there is little understanding of the biology of bees and no management of the colony can take place, but at least the bees survive.

(iii) To Keep Bees

This is true beekeeping and only takes place when the person concerned has some understanding of bees and can predict certain events and therefore can employ well practised management techniques. Advantages of beekeeping:

(a) a beekeeping project can be profitable from start-up

(b) it need not depend on outside inputs

(c) bees feed themselves

(d) it does not require ownership of land

(e) it can involve all the family

(f) can create work for local industries

(g) an excellent activity for a co-operative

The bee resource already exists — what we need to do is to make better use of the resource. Plants benefit from insect pollination by an increased seed set. This results in better quality fruits. Beekeeping is particularly advantageous here and also in agro-forestry projects. It is one of the few forest income yielding activities that does not destroy trees. When reafforestation schemes are being considered thought should be given to tree species that provide nectar, pollen and honey dew as beekeeping can develop as a useful economic activity with the growing forest. Therefore, those that make these decisions — the planners and administrators need to have a full range of information about bees — there has to be some bee-awareness at this stage.

Similarly, cutting down large areas of suitable bee forage and replacing it with monoculture can be disastrous. However, things can be improved if poor melliferous plants are replaced with good nectar and pollen producing plants or even if marginal lands are left with good indigenous floral cover.

A knowledge of bee forage is an essential part of beekeeping and agroforestry. It is another area with need for input of information and education. The person keeping the bees needs to know this, but so do the farmers, foresters and planners.

Sometimes it is necessary that the input comes from a higher authority.

A good understanding of bees + Good management of operations = A strong colony.

A strong colony + A good nectar flow = Maximum honey flow.

Therefore Maximum Honey flow = Good Beekeeping.

Many years ago a British Aid agency had the following advertisement as part of its fund raising programme in the UK: "Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime." How true this could be of beekeeping. Give a man honey and you give him an excellent food supplement. Teach a man/woman/child to keep bees and you give them and their family:

(i) a rich carbohydrate source

(ii) food to vary a limited diet

(iii) medicine with a number of uses

(iv) two cash crops, honey and beeswax

(v) export crops and hard currency earners

(vi) increased pollination, therefore better crops for humans and animals

(vii) the bonus is that bees feed on nectar and pollen which is free!

Aid agencies are aware of these advantages and a number of excellent projects are in operation. However, this is often in isolation and the effectiveness could be enhanced through better dissemination of information and co-ordination of training. IBRA wants to establish, at inter-governmental level, a network for support, co-ordination and information exchange.

In the first instance a feasibility study needs to be undertaken. The purpose of the study would be to ascertain whether current programmes encounter common problems in:

(i) getting established

(ii) providing training

(iii) on-going management

As we already know the answer to this would be "yes". IBRA has evidence to this effect already and is constantly being approached by individuals, cooperatives and institutions for help. It is one of the great frustrations of my job and one which brings me much sadness that IBRA does not have the financial resources to allow me to send out the material which I have available.

If the route I am outlining was followed then the next step would entail establishing — and this should be at Intra-governmental level — the will and the political desire to provide solutions. IBRA is in a unique position to do this, because over almost 50 years we have succeeded in establishing the credentials of - status, authority and neutrality which give us the independent integrity to win the respect of all concerned.

To establish this "will" is not an easy task, but once established then it would be relatively easy to develop a network, perhaps "honeycomb" would be a better word, which would give mutual support as well as providing a conduit for aid from donor agencies.

East Africa would make an excellent region in which to undertake a feasibility. Within this region there are examples of very good practice and examples of where the need for development is paramount. The next step in development would be to link up the regional combs into a continental or even worldwide honey comb.

Through these combs or networks, information could diffuse where needed and there would be a feeling of mutual support. There is so much information and it should be available and shared.

Information — the Route to Development

The honey bee is probably the most studied of all the insects — most probably except for mankind, the most studied in the whole animal kingdom. The results of much of this study is to be found in the IBRA library. Hence, that could play a prime role in the education and information dissemination programme.

The backbone of the library indexing system is another of IBRA's quarterly journals — *Apicultural Abstracts*. Each edition of *Apicultural Abstracts* contains between 350 and 400 abstracts of items of apicultural interest and concern. Items will be grouped under general headings and will cover:

(i) All aspects of honey bees (*Apis* species)

(ii) Other species of Apoidea

(iii) Developments in beekeeping equipment and techniques

(iv) Bee forage

(v) Hive products and processing

(vi) Pollination

(vii) General

All the individual AA entries are recorded on card and since 1973 on disk. *Apicultural Abstracts* have been published since 1950 (since 1962 as a separate volume from *Bee World*) and the abstracts from 1950 to 1973 are recorded on micro-fiche. This enables us to make rapid searches for information on specific topics or for individual references. Items can be found by author,subject or by using key words.

There is no technological reason why this sort of information could not reach someone here in Africa seconds after making request.

Someone working in the library can retrieve the actual papers and read each in detail. So the abstracts are only the tip of the iceberg of what IBRA library holds as actual papers. I should also point out that these papers are not confined to apicultural or entomological journals. We can reproduce, in booklet form, a number of original articles for certain topics and themes that have a particular coherence and unity. All these things can be done but at a price. Many people do not realise that IBRA is a non-governmental, non-profit making organization. We have to raise the money for every project we undertake as well as maintain, expand and develop the library service. The whole operation depends on members paying their subscriptions and increasingly, support by way of grants from commercial organizations or other charitable foundations. The result is that I spend most of my time not working with bee information, but fighting for funds in order to ensure IBRA's survival.

Knowledge which has been acquired and then just gets stored away is useless. So IBRA not only collects information, but also disseminates it by a variety of other methods and in so doing hopefully can add value to that information.

Every four years we hold an international conference on tropical apiculture. The first was in London in 1976, the 3rd was here in Nairobi in 1984, in Africa again in 1988 (Cairo), the latest was in Costa Rica in 1996 and the next, in 2000, will be in Thailand. Each of these conferences has produced a publication based on proceedings and each publication has become a valuable textbook on tropical apiculture.

Other books, like Dr Crane's *"World Perspectives in Apiculture"* are now a little old to those fortunate enough to have access to the latest publications. However, it is still a relevant text and would be a useful asset to any small beekeeping co-operative's library or to the individual beekeeper keen to develop the craft. *"The Pollination Directory for World Crops"* is another valuable book.

Similarly "Pest control safe for bees" is, I believe, a first class way of getting information over to farmers in general. Most of our publications are in English. For many this is not their first or most fluent language. Therefore, the design of this book is excellent as all the major points are illustrated with simple drawings — and as we all know a picture can be worth a thousand words. I would like to see other books produced on this format catering for the needs of the grassroots — the beekeeper in the field.

IBRA published a series of leaflets providing information often needed and sought by beekeepers developing their projects, with financial support from Canada on:

(i) Suppliers of equipment for tropical and subtropical beekeeping

(ii) Marketing bee products: addresses of importers and agents

(iii) Planting for bees in developing countries

(iv) Opportunities for training in apiculture world wide

(v) Sources of voluntary workers for apicultural development

(vi) Sources of grant aid for apicultural development

(vii) Obtaining apicultural information for use in developing countries

(viii) Apicultural reference books for developing countries

(ix) Education aids on apiculture

(x) Writing about apiculture: guidelines for authors

Probably one of the best texts available is no longer in print although we get at least one request a week for a copy. *"Beekeeping in Rural Development: Unexploited Beekeeping Potential in the Tropics with Particular Reference to the Commonwealth."* It was produced in 1979 in conjunction with the Commonwealth Secretariat. It is time for a new and up-dated version, but on exactly the same format. Again it could be done. However, the demand must come from Commonwealth Governments to the Secretariat — the voices of hundreds of individuals are not enough.

Dr Crane's *"Bibliography of Tropical Apiculture"* is still in demand, but now in need of radical updating.

We have some excellent material available in chart form. This is fine for the lecture room or display in a community hall, but is not easy for the individual to use in the field. Some feedback also tells me that they make attractive displays on the walls of administrators offices and do not get out into the field.

There are other books, which are not IBRA publications, which could so easily be put together in a variety of library packs ranging from good basic material which would Iam sure be valued and much treasured in local schools or community centres to detailed libraries worthy of agricultural institutes and places of higher education. The basic cost could be about £35 ($60) for a starter pack up to a full library costing perhaps £1800 ($3000). None of this involves expensive ongoing aid — just information suitably presented to get the projects up and running. IBRA has all the information and expertise. We have produced a booklet on top bar hives: It is not saying the topbar hive is the absolute answer; in many cases it is not. It is an attempt to make information available to more people in an understandable form and much more of this is needed. I hope this will be the first of a series of simple books aimed at giving basic information in a way which will put a beginner on the road to at least an interesting hobby and at best a form of economic support; "no man is an island"

Beekeepers or bee scientists working alone gain knowledge only from that which is in their immediate experience. Wherever there are bees there is someone working with them and studying them. Therefore, there are innumerable islands of knowledge, hence the need to have continual contact with others in order to share the knowledge gained.

Beekeeping is an international craft. Advancement depends on the interchange of ideas and the ability to provide ongoing support. This requires access to publications, libraries and is enhanced by personal contact. In a world that is often split by conflict, IBRA has tried and often succeeded in being a unifying agent. It was set up 50 years ago.

We are now looking outwards. We are here to listen to needs and to try and provide the information that meets many of these needs.

MORPHOLOGICAL AND ADAPTIVE VARIATION OF *APIS MELLIFERA*

Tom Rinderer
USA

Introduction

The genus *Apis* is comprised of 9 species of honey bees. Some of these species occupy single combs that are exposed to the environment. These bees only live in the tropics of Asia, although one, *Apis flora* somehow has hitchhiked on an airplane and gotten to Africa. It now has a small, but expanding population which may one day come to Kenya. It is a good pollinator, especially, of orchard crops, but produces only a small amount of honey since it is a small bee with a small nest. Some of the other species of the genus occupy cavities. Two of these species are used commercially. *Apis cerana* the eastern honey bee, is found in Asia and extends from the tropics into central and northern China and southern Russia. This species is kept by beekeepers, but generally produces only a small amount of honey (by commercial standards) and is prone to absconding when beekeepers disturb their nests. This tendency makes their culture difficult. In most parts occupied by the species, no breeding programmes have been attempted with *A. cerana*, both in honey production and reducing absconding. This is generally true for wild species with economic value. Breeding programmes generally can advance the economic value of such species very rapidly.

The other species of hive dwelling honey bees is *Apis mellifera*, the western hive honey bee. This species extends from the Cape of Africa to Scandinavia and eastward to include much of the Middle East and Central Asia. The wide range of habitats has resulted in populations of locally adapted honey-bees, which can be distinguished as subspecies. About 24 sub-species of *A. mellifera* are generally recognized, each with specific morphological characteristics that are characteristic. A process that uses a computer assisted measurement system of dissected body parts is used to collect data. These data are submitted to a multivariate discriminate analysis procedure. This procedure will clearly identify members of specific subspecies. Indeed, it will identify hybrids between subspecies and give reasonable information on the degree of hybridization. Other procedures that involve DNA analysis, especially the newer sequence data analyses can do similar things, but they are far more costly.

Variations

Morphological variation results from specific adaptation to different ecosystems. The same is true for behavioral variations. Important characteristics of the ecology of much of Europe include a clear winter-summer seasonal cycle. This is coupled with a high predictability in moisture and flowering. The honey-bees of Europe are adapted to the conditions by:

(i) Sometimes foraging for mostly honey reserves

(ii) Being less sting prone

(iii) Producing only a small number of swarms a year

(iv) Expanding colony numbers in anticipation of upcoming seasonal events

(v) Having stable population of colony numbers.

East Africa typically presents a very different ecology for honey bees. Chief conditions are:

(i) seasonal of rain and dry season cycles which are unpredictable in timing, duration and intensity. Honey bees have evolutionary responses to these factors

(ii) They forage as often for reproduction as they do for honey reserves

(iii) They defend stores more intensely and hence are more sting prone

(iv) In good conditions they continue to reproduce from 6 to 12 swarms a year

(v) The immediate availability of resources triggers a colony to expand its numbers

(vi) There is a wide fluctuation in colony numbers throughout the year.

Such behavioral responses to ecological conditions dictate beekeeping strategies. In Europe, perennial colonies have allowed beekeepers to develop methods of colony increase by division, requeening procedures, artificial migration of colonies, and above all, breeding programmes.

The annual colonies of East Africa have essentially restricted beekeeping to swarm catching and honey harvesting. However, the situation in East Africa is more complex than this simple sketch. There are three subspecies of *A. mellifera*, which inhabit different East African ecological zones. *Apis mellifera litorea* is a subspecies that occupies the coastal plain below 500 meters. Above the coastal escarpment, the major subspecies *Apis mellifera scutellata*, is found. This subspecies ranges throughout most of East Africa. However, where mountains cause rain shadows, that rainfall stability has caused the evolution of a third subspecies, *Apis mellifera monticula*. This subspecies if found between 2000 and 3000 meters. In the areas where the ranges of these three subspecies meet, hybrid zones exist where the honey bees have intermediate characteristics. Hence, the three species form a graded, stepwise ecocline along the attitudinal range.

These subspecies and the bees of the two hybrid zones are identifiable using a discriminate analysis of morphological measurements. Also, they have notable behavioral differences. *A.m. monticula* is considered to be more perennial, gentle and a very good honey producer, *A.m scutellata* is migratory, prone to abscond and sting and in comparison, a poorer honey producer. *A.m litorea* is similar to *A.m scutellata*, except that it is more prone to sting and perhaps less migratory due to living in a range with somewhat more predictable rain.

Implication

What does all this mean for East African beekeeping? East African beekeeping ecological zones with their different subspecies may be a useful genetic preserve. Hybrid zones, especially the *A.m monticula—A.m scutellata* zone might provide breeding stock that better suits beekeepers and still adapted to local ecology. Morphological studies can be used to identify hybrids of behavioural and beekeeping studies. It is highly likely that genetic selection of hybrids could produce bees that were well adapted to most of the area, at least during honey production periods, that produced more honey and had reduced tendencies to sting, swarm and abscond. If such was the case, traditional swarm catching of colonies could be combined with requeening with selected queens to produce at least annual collections of productive gentle colonies. Better stock may economically justify improvements in beekeeping technology. The commonly used Kenya top bar hive was designed as a traditional hive with the thought idea that fully movable frame was the goal of the programme of apicultureal development. Once movable frame beekeeping is in place simple centrifugal honey extraction procedures can be employed to produce clean export grade honey. The co-operative system of the Yucantan in Mexico is a good example. Improved honey bee stock led the way from a few people keeping bees to apiculture being organized into large co-operatives that collect honey from thousands of small producers for international markets. I believe that improved honey bee stocks are both very possible to achieve in East Africa and would greatly enhance the economic value of beekeeping in the area.

TECHNIQUES FOR IDENTIFICATION AND PREVENTION OF HONEY BEE DISEASES AND PESTS

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Introduction

Beekeeping in East Africa is mainly based on traditional beekeeping methods where swarms settle in hollowed logs or other hollow constructions put out by beekeepers to attract swarms. Honey and wax are harvested from these colonies sometimes with or without the destruction of the colony. If colonies are not destroyed in the harvesting process, they may still disappear later from the site due to absconding. Once colonies leave their wax combs they will soon succumb to wax moth *Galleria mellonella*. We have learned that perhaps 95%of the colonies in Kenya are kept or managed in this traditional way. 4-5% of available colonies are found in Kenya top bar hives (KTB) or similar devices where combs may be lifted from the bee cluster. Very few of available colonies are kept in modern Langstroth movable frame hives, although the numbers are likely to increase.

Major problems that face traditional beekeeping in Africa, apart from non-biotic factors such as theft, or sometimes insufficient flora, usually relate to predators such as the honey badger, *Mellivora capensis*, the honey guide bird, *Indicator indicator* or different ant species. Until 1958, there were no reports of any microorganisms causing disease in honey bees in East Africa. In the *World Bee Health Report* , the only microorganism pathogenic to honeybees suspected to be present in East Africa were the microsporidian parasite, *Nosema apis*. As pointed out by Peter Paterson, this record should also include *Melissococcus pluton*, the causative agent of European foul brood (EFB) . However, in both the case of *N. apis*, as well as for *M. pluton*, a confirmative diagnose of both organisms is missing and rely simply on suspicion of *N. apis* being present or presence of bacteria from smears of diseased larvae resembling the causative agent of EFB. Thus, no single microorganism causing disease among honeybees have been conclusively identified from East Africa.

If the apparent absence of pathogenic microorganisms in East Africa represents lack of information based on insufficient diagnostic surveys, or if they are in fact absent, remains an open question. Because of the ongoing transition from traditional beekeeping to beekeeping in modern beehives, this question needs to be answered, since modern methods may increase pathogen load, if present. Although the transition into modern methods is slow, it is likely to continue and grow, since successful frame hive beekeeping has capacity to generate more profit.

Pathogens and Bee Wax

Virtues of movable frame hives include the possibility of moving frames with bees and brood between colonies and storing and reusing drawn comb. The wax production may suffer, to super withdrawn comb during a honey flow, increasing production because the bees divert their efforts into foraging instead of comb production . However, since wax combs may transmit pathogens as wax combs are shifted between colonies, the transition from traditional beekeeping to beekeeping using movable frame hives, may cause pathogens that could be present, also to cause problems not seen in traditional beekeeping. Pathogens that need to be considered include virus, fungi, protozoa and bacteria.

Only bacteria and protozoa will be considered to some detail, although both fungi and virus cause considerable losses to beekeeping worldwide. Apart from sac brood, differential diagnosis of honey bee viruses rely on serological techniques. Because of the ability of the parasitic mite, *Varroa jacobsoni* to trigger and vector bee viruses, this field of honey bee pathology is of great interest today. *V. jacobsoni* has not been found, so far, south of the Sahara, although there is one report from Kenya of another parasitic mite, *Tropilaelaps clareae*. This mite also breeds on bee brood and causes considerable damage to *A. mellifera* colonies elsewhere, possibly due to associated virus infections. Little is known of the epizootiology of honey bee viruses, but it is likely that wax transmission may occur.

The most important fungal disease of honey bees, chalk brood, caused by *Ascosphaera apis*, can be identified on inspection by the appearance of chalk brood mummies in infected colonies. The fungi is not specific to honey bees, but is definitely transmitted with spore-contaminated wax within and between colonies.

Protozoa

Three protozoan parasites, two microsporidia and one amoeba, are known to cause disease in honeybees, although both gregarines and flagellates may also infect honey bees.

Microsporidia

The microsporidians known to infect honey bees are *Nosema apis*, spread in races of European bees all over the world and *Nosema ceranae*, recently described from the Asian honey bee, *Apis cerana* . In the laboratory, both parasites are cross infective in both bee species , but if cross infections occur in nature is not yet known. Diagnosis of microsporidia in honey bees is dependent on microscopical examination of the intestinal tract or of squash preparations of whole bees. The spores of the parasites are easily seen in a light microscope at a magnification of about 400. Unless molecular techniques, or transmission electron microscopy is used, differential diagnosis of known microsporidia infecting honey bees is depenedent on a slight difference in size in the light microscope.

The parasite spores are voided with the faeces, and soiled comb is the primary source of infection . Reuse of stored comb or transfer of old comb therefore may help in spreading microsporidia within and between colonies. The impact of nosema disease on the performance of honey bee colonies is substantial in temperate climates , but is believed to be less severe in tropical climates, although comprehensive data from such regions are lacking.

Malpighamoeba Mellificae

Infections of *M. mellificae* have less impact on productivity of infected colonies compared to infections by microsporidia. However, the infection is more common in combination with *N. apis* than as a single infection and may aggrevate the conditions caused by this parasite. *M. mellificae* can only be conclusively identified through microscopical examinations of the Malpighian tubules, where the round cysts can be found. The infective cysts of the parasite is spread to spores of microsporidia, through the feces via contaminated wax.

Bacteria

Several different bacteria may cause various disease conditions in honey bees, but the two far most important are: (1) the opportunistic *Melissococcus pluton* causing European fou lbrood, and (2) the more fatal *Paenibacillus larvae larvae*, causing American foul brood.

Melissococcus Pluton

M. pluton multiplies in the gut of the young bee larvae and competes for the food recources with its host . Presence of *M. pluton* is confirmed by cultivating the bacteria from diseased larvae (where several secondary invaders may also be found) on a suitable medium, under anaerobic conditions. Wax combs, where diseased larvae have been present, may transmit the disease. European foul brood is regarded as a serious disease of honey bees, causing loss of production, and even of colonies. Especially under tropical conditions, where bees may rear brood continously, but without constantly available nectar and pollen, the nutritional status of the colony cause insufficient amount of brood food to be produced for both the larvae and the bacteria and may eventually result in considerable larval mortality. Bacteria are voided with the larval faeces and may infect other larvae that come into contact with infected comb.

Paenibacillus Larvae Larvae

American foul brood, caused by the spore forming *P. larvae larvae* is one of the most serious diseases of honey bees. Many countries have regulations to prevent the spread of infectious bee diseases and in many places there are compulsary destruction of colonies and comb if infections of American foulbrood are found. The field symptoms are relatively easily recognized by beekeepers where the ropiness of the young infected and newly dead larvae is characteristic. If larvae of suitable age is not available, diagnosis may be more difficult and require cultivation of the bacteria. Investigations of honey in areas affected by American foul brood, demonstrate that infectious spores are often present in the honey, but without any visible signs of disease in the brood. Investigations of honey are therefore of particular interest for the purpose of finding low or subclinical infection levels of American foul brood.

The spore produced by *P. larvae larvae* is extremely heat resistant and viable spores have been isolated from wax combs, 80 years after the combs were infected. For practical purposes, it means that beehive material of any kind that have been in contact with infected colonies, must be regarded as a potential source of new infection, indefinitely.

The most effective way of natural spread of American foul brood is when infected colonies break down and are no longer able to defend their stores from other colonies. Weakened colonies are robbed out and the infected honey is brought back to the robbing colony, eventually causing establishment of a new infection. When beekeeping is practiced, the beekeeper is the most important factor in spreading disease by moving infected colonies and by transfer of infected comb material between colonies.

Epizootiological Considerations and Conclusions

It is most likely, I would go as far as to say it is certain, that pathogens such as *P. larvae larvae* have been introduced into East Africa. We know that European honey bee queens with their attentant bees have been introduced and during the 70s in relatively large numbers (Paterson, personal information), and there are several Kenyan beekeepers that report of independent bee imports of European bees from South Africa into East Africa. These bees do not seem to survive, for some undetermined reasons, but they may well have brought pathogens common to European bees elsewhere in the world. It also seems likely that the British have brought intact colonies of European bees into East Africa, as we know they have into other areas, such as North America, during colonial times.

Besides import of bees into East Africa, there is also import of honey from major producing countries such as Mexico and the United States. We know from our own investigations, that in all commercial honey produced in areas where American foul brood is prevalent (for example Mexico and the United States), you find large numbers of infective spores in the honey on the market. Unless all such honey is kept out of reach of honey bees, and more or less well emptied containers disposed of properly, imported honey may be a constant source of American foul brood infections.

However, presence of pathogens is far from the only factor determining disease development in any organism. Factors that relate to the mode of parasite transmission (direct or indirect, horizontal and / or vertical), pathogen population (infectivity and virulence, survival capacity, dispersal capacity, pathogen density, spatial/temporal distribution) and host population (susceptibility, density, behaviour), also need to be considered to understand the dynamics of disease development. An attempt to explain the low incidence of disease among honey bees in East Africa could prove to be instrumental for the understanding of epizootiology of honey bee diseases in general.

If absence (of for example American foul brood) represents insufficient diagnostic surveys, pathogens may surface to become clinically visible, with the introduction of modern beekeeping techniques. If pathogens cannot be found, or are present without causing clinically visible symptoms, some factors of general interest for the epizootiology of honey bee diseases impede the development of diseased colonies.

BEHAVIOURAL ECOLOGY OF THE WILD HONEY BEE, *APIS DORSATA* AND ITS IMPACT ON ECONOMIC DEVELOPMENT IN VIDARBHA, INDIA

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Abstract

Apis dorsata is found in most states in India, usually in forest areas. It is more widely known as the rock or giant bee, being the largest of the other three found in India. Unlike the others, *A. dorsata* constructs a single comb in unsheltered places, sometimes attached to branches or fallen tree trunks and frequently hanging from the ceiling of high buildings and houses. The population produces about 10-15 kg of honey.

Apis dorsata has a regular annual cycle of migration observed in India. In June-July before the monsoon starts, they migrate to the mountains, and again in October-November return to the plains and remain upto February-March where the colonies are found throughout the forests of the plains. Swarm migration occurs without building of any comb. The preliminary study suggests that *A. dorsata* has a regular system of annual migration, which needs further detailed observations to explore the causes of migration, nest finding, resting on natural places and communication during migration.

SESSION III

2a.

2b.

2c.

Plate 2

Plate 2. Three types of honey beekeeping methods in East Africa: 2a. traditional log wood hive, Boabab tree in Mwingi district; 2b. mixed honey/brood comb of Kenya top-bar hive; 2c. rectangular frame with pure honey comb, Langstroth hive.

FLORAL CALENDER FOR BEEKEEPING IN NORTHERN TANZANIA

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Introduction

Beekeeping in much of Tanzania, as in many other developing countries, is done by the "let alone method". This means that beekeepers site their hives and leave them unattended until the harvesting period. They use various indicators to determine when it is time to harvest. In Tanzania, typical harvest indicators are as follows:

(i) Field crops such as millet start to ripen

(ii) The rainy season ends and the dry season starts

(iii) Dead drone honeybees are found at the hive enterances

(iv) The intensity of sound made by foraging bees decreases

(v) The activity of foragers at the hive enterance significantly decreases or stops altogether

These indicators are not perfect and they can result in harvesting starting too early, causing unripe honey to be harvested.

Flowering Calenders

Flowering calenders can make it easier to plan various beekeeping management operations such as the siting of hives near particular crops and deciding the best time for honey harvest.

The floral calender shown here is based on our recordings of dates when bee plants flowered in one area Njiro Wildlife Research Centre, which is situated in northern Tanzania. The full opening of the first few buds was taken as the date of first flowering. The withering of flowers and initiation of fruit formation was taken as the end of flowering.

Figure 1. Flowering period

Plants	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Acacia polyacantha												
Grewia bicolour												
Acacia nilotica												
Acacia brevispica												
Acacia senegal												
Cordia abyssinica												
Clausena anisata												
Rhus natalensis												
Pterolobium stelatum												
Vernonia expertifolia												
Coffea arabica												
Acacia seyal												
Acacia nubica												

How the Floral Calender can Assist

The flowering periods of the leading 13 melliferous plants have been recorded as shown on Figure 1 and the floral calender can be used in beekeeping management and improving production. To provide bees with forage between January and February, it is best to site hives near blooming *Acacia polyacantha* and *Grewia bicolour*.

Figure 1 also shows that the "build up" period in this area will be between March and June, when the majority of plants are in bloom. This is therefore the time to divide the colonies, check for queen cells (reproductive swarming might occur) and if frame hives are being used, increase number of supers.

The best harvesting period in this area should be between October and November, before the start of the dearth period when few plants are flowering. This is the time when feeding of bees is encouraged to prevent absconding and to ensure that the colony remains strong enough for the fourthcoming season.

CURRENT SUCCESS IN FIELD TRIALS OF IMPROVED TOP BAR HIVES IN TANZANIA

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Introduction

Traditionally beekeeping in Africa is respected as a source of honey, which is valued not only as nutritious food, but also as a product associated with cultural values.

Traditional hives and beekeeping methods have some merits, they are generally inefficient, leading to low yields and presenting threats to conservation of both the bees and their habitats. Careless attempts of using imported honeybees and technology have produced disappointing results in some beekeeping development programmes.

Traditional hives in Africa are characterized by fixed combs which do not allow harvesting of honey without damaging the brood combs. The high technology frame hives have been introduced in various parts with little success among the prominent individual beekeepers. Different designs of top bar hives have been developed and are becoming more popular than before. The problem in using top bars in place of complete frames is that the bees may attach the combs to the side walls, making their removal difficult. In addition to easy removal of combs, movable combs are necessary in ensuring that the beekeeper harvests only honey or empty combs without damaging the brood. Destruction of brood combs may result in loss of colonies following harvesting operations.

According to Kigatiira (1974), the Kenya top bar hive (KTBH) whose long side walls slope inward at about 25° has been used successfully without much problem of comb attachment. Detailed experiments done by Free and Williams (1981) and Budathoki and Free (1986), indicated that a slight slope of only 5 or 7.50° resulted in much less comb attachment than 0°. The Tanzanian top bar hive whose side walls are vertical has been used widely in various parts of Africa, including Botswana and Kenya, but no serious problems of comb attachment have been reported (Ntenga, 1972; Ntenga and Chandler, 1972; Hassan and Bradbear, 1994). Hives with vertical walls are easier and cheaper to construct and contain more space for honey storage than those with pronounced sloping walls like the KTBH. In view of this contradicting information, it is fundamentally important to carry out adaptive research and recommend what is appropriate and affordable by poor people in Africa, who would like to take up beekeeping in order to improve standards of living.

This paper summarizes the latest observations from field trials with top bar hives at Njiro Wildlife Research Centre. Most trials were done in collaboration with grassroot beekeepers in Arusha region.

Design of Top Bar Hive

The degree of comb attachment to side walls of top bar hives is least when the side walls are slightly sloping inwards. A good design of a topbar hive is one in which comb attachment to the side walls is minimum or does not make harvesting difficult. Our hypothesis in connection with the problem of comb attachment was that the angle of slope of the side walls influence comb attachment.

Earlier observations in 1992 at Njiro apiaries indicated that there was a noticeable reduction in the degree of comb attachment from vertical walls of top bar hives (0°) to slight slope (5 or 10°), but comb attachment increased again as the angle of slope increased from 10 to 20 and 30°.

Variations observed were probably due to variations in initial colony strength and hive placement. Therefore, detailed observations were made using 20 balanced colonies established in hives with sloping side walls of 0 and 10° only, either hanged on wires or placed on wooden hive stands. The total number of combs built in the 20 hives was 445. The length from the bottom of the top bar to where the comb attachment started (length A), and that of the comb attachment (length B) were measured (Fig. 1 and Table 1).

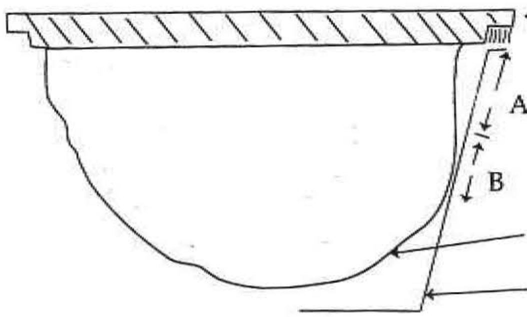

Figure 1. A comb built under a top bar showing the position and length of comb attachment to the side wall of the hive

Table 1. Comb attachment to the side walls of the two designs of hives (vertical 0° and trapezoid 10°)

Angle of Slope	No. of combs attached	No. of combs not attached	Mean length (mm) of A* ± SE	Mean length (mm) B* ± SE
0°	30	193	47 ± 3	45 ± 55
			20 - 120	10 - 120
10°	22	252	40 ± 2	38 ± 2
			15 - 92,	10 - 96

* A is the length from bottom of a top bar to the point where comb attachment begins.

* B is the length of the comb attachment.

* SE is the standard error of the mean.

The results indicated that, comb attachment was more pronounced on absolute vertical hive walls (0°) than on a slight trapezoid (10°) hive. There was a noticeable association between the slope of the side walls of the hives and comb attachment (Chi-square = 3.860, df = 1, $P < 0.05$).

Therefore, a slight slope of the side wall of the hive is necessary in reducing the degree of comb attachment.

Accomodation of Top Bar Hive

A top bar hive accommodating 20 top bars is large enough for a good honey crop in most areas of northern Tanzania. Based on our experience with the original Tanzanian Transitional Hive (TTH) accommodating 27 bars, top bar hives of width 48.6cm, height 25.7cm and length 89.2cm were constructed using lumber 1.9cm thick. This hive was found to be larger than what bees needed for storing honey in a good season in the Northern parts of Tanzania. Subsequent experiments were conducted using hives of the same width and height, but accommodating 20-23 top bars of 32mm in width.

Out of the 20 hives, the mean number of combs built in a good season was 16 and range 10-22 combs. The mean number of honey combs was 8, mode 9, and maximum 10. A hive accommodating 20 bars only was considered to be big enough in the Northern parts of Tanzania where honey harvesting can take place more than once in a good year. These areas receive heavy rains between March and May and shallow rains in October to November when major and minor honey flows are observed.

The Size and Shape of Hive Entrance of Top Bar Hives

The hive entrance is the only passage of communication between the nest and the surroundings. Pests also make their way to the nest through the hive entrance.

Honey bee colonies were established in top bar hives with entrance slots 6-15mm high along one of the end short walls and allowed to grow until they have built combs to nearly full size of the hive (Figs 2a and b).

During harvesting, the entrances were carefully examined to record the modifications made by the bees. The amount of propolis used to reduce the entrances was removed and weighed. The mean weight of propolis removed from modified entrances of 20 hives was 16.3g. The rectangular entrance was modified to holes of varying shapes and sizes. The weight of propolis used to reduce the entrance size was positively correlated with the number of honey combs ($r = 0.631$, $df = 19$, $P < 0.01$). Honey bee colonies with more honey combs used more propolis to reduce the entrance, consequently making the hive entrance smaller than those of hives with less number of honey combs.

In the subsequent experiments, honey bee colonies were established in hives with 16-20 entrance holes of 8 mm diameter, 2 cm above the floor board in a zig zag pattern along the short walls of the hive (Fig. 2b). Examination of the entrance holes during harvesting showed that bees had smoothened or polished the walls of entrance holes without adding propolis to reduce the diameter. Foragers and drones were also passing in and out of the entrance holes without difficulties, but large pests such as greater hive beetles were not able to enter into the hive through the holes.

This type and number of holes of hive entrance was considered a good compromise between comfortable passage for bees, ventilation and control of large pests from entering the hive.

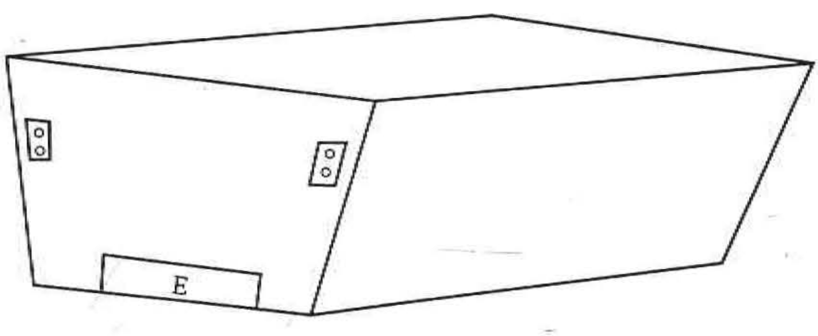

Figure 2a. A top bar hive showing the sloat – type of entrance (E) on the short side walls

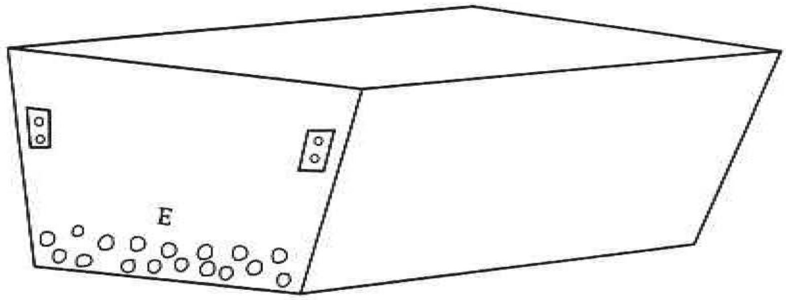

Figure 2b. A top-bar hive showing the zig zag entrance holes (E) on the short side walls

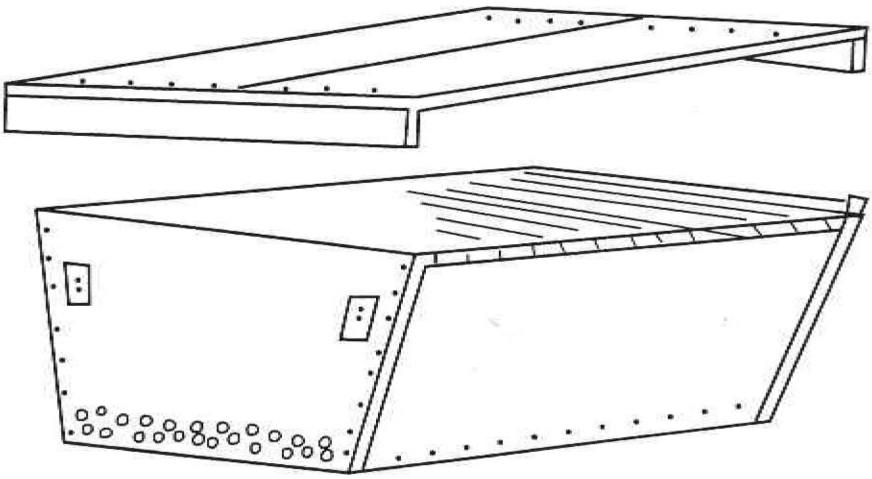

Figure 3. A complete improved top bar hive accommodating 20 top bars, 32 mm wide and the long side walls sloping inwards at 10°

Simplified Carpentry Techniques

During the process of developing a suitable top bar hive for Tanzania, we have also looked at the possibilities of simplifying the carpentry work, to reduce the cost of making the hive, control of pest, avoiding dampness and wastage of timber.

The hive shown in Fig. 3 is combining the following advantages:

(i) minimum use of timber

(ii) no losses when cutting the timber

(iii) all pieces of timber can be cut with a hand saw

(iv) joining the pieces is easy with a hammer and 3 inch nails

(v) the slope of the side walls is achieved automatically, if the short side walls have been cut correctly

(vi) fitting of the bottom board is easy with the help of a hand planner, but precision is not necessarily critical

(vii) cutting the topbars to correct length need not be very precise

(viii) rain water cannot enter the hive

(ix) pests can only have access to the hive through the entrance holes

(x) this hive can be produced and sold in form of parts and then easily joined together into a hive by the beekeeper.

Discussion and Conclusion

Experimental results using top bar hives with vertical side walls (0°) and those with slight slope (10°) suggested that the latter design gave better results in terms of the degree of comb attachment. The critical question is: does the observed comb attachment present a serious problem during inspection? Our practical experience and those of beekeepers confirm that comb attachment is not a serious problem as long as a hive tool or a knife is in hand when the beekeeper is inspecting a colony. However, the slight slope of the side walls of a topbar hive is advantageous in that the gap left between the comb and the sloping side walls makes removal of a heavy honey comb easier than in vertical side walls, which leave a very narrow gap between the hive wall and the comb.

Suspending hives on wires or placing them on wooden benches did not present serious problems of comb attachment or cross combs as long as the hives were horizontally placed. Therefore, in areas where the honey badger and safari ants are not rampant, simple hive stands made from locally available materials could be used. Similarly, in areas where timber is not available or expensive, top bar hives using alternative materials such as clay pots, palm leaves, reeds, calabashes, and used metal drums could be successfully used in production of honey. Success has been recorded in our outreach projects with grassroot beekeepers in Magugu along the rift valley.

A top bar hive with slight sloping sides, accommodating 20 bars has been popularized in the Northern part of Tanzania. However, in areas like Miombo Woodlands where the major honey flow allows the colonies to store large amount of honey, a top bar hive accommodating up to 30 bars could be used.

Honey production in some hives have been comparatively low: average 4-6 kg/hive per season. Therefore, it is of utmost importance that the top bar hives are made very cheap and simple. It is also important that a colony management system which ensures survival of the colony after harvesting is followed. These systems are being tried at Njiro.

Beekeeping is essentially a rural occupation and should be a component of every integrated rural development programme. However, the pronounced defensive behaviour of African races of honey bees should be given due consideration, because beekeepers are naturally enemies of honey bee colonies. The bees must be manageable with minimum inputs, while conserving them and their habitats. Such bee management systems will be successful only when they have been developed and tried with indigenous bees and beekeepers.

Management of honey bee colonies in top bar hives offers a step forward from traditional methods towards better utilization and conservation of the African races of honey bees.

Acknowledgment

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CONSTRAINTS IN TRANSFORMING TRADITIONAL TO MODERN BEEKEEPING IN KENYA

P. D. Paterson

Kenya

Background

Examples abound in both industry and agriculture of successful transition from traditional to modern technology, the progress that has been made in beekeeping is disappointing. There is an impressive number of Kenya top bar hives in the field and a few frame hives, but I am not aware of many that could be described with any integrity as being as successfully and productively utilized as an experienced beekeeper would anticipate. I have run a few frame hives with satisfactory results, the late Jim Nightingale of Njoro successfully run both Langstroth and Kenya top bar hives and at the present time Cole Dodge with Honey Care Int is running about 300 hives a few kilometers from here. This begs the question why such a limited transition to modern beekeeping?

The answer is to be found in the conference theme: "Commercial insects in the African economy" - especially in the relationship between commerce and economics. Traditional beekeeping is a commercial venture, whether geared to the local economy, monetary or subsistence and industrial or rural. Home consumption and the local market have provided a fair demand for honey. Over the last century the rural beekeepers of Angola, Ethiopia, Tanzania and to a lesser extent Kenya, have obtained a significant proportion of their beekeeping cash returns from demand for beeswax from industry located across the seas.

Historically the earliest method of acquiring honey in East and Central Africa, as elsewhere, has been through the methods employed by hunter gatherers who relied on raiding wild colonies of honey bees, sometimes making use of an almost symbiotic arrangement with the honey guide bird, *Indicator indicator*. The natural progression of honey hunting was that of keeping bees by provision of simple, but efficient fixed comb hives. In Kenya this has taken the form mostly of hollowed out logs, the methods and designs varying significantly from one area to another. Differences are to be found in whether the logs are opened at the ends or from a trap door entrance in the centre of the lower side of the hive.

Some logs are hollowed cylindrically and some are split down the length of the log. Some hives have been hung high in the trees where they benefit from cool breezes and are relatively safe from predators such as driver ants and honey badgers, in other instances hives are hung close to the ground and are more accessible to the beekeepers. Some log hives are harvested *in situ* and some are lowered to the ground, sometimes onto a makeshift platform that the beekeeper has previously constructed below where the hive hangs. In hot areas hives are often protected by layers of grass from the sun. There may of course be other minor local variations in materials and in recent times wooden boxes and tin sheet has played a part in hive construction that has followed traditional principles. In some regions the bark of trees is used and there are variations in whether hives are hung horizontally or vertically, as is the custom near Tabora, Tanzania.

We shall never appreciate the constraints to transforming traditional beekeeping methods to modern methods. Alas, it is a common belief that traditional beekeeping is much the same as honey hunting except that a hive has been provided. That is plainly not true except in the crudest of instances.

In the course of honey hunting there may often be little or no advantage to the hunter in preserving the colony and therefore all the combs of the colony may be harvested, leaving little or nothing behind. This may result in the destruction of the colony although it is conceivable that even with such crude methods the adult bees could abscond and start again elsewhere or even come back to the same place after the raid is over. Relatively few detailed observations of honey hunting have been recorded by modern beekeepers. Traditional beekeepers, as opposed to honey hunters, expect to return to their hives, season after season. Methods of traditional beekeeping vary according to local tradition, ethnic and tribal custom. Most beekeepers, just like sericulturists, are intelligent and careful people. Kenyan beekeepers have worked their craft down to a fine art. No doubt there are some crude beekeepers who are not worthy of the name, but all those whom I have observed in the field are to be admired. They are generally extremely careful and are the first to be concerned for the welfare of their colonies. Inevitably with fixed comb beekeeping some brood combs may be damaged and some are harvested for brood anyway, but most of what I have seen is a careful harvesting of honey combs only. In most cases it matters little to the traditional beekeeper whether the new white combs are mixed with older dark combs but if there is a need to separate them for market purposes this can easily be done.

The benefits that traditional beekeeping offers are:

(i) The cost of hives is labour only or a comparatively low, but affordable local value. Therefore all honey is profit.

(ii) Hives could be set up anywhere and in former times they would not be tampered with. Local custom respected ownership.

(iii) Bees liked these hives and readily occupied them.

(iv) Auxiliary equipment comprises of a rope, honey bucket and smoking material, all readily and cheaply available.

(v) There were no dangers of fire hazards or anything else. Beekeepers do not cause fires.

Modern Beekeeping

Now, in order to consider the constraints of transforming traditional to modern beekeeping, it is necessary to determine what advantages the latter has to offer over the former.

By modern beekeeping I mean the use of hives that have been comparatively recently introduced and are advocated for use in Kenya, in particular movable comb hives, that is the various forms of top bar hives and frame hives such as the Langstroth. The advantages of movable comb hives over traditional hives are as follows:

(i) They facilitate beekeeping management techniques which if correctly and consistently applied may result in greater honey yields.

(ii) Frame hives may be relatively easily moved by vehicles. Movement of top bar hives is not very satisfactory.

Beekeepers want maximum output and minimum input. In order to identify the constraints of transforming traditional to modern beekeeping, I shall draw your attention to what has made modern beekeeping succeed, where it has worked elsewhere and to what is missing from that formula in Kenya.

Where modern beekeeping has worked in Europe, Australia, the Americas and Asia, indeed everywhere except Central Africa, there has been the following in order of importance:

(i) Knowledge

(ii) Strains of bees that lend themselves to these hives

(iii) Flora to yield good honey crops

(iv) Good quality cheap beekeeping equipment

Let us now consider what measure of these we have in Kenya:

(i) Knowledge. We do have that. We have the literature for which much credit must go to the International Bee Research Association who have made available and disseminated so much of the apicultural information that exists and developed one of the earliest computerized data bases of any scientific field of this nature. We have many examples of people who have made these techniques work in Kenya. The knowledge and information is here, in some measure. In every other field in this country where there has been success it has been replicated elsewhere and prospered. This has been very limited in the case of beekeeping.

(ii) Strains of bees. The answer to that is plainly negative. Whereas the local African bee has been induced to live in modern hives of every kind and it has been repeatedly demonstrated that all these hives work with African bees just as they do with European races of bees, it is clearly evident that the African bees are difficult to handle and generally speaking not conducive to proper management. Management of African bees is possible, but it is unpleasant and sooner or later many beekeepers decide they have had enough and adopt techniques management that do not always warrant sophisticated hive design. African bees, under good management, do not abscond.

Climate, in particular altitude and temperature, does affect the behaviour of bees which tend to be more manageable in the cooler regions and I suspect also that latitude may have a bearing on behaviour. The fact is that there are successful frame hive beekeepers in both these countries. There are of course also frame hive beekeepers in Rwanda, Burundi and Ethiopia but the proportion is tiny in comparison to the traditional beekeepers and the measure of success is limited.

(iii) Flora and good honey crops. This varies from area to area. Some areas are undoubtedly excellent and others are poor or very marginal. On the whole, the tropics are not noted for the big honey yields that may be obtained in temperate regions which have long daylight hours and especially where there are vast areas of nectar yielding species. Incidentaly the agriculturally marginal areas of Kenya where there are distinct flowering periods often yield better honey crops than some highland areas such as Nairobi where there are flowers all the year round and if is a bit cold today the bees will wait till tomorrow!

(iv) Opinions vary, but I am quite sure that some of my beekeeping colleagues from England and Canada would consider the quality of locally available hives unsatisfactory or very borderline. Frame hives should be made to one sixteenth or at least one eighth of an inch in accuracy. We just do not get that here. Seasoned wood is also hard to come by. If hives are not well made they will only produce problems for beekeepers later.

We do have the basic knowledge, but unfortunately there are design faults that have been allowed to go out into the field either through ignorance or sheer lack of attention to detail. A prime example is that of top bars for KTB hives. The original Kenya design of top bars was that of a V. It is not perfect, but it works reasonably satisfactorily. It has since been replaced by a protrusion. This has worked in some cases, but in many cases it has not and has inevitably resulted in some beekeepers saying the hives just do not work. The best by far I now believe is a wax strip.

In 1974 the Kenya Ministry of Agriculture produced handbook. It was reprinted once or twice and now has gone into oblivion. In this booklet there is a plan of a KTB. It has been reproduced in many publications but has been changed not for the better, but for the worse. In this booklet the sides and the ends of the hives were made from timber for the same width. That meant that when it was assembled the ends were slightly higher than the sides because the sides sloped inwards. The result was that the higher end walls caused the lid to leave a bee space above the top bars and no bees were crushed when the lid was replaced. The design has been copied many times in many places often with a modification that when constructed the ends walls are the same level as the side walls and so when the lid is replaced the bees are crushed. Many so called KTBs have the upper edge of the side walls planed flat with the result that a formerly efficient V edge runner has been removed. Lack of understanding and attention to detail has meant that a good simple beehive has been made worse.

Thus these constraints are that we do not:

(i) have a bee that is nice to work with

(ii) generally get very good crops

(iii) have good hives at affordable prices for the rural beekeeper

This is not to say that the economics of modern hives cannot work, but rather that traditional methods are generally a safer proposition.

The rural beekeeper is likely to do just as well with a traditional hive with little input and modest output. The incentive to go in for modern hives is marginal.

Prospects

Could the Prospects be Improved?

(i) A better bee — unlikely. Any breeding programme is only as good as the beekeepers who uses it and where are the beekeepers who would use and maintain a super strain, suppose one were to be developed? They could be there, but for the moment they are not.

(ii) Yields are dependent upon the weather and flora. Thus they will continue to be variable with few areas being outstanding at least by temperate standards.

(iii) Quality of hive production is possible, but where is the quality control?

Thus where do we go from here? Furthermore can traditional beekeeping survive. Anyone who has observed the incidence of traditional hives hanging by the roadside will know that over the last 40 years they have rapidly disappeared to the point where one has to look very hard to see one at all. The reason for the decline is twofold.

(i) There are fewer trees available suitable for hive making

(ii) The vastly increased incidence of theft is making traditional beekeeping impossible in ever increasing areas

Urban drift and a disinclination of younger people to practice the traditions of their fathers is a factor, but I do not think it is very significant.

If beekeeping is to survive in Kenya the constraints will have to be overcome. Modern beekeeping has not come up with entirely satisfactory solutions to date. There will always be a place for top bar and frame hive beekeeping for the specialist, the enthusiast and the research worker. For the commercial honey farmer, large or small scale, modern beekeeping will be that which is most economic. It may be that a few commercial people will manage to run efficient beekeeping units using what you might call internationally modern methods.

Speaking for the small scale farmer, modern methods will have to be appropriate with much more attention to detail than has been the case to date. This also requires more practical field research and trials. I would like to see more promotion given to multi chamber top bar hives as described in *Bee World* 69(2): 63-68 (1988). In addition to work on top bar hives I would like to see more consideration to fixed comb hives, possibly multi chamber, such as King's Omdurman hive, readily and cheaply available and probably made of some modern material. My friend Werner Lohr has visions of plastic logs, in addition to other possibilities: he may be right.

Conclusions

Modern beekeeping must be appropriate if it is to play a role in the African economy. I agree with Hans Herren that much of what passes as appropriate technology is in fact inappropriate. May those of us who are privileged to participate in this workshop be sensitive to the needs of the barefoot farmers.

Finally in the light of some of what I have been hearing at this workshop I would like to add a post script as to some of what I believe has also been constraints to moving forward.

Unlike one of my colleagues I may not be politically correct, a philosophy which I believe has often done more damage than good and which has often caused us to evade some crucial issues that may be unpalatable.

The question of integrity was mentioned and this is too often lacking. Sometimes some people say what is convenient and for example anyone who is familiar with project proposals knows full well that they are written more for what the donor wishes to hear than what is strictly meant, required or intended leaving the donor to choose whether or not to come forth with the funding. We are more likely to report on the successes than the failures of our research and development, yet sometimes the very failures are the crucial information that is required. Instead we gloss over them and even pretend that something works when it does not. I have seen that in some of the so called appropriate technology that has gone out in some countries. There have from time to time been backward steps but such does not make nice reading in annual reports so that does not always get mentioned.

Too often we have seen new designs advocated when they have no proven merit. Knowledge is present, but there are constraints to its dissemination and a part of the problem is that there is too much information and the good work has not been filtered out from the bad. Example, Mr Jones told us that he looked up Kenya 1984 in Apicultural Abstracts. There were too many entries so he took say 1990 instead. What this illustrates is a modern tendency that we see over and over again, which is that it is only recent research that is considered. There is an attitude that anything before 1980 is not relevant and anything pre independence is from the dark ages. We neglect good research from the past to our cost. It was the foresight of Eva Crane who drew attention to the Greek basket hives which largely led to the development of the Kenya top bar hive and its deviants.

When I recently requested a ten year old paper on the Handeni honey plant in Tanzania from GTZ, I was told it was no longer available. Both a commercial enterprise and an NGO were considering reviving it and wanted to know what had happened earlier. European foul brood was mentioned yesterday and it was said that there were no record. May I tell you the reference? It is *Bee World* 1958 **39(9):** 230-2, Foul Brood in Tropical Africa by F.G. Smith. Good quality honest research is to be encouraged, but it is a pity to remain ignorant of that which has already been done.

OVERVIEW OF BEEKEEPING DEVELOPMENT IN KENYA

R. M. Mbae

National Beekeeping Station, Kenya

Introduction

In general 75% of Kenya is suitable for beekeeping. Beekeeping is particularly in arid and semi-arid areas, where other agricultural activities like crop farming are minimal and *Acacia* sp. vegetation is in abundance. There are also substantial apicultural activities in agriculturally high potential areas, where better quality products and improved production facilities are employed.

Kenya's honey production potential is estimated at 100,000 metric tonnes with an equivalent of 10,000 beeswax. However, only about 10% of these products are realized, because most of the highly productive areas are unexploited. The production of these products mostly come from traditionally hives (2 million), Kenya top bar hive (200,000) langstroth (2000) and others like box hives and mud block hive (1500). Therefore, most of the bee products from Kenya come from traditional beekeeping. Other products like royal jelly, pollen, propolis and bee venom are insignificantly produced due to lack of awareness, knowledge on production technique and undeveloped marketing system. The major constraint however, in traditional beekeeping, is low productivity per hive, minimal managerial practices, as well as lower quality products, compared to use of top bar or frames hives.

Honey is mostly used in nutrition, fermented drink, preservation in pharmaceuticals and herbal medicine. Beeswax is normally used in candle making, cosmetics, medical field, textile industry and equipment production.

Development of beekeeping industry peaked during the period 1972-1984, when various studies and programmes were carried out including the following:

Training

This involved basic courses and higher training of personnel on beekeeping.

Research

Through research the following achievements were made:

(i) Bee races were positively identified in Kenya, *Apis Mellifera nubica, Apis mellifera monticola* and *Apis mellifera litorrea*

(ii) Development of appropriate equipment, such as local manufacture of Kenya top bar hive and other accessoriies like catcher box, smoker, protective kit, queen excluder, feeder boxes and hive tools

(iii) Identification of different bee flora in various ecological zones was carried out

(iv) Studying of bee behaviour, absconding, swarming, migration and supsedure and their causes, effects and management implications.

Extension

(i) Production of equipment

(ii) Establishment of co-operative societies

(iii) Establishment of refineries

(iv) Development of technical packages.

Establishment of Centres

Areas of economic importance national beekeeping stationary and demonstration centres to apiculture in Kenya to-date:

(i) Pest and disease control

(ii) Development of appropriate equipment. KTBH having successfully been adopted, requires future research so that beekeepers in different ecological zones are able to utilize it

(iii) Improvement of processing techniques. Simple, cheap and appropriate technology applicable in traditional beekeeping suggests further research into this area

(iv) Marketing system. Demand-driven organization of stakeholders in the industry. The government is co-ordinating this development

(v) Environmental conservation

(vi) Production and utilization of bee products, particularly pollen, royal jelly, beevenom and propolis

(vii) Selection and breeding.

Current / Purposed Programmes

(i) Training of farmers, staff, scientists, manufacturers, tailors and processors

(ii) Research towards effective control of waxmoth

(iii) Survey and data collection on bee diseases

(iv) Production of equipment

(v) Selection and breeding

(vi) Bee products: processing, analysis, utilization and marketing

(viii) Honeybee pollination on crops.

POLLINATION SERVICES BY AFRICAN BEES

C.J. Coleman
Zimbabwe

Background

During the last 20 years I have been working in the pollination field in Zimbabwe. As people become more informed regarding the enormous financial benefits of using the service of custom pollination, the need for numbers of pollination hives has escalated. To provide adequate hives, that is units of a specific standard and in sufficient numbers, we have to establish a suitable education programme for the beekeepers and growers. In addition, attendance at seed production field days and farmers' association meetings will ensure that accurate information is given to farmers.

Education

In Africa there is a tendency to perpetuate beekeeping using the top bar hive. The top bar is good in its place, but in order to meet pollination needs, and stop the drain of natural resource, serious thought should be given to a hive which will tolerate transportation and migratory beekeeping. I believe, persons that have proved their ability to manage our bees, should be offered the opportunity to develop commercially. There is little or no planning in this direction. The result is a dearth in units suitable for field work in pollination, which means enormous loss of revenue in seed and horticultural production. In fact beekeeping clubs in Africa are ready to move into commercial techniques to make pollination services available to the agricultural industry. The people are limited by lack of educational opportunities to develop present skills.

The problem lies in the cost of equipment, not in ability. Finance should be raised to support suitable candidates in loan form.

There is a natural fear of our bee which has been capitalised by dissemination of inaccurate information regarding the African bee, as a result of the unfortunate circumstances in South America. The notorious killer bee! It is our responsibility, to correct this impression and grant credit where it is due. We have a fantastic bee!

Research

In Zimbabwe we have a vacuum — silence that screams. This, I believe, is the general picture throughout most of Africa. We know there is lack of honey bee penetration into our crops. How serious this is, and to what extent it affects production needs researching. We would appreciate assessment of our bee in our crops — African bees working in African crops.

Breeding

In Zimbabwe, in our apiaries we use carefully selected strains of *Apis mellifera* scutellata. I believe, in the course of time, we have been left with the more aggressive survivors of mismanagement. We have proved that selective breeding of queens with controlled mating, produces a strain of quiet, productive bees. It has to be acknowledged by beekeepers internationally that we have a superior bee. Let us learn to use this asset to full advantage.

Our breeding programme uses the Doolittle Queen Breeding System employing the modified long hive — two brood chambers, maintained without queens, adjacent to and on either side of the queen compartment. The queen compartment consists of four drawn brood frames which are replaced regularly to increase laying area, and facilitate continuity of laying. If the queen does not have space to lay prolifically, insufficient pheromones will be produced, and laying workers will result.

Controlled mating is ensured by saturating the immediate area, 35^2 kilometres with our gene pool. This results in only desirable drones being available for free mating, perpetuating characteristics of docility, productivity, low swarming, migration and propolising tendencies.

Pollination Unit Preparation

Agriculturalists need to be assured of a good service. In order to achieve this, a standardised balanced unit should be available. A recognised and acceptable inspection system should be in place. To enable bee keepers to attain this, education and commercial organisation of the industry are essentials.

In our operation, pollination units are reconstructed when hives are returned from the fields to the home base apiaries. A standard unit consists of six brood frames — four of which are of varying stages of emerging brood, two brood frames of food, and the remaining four of drawn wax. We believe the unit should have a minimum of 20,000 bees and a vigorous young queen to promote growth.

Food stores should be depleted of pollen, compelling house bees to collect pollen for emerging brood.

Methods of Preparation

(i) **Decoy hives:** That is 5 frame nucs which catch natural swarms. This is a common means of procuring swarms in Zimbabwe, because of the inherent high swarming tendency of *A.m.scutellata*. The migrating trapped swarms are amalgamated to standard and requeened with a selected scutellata queen.

(ii) **Production units:** These are larger established colonies in Langstroth hives. Colonies with bred queens are split to the above standard, the queenless split being requeened with a bred mated queen. Should the field queen show signs of ageing, she is also replaced.

(iii) **Feeding:** A communal feeder is used to provide the bees with sugar syrup.

Movement of Pollination Units

In Zimbabwe we move bees up to 700 kilometres — exercising due care regarding the prevailing capensis problem in South Africa. The units are given a super chamber with foundation wax each, for ventilation, in preparation of movement. The hives are strapped on the morning of the day of movement using nylon cord. Hives are closed using thoroughly saturated cheese cloth, immediately prior to loading, in the evening. All movement takes place at night after all bee activity has stopped. When distances exceed 200 kilometres, hives are irrigated for 1 hour prior to closing. This reduces bee activity earlier allowing more travelling time. Loaded hives are irrigated every 3 hours in transit to reduce stress.

Movement of pollination units requires close co-operation between growers and apiarists so that bees arrive at optimum flowering, and are removed as soon as pollination is completed, to avoid starvation. Growers have to acknowledge bees are like livestock and accord them the same care and respect. Pollination units should not be moved around by the grower.

Geographical Features

When placing bees near an expanse of water, make allowance for their reluctance to fly across the water. Where there are other features, (corpse of trees or rocky outcrop) these may offer protection to the bees resulting in bee flighting to a more attractive nectar source. So in these instances, entrances should be staggered to avoid a velocity drive of bees in one direction.

Hive Stands

Stands should be inexpensive, temporary and effective in protecting bees from insect damage - in particular the small brown ant — safeguarding from flooding and damage to equipment. In orchards we use concrete palettes for individual hives. In fields, soil in drawn up to a height of approximately 15 cm, treated for ants, securely covered with polythene sheeting, whose edges of which are buried, to prevent flapping in the wind and annoying the bees. This should be done between 7 and 10 days prior to placement of bees.

The beekeeper and grower should decide on hive placement in advance. This avoids frustration of alternative floras in adjacent fields and cutting out flourishing crops to place hives strategically. We find bee placement within the crops critical.

Contracts

We have contracts to protect the grower, seed producer and beekeeper. It assures the beekeeper of adequate notification of bee requirements, spraying programmes, security of equipment and bees while in the field and making provision for payment.

Pollination of Crops in Zimbabwe

Hybrid sunflowers for seed

As already mentioned, advance planning between all concerned is a prerequisite to success. Planting ratios and bee placement should be established before planting. In Zimbabwe, we find two rows of pollen donor (male) to four rows of seed producing plants (female), the most successful. Planting ratio of three pollen donor to eight seed producing, had inadequate pollination in centre rows. We have recently had good results with planting ratio of two pollen donor with a third insurance row underplanted by hand, at a later date, to four rows of the seed bearers.

The number of pollination units required is determined by variety and plant population. In multi-flora pollen bearers , additional hives will be required. 45,000 to 60,000 plants to the hectare requires three hives.

Should flowering of pollinizor and seed bearer fail to synchronise, supplementary bouquets may be brought in and placed at 5 metre intervals, in containers suspended at the same height as the seed bearing plant flowers.

We look for bee activity of three bees per ten actively flowering heads at 75% blossoming. Time of day, weather and presence of European bee eaters should be taken into account when assessing bee penetration.

Placement — In fields of up to ten hectares, bees with slightly more food supplies are moved at 5 to 10% flowering in one movement. This obviates unnecessary transport and expense.

In fields of ten to one hundred hectares, two equal movements of bees at:

(a) 5 to 10% flowering
(b) 35% flowering

This facilitates closer crop monitoring and less rentals for the grower.

Hive stands should be 200 to 250 metres apart, arranged in stations of five hive units with entrances facing different directions to avoid drifting.

When an attractive alternative flora is in the area, bees should be placed on the farthest side of the field, forcing bees to fly over the crop to be pollinated.

Runner Beans for Green Beans

Phaseolus grown under shade cloth for maximum yield and quality. Beans are comparatively unattractive to bees and when grown under shade cloth any chance of incidental pollination is minimised; humidity is high encouraging mould in the hives and heavy losses are incurred. Continued spraying of beans with copper based fungicides inhibits the laying of the queens and colonies become severely depleted. Since pollination is prolonged it is necessary for the beekeeper to rest the colonies every 4 weeks. When seven or more hives per hectare are in place it is necessary to feed the bees sugar syrup and supplement with frames of pollen. Syrup is fed communally and must be in place before bee activity begins in the morning and regular.

Placement — individually, at least thirty metres from the edge of the field and equidistant within the field with entrances in alternating directions encourage maximum distribution of bees throughout the field. Attention to placement of hives since foliage is dense, profuse flowering and varying heights increase pollination problems.

Yield — The top yield attained exceeded 60 tons of green beans per hectare.

Sweet Peppers

A recent experiment was carried out in the Lowveld, on the southern borders of Zimbabwe. Groups of plants were screened to exclude bee activity, while adjacent free pollinated plants were demarcated as a control. This first experiment showed a definite advantage in fruit size plus 100% increase in yield. Unfortunately, disease in the crop prevented further work being undertaken.

Deciduous Fruit

In Zimbabwe trees are pollinated for maximum set of 90%. The fruit is thinned by hand to achieve full and even distribution of fruit. Initial irregular flowering is pollinated by resident hives, which are in strategically placed houses.

Apples: Usually apples bloom simultaneously with *Brachystegia*, so hive numbers may be increased and hives placed away from the attractive flora. Bees could be fed within the orchard and petals of the blossom crushed in the syrup to scent the hives. It may be necessary to introduce bouquets of pollinizor blossom for extra pollination. We find it more effective to suspend the bouquets at blossom height throughout the orchards.

Placement — in mature orchards, three pollination units per hectare at 10 to 15% flowering for an average period of 3 weeks. Hive stands are individual, set low within the orchard, at a minimum distance of 20 metres from the perimeters, and at 50 metre intervals.

Yield — Average 25 tons per hectare.

Pears: Smaller pollination units with lower dispersal powers, are more successful in pollinating this relatively difficult to pollinate crop. Initial trials were carried out with standard units with very inadequate results. Subsequently, trials with 60,000 bee units in an effort to increase the pollinator force, had dismal results. Finally, increased numbers of units of depleted strength (10,000 bees) were introduced. This furnished the orchard with the same bee force working in a state of emergency. Emerging brood required immediate food and care from a depleted workforce and this did not allow long flights. Bees were, therefore, compelled to work in close proximity to the hive. The result was tremendous pollination, heavy fruiting, requiring branch supports.

Placement — in mature orchards three units per hectare at 5% flowering. Stands should be at 50–metre intervals and set low in the trees with entrances in alternating directions.

Stone Fruits

Plums: Santa Rosa frequently flower in inclement weather conditions. In addition the flowers rapidly lose their attractiveness in the hot sun, limiting the effective time for pollination by bees. Six hives per hectare are required for 3 weeks to ensure a good fruit set. In mild weather conditions this number may be reduced.

Nectarines and peaches: Hives should be placed back to back in two unit stands at 200 metre intervals throughout the orchard at the rate of one hive per hectare in mature trees. Peaches are wind pollinated, but when orchards are on protected slopes or cold windy ridges, we find heavy blossom shed from lack of pollination and sparse, large fruit. In one well-managed orchard in the eastern highlands of Zimbabwe, an average of 14 tons fruit per hectare was produced over a period of 3 years, prior to the introduction of bees. Subsequently, the average yield of this orchard has increased to 26 tons per hectare over a 2 year period. This is an increase of 85%.

Citrus

One production hive per hectare for 25 days. Fruit shed is reduced and yield increased in lemons by over 40%.

Litchi

Mature trees require three hives per hectare for 25 days at 5% to 10% flowering. Litchi groves in Zimbabwe are in an area particularly high in natural bee population. With bee activity of 30 to 40 bees per mature tree throughout the day, an increase of 35% yield on average over the last 3 years, was achieved.

Raspberries and Blueberries

Three hives per hectare for 6 weeks at 5% flowering. We are assured by growers that there is an increase of yield and quality and continued use of pollination is proof of this, but no figures are available.

Paprika

This crop is attractive to bees and required one hive per hectare at 5% flowering. Heavy spraying schedule is a problem.

Passion Fruit

Has two peak flowering periods in the crop cycle. One hive per hectare for 3 months from inception of flowering.

Kiwi Fruit

Three hives per hectare at 5% flowering of fruit bearing stock. Placement should be underneath the trellises of vines, individually, on stands at even spacing. At six hives per hectare, without thinning of fruit, increase of yield at 60% was recorded. All picked fruit exceeded 80g in weight.

Legumes

Silverleaf clover for seed. The profuse flowering of very small blossom, set deep within abundant, sticky foliage, makes this crop difficult to pollinate. To prevent hives being overgrown, hive stands must be well cleared. Placement of three hives per hectare at 5% flowering for 25 days. Seed will only set with pollination. Yield increase of 85%.

Flower and Vegetable Seeds

Control plots of one hectare with three hives per hectare on individual stands, at equal distances. Due to uneven germination in vegetables, extended pollination was necessary. In flower varieties, problems in bee preferences were experienced due to a lack of preplanting planning.

Cineraria

In shade houses of 0.25 to 0.5 hectare bees were placed within the shade houses. Structures were of thatching grass, allowing bees minimal alternative foraging.

In custom pollination, it is unusual to glean any honey. To make it a commercially viable exercise for the beekeeper, loss of honey production has to be compensated for by the pollination charge per day per unit.

It is generally concluded that this expense to the grower is more than offset by the increase in production. There is no doubt that increased awareness of this facility is of benefit to the whole community.

FOREST CONSERVATION AND BEEKEEPING IN ZAMBIA

B. P. Munalula

Zambia

Abstract

Beekeeping in the north-western Province of Zambia is built on the traditional production methods and the experience of families and ancient practitioners, and is appropriate for the beekeepers' level of understanding and competence. Substantial levels of production have been achieved with traditional methods which are currently in use, and much is going to waste, because market outlets are uncertain or unknown.

Modern methods are appreciated as they ensure maximum returns through reasonable and economic exploitation of forest resources. They should, however be introduced slowly in order not to impact the current production levels achieved or lose the rich traditional practices which may be the appropriate technology of the future. The introduction of modern methods must also be backed by a sound, but unambitious research, which is focused on increasing the productivity of hives and the proper training of beekeepers and field staff.

Continued success at all levels of production impinges on the industries' impact on the available forest resources, the presence of an effective extension delivery system, community management and utilization of forest resources.

Beekeeping in the Northwestern Province of Zambia

Background

The North-western province shares common border with the Democratic Republic of the Congo on the north, and the Republic of Angola on the west. The East is the Copperbelt Province, while the south is the Western Province. Its rainfall ranges between 900 to 1000 m annually.

Being close to the Congo rain forests, it enjoys the indirect influence of good rains, especially in the northern tip of Mwinilunga District where cropping may be all year round. The trees are tall and sporadically form a dense interlocked canopy in some areas. The population is scanty, only 3.0 per sq/km. The settlement pattern ranges from isolated homesteads to clusters of twelve to fifteen strong households. These are spread over some pockets of rich soils and perennial rivers and streams. Agriculture is still developing; it is constrained mostly by lack of improved tools. The tradition of cattle keeping is slow and the use of work oxen just emerging.

There are no large industries except for one copper mine on the outskirts of Solwezi township. The forests are almost intact except for a few areas of settlement concentration and selected timber felling.

History

The practice of honey hunting and trapping is an age old instinct and tradition among the Lunda, Luvale, Chokwe and the Kaonde, who almost comprise the entire population. It is strongest in central and eastern Angola and the southern Congo where the groups hail or have strong ethnic ties. It has spread over the whole North-western province of Zambia and has spilled into the Western Province and the south.

The use of hives was first recorded in Angola in 1594. David Livingstone gives first written evidence of log and bark hives among the Lundas of Ishindi in upper Zambezi in 1854.

Beekeeping or honey hunting became an important economic activity on contact with Portuguese traders in the west coast of Africa early in the 17th century. It expanded into the upper Zambezi and Kasai 100 years later. The tools used were crude, but adequate and are still in use in many areas. These are an axe, a hunting knife, a strong fibre rope for hanging hive or lowering the honey. A bark cloth was used for straining the honey until the Portuguese introduced the calico cloth. Technology has advanced to the extracting of propolis which they used for mending calabashes, canoes and wooden dishes.

Traditional smokers are made of dry grass and green branches of inflammable bushes which are tied together in a long bundle and lit at one end.

Batting in the traditional practice differs from place to place. Some only make specious hives and bees colonize them. In others, the hive is smoked with selected herbs or bushes like genus *Strobilanthopsis*, or smearing propolis on hive doors.

Production Method

Several types of hives are in use in the Province. These are the log hive, kafikufuku, mat hives, odd boxes and drums, calabashes and bark hives.

(i) Log Hives

The log hives are generally from dry logs hollowed by insects and fungi. They can be whole tubes or split and put together after preparation. A central hole for cropping is made and covered with dry barks. The ends are covered with bark or grass doors.

(ii) Kafukufuku

The cylinder is formed slake of dead wood over a frame of three rings of tough and flexible branches. A thick layer of thatching grass serves as insulation and protection from rain. The ends are covered as in the log hives.

(iii) Mat Hives

A cylindrical hive made by rolling a robust reed mat is used commonly in many households. The overlapping joints are stitched and the whole structure covered generously with thatching grass. The ends have grass doors.

(iv) Calabash Hives

Empty calabashes are readily occupied by swarms. A normal calabash holds 30 litres. The mouth is blocked with grass and small holes made on the bottom. Colony expansion can be facilitated by linking two calabashes in a horizontal position (Kalombo hive).

(v) Bark Hives

The most popular, seen hanging on trees along streams, road sides and outlying woodlands. This consists of a strong bark of fibrous trees with straight features. The doors are made of grass or bark with a small hole in one. The shape is maintained by driving strong wood pegs to hold the overlapping joints. Two or three rings of tough, but flexible branches help maintain the shape.

Hive Siting and Management

Traditional beekeepers have become highly skilled, learning from their parents and ancient practitioners. They appreciate and know the importance of bee forage. They site their links in forests with species which can support beekeeping. These are areas which flow 70-80% of the year. Hives are hung in trees at a range of 3 to 6 metres above the grounds. Hanging is by strong fibre ropes or placing on forks in trees. There is no manipulation of the hives, removing them only when they are damaged or need cleaning and rebuilding. Cropping has in the past been burning and killing of bees in great quantities with fire.

The Industry

The backbone are the over 5000 poor beekeepers who derive a major part of their income from the sales of bee products. The sale of bee products made a significant, but minor contribution to the overall household food security.

The wide range of bee forage, favourable rains and the traditional acumen of the people, give this area a greater advantage over the rest of Zambia. A survey conducted for a project by Africa in 1995 revealed the following in three districts of the project area alone: Two factories have been set up in Kabompo and Mwinilunga with a capacity to process 300 tonnes each. The factories are too small to process the staggering 1351 tonnes produced in the project area alone. The North-western Bee Products Company Limited is seeking accreditation for organic certificate to obtain access to European markets. This is unnecessary as there are local and regional outlets offering higher prices. Accreditation tests the chemical content of the product in forest areas where chemical sprayings are unknown.

Cropping Season and Flora

North-western maintains two nectar flows classified as main and minor. The main nectar flow runs from August to October when the rain season begins.

The honey is cropped from November to December and sometimes up to January. The supporting tree species are mainly the *Brachystegia longifolia* and sister species. *B. longifolia* is a bee tree with heavy nectar flow between September and November. The species are found throughout Zambia, especially in Miombo woodlands, *Cryptosepalum* and *Parinair* forests. It extends over most Tanzania, Southern Congo, Eastern Angola and Northern Mozambique.

The second and minor nectar flow runs from March to April. Cropping is from May to mid June. The dominant tree species are the *Julbernardia paniculata* and *Julbernadia globiflora*. Weeds such as *Erlangee misera* contribute to the honey build-up during this nectar flow.

Julbernardia species are common in Zambia. They occur in dry evergreen forests in most woodland types on plateaus and escarpments. They are common also in Kalahari sands and are confined to the Congo, Tanzania, Malawi, Angola and Northern Mozambique. The tree is valuable as it flowers for four months during the period and at a time when many trees do not flower. A third species is the *Cytosepalum exfloriatum Pseudotaxus spp.* It flourishes in sandy areas of Zambezi and Kabompo. The species flowers in June to September and supports the main crop from November to December.

Extension

The beekeeping division of the forestry department is in charge of extension. Previous beekeeping operated on individual basis and covered a small number of beekeeping extension officers. These were augmented by salaried Indunas who were selected from among the experienced beekeepers. Today beekeepers have been organized in groups along routes, in readiness for registration and mobile training. Hives and marketing are done on individual basis. Efforts are being made to contact communal depots for each group.

A new development has been the involvement of women in beekeeping. With the realization that female-headed households form a third of the total population, attempts are being made to involve women as well. Women have for long been associated with beekeeping practices through their practicing husbands and relatives, and some own bark hives.

Twenty four (24) groups have been formed with a total membership of 591. Each group has elected office bearers who are trained in group dynamics and simple accounting. They own frame hives communally until they mature and operate as individuals in registered groups. The FAO study conducted for the project in 1996 confirmed that women had sufficient experience to deal in beekeeping as an income generating venture.

Common Beekeeper Problems

The common problems faced are as follows:

1. Inadequate markets and transport. There are no loans for simple transport such as bicycles. Buyers are few and mostly unknown and unpredictable. Some individual beekeepers own up to 1000 hives and need transport to harvest them properly

2. Lack of protectives during harvest

3. Pests such as termites, are causing absconding to bees

4. Adverse weather such as partial drought and frost, and fires affect honey production

5. Honey badgers cause 100% destruction when attacking hives, but remain comparatively minor problem.

The Future

Continued success in beekeeping in the Province impinges on the impact of the industry on the natural resources, need for conservation and presence of an active extension delivery system. However, the selective nature of the damage and destruction of trees through beekeeping is relatively modest. Moreover, it does not lead to deforestation and thus does not affect the bee pasture. Most of the tree species from which hives, doors and trays are made, do not yield appreciable and suitable timber.

Traditional beekeeping should be assessed in the context of forest damage and destruction from local communities. Beekeepers are responsible for the destruction of a selected portion of trees through making hives. They also exclusively damage particular species when making doors. All beekeepers and forest dwellers destroy saplings by tearing off bark strips for cordage. Villagers and forest dwellers are responsible for clear felling of forest and woodlands in ecologically vulnerable zones of catchment areas and river banks. The same group is to blame for late bush fires in the dry season. The fire is used to keep out stray bees, create a clear vision for walking, hunting or trapping. Fires are set to reduce grazing for game and domestic animals; to ward off dangerous animals and for better cover from stings during honey cropping. Carelessness and arson are the other causes among children.

The crimes are many, but the answer lies in conservation through sustained utilization of forest resources by communities. The beekeeper is aware of the dangers and their effect on the harvest.

APICULTURAL PROMOTION AND DEVELOPMENT IN UGANDA

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The Uganda Honey Keepers Associations (UHA) is a national body that involves a broad spectrum of rural peasant honey keepers in Uganda. UHA has designed a programme of apiculture promotion and development in Uganda, stressing the following areas of intervention:

- mobilisation and training of trainers (TOT) and civic leaders from village to district levels;
- mobilisation and training of 70,000 potential/actual farmers from parish/ village to subcountry levels;
- distribution of appropriate modern apiculture technologies suitable for Uganda;
- refurbishing collection centres at county and district levels;
- establishing honey refining (for export grade honey, beeswax, propolis, royal jelly, etc) in selected districts throughout the country;
- markets research and encouraging and promoting local village level market outlets such as the promotion of honey as a traditional foodstuff and form of nutrition for honeybee products;
- strengthening UHA coordination at national level, down the districts to village

SESSION IV

a

b.

Plate 3

Plate 3. a. The wild silkmonth, *Gonometa sp* (Lasiocampidae) stimulated to lay eggs on its silk-cocoon after emergence; b. the fourth instar larvae of the silkmonth, *Bunea alcinoe* (Saturniidae) feeding on the host plant, *Balanites aegyptiaca*.

WILD SILKMOTH FARMING FOR INCOME GENERATION AND ITS IMPACT ON BIODIVERSITY

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Abstract

Silkmoths grown in wild condition are known as wild silkmoths. Wild silk constitutes about 10% of the total silk output in the world, but has a strong local and international demand. Wild silkmoth farming is very old, traditional, profitable and income generating avocation of the people of India since prevedic period (> 10,000 BC). Presently, wild silkmoth farming has its importance on socio – economic and ecological front. The scope of wild silkmoth farming include creation of employment opportunity for the tribals, perennial and assured income with nominal investment and nonuse of machinery and power, conservation of soil, ecosystem, forest and biodiversity. Farming of indigenous wild silkmoth races generates more income due to its higher productivity, but limited due to scarcity of wild seed cocoons in the forest and difficulties in collecting it. To provide income generating avocation to more people and to boost silk production, exotic and high yielding variety (HYV) ecoraces are introduced by the government. Easy availability of HYV eggs resulted in apathy to indigenous races and encouraged germplasm erosion. Continuous inbreeding of HYV ecoraces causes qualitative and quantitative genetic depression, reduces silk production and income generation. Conservation of wild silkmoth biodiversity and cultivation of hybrid eggs along with improvement in some farming practices are suggested for better productivity, strengthening tribal economy and sustainable use of the forest to make the wild silkmoth farming an economic enterprise. Further, social forestry programme could cater for tribal welfare, forest conservation, supply of fibre fuel and food through wild silkmoth farming.

Introduction

Biodiversity among sericigenous fauna is common. The silk producing animals primarily categorised into insect or non insect group (Fig.1). The latter, includes an Adriatic mussel and a Madagascarian spider, whereas the former embraces all silk spinning insects either nourishing on the mulberry plant, or some other non mulberry species. The silk of non insect origin is of no importance to textile market as its use is limited in the area of optical instruments.

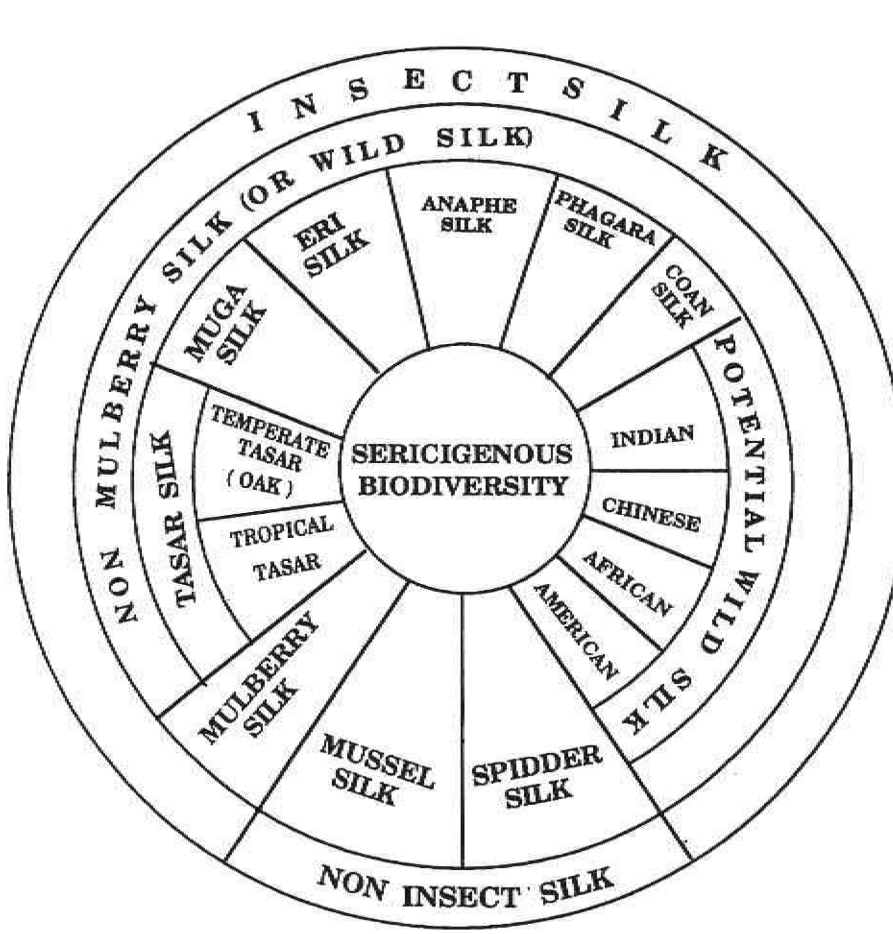

Figure 1. Biodiversity clock of sericigenous fauna

Mulberry silk, produced by the fully domesticated *Bombyx mori* Linn. constitutes about 90 % of the total silk production in the world. Other insect species that depend on non mulberry plants mostly grow in the forest under tender cares of the mother nature, are known as the wild silkmoths. In the animal kingdom, the wild silkmoths are one among the fauna expressing enormous diversity (Table 1). They constitute an array of about 500 species abounding the temperate and tropical forests though they constitute a very small fraction to the total silk production in the world and thus of little economic importance. The diversity among them is amazing and fascinating to the scholars in the world. The wild silkmoths include a variety of species that feed on a variety of food plants to produce different kinds of silks such as Tasar, Eri, Muga, Anaphe, Fagara, Coan and potential wild silks. In the world the sericulture zone is very diverse and extends from 10°S to 50°N Latitude (Fig. 2).

Table 1a. Some commercially important wild silkmoths of the world

Sl.No.	Species of the silkmoth	Family	Type of silk	Distribution
1.	*Antheraea paphia* Linn.	Saturniidae	Tropical Tasar	India
2.	*Antheraea mylitta* Drury	Saturniidae	Tropical Tasar	India
3.	*Antheraea pernyi* G & M	Saturniidae	Temp. Tasar	China, India
4.	*Antheraea Yamamai* G & M	Saturniidae	Temp. Tasar	Japan
5.	*Antheraea roylei* Moore	Saturniidae	Temp. Tasar	India, China
6.	*Antheraea assamensis* Helfer	Saturniidae	Muga	India
7.	*Samia ricini* Donovan	Saturniidae	Eri	India China
8.	*Samia cynthia* Drury	Saturniidae	Eri	India, China
9.	*Anaphe vanata* Butler	Notodontidae	Anaphe	Nigeria
10.	*Anaphe infracta* Wals.	Notodontidae	Anaphe	Nigeria
11.	*Anaphe reticulata* Walker	Notodontidae	Anaphe	Uganda
12.	*Anaphe panda* Boisduval	Notodontidae	Anaphe	Zaire,Togo, etc.
13.	*Epanaphe molonei* Druce	Notodontidae	Anaphe	Nigeria
14.	*Epanaphe carteri* Walsingham	Notodontidae	Anaphe	Cameroun
15.	*Epanaphe vuilleti* Joan	Notodontidae	Anaphe	Cameroun
16.	*Attacus atlas* Linn.	Saturniidae	Fagara	India, China,
17.	*Attacus cramer* Fldr	Saturniidae	Fagara	India, China,
18.	*Attacus edwardsi* White	Saturniidae	Fagara	India, China,
19.	*Attacus doherteyi* Roth	Saturniidae	Fagara	India, China,
20.	*Attacus standingeri Roth*	Saturniidae	Fagara	India, China,
21.	*Pachypasa otus* Drury	Lasiocampidae	Coan	Italy, Greece,
22.	*Pachypasa lineosa* Vill	Lasiocampidae	Coan	Italy, Greece

Table 1b. Some important potential wild silkmoths of the world (Indo - China, South East Asia, Saturniidae)

No.	Name of species	No.	Name of species
1.	*Attacus lorquinii* Fldr.	2.	*Attacus caesar* Msn.
3.	*Attacus inopinatus* J. & L.	4.	*Archaeoattacus edwardsii* White
5.	*Samia watsoni* Ober	6.	*Samia carringii* Hutton
7.	*Samia walkeri* Fldr.	8.	*Samia Yayukae* Pksd & Pglr.
9.	*Samia peigleri* Nmn & Nsg	10.	*Rhodinia verecunda* Inoue
11.	*Fhodinia Jankoswii* Obrtr.	12.	*Loepa anthara* Jordan
13.	*Loepa miranda* Moore	14.	*Loepa megacore* Mell
15.	*Cricula haytiae* Pkstd & Shdjn	16.	*Caligula Japanica* Shiraki
17.	*Caligula Jonasii* Sonan	18.	*Caligula boisduvalii* Evsmn
19.	*Caligula thibeta* Okano	20.	*Caligula zuleika* Hope
21.	*Saturnia pyretorum* Watson	22.	*Saturnia boisduvalii* Eversman
23.	*Actias selene* Fldr	24.	*Actias heterogyna* Kishida
25.	*Actias neidhoefesi* Ong. & Ya.	26.	*Actias maenas* Dbld.
27.	*Actias groenendaeli* Roepke	28.	*Actias dubernardi* Ober.
29.	*Actias rhodopneuma* Rober	30.	*Antheraea alleni* Holloway
31.	*Antheraea formosana* Sonan	32.	*Salassa lola* Westwood
33.	*Salassa megastica* Swinhoe	34.	*Rhodinia fugax* Butler
35.	*Rhodinia verecunda* Inoue	36.	*Rhodinia Jankowskii* Ober.

Table 1c. Some important potential wild silkmoths of the world (American and African)

No.	Name of species	No.	Name of species
	(American potential)		
1.	*Gloveria psidii* Salle (= *Eutachyptera psidii*)	2.	*Eucheria socialis* Westwood (Only butterfly silk)
3.	*Malacosoma Incurvum* Aztecum	4.	*Malacosoma americanum* Fabr.
5.	*Antheraea montezuma* Salle.	6.	*Antheraea godmani* Druce
7.	*Antheraea polyphemus* Linn.	8.	*Hyalophora cecropia* Linn
9.	*Hyalophora euryalus* Boisdv	10.	*Hyalophora columbia* Strecker
11.	*Callosamia promethia* Drury	12.	*Actias luna* Linn.
13.	*Saturnia walterorum* H. & J.	14.	*Saturnia pyri* D. & S.
	Sl. No. (1, 3, 4 Lasiocampidae; 2 Pieridae and rest Saturniidae)		
	(African potential)		
1.	*Gonometa postica* Walker	2.	*Gonometa rufobrunea* Arvls.
3.	*Borocera cajani* Vinson	4.	*Argema* Sp.
5.	*Antistathmomoptera* Sp.	6.	*Gonimbrasia* Sp.
7.	*Atheletes* Sp.	8.	*Bunaeopsis* Sp.
9.	*Imbrasia* Sp.	10.	*Bunaea* Sp.
	Sl. No. (1,2, 3 Lasiocampidae; and rest saturniidae)		

Wild Silkmoth Farming

Farming of wild silkmoth involves all aspects that finally lead to the production of silk fabrics. Primarily, it involves raising of host plants, production of silkmoth eggs, rearing of larvae till formation of cocoons, processing of cocoons to obtain silk yarn and its utilization in weaving silk fabrics.

The silkmoth is holometabolic, completing its life cycle in four steps viz. egg, larva, pupa and moth. At the beginning of the life cycle moths emerging from the diapausing cocoons mate to lay eggs. After about a week of incubation, tiny larva come out from egg. The larval stage is the only feeding stage and lasts for about 5 weeks. Generally, the larva is a tetramoulter and its body grows to

1. AFGHANISTHAN
2. ALGERIA
3. ARGENTINA
4. BANGLADESH
5 BHUTAN
6 BRAZIL
7. BULGERIA
8 BURMA
9 CHILE
10 CHINA
11 COLUMBIA
12 CONGO
13 EGYPT
14 ETHIOPIA
15 FRANCE
16 GHANA
17 GREECE
18 HUNGARY
19 INDIA
20 INDONESIA
21 IRAN
22 ITALY
23 IVORY COAST
24 JAPAN
25 KENYA
26 KOREA (NORTH)
27 KOREA (SOUTH)
28 LAOS
29 LEBANON
30 MADAGASCAR
31 MALAYSIA
32 MAURITIUS
33 MEXICO
34 MOROCCO
35 NEPAL
36 NIGERIA
37 PAKISTAN
38 PAPUA NEW GUINEA
39 PARAQUAY
40 PRK
41 PERU
42 PHILIPPENES
43 POLAND
44 ROMANIA
45 SPAIN
46 SRI LANKA
47 SYRIA
48 TANZANIA
49 THAILAND
50 TUNISIA
51 TURKEY
52 UGANDA
53 U.S.S.R
54 VENEZUELA
55 VIETNAM
56 YUGOSLOVIA
57 ZAMBIA
58 ZIMBAMBWE

Figure 2. Sericultural map of the World

considerable extent both in size and weight. At the end of this stage the caterpillar spins a protective shell of silk around it by extending a continuous silk filament through its mandible. The silk filament is a mixture of fibroin or silk proper produced in the silk gland and sericin or silk gum produced in the stomach. In about four days the larva transforms itself into a chrysalis. At this stage the cocoons are either directed for processing to obtain silk yarn or are kept in grainage for continuance of life cycle. In non diapausing cocoon, transformation of pupa to moth stage is continuous. After about 10 days the moth emerges by piercing the cocoon shell. Moths of opposite sex mate and the mated female moths after separation, lay eggs to repeat the cycle. The number of repetition of life cycle per year depends upon the voltinism which is proven to be influenced by eco - climatic factors (Fig. 3).

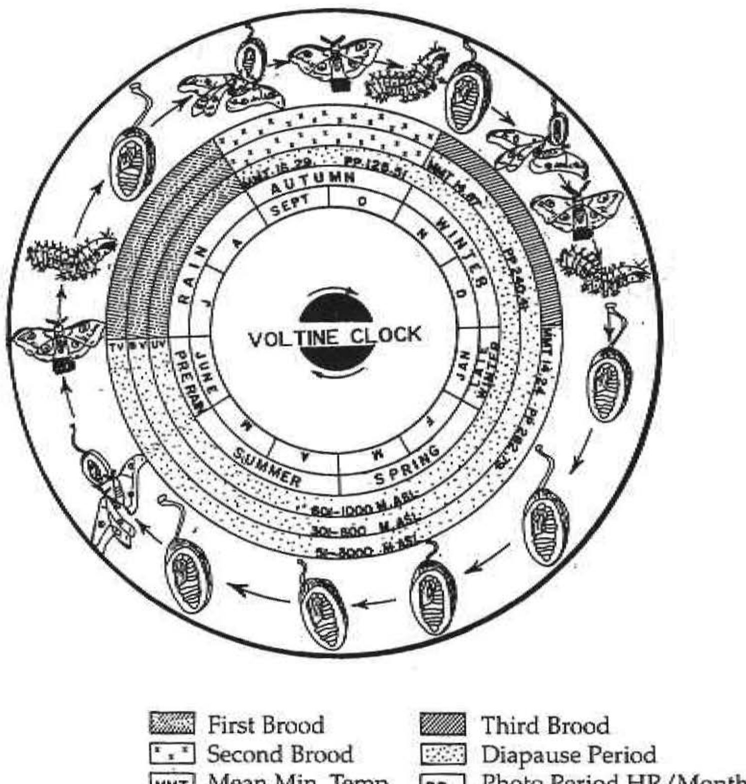

Figure 3. Voltine clock of Tasar silkworm

Selected quality cocoons are treated in steam lightly roasted to fix the silk and to stifle the pupa inside for preparation of silk yarn. Then they are boiled to soften the gum and thereby loosen the silk strand. Filaments from 5 - 10 cocoons are reeled simultaneously to a single thread. The silk yarn so obtained is woven into silk fabric either with the help of loom or machine.

Scope of Wild Silkmoth Farming

Wild silkmoth farming has its importance on socio - economic as well ecological front. It provides perennial and substantial income to people with nominal investment in their natural dwellings. The otherwise idle force of the family like women, children, and older people can be utilized. Due to the rising demand for wild silk goods both at home and abroad the future of wild silkmoth farming appears bright and safe with least chance of a fall in price. The pruned branches of the host plants are used as firewood suppressing any temptation for illegal felling of trees for the purpose, a practice common at countryside India. Wild silk larvae and pupae are used as food for fish, poultry and even consumed by

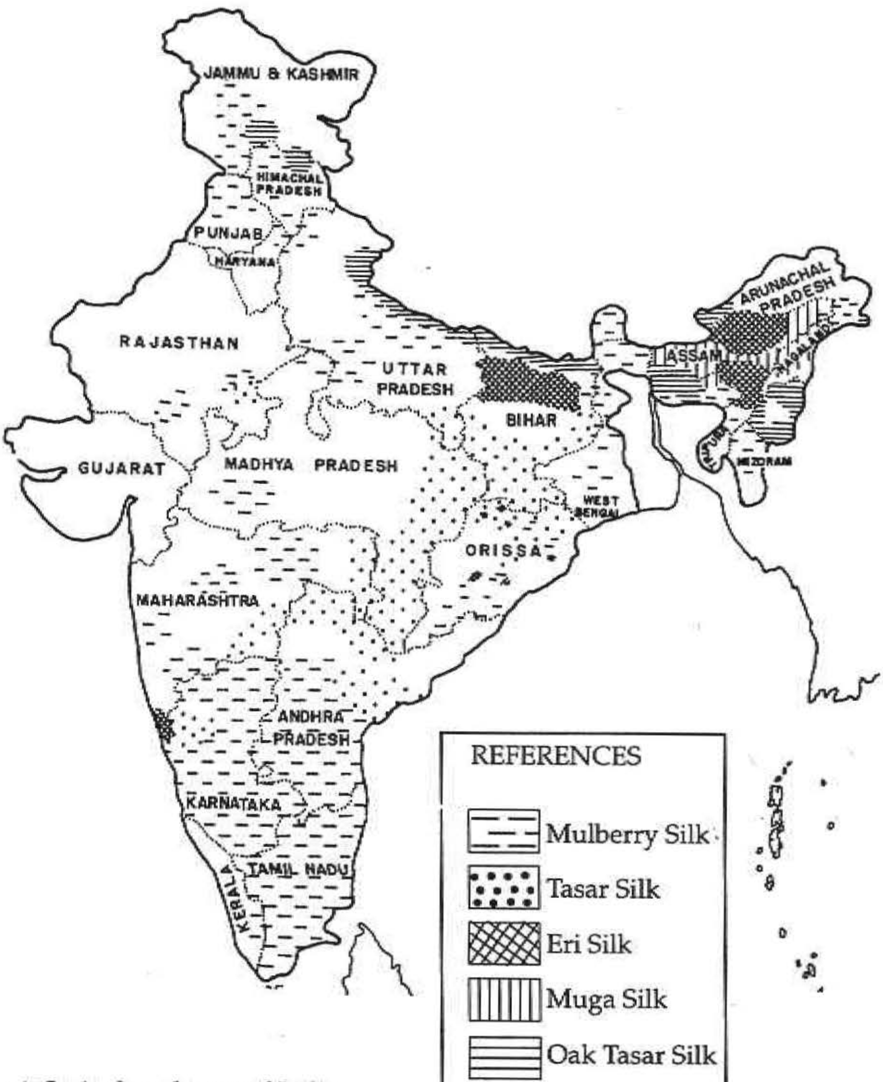

Figure 4. Sericultural map of India

the aborigines. They also use the pupae as medicine. Prospect of using the pupae in the preparation of cosmetics is bright. Wild silkmoth farming checks indiscriminate diversion of the forest for sustainable non - forest use and thus helps in its conservation. Other beneficial contributions specific to forests are reduction of carbon dioxide, increase in atmospheric oxygen, harmonisation of rainfall, prevention of flood and cyclones, increase of soil fertility, prevention of soil erosion, and protection to wild flora, fauna and conservation of biodiversity is an indirect benefit.

Wild Silkmoth Farming in India

The wild silkmoth farming in India is confined to cultivation of tropical tasar silkmoth, *Antheraea paphia*, temperate tasar silkmoth, *Antheraea pernyi*, Muga silkmoth, *Antheraea assamensis* and Eri silkmoth, *Samia ricini* (Fig. 4). *Antheraea* spp. has a wide biodiversity (Table 2). The tropical tasar silkmoth *A. paphia* is exclusively cultivated in India. Indian scholars use the name *A. mylitta* for tropical tasar silkmoth. However Peigler and Wang (1996) regarded *A. mylitta* as a junior synonym of *A. paphia*. Primary food plants of *A. paphia* include *Shorea robusta* Gaertn., *Terminalia alata* Hyene ex Roth. (= *T. tomentosa*) and *T. arjuna* Wight and Arn. Besides, a list of more than four dozens of Indian food plants also exist (Table 3).

Table 2. Biodivesity of *Antheraea* species in the world

No.	Name of species	No.	Name of species
1.	*Antheraea paphia* Linn.	2.	*Antheraea mylitta* Drury
3.	*Antheraea assamensis* West wood	4.	*Antheraea pernyi* Guerin
5.	*Antheraea yamamai* Guerin	6.	*Antheraea roylei* Moore
7.	*Antheraea frithii* Mr.	8.	*Antheraea knyvetti* Hmps.
9.	*Antheraea helferi* Mr.	10.	*Antheraea sivalika* Mr.
11.	*Antheraea andamana* Mr.	12.	*Antheraea crompta* R. & J,
13.	*Antheraea janna* Stoll,	14.	*Antheraea semperi* Fldr.
15.	*Antheraea larissa* Ww.	16.	*Antheraea ridlei* Mr.
17.	*Antheraea pristina* Wkr.	18.	*Antheraea surakarta* Mr.
19	*Antheraea delegata* Swh	20.	*Antheraea polyphemous* Cram.
21.	*Antheraea mylittoides* Bouv.	22.	*Antheraea pratti* Bouv.
23.	*Antheraea rumphi Fldr.*	24.	*Antheraea harti* Mr.
25.	*Antheraea gephyra* Niep.	26.	*Antheraea pasteuri* Bouv.
27.	*Antheraea rafrayi* Bouv.	28.	*Antheraea cordifolia* Weym.
29.	*Antheraea imperator* Wts.	30.	*Antheraea brunnea* Eecke,
31.	*Antheraea eucalypti* Scott	32.	*Antheraea larissoides* Bouv.
33.	*Antheraea billitonensis* Mr.	34.	*Antheraea sciron* Ww.
35.	*Antheraea prelarissa* Bouv.	36.	*Antheraea fiekei* Weym.
37.	*Antheraea montezuma Salle*	38.	*Antheraea godmani* Druce

Table 3. Food plants of the tropical tasar silkmoth, A. *paphia*

Sl. No	Food plant species	Sl. No	Food plant species
1.	*Terminalia alata*	27.	*Lagerstroemia indica*
2.	*Terminalia arjuna*	28.	*Lagerstroemia speciosa*
3.	*Terminalia catapa*	29.	*Zijiphus jujuba*
4.	*Terminalia belerica*	30.	*Ziziphus mauritiana*
5.	*Terminalia glabra*	31.	*Ziziphus xylopyra*
6.	*Terminalia foetidissima*	32.	*Zizphus rugosa*
7.	*Terminalia manti*	33.	*Ficus religiosa*
8.	*Terminalia myriocarpa*	34.	*Ficus bseila*
9.	*Terminalia procera*	35.	*Ficus retusa*
10.	*Terminalia mucronata*	36.	*Ficus benjamina*
11.	*Terminalia chebula*	37.	*Bauhinia variegata*
12.	*Terminalia paniculata*	38.	*Bamby malbaricum*
13.	*Terminalia pyrifolia*	39.	*Bamby neptaphylum*
14.	*Terminalia muellerian*	40.	*Hardwickia binata*
15.	*Terminalia utrina*	41.	*Melostoma malbaricum*
16.	*Terminalia pallida*	42.	*Careya arborea*
17.	*Terminalia bialata*	43.	*Casuarina equisetifolia*
18.	*Tectona grandis*	44.	*Carissa caranda*
19.	*Madhuca indica*	45.	*Rhizophora caleolaris*
20.	*Anogeissus latifolia*	46.	*Pentaptera tomentosa*
21.	*Rosa indica gigantea*	47.	*Pentaptera glabra*
22.	*Shorea robusta*	48.	*Carsia lanceolata*
23.	*Shorea talura*	49.	*Dodonea viscosa*
24.	*Syzygium cumuni*	50.	*Webera corymbosa*
25.	*Syzygium sphoerica*	51.	*Cipadessa fructosa*
26.	*Lagerstroemia parviflora*	52.	*Cantium didynum*

Wild silkmoth farming is an ancient tradition of the people of India since prevedic period (> 10,000 BC) and remained obscure for a long time. It received royal patronage till the British rule (1680) when the Indian wild silk was at the peak of its glory all over the world (Pandey, 1944). From first Century AD, upto the colonial rule, tasar silk items were exported to several countries by indigenous ships through the ancient ports of Eastern India. Wild silkmoth farming got a set back during the colonial rule due to its restrictive and negative trade policies. After 1930, wild silkmoth farming got state patronage but did not flourish due to free movement, second world war and merger of princely states with the Indian union. The uncompromised demand for wild tasar silk transformed this age old tribal craft into a modern farming activity and cottage industry of immense economic value.

In the post independence period the Government of India organised the wild silkmoth farming by establishing Central Tasar Research and Training Institute in 1964. At present a large number of units of Central Silk Board (CSB) and the respective State Governments look after the wild silkmoth farming.

Out of the 843.93 million people (1991 Census) only 0.398 million are engaged in tasar farming; 28.10 million poor people live in the tasar belt. The socio - economic profile of wild silk moth farmers is very poor (Table 4). Similarly, only 5% of the existing tasar host plants are exploited in farming of the tasar silkmoth. The production of tropical tasar silk has increased from 124 MT in 1950 to 650 MT in 1995 and the trend of increase is far lower than that of mulberry silk.

Table 4. Socio-economic profile of wild silkmoth farmers in Orissa

Profile	Distribution		Percentage
Category	Scheduled Tribe (ST)	—	77.76
	Scheduled Castes (SC)	—	12.18
	Other Backward Class (OBC)	—	10.06
Family structure	Adult (4)	Male	24.82
		Female	24.02
		Total	48.84
	Children (4)	Male	24.54
		Female	25.62
		Total	51.16
	Total Member (8)	Male	50.36
		Female	49.64
	Worker (4)	Male	22.97
		Female	21.67
		Total	44.68
Land holding	Landless	—	11.33
	Land up to 2.5 ac	—	57.72
	Land up to 5 ac	—	24.85
	Land above 5 ac	—	6.10
Literacy	Illiterate	—	34.71
	Primary school	—	39.94
	Middle school	—	19.56
	High school	—	5.77
	College	—	0.00
	Trained in silkmoth farming	—	6.00
Income (Rs.8722)	Agriculture (Rs.3242)	—	37.17
	Wage labour Rs.1724)	—	19.77
	Forest collection (Rs.1945)	—	22.30
	Wild silkmoth farming (Rs. 1811)	—	20.76

The noxious impact of materialism is gradually tossing away tasar farming in the priority of occupation of tribal rearers. They are enticed by other lucrative offers of urban areas. Demand for land, agriculture, fuel and houses with increase in population and passion for materialist possession, is seriously shrinking the rearing patches and host plant population affecting wild silkmoth farming. A survey of such corrosion in the State of Orissa (Fig. 5), which is the third largest producer of tropical tasar silk, may well stand as an example (Table 5). In Orissa, over a period of 25 years tasar cocoon production has been reduced to 52.71%, host plant population to 55.49%, tasar rearing patches to 58.64% and number of rearer families to 21.66%, despite support by the Government (Nayak, 1996). Decline in forest and tasar food plants in Orissa vis - a - vis India is given in Table 6.

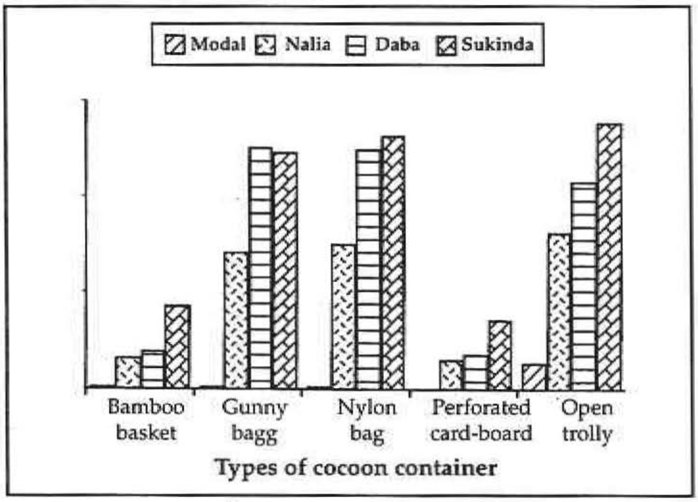

Figure 5. Effect of cocoon transportation in different types of cocoon containers (% of cocoon damaged)

Table 5. Decline in wild tasar silkmoth farming in Orissa

Year	Number of tasar cocoons produced (10^3)	Number of tasar food plants (10^3)	Number of tasar rearing patches (No)	Area of tasar rearing patches (h)	Number of tasar rearers (No)	Number of tasar growing villages (No)
1970	56251	8387	5123	64127	37954	2293
1995	30157	4654	3004	23641	8220	984
	(5361)	(55.49)	(58.64)	(36.87)	(21.66)	(42.91)
Deterioration	26594	3733	2119	40486	29734	1309
	(47.29)	(44.51)	(41.36)	(63.13)	(78.34)	(57.09)

(Figures in parentheses are percentage values)

Table 6. Decline in forest and tasar food plants in India and Orissa (in million hectare)

Item	India			Orissa		
	1980	1995	Depletion	1980	1995	Depletion
Total forest area	147.2	67.2	80.0	6.08	5.48	0.60
Total tropical forest area	44.5	20.8	23.7	6.08	5.48	0.60
Total forest in tasar belt	11.2	5.3	5.9	2.02	0.89	1.13
Forest area under *Shorea robusta*	9.7	4.8	4.9	1.69	0.77	0.92
Forest area under *Terminalia alata*	2.0	0.9	1.1	0.33	0.12	0.21
Area under tasar	0.4	0.2	0.2	0.051	0.024	0.027

Innovative Suggestion in Wild Silkmoth Farming for Higher Income Generation

Wild silkmoth farming, bestow a rearer a variety of sources of income in an easy cosy way. Apart from the final product i.e. cocoon, yarn or fabric, a rearer gets a handsome return through the byproducts of wild silkmoth farming such as compost from silkworm litters, animal feed, food, medicine and firewood as described earlier. Proper technical and scientific management of rearing is expected to enhance the present rate of income (Table 7).

Table 7. Income generation through cultivation of the tasar silkmoth

Items of input and output	Details of the item	Traditional cultivation (ISTP survey, 1992)		Modern farming (Nayak, 1996)	
		Quantity	Value(Rs)	Quantity	Value(Rs)
Material cost	Egg	100 laying (Govt.supply)	100	200Dfl (Own production)	200
	Forest tax	1000 plants (Dispersed)	05	10,000 plants (organised)	50
	Rites	Twice	60	Thrice	100
	Disinfectant	–	–	Turmeric Margosa formalin	25
	Miscellaneous	–	05	–	25
	Total	–	170	–	400

Labour cost	Adult labour	77	2310	70	2100
	Idle labour	2	50	10	250
	Total	79	2360	80	2350
Total farming cost	Material input	–	170	–	400
	Labour input	77MD	2360	80MD	2350
	Total	–	2350	–	2750
Income generation	Cocoon production	3162	1811	10,000	6250
	Income excluding material input	–	1641	–	5850
	Income per day of labour	79	20.77	80	73.13
	Net income excluding material and labour input	–	– 715 (loss)	–	3500 (profit)
	Net income per day	79	– 9.05 (loss)		43.75 (profit)
Income from firewood	@ 20 kg per plant	2 MT	2000	20 MT	20,000

A brief comment on systematic wild silkmoth farming which would imbibe the existing loopholes and shoot up the income trend is as follows:

(i) Production of healthy and viable eggs, selection of healthy and quality seed cocoon, preferably from the wild ecoraces to be procured for grainage operation.

(ii) Every available measure may be taken for safe transportation of the selected seed cocoon to grainage houses preventing damage or death of pupa.

(iii) Countryside thatched huts after proper modelling to suit the need can be used as effective grainage houses, as they are found to be more effective. Safest sanitation condition during grainage operation must be practised.

(iv) Increase in rate of copulation can be obtained by utilizing coupling devices such as mosquito net, where chance of escape of silkmoths permanently ceased, while limiting the space to comfortable range providing the moths a close proximity conducive for mating.

(v) Oviposition safe, economic and ecofriendly cups of host plant leaves may be utilized, instead of the presently utilized plastic devices.

(vi) Egg sterilisation instead of harmful chemicals such as formalin, vegetable disinfectants viz turmeric, *Curcuma longa* and margosa, *Azadirachta indica*, may be utilized to prevent chances of any loss of vigour in the progeny.

(vii) Among the primary host plants, *T. alata* when used in rearing, gives better result than its other counterparts and is hence recommended for wild silkmoth farming.

(viii) Eggs certified as disease free after microscopic examination of mother moth may be used for rearing. After proper incubation and just prior to hatching eggs may be distributed to rearers. Distribution of chawki worms would be more encouraging.

(ix) Safe transportation of eggs must be executed through well ventilated and no pressure exerting devices, avoiding jerking, wind or direct sunlight.

(x) Host plants, once utilised for rearing, may be left untouched for the next 1 - 2 years for a flourishing yield.

(xi) Particular ecorace and voltinic variety, gives good result at specific ecolocations, failing in uncondusive zones. Hence, rearing sites may be specified according to the silkmoth variety.

(xii) Establishment of germplasm banks at appropriate ecolocalities may be taken up for conservation, evaluation and stabilisation of pure races for further utilization.

(xiii) Hybridization between different ecoraces should be a continuous process to maintain the silk yield, preventing inbreed depression The process of hybridization and scientific management of germplasm bank through three tier seed organisation system utilising the wild reserve, is prescribed (Patro, 1997).

(xiv) Healthy practices during rearing, such as transfer of larvae from one host plant to another through twigs, round the clock vigil over the fields protecting intrusion of pests and predators, and isolation of larvae, with disease symptoms should be executed.

Impact of wild silkmoth farming on the biodiversity

The occurrence of *A. paphia* is concentrated in the central plateau of India and shrinking slowly, while descending southwest (Fig 3), between 12 to 30° N latitude and 72 to 96° E longitude, experiencing a diverse range of ecoclimatic conditions. Thus, the gene pool of *A. paphia* diversified, giving rise to 44 ecoraces, choosing a variety of host plants for nourishment, exhibiting allelic variation and expressing differences in productive and reproductive performances among them.

Recent survey indicated that the population of important wild ecoraces is fast declining (Table 8). Six such ecoraces, viz Laria, Sarihan, Andhra, Bhandara, Tira and Modal, showed drastic decline in their natural population over the last 11 years (Nayak, 1996; Sinha and Naqvi, 1997). In the State of Orissa the trend of cocoon collection of wild ecoraces decreased from 3.45 to 0.11 million in number over a span of 65 years, whereas the reduction in cultivation of wild ecoraces stands at 1.48 in 1995 from 24.25 million in 1930 (Table 9).

Table 8. Decline in collection of wild tasar silkmoth of six ecoraces of A. *paphia* L. (in 10^5 number)

Year	Laria (Bihar)	Sarihan (Bihar) Pradesh)	Andhra (Andhra Pradesh)	Bhandara (Maharastra)	Tira (West (Bengal)	Modal (Orissa)
1985 - 1986	12.27	6.52	11.05	8.45	9.69	10.40
1986 - 1987	10.72	5.90	9.72	6.10	8.83	8.60
1987 - 1988	10.17	5.43	9.13	5.92	7.90	1.90
1988 - 1989	9.73	4.15	8.15	5.53	7.14	0.70
1989 - 1990	8.63	3.24	6.93	3.40	6.65	0.18
1990 - 1991	7.13	2.70	3.65	2.68	5.71	0.13
1991 - 1992	3.03	1.95	2.81	1.33	2.65	0.15
1992 - 1993	3.11	1.40	2.33	1.22	1.88	0.14
1993 - 1994	2.48	0.97	1.86	1.14	2.20	0.12
1994 - 1995	1.72	1.12	1.44	0.77	1.55	0.11
1995 - 1996	1.53	0.85	1.52	0.85	1.38	0.11

Table 9. Trend of collection of tasar cocoons in Orissa (in 103 number)

Year	*Antheraea paphia* (Modal + Nalia)					*Antheraea mylitta* (Daba + Sukinda)			Grand Total	
	Wild cocoons	Crop cocoons	Sub-total cocoons	Rearer (No)	Egg (Kg)	Crop cocoons	Rearer (No)	Egg (Kg)	Tasar cocoons	Rearer (No)
1930	3450	20809	24259	875	–	–	–	–	24259	875
1935	3200	13202	16402	2771	–	–	–	–	16402	2771
1940	3506	13385	16891	1058	–	–	–	–	16891	1058
1945	3017	9825	12842	984	–	–	–	–	12842	984
1950	2790	7754	10544	792	–	–	–	–	10544	792
1955	2384	4641	7025	448	–	–	–	–	7025	448
1960	1771	2681	4452	2522	8.20	–	–	–	4452	2522
1965	2542	16442	18984	12959	41.60	14532	2476	324	33516	15435
1970	2388	13353	15741	13857	10.10	40520	4364	652	56261	18221
1975	2019	10984	13003	10220	–	37514	5186	866	50517	15405
1980	1225	9585	10810	7711	–	32231	6314	1156	43041	14025
1985	308	9128	9436	2853	–	25621	7193	1354	35057	10046
1990	126	1488	1613	1720	–	30782	6589	1228	32395	8309
1995	116	1370	1486	1278	–	28671	6700	1210	30157	7978

The tropical tasar silkmoth has been reared by the people in the forests of Orissa for a long time. In the post independence period, government patronage encouraged involvement of more rearers in the trade (2476 rearers in 1965 to 6700 rearers in 1995). CSB launched the cultivation of high yielding variety (HYV) ecoraces, viz Daba and Sukinda. At first the cocoon production increased to 40.5 million in 1970 from 14.5 million in 1965, but thereafter declined to 28.67 million in 1995, though supply of HYV eggs increased from 625 kg in 1965 to 1216 kg in 1995. In 1970, due to the astounding performance of the HYV ecoraces, the government abandoned the culture of wild ecoraces. The rearers lured by the cosy money, lost interest in the wild ecoraces. The number of rearers of wild ecoraces reduced from 13,857 in 1970 to only 1278 in 1995.

Thus a combined effect of an increased attraction towards HYV, apathy towards wild ecoraces and destruction of forest, led to drastic reduction in the wild cocoon production potential. Eggs of HYV ecoraces not only failed to increase the production (Alam and Thangavelu, 1996), but also faced a qualitative and quantitative genetic depression (Nayak, 1996). There may be least doubt about loss of forest area all over India (Table 6) including Orissa, but the decrease in number and area of tasar rearing patches was in all possibility due to the less enterprising nature of tasar farming as compared to other available avocations. It may then be safely interpreted that Government has failed to boost the tasar farming through introduction of two HYV ecoraces such as Daba and Sukinda. Supply of eggs increased quantitatively, but the hopeless production trend was a result of continuous inbreeding and adoption of unhealthy practices in all the tiers (P1 to P4) of its seed organisation system (Patro, 1997). Due to qualitative and quantitative degradation, prevalence of disease and low price after harvest, the traditional rearers have abandoned their age old tradition of wild tasar silkmoth farming.

Consequent upon universal degradation of forest ecosystem, blended with the above problems, it is high time to build suitable strategies for protection and preservation of genetic stock of the indigenous tasar ecoraces of India. Otherwise, shrinking in population size, would result in decrease of genetic variation. Low genetic variability reduces the adaptive potential of the species in changing ecological condition and consequently the species would be at the verge of extinction. In order to overcome this, the following steps are suggested for conservation of the biodiversity of the tropical wild tasar silkmoth:

(i) Conservation of selected areas of the forest ecosystem for *in situ* study cum conservation of different ecoraces.

(ii) Conservation of rare, vulnerable and endangered ecoraces.

(iii) Prevention of genetic erosion of ecoraces for present and future need.

(iv) Increased emphasis on wild silkmoth farming for income generation through advanced techniques described earlier.

(v) The above suggestion would automatically lead to study cum conservation of host plants and their systematic utilization.

Thus it may be confidently stated that conservation of sericigenous fauna and flora in the wild, would ensure higher income and sustainable use of the forest, through wild silkmoth farming. In addition, conservation of forest ecosystem points the globe green and comfortable for the human race.

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STRUCTURAL CHARACTERISTICS OF WILD SILKS AND THEIR UTILIZATION

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Abstract

Research on wild silkworm is considerably behind compared with that of *Bombyx mori*. Basic and applied studies have recently progressed, especially after the International Society for Wild Silkmoths was established in 1988.

The structure and ultrastructure of silk glands and the cocoon filaments from several species of Saturniidae insects were observed using both light and electron microscopy. The most important finding was that these cocoon filaments from Saturniidae insects contain numerous vacuoles in the cocoon filament. Other families, however, have no such vacuoles in the liquid silk nor the fine canals in cocoon filaments. The reason was found to be in the ultrastructural differences between the degenerating cuticular intima of the silk glands from Saturniidae insects and the others. These structural characteristics of Saturniidae cocoon filaments result in higher quality of textile than *Bombyx* silk: soft to touch, with heat retention and bacterial resistance.

Cocoon filament formation in *Bombyx* and *Antheraea yamamai* were compared. In *Bombyx*, masses of fibroin fibres form in the silk layer by exocytosis. They are transferred into the columnar fibroin through the cuticular membrane without the release of lysosomal materials. Numerous accumulated masses of fibroin fibres move forward into the middle and anterior silk gland, their shapes changing from circular to elongated as they orient to the long axis. They compact into a filament by passing through the anterior silk gland to the spinneret. They have no vacuoles in their cocoon filaments.

In *A. yamamai* which has no cuticular intima or extremely degenerated one in the posterior silk gland, fibroin fibres accumulate on the central fibroin column when they are released by exocytosis. Lysosomal materials are also secreted directly, forming many vacuoles deep within the central fibroin column. Masses of fibroin fibres and vacuoles move forward together in the middle and anterior silk glands, elongating as they move. These fibre masses and vacuoles pack tightly together and make the cocoon filament by passing through the spinneret. There are numerous tubular vacuoles in the filament.

We recently succeeded in making some smashed silk powder from waste cocoons of several wild silkmoth species, using a new type of mechanical smashing machine. These materials will greatly expand new types of applications, such as food, cosmetics, paper and non-textile sheeys, and interior ornamental materials.

Silk Glands of Insects and their Secretory Materials

The silk gland of Lepidoptera varies in shape, consisting of N,NZ, and Z types (Akai, 1976). *Pieris rapae, Barathrus brassicae, and Papilo exuthus* exhibit the N type. These silk glands are immature, the middle silk gland is S-shaped, and the posterior gland is reduced without tracheal distribution. *Bombyx, Dendrolimus spectabilis, Canephora asiatica* and others exhibit the NZ type, characterized by an S-shaped middle silk gland and a well-developed zigzag-shaped posterior middle silk gland and a well-developed zigzag-shaped posterior gland with tracheal distribution. These species make cocoons. *Antheraea yamamai, Antheraea pernyi, Antheraea mylitta*, and other wild silkmoths exhibit the Z type characterized by zigzag-shaped middle and posterior silk glands, but with a dense tracheal distribution; they make large cocoons (Akai et al.,1998). The middle silk gland is usually larger than the posterior in most species, except for some of the *Antheraea* silkmoths i.e, *A. yamamai, A. mylitta*, and a few others, functioning as a pool of liquid silk. In these species the posterior silk glands hypertrophy during the last larval stadium. They synthesize and store large amounts of fibroin, resulting in an inversion in size between the middle and posterior silk glands on the second to third day of last larval instar (Akai, 1970) (Figure 1).

At completion of larval maturation during the fifth stadium, the silk glands of B*ombyx mori* are about 25 cm long and comprise about 40% of the body weight. The gland has three divisions (*Figure* 2). The posterior part secretes fibroin, the main component of silk. Gelatinous components, consisting of three layers of sericin that coat the fibroin, are secreted by different regions of the middle area (Akai, 1976).

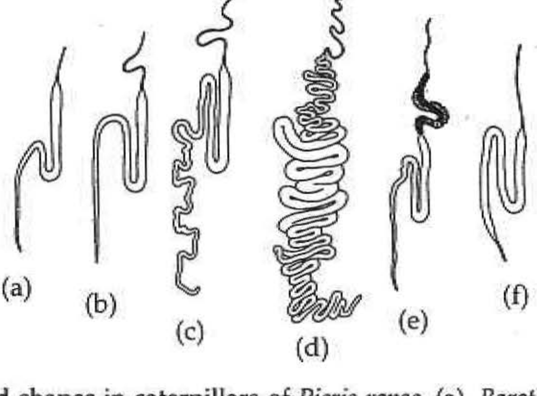

Figure 1. Silk gland shapes in caterpillars of *Pieris rapae*, (a), *Barathra brassicae* (b), *Bombyx mori* (c), *Antheraea yamamai* (d), *Diacrisia subcarnea* (e), and *Euproctis flava* (f) (From Akai, 1976)

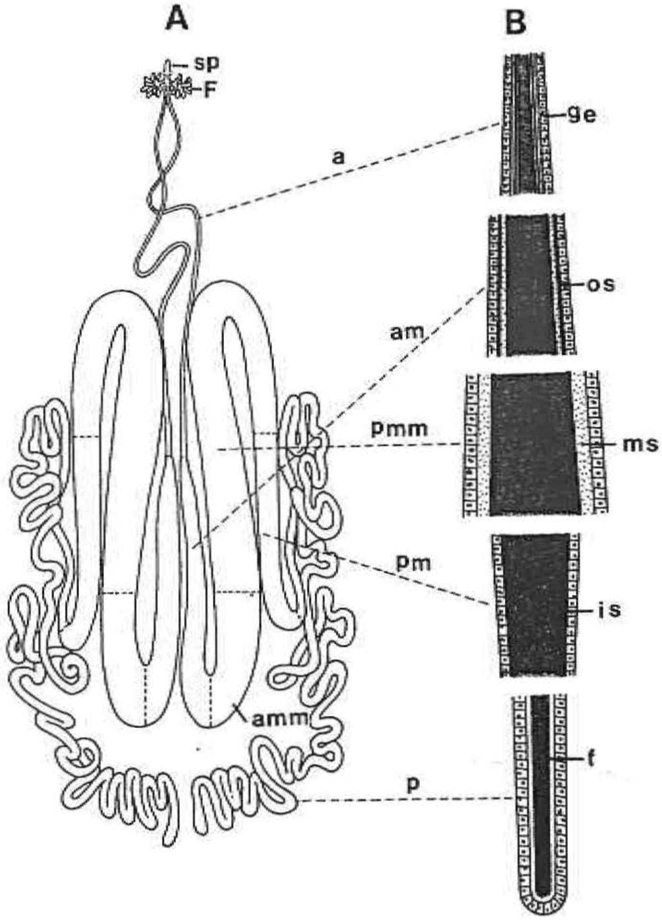

Figure 2. A: The silk gland of *Bombyx mori*. B: The secretory materials found in various regions of the gland. a, anterior silk gland; am, anterior division of the middle silk gland; amm, anterior part of the middle division of the middle silk gland; F, Filippi's gland; f, fibroin; ge, gland epithelium; is, inner layer sericin; p, posterior silk gland; pm, posterior division of the middle silk gland; pmm, posterior part of the middle division of the middle silk gland; sp, spinneret (From Akai, 1976)

The middle silk gland has posterior, middle, and anterior divisions. The inner layer of sericin is secreted exclusively by the posterior division, the middle layer of sericin by the middle division, and the outer is derived from both the middle and anterior divisions (Fig.2)

The anterior silk gland functions as a duct and does not secrete. Its inner surface is covered with a thick cuticular intima that shows a radial structure under light microscopy. The paired ducts join to form a common duct that enters the spinneret. Filippi's glands (also called Lyonet's glands) connect to the region where the paired duct fuse.

The spinneret is located in the apical part of the labium near the mouth cavity. Liquid silk transferred to the spinneret passes through the thread press, which consists of two concave chitinous plates.

The number of cells in several regions of the gland of *Bombyx* varies between larvae of different sex and strains. These are about 300 cells in the anterior, 250 in the middle, and 500 in the posterior region. In *A. yamamai*, the number of cells in each gland division is approximately twice that of *Bombyx* (Akai, 1976).

During larval development, cells in the different regions of the gland grow to different degrees. Ono (1951) estimated that cells of the anterior silk gland increase in volume 500-fold, while those in the middle and posterior silk glands increase about 86,000 and 57,000 times, respectively.

Structure of Cocoon Filaments

The mature larvae of silk-spinning insects spin a single filament to make a cocoon. Cross section of the filament from the cocoon shell of *B.mori*, scanning electron microscopy showed the many compact structures making up the filament (Figs. 3,4). In ultrathin section of the filaments of *B.mori* there are also compact filament sections without any porous fine structure, surrounded by densely stained sericin layers. In cross section of the cocoon shell, all the filament sections in the outer, middle and inner parts of the cocoon had similar profiles. In *A. yamamai* cocoon, vacuoles of various sizes were visible in the filament sections in cross section and tubular structure along the axis in the longitudinal section (Fig. 5).

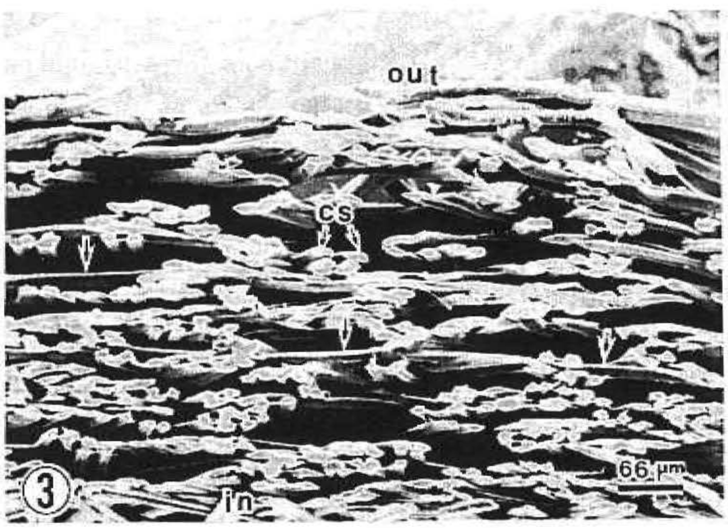

Figure 3. Cross section of the cocoon shell from *B. mori*. Cross sections of cocoon filaments (cs) and lateral cocoon filaments (arrows) compose alternate layer in the shell. out, outer surface; in, inner surface

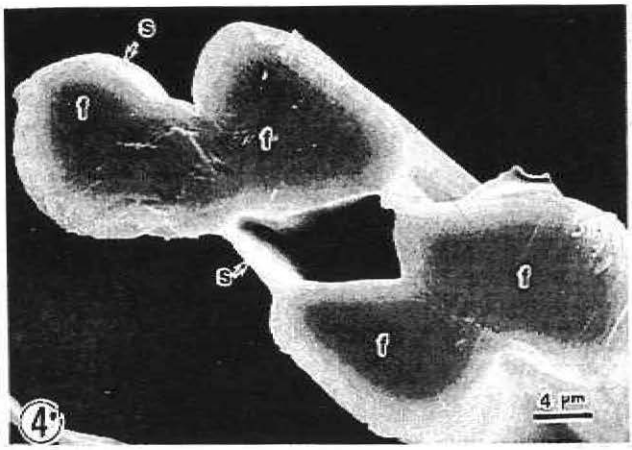

Figure 4. Cross section of cocoon filaments from *B. mori.* Each cocoon filament is composed of two fibroin filaments (f) covered by sericin (s). The filament has no tubules or vacuoles inside

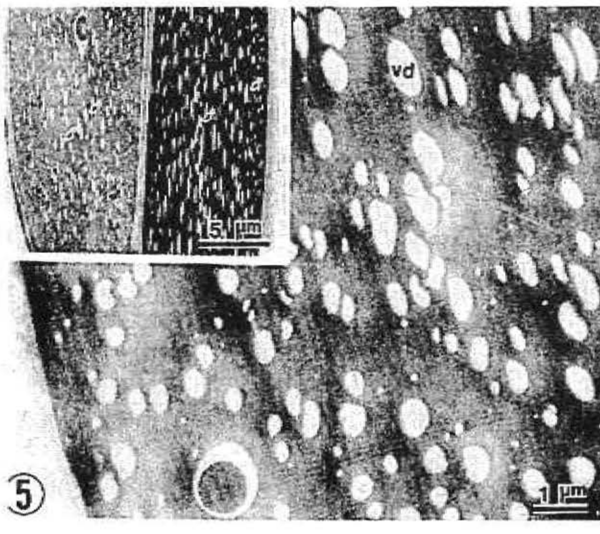

Figure 5. Cross section of cocoon filament of *Antheraea yamamai.* Various sizes of vacuolar droplets can be seen within it. Inset shows a pair of cocoon filaments sectioned at an oblique angle, showing the tubular shapes of their vacuolar droplets

We next observed, under light and electron microscope the silk gland and the cocoon filament of *A. mylitta,* which has the greatest capacity for silk protein production among all silk-spinning insects. The vacuoles were distributed in across sections of the posterior, middle and anterior silk glands. The average sizes in the posterior gland was about twice that in the middle gland, and more than thirty times that in the anterior gland. Round-shaped vacuoles originating in the posterior silk gland change into fine tubular vacuoles as they pass from the anterior part of the middle gland to the anterior gland (Akai et al.,1994). The cocoon filaments are large in size and contain many fine tubules oriented along the longitudinal axis, as do the other silk-spinning insects belonging to Saturniidae, for example, A. *yamamai* and *A. pernyi* (Figures 6,7).

Cricula trifenestrata, which produces a beautiful golden cocoon, is a member of the Saturniidae (Nassig, 1989) and makes a mesh cocoon with a small amount of silk. Cross section of the cocoon filaments by SEM clearly showed that they contain numerous tubules of various sizes, as does *A. mylitta*, belonging to the same family (Akai et al., 1996 Figure 8).

Other Saturniidae species, *A. paphia*, *A. assams*, *Samia cynthia ricini*, *Rothschildia arethusa* (Figure 9), *attacus atlas*, were observed by SEM, and all cocoon filaments showed the porous structure in the filaments. Other families, *Bombyx*, *mandarina*, *Gonometa postica* (Figure 10), *Anaphe reticulata* and *Cryptothelea formosicola* were also observed. The results showed that all of these filaments were non-porous (compact), as shown in Table 1.

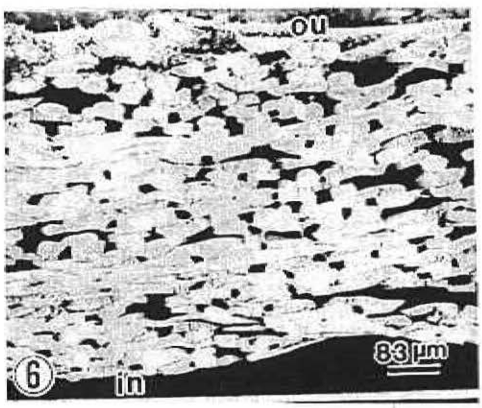

Figure 6. Cross section of cocoon shell from *Antheraea millita* by SEM. ou, outer surface; in, inner surface

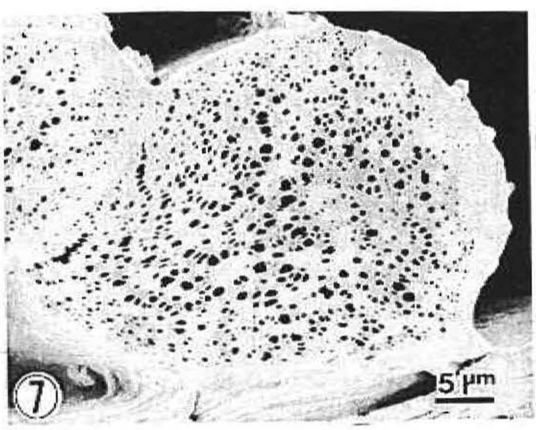

Figure 7. Cross section of cocoon filaments from *Antheraea myllita* by SEM. Various sized tubules are seen

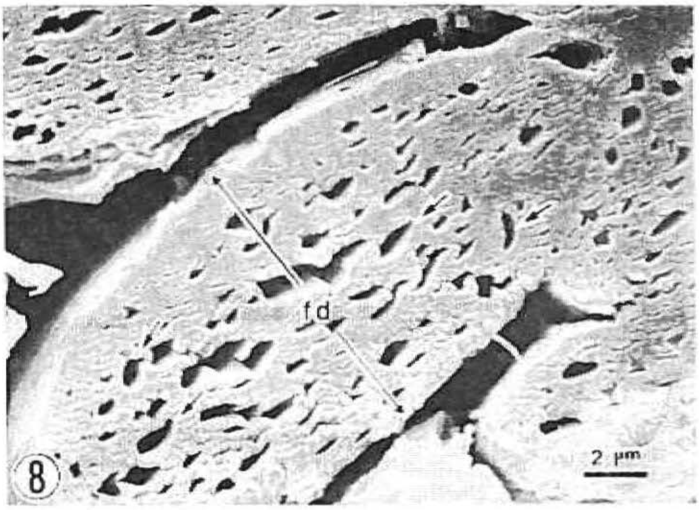

Figure 8. Cross section of cocoon filaments from *Cricula trifenestrata*, by SEM. The filaments contain various sized tubules along axix (arrows). fd, filament diameter

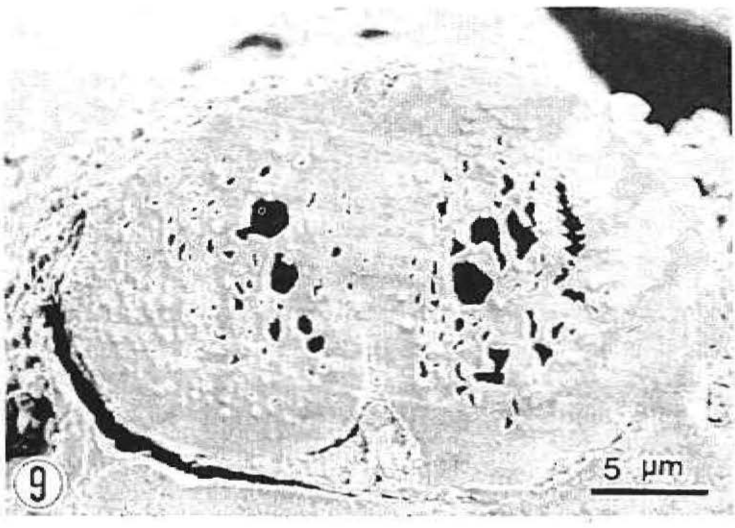

Figure 9. Cross section of cocoon filaments from *Rothschildia arethusa* by SEM

From these and earlier observations (Akai, 1970; Akai et al., 1989; Akai et al.,1993; Akai et al., 1996), we concluded that the cocoon filament of Saturniidae insects is porous, with numerous fine vacuoles or tubular structures, while other families including Bombycidae, Lasiocampidae, Thaumetopoeidae and Psychidae are all non-porous, without tubular structures in the filaments. These structural differences in the cocoon filaments by family are the result of evolutionary changes in the degeneration of the cuticular intima of the silk glands from some families.

Table 1: Fine Structure of Cocoon Filaments from Silk-spinning Insects

Families	Species	Characteristics
Bombycidae	*Bombyx mori*	compact filament
	B. mandarina	compact
Saturniidae	*Antheraea yamamai*	porous filament
	A. pernyi	porous
	A. mylitta	porous
	A. paphia	porous
	A. assamaensis	porous
	Samia cynthia ricine	porous
	Rothschildia arethusa	porous
	Attacus atlas	porous
	Cricula trifenestratea	porous
Lasiocampidae	*Gonometa postica*	compact
	Barocera madagascariensis	compact
Thanmetopoediae	*Anaphe reticulata*	compact
Psychidae	*Crypotothelea formosicola*	compact

Ultrastructure of Silk Gland and Fibroin Secretion

Nuclei of the posterior silk gland cells of mature B. *mori* are extremely ramified, and contain numerous nucleoli. During the fifth instar changes in size and shape of the nucleolus correlate with changes in RNA synthesis (Akai and Kobayashi, 1966;Akai, 1976). Quantitative auto radiography shows that the most active period of RNA occurs during days 3 and 4 of the fifth instar, corresponding to ultrastructural changes in the nucleoli (Akai, 1976).

During the larval moult cycle, the intracellular organelles change in number, size and conformation. Early in the fifth instar, there is little RER in the cytoplasm, but large numbers of free ribosomes. From the middle of the instar to the spinning stage, free ribosomes disappear and the RER fills the cell (Akai, 1983; Figure 12).

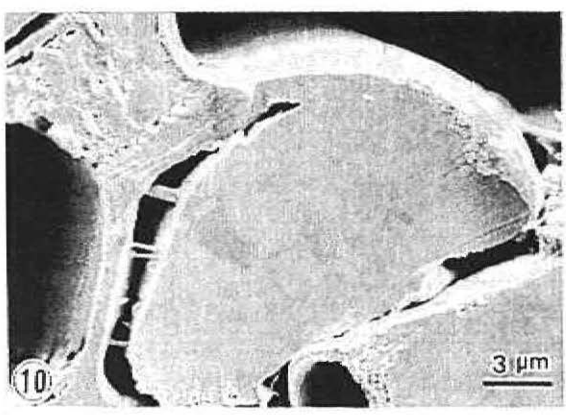

Figure 10. Cross section of cocoon filament from *Gonometa postica* cocoon, by SEM

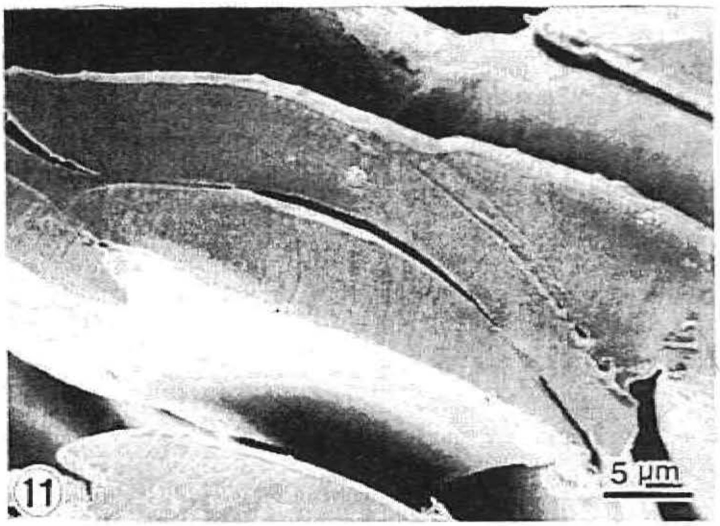

Figure 11. Cross section of cocoon filament from *Anaphe reticulata*, by SEM

Figure 12. Posterior silk gland cell in fifth instar larvae of *B. mori*. Golgi complexes (g) are surrounded by RER, and Golgi vacuoles contain many elementary fibroin fibres (arrows). et, RER, m, mitochondria; n, nucleus Inset: Enlarges Golgi vacuole containing several elementary fibroin fibres (arrows)

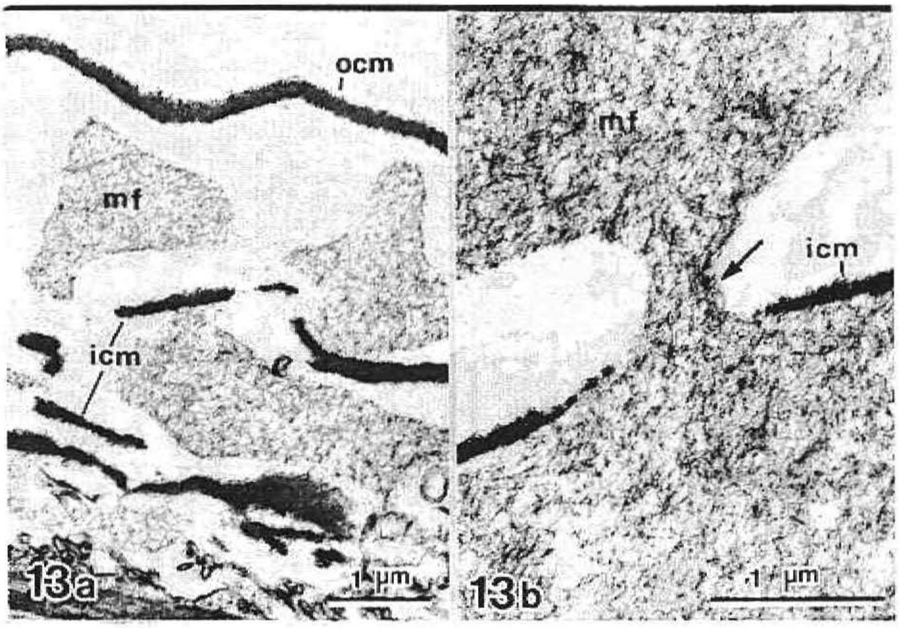

Figure 13 a,b. Masses of fibroin fibres and cuticular intima of *B. mori*. Masses of fibroin fibres (mf) are stored in silk layer (sl) and pass through (arrow) the inner (icm) and outer cuticular membranes (ocm)

Golgi complexes consisting of several Golgi vacuoles and vesicles occur in an area containing RER (Akai, 1976). Vesicles arise from the RER and are transferred to the Golgi complex. In the early stage of each instar, fibres are absent from the Golgi vacuoles, but they appear later and increase gradually as the larva grows (Akai, 1971). Elementary fibroin fibres are also present in fibroin globules, in the silk layer, and in columnar fibroin in the lumen (Akai and Kataoka, 1978, Akai et al., 1993; Figures 12, and 13a,b).

Mature Golgi vacuoles containing high concentrations of elementary fibroin fibres leave the Golgi complex as fibroin globules and accumulate in the apical cytoplasm (Akai, 1976). Fibres in the fibroin globules are released into the silk layer by exocytosis and are temporarily stored as massive fibroin fibres, then finally transferred into the lumen passing through the outer cuticular membrane (Figure 13a, b).

The apical surfaces of the posterior silk gland cells of *B. mori* are covered with numerous microvilli where ATPase is concentrated (Akai, 1970). Bundles of microfilaments are arranged periodically along the inner apical surface of the cells (Akai, 1976). In mature *Antheraea mylitta,* bundles of microfilaments are extremely large and prominent around the lumen.

Intracellular transport of fibroin has been studied by autoradiography (Rabinovitch and Vugman, 1959; Akai, 1963). Tritiated glycine was incorporated into the RER of the posterior silk gland cells in *B. mori* 10 minutes after ingestion (Akai, 1965). Silver grains appear above the Golgi complexes within 15 minutes, and labelled fibroin globules accumulate in the apical cytoplasm within 45 minutes. The fibroin masses are stored in the silk layer within 90 minutes, and the columnar fibroin in the lumen is labelled within 120 minutes.

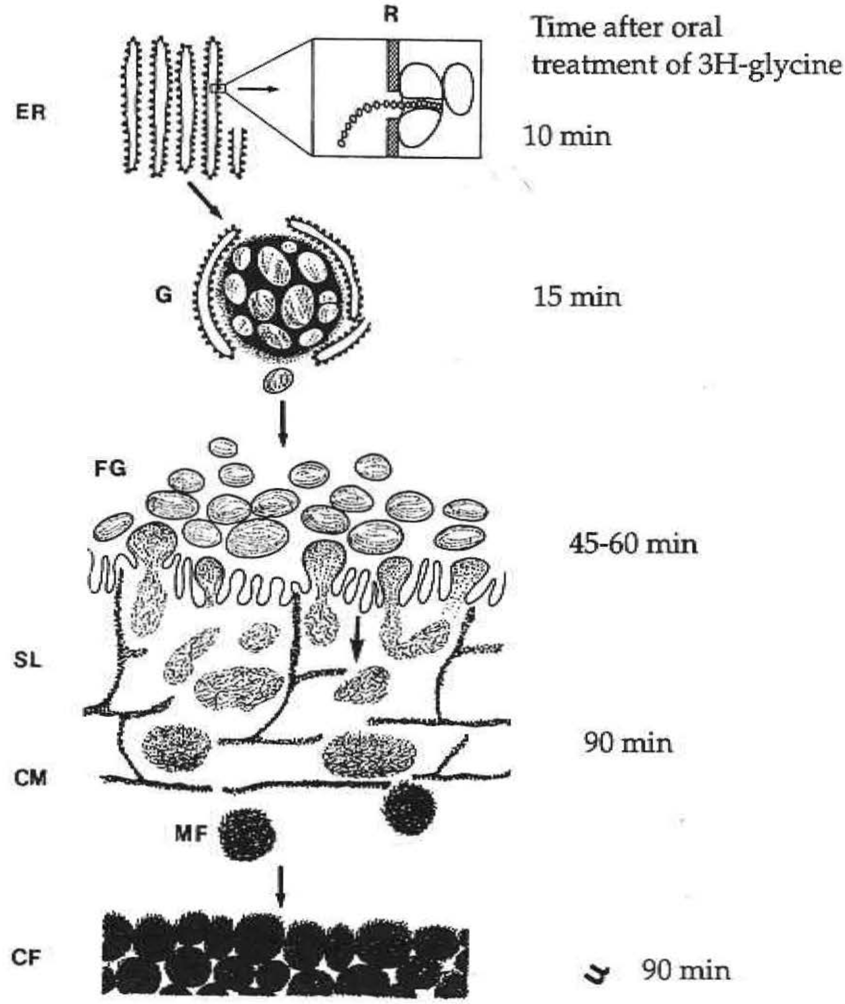

Figure 14. Time course of fibroin synthesis and intracellular transport. Tritiated glycine incorporates into rough endoplasmic reticulum (ER) of the posterior silk gland cells about 10 min after oral treatment. Silver grains appear above Golgi compolexes (G) within 15 min, and labelled fibroin globules (FG) accumulate in apical cytoplasm within 45-60 min. Masses of fibroin fibres (MF) formed by exocytosis are temporarily stored in the silk layer (SL) within 90 min. Next, masses of fibroin fibres pass through the cuticular membrane (CM) and are stored on the columnar fibroin (CF) in the lumen. R, ribosome (From Akai, 1990)

Cytoplasmic enzymes gradually accumulate in the silk gland cells of *Bombyx* larvae during the feeding period, but autophagosomes and autolysosomes are formed and functional regression of the silk glands occurs, only when feeding ends (Matsuura et al., 1976). Secondary lysosomes are rapidly converted into autophagic vacuoles, whose content is discarded into the gland lumen.

In *B. mori*, ecdysterone (moulting hormone analogue) administrated at 96 hours to the fifth instar, causes the cells to undergo premature histolysis (Akai, 1976). Within a few hours, the RER is lamelated and concentrated as cytoplasmic islands (Figure 15). These islands are enclosed by a separate membrane to become autophagosomes. A similar transformation occurs in silk gland cells during normal larval-pupal metamorphosis.

In *A. mylitta*, autolysosomes or lysosomal residual bodies from mitochondria and other organelles increase in the mature and spinning stages. These lysosomes are released into mature and spinning stages. The lysosomes are released into the lumen because of the degeneration of the cuticular intima and silk layer, invading the liquid fibroin column in the lumen (Figures 16 and 17; Akai et al.1993). Digestion results in numerous vacuoles in the fibroin column and the cocoon filaments.

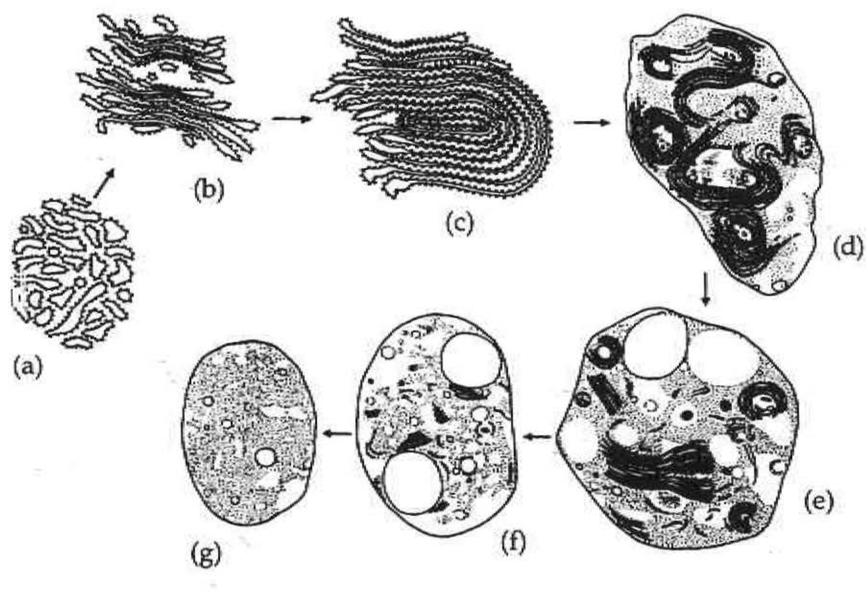

Figure 15. Lysosomes form from cytoplasmic organelles in the posterior silk gland ecdysterone treatment of last instar larvae of *Bombyx*. a, RER just after ecdysterone treatment; b, lamellar RER at 6-12 hr after the treatment; c, lamellar body of RER at 12-18 hr after the treatment; d, autophagosome at 12-24 hr; e-g, advanced autophagosomes or vacuoles at 24-48 hr

The cuticular intima consists of an outer membrane 0.1-0.5 µm thick, some discontinuous inner membranes and vertical supports. Masses of fibroin fibres and lysosomes occupy spaces in this cuticular cytoskeleton (Figures 13a,b,14). In *B. mori*, elastic pores, of different sizes occur on the outer cuticular membrane and secretion of fibroin fibers through the pores also occurs throughout the active secretory period of fibroin. The intima has probably evolved to facilitate silk secretion (Akai, 1984 a,b). The intima is also composed of horizontal cuticular membranes and vertical cuticular supports containing numerous masses of fibroin fibres in *Bombyx mandarina* (Shimizu and Akai, 1994). In the silk gland of *Antheraea*, including *A. yamamai* and *A. mylitta*, the cuticular intima degenerate.

Liquid Silk and Cocoon Filament Formation

Ultrastructure of the liquid silk materials in the lumen of *B. mori*, *A. yamamai*, and *A. mylitta* were studied using both TEM and SEM (Akai, 1990, Akai et al.,1994). In B. mori, the elementary fibroin fibres in the fibroin globules in the gland cells are released into the silk layer by exocytosis, forming masses of tangled fibroin fibres 15 µm in diameter; these are stored in the silk layer for 30-60 minutes. Lysosomal materials, frequently discharged into the silk layer from the gland cells, are completely digested in this layer without passing through the cuticular membrane. In contrast, fibroin fibres pass through the holes of the outer cuticular membrane and accumulate on the surface of the fibroin column in the central lumen. Therefore, the fibroin column is composed solely of fibroin fibres (Fig.18).

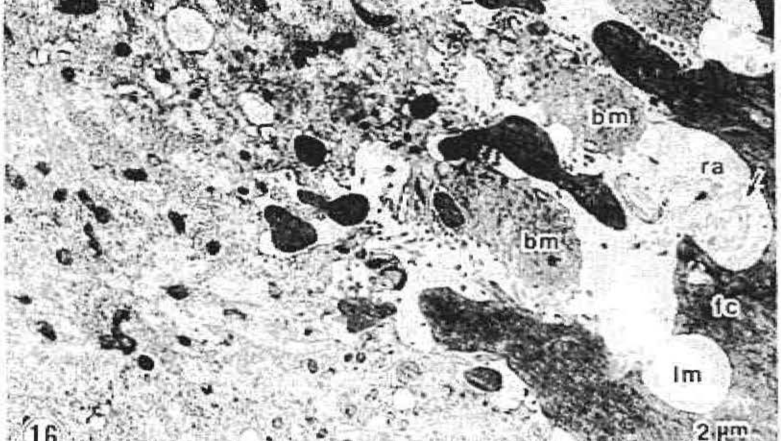

Figure 16. Fibroin secretion and vacuole formation. Small secreted fibroin masses (small arrows) conjugate with each other, and accumulate on the fibroin column (fc). Well-developed bundles of microfilaments (bm) extend into lumen. A residual autophagosome (ra) is incorporated in fibroin column (large arrow). Digested lysosomal materials (lm) create a vacuole

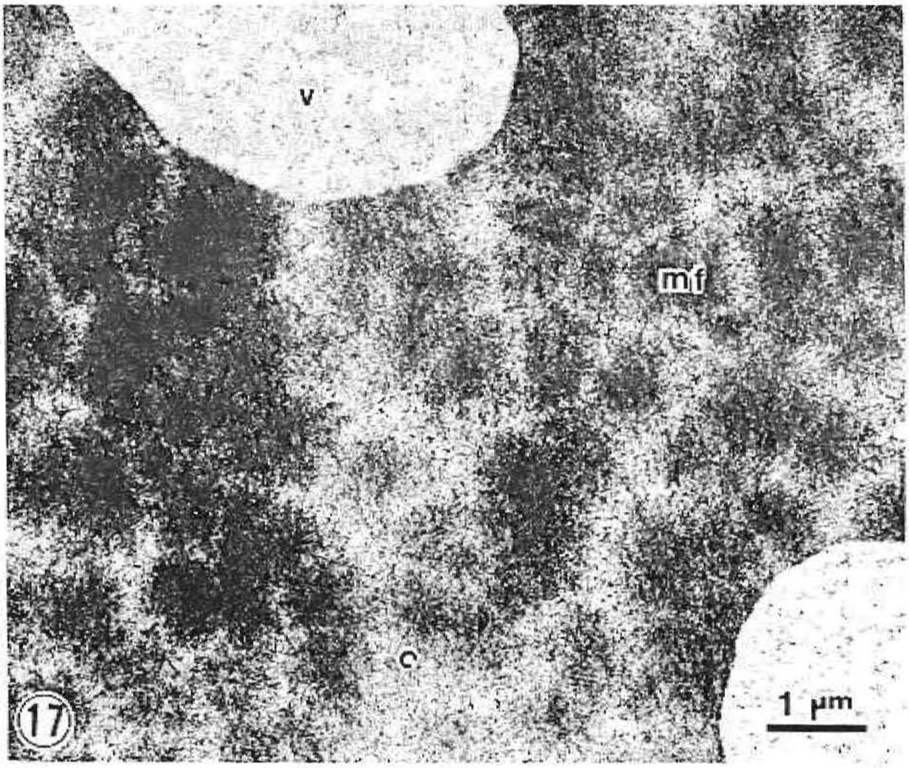

Figure 17. Masses of fibroin fibres (mf) compose the central fibroin column. The vacuole (v) are contained in the fibroin column

Neither *A. yamamai* nor *A. mylitta*, however, have silk layer, because there is no cuticular intima. The elementary fibroin fibres in the fibroin globules are directly released into the lumen to form masses of fibroin fibres 0.5 -1 μm in diameter on the surface of the fibroin column in the central lumen. During the maturing and spinning periods, lysosomal materials are released into the lumen, and these pass directly into the fibroin column. They become vacuoles ranging from 0.5 to 5 μm in diameter, containing small amounts of fine fibrous materials. The fibroin column is thus a mixture of fibroin fibres and vacuoles.

Cocoon filament formation in ***B. mori*** and ***A. yamamai*** are compared in (Akai et al., 1993). In *B. mori,* masses of fibroin fibres form in the silk layer by exocytosis. They are transferred into the columnar fibroin through the cuticular membrane without the release of lysosomal materials. Numerous accumulated masses of fibroin fibres move forward into the middle and anterior silk gland, their shapes changing from circular to elongated as they orient to the long axis. They compact into a filament by passing through the anterior silk gland to the spinneret. They have no vacuoles in their cocoon filaments.

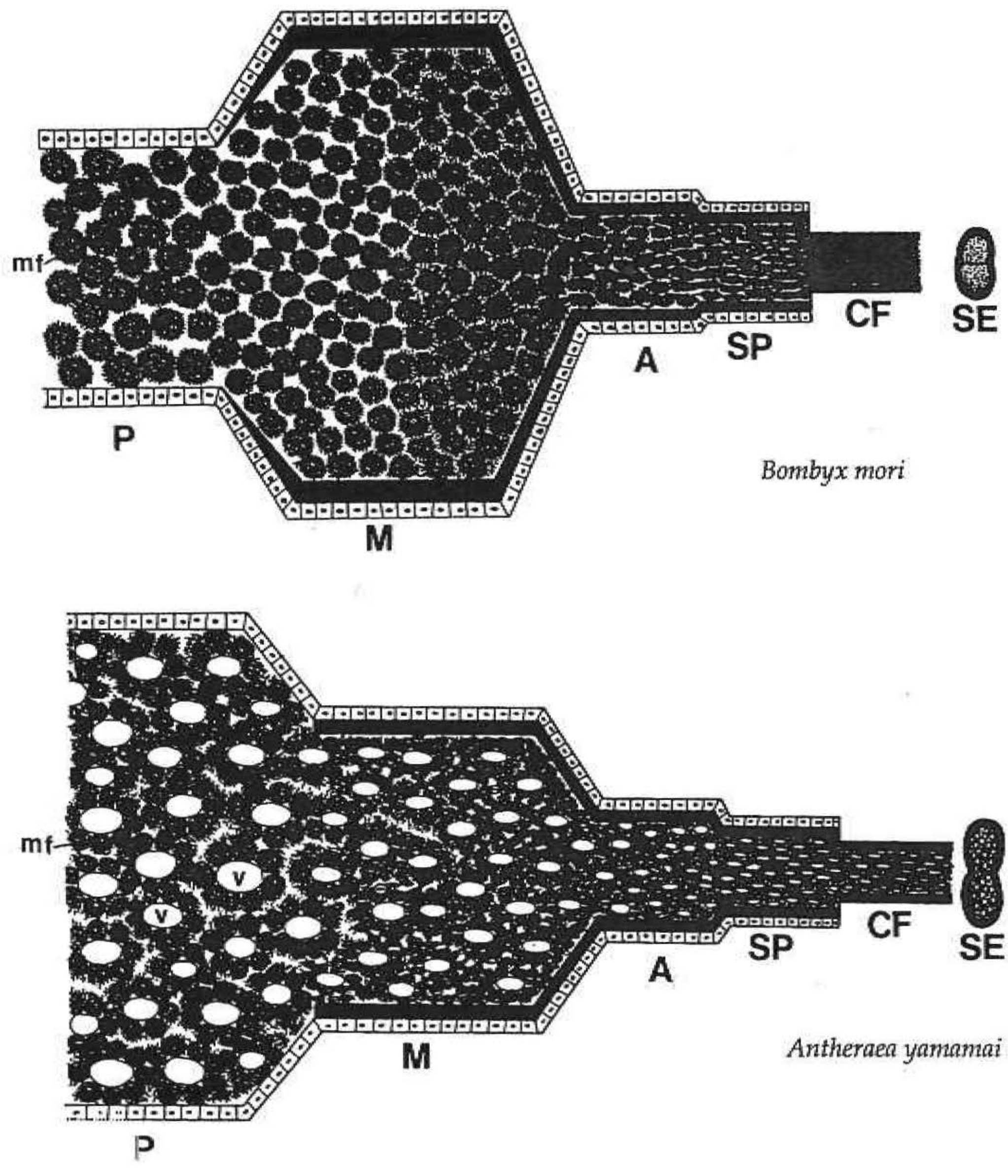

Figure 18. Cocoon filament formation in *Bombyx* and *Antheraea yamamai*. In *Bombyx* (upper), profiles of fibroin fibre masses change from circular to elongate as they pass from the posterior to the anterior. In *A. yamamai*, vacuoles surrounded by masses of fibroin fibres pass from posterior to anterior, with their profiles changing from circular to elongate. The cocoon filament also contains filament; (M, middle silk gland; mf, mass of fibroin fibres; P, posterior silk gland; SE, cross section of cocoon filament; SP, spinneret (From Akai 1990)

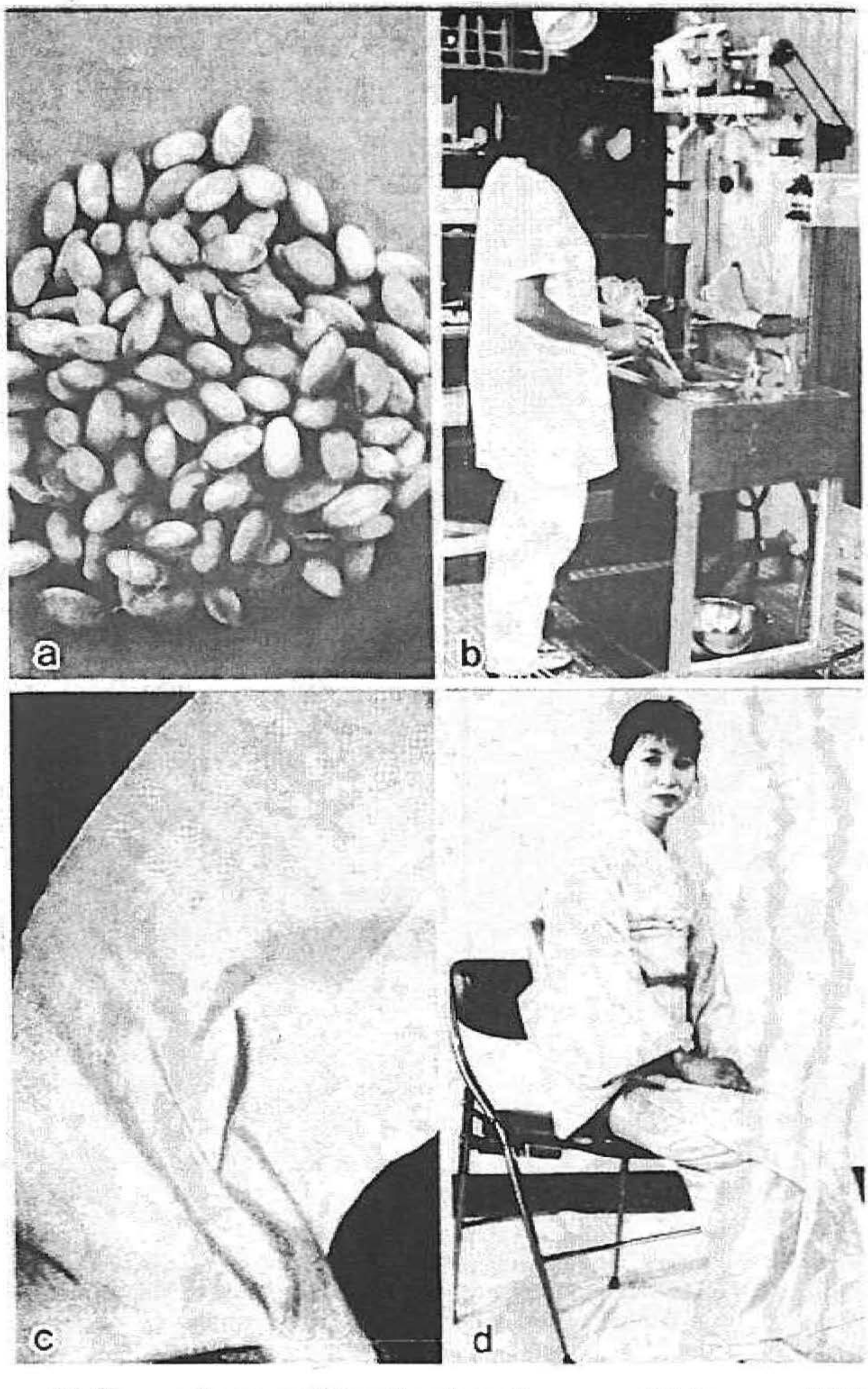

Figure 19. Harvested cocoons (a), reeling from the cocoons (b), Japanese Obi (c), and Japnese traditional Kimono (d), from *A. yamamai*

In *A. yamamai*, which has no cuticular intima in the posterior silk gland, fibroin fibres accumulate on the central fibroin column when they are released by exocytosis. Lysosomal materials are also secreted directly, forming many vacuoles deep within the central fibroin column. Fibroin fibres and vacuoles move forward together in middle and anterior silk glands, elongating as they move. These fibre masses and vacuoles pack tightly together and make the cocoon filament by passing through the spinneret. There are numerous tubular vacuoles in the filament.

Utilization of Wild Silks

All of the wild cocoons spun by silk-spinning insect species can be used to produce characteristic silk fabrics by reeled raw silk or spun silk thread. The fine structural character of the cocoon filament, for instance, porous or non porous (compact), is one of the most important factors determining what kind of final product can be expected by the raw silk or spun silk yarns.

Anthraea yamamai, A. pernyi, A. assama, and *A. mylitta* can be manufactured from reeled raw silks, because of its characteristically blue colour and special luster, after the degumming. Kimonos made of *A. yamamai* silk is also very expensive (Fig. 19).

Anthraea pernyi silk, which is produced in large quantity in North China, has a slightly lower price than *B. mori* silk. *A. assama*, (Muga) raw silk which is called "golden silk" in India, is very costly and the fabric itself is also expensive, because of the fondness for Indian women to Muga silk saris. *S. c. ricini* (Eri silkworm) is the most popular wild silkworm throughout the world, producing cocoons which are soft in touch, typical of "Hafunuke mayu" (thin-end) cocoon; but their thin end makes them difficult to reel. Recently, their spun silk and textile have become highly valued for their softness, just like a cashmere muffler.

In recent decades *B. mori* silks have been over-produced on the market and the price of popular silk fabrics has become extremely low. Silk-loving consumers are now interested in some of the wild silks, which have different characteristics. The newly developed golden cocoon of *Cricular trifenestrate* has been discovered and appreciated by silk-loving consumers in spite of its high price, because of its natural golden colour.

Concerning the future utilization of wild silks, it is important that each silk product retain its own distinctive features and a high market price. Consumers demand special individual characteristics of silk fabrics and the final productions used.

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CONSERVATION AND UTILIZATION OF AFRICAN BUTTERFLIES: THE KIPEPEO PROJECT AND THE FUTURE OF BUTTERFLY FARMING IN EAST AFRICA

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Introduction

Butterfly farming is a new industry that has grown over the last 20 years or so. Although people have reared and sold butterflies for more than a hundred years, it has always been on small scale and was formally dedicated to the collectors trade in dead pinned or papered specimens. The recent rapid growth of butterfly farming into what is now a multi-million dollar industry has come about, because of the popularity of live insect exhibits. Typically, butterflies are kept in a large greenhouse or conservatory, which is attractively landscaped, usually with a waterfall and stream, and filled with tropical plants. Members of the public pay gate fees to come and enjoy the view of exotic and beautiful butterflies which they would otherwise never see alive. When such exhibits are well managed and stocked, the effect can be quite stunning. The only way stocking levels can be maintained in Europe and America is through the importation of live butterfly pupae from the tropics.

Kipepeo Project

The Kipepeo Project (KP) is a butterfly farming project with a double agenda: It aims both to provide an opportunity for a rural community in Kenya to benefit from the butterfly trade and at the same time to win their support for the conservation of an internationally important forest, the Arabuko Sokoke Forest (ASF) on the north coast of Kenya. This forest is famous for its avifauna which includes six rare and endangered species (Sokoke scops owl, east coast akalat, spotted ground thrush, sokoke pipit, aman sunbird and Clarke's weaver) in addition to a further 17 species, which are coastal endemics. It is also home to four rare or threatened mammals (elephant, ader's duiker, golden-rumped elephant shrew and sokoke bushy-tailed mongoose). Situated between Malindi and Mombasa, over 400km^2 in area and containing no human settlements, Arabuko-Sokoke Pipit is the largest remaining piece of the coastal forest mosaic, which once stretched from Southern Somalia to northern Mozambique. During long periods of isolation from other forests, this coastal mosaic evolved a distinctive fauna and flora of its own, which is now seriously eroded. The protection of ASF is the last best hope of retaining a viable fragment of this once extensive ecosystem. It has been ranked as the second most important forest in Africa for its birds alone (Collar and Stauart, 19985). Its conservation is therefore of global significance.

All of this, however, means little to the people around the forest. Their numbers are growing rapidly and they are hungry for land, short of cash incomes and jobs, impoverished and harassed by forest wildlife, misled by local politicians, and hostile to the forest. Independent surveys(Mogaka,1991, Maundu 1993), estimated their per capita cash incomes as less than US $ 50 per year, and showed that over 90% are unhappy with the forest's presence with over 50% wanting the entire forest cleared for settlement. Wildlife corp-raids by elephants and baboons cause much anguish and economic hardship, and are a major cause for resentment. The population surrounding the forest, cultivates the edges and erodes its interior through subsistence demands for fuelwood, poles, game-meat, wild honey, fruits and medicinal plants. The forest has been invaded no less than five times in the last 3 years, each time with the aim of cutting plot-lines in anticipation of de-gazettement, and each time led or encouraged by government officials in the administration. In March 1995, the Kilifi District Development Committee supported a call for the excision of 1200 ha in its southeastern portion for settlement.

It is obvious that Arabuko Sokoke cannot survive without the long-term support of the local people and their leaders, but there is little prospect of this, unless it is seen to be of benefit to them. The Kipepeo Project is one of several efforts(including, most notably, assistance for schools and water supplies from the Kenya Wildlife Service (KWS) Community Programme), to build such support. It is situated near the forest at the National Museums of Kenya(NMK) site at Gede Ruins, 18km south of Malindi and is administered by the East Africa Natural History Society (EANHS) in Nairobi. Set up in June 1993 with an initial grant of US $ 50,000 from the Global Environmental Facility Small Grants Programmme, administered by UNDP, it has introduced butterfly farming to the forest-adjacent community as a means of earning cash incomes from the forest. More recently, with the arrival of a British volunteer(VSO) and with support from the IUCN Netherlands Committee Tropical Rainforest Programme, it also became a vehicle for environmental education with an active schools programme centered on ASF in collaboration with the Wildlife Clubs of Kenya. The Kipepeo Project aims to help to secure its future showing that the forest can provide unexpected sources of income to the local community and by teaching local children about extraordinary biodiversity and conservation importance.

Butterfly Farming

Before the commercial activities of Kipepeo began, there was a nine month survey of butterfly populations in ASF (Ayiemba, 1995) and a month-long socio-economic and attitudinal survey of the local community (Maundu, 1994). We are therefore in a position to obtain prior before and current data, that will help in objectively assessing the success of the project as a conservation tool. With the aid of a grant from the WWF/USAID Biodiversity Support Programme, these surveys are being repeated in 1997 by the same personnel. This will provide an assessment of the impact of wild butterfly populations of three years of harvesting for breeding, and will examine perceptions of the financial benefits of butterfly farming and whether these have increased community support for the conservation of Arabuko Sokoke forest. Selected kipepeo farmers will also be trained in butterfly monitoring and the socio-economic and attitudinal survey will include questions on events in the last three years such as the forest invasions and the de-gazettement proposals.

Both of the pre-project surveys were essential in project implementation. The butterfly survey helped us to select species for breeding, based on abundance and seasonal availability. It involved walking transect and general collections using butterfly nets and traps in the three different vegetation types of the forest. About half(139) of the total number of 40 of the common and more easily recognized species were recorded for each month of sampling. The community survey enabled us to introduce the project and to recruit project ground to identify those households which satisfied the criterion of being immediately next to the forest. Over 150 such households were mapped, and 144 of these were subsequently interviewed and 132 agreed to participate. The use of an objective (and obviously practical) criterion for participation, and the direct involvement of the community in the identification of participants, were important elements in establishing trust in the project. We ended up with a more or less continuous chain of future butterfly farmers along 45 kilometres of the eastern margin of ASF, roughly one third of its total circumference.

The farmers were trained in butterfly rearing techniques, both in their households and at the project headquarters at Gede Ruins. These activities were carried out in parallel with construction of two large flight cages and a breeding shed with water storage tanks, the establishment of plant nursery, and further research on forest butterflies and their food plants. A local extension officer was recruited and trained together with casual staff in the basics of butterfly rearing. As a dry run, some 20 volunteers from the forest-edge community participated in a short experimental rearing programme which established that our techniques would work out on the forest-edge farms. Lastly, an agreement was negotiated with a British company, Entomological Livestock Supplies Ltd, for the supply and purchase of butterflies in 1994.

Exports started more or less on schedule in February 1994, and by the end of the year over 10,000 pupae belonging to 14 species had been exported, earning a little over US $ 15,000. About 40% of the pupae had been produced by the community and the remainder by the farm headquarters. Total payments to the community for the year amounted to just over 260,000/=. In 1995 the number of pupae exported grew by 23% (to ca.12,500) and overall community by 25%. Growth accelerated in 1996 with around 18,800 pupae exported, and increase of 49%, earning around US $ 27,000. So far this year(mid-August 1997), a further 16,350 pupae had been exported. Todate cumulative exports amount to a little over 58,000 butterflies earning about US $ 86,000. Cumulative payments to the community amount to over 1.5 milion Kenya shillings.

These are relatively small sums of money and it is obvious that the market for butterflies can never be on the scale of that for honey and silk, but in the right context, butterfly farming can make a valuable contribution to rural economies. Globally the trade is worth some US $ 20 million at present, with most of the butterflies being produced in Asia (especially the Philippines) and South and Central America (especially Costa Rica). African countries have been slow to get into the trade and although many individuals have been rearing and exporting African butterflies on a backyard garden basis, there are few large scale butterfly farms on the continent. Currently, Costa Rica exports about US $ 1 million worth of live butterflies a year, and the potential for African species must be at least as much as this. How should this potential be realized and what are the constraints?

The first point to realise is fairly obvious: the most attractive and desirable butterflies are found in forests, and any butterfly farming venture in Africa must be forest-based. Arabuko Sokoke is a relatively poor forests for butterflies with only around 260 species and it lacks many of the more spectacular African species. Kakamega Forest in western Kenya is better with around 450 species, while a tropical forest of comparable size in west and central Africa would have 600-700 species or more. There is considerable potential for butterfly farming in these richer forests, which give opportunities for bringing entirely new species to the international market. But of course forests are disappearing at a rapid rate for a variety of reasons, mostly economic. Butterfly farming, provides an opportunity to add value to the sustainable use of important indigenous forests and to help conserve them. If the benefits of butterfly farming flow to the communities that live in and around the forests, this can build critical support for their conservation. The opportunities for sustainable use of non-timber forest products are fairly limited, so there is a strong case for a policy which restricts butterfly farming activities, through appropriate licensing, to forest communities. The Kipepeo Project provides a model for the development of butterfly farming along such lines.

Secondly, the technology required for rearing butterflies is very basic and the financial investment can be very small. A simple mosquito net draped and tied over a small tree or shrub can be a very effective piece of butterfly rearing equipment. Recycled plastic containers can also be useful, although if they are overcrowded with livestock and if humidity gets too high, disease can be severe. At the other end of the scale you can have large flight cages with misting systems to deal with unfavorable dry season conditions. Even at this level the investment need not be large.

Thirdly, the Kipepeo Project has shown that butterfly farming will be readily adopted by rural farmers, despite the fact that it is an alien concept. Initially, some scepticism was expressed as to whether it would be taken seriously by the local community. A key factor in rapid acceptance was spot cash payment for pupae. As soon as people heard that someone had got money for rearing butterflies, they were interested and one of our major problems has been in restraining interest to realistic levels.

Fourthly, effective market access is vital and what this means in practice is that butterfly farms must be situated close to international courier facilities. The Kipepeo Project is about 100 km away from Mombasa on a tarmacked road so that consignment of pupae can be delivered to a DHL or FedEx Office in an hour or less. This is vital, since the pupal stage of butterflies can be as short as 5 or 6 days and if the butterflies emerge in transit, they are useless and will not be paid for. Transit losses (including those due to disease and parasitized pupae) for Kipepeo amount to between 10 and 25%. If market access was any more difficult, this figure would be considerably higher.

The two biggest constraints(apart from market access) to successful butterfly farming are caterpillar mortality and seasonality. Diseases are a particular problem for centralized facilities for butterfly farming. Caterpillars suffer from viral, bacterial, and fungal diseases and the high densities that exist in a large rearing facility, provide ideal opportunities for diseases to spread. At certain times of the year, especially later in the season after the rains have started, we can have 100% losses of some species (particularly the swallowtails). Insect parasitoids can also be a problem, particularly the smaller egg parasites, which are difficult to screen. At Gede, we suffer from continual attack by chalcidoid wasps which necessitates labour-intensive collection of eggs several times a day.

Seasonality means that we live in a boom-bust situation. During the dry season months, butterfly production is hard. Females, particularly the swallowtails, refuse to lay eggs, fresh leaf growth for caterpillars is rare, and the wild populations on which we still depend for our livestock decline to very low levels. We do not succeed in meeting our orders at these times. Once the rains start, the problem is reversed and we have an oversupply, especially of the commoner species which we are unable to market. Our farmers are understandably frustrated when we cannot buy their pupae at these times. This problem also exists in Costa Rica where there is a large market excess from May to August and insufficient supplies during the rest of the year.

Future

The key to the immediate future for the Kipepeo Project lies in developing a substantial domestic market for the butterflies, through the establishment of live butterfly displays as ecotourist attractions. A domestic market has considerable advantages over the export market. The smaller, but still very attractive species can be used; these are unsuitable for export, because of their short pupal period. Transit losses(which average 22% for Kipepeo) can be virtually eliminated, and the money at the door from visitors and shop sales, eases the cash flow problems which often result from delayed payments for exports. Plans are being developed to establish an eco-cultural centre at another NMK site at Mnarani Ruins in Kilifi. This will focus on the ineractions between coastal people and forests and will feature live butterfly displays from ASF, Shimba Hills and one of the Kaya forests, with the livestock being purchased through Kipepeo from the relevant forest edge communities. Such an exhibit will also serve the double agenda of the Kipepeo Project by providing an opportunity for passing on conservation messages about the forests to local and international visitors, as well as a market for the Kipepeo.

SESSION V

TECHNIQUE FOR HIGH PRODUCTION OF ROYAL JELLY

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Abstract

Royal jelly is a thick fluid, that is secreted by pharyngeal and mandibular glands of worker bees and is fed to queens. It possesses obvious physiological activity, a complicated chemical composition and magical health care properties. When there are excessive nurse bees in the colony, they will always build natural queen cells to rear queens. This habit of the bees is used to produce royal jelly. The main factors that influence the quantity and quality of royal jelly are as follows: bee strain, strength of the bee colony, right age of nurse bees, age of grafted larvae, number of artificial queen cells, the site of the royal jelly frame in the colony and food and air temperature.

The procedure for producing royal jelly includes organizing the colonies for production, preparing larvae of the right age, grafting, extracting royal jelly, filtering and cold storage. In order to get high production of royal jelly, the following measures are needed: selecting and keeping high-yield royal jelly bee strains, using double-queen colonies, keeping colonies well fed and stimulating feeding.

BEEHIVE PRODUCTS AND INCOME GENERATION USING EUROPEAN RACES OF *APIS MELLIFERA*

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Background

Generally one can divide the races of *Apis mellifera* into three groups:

(i) European races

(ii) Oriental races

(iii) African races

The four races of well known economic value, of European honey bees are:

(i) Dark bees (*Apis mellifera mellifera L*)

(ii) Italian bees (*Apis mellifera ligustica Spin*)

(iii) Carniolian bees (*Apis mellifera carnica Pollman*)

(iv) Caucasian bees (*Apis mellifera caucasica Gorb*)

The races of European bees have adapted to a wide range of environmental conditions. The Italian race is the most popular worldwide with a number of cold countries preferring the Carniolian Caucasian or dark race. The races are often crossed in an effort to combine the better characteristics.

Beeswax is obtained as the result of honey production from capping prices or old combs rendered down. Beekeepers producing honey earn up to 5% of their income from wax production. Has outstanding properties compared to other waxes. Price is US$4,000.00 to US$ 7,000.00 per tonne.

The world demand for bee venom is limited, for example one beekeeper in the United States could produce all the venom used in the USA. Ten hives can produce 2 gm of venom. One gram of bee venom sells for US$ 100.00 to US$ 150.00.

Brood is usually sold as human food. The average colony can spare about 500 gm of larvae every six days. Bee brood have a protein level of 15.4% and vitamins A and D. It can be fed to birds, reptiles, fish, mammals and some insects.

Domestic and export markets exist mainly for nucleus colonies of bees. Colonies can carry bee diseases so health certification is often required. Nucleus colonies can be worth US$ 100.00 on some export markets. Some countries will not allow the import of bee colonies.

Honey is the most important product of the beehive. The lighter the colour the more valuable. Honey can be sold as liquid candy (crystallised), creamed, chunk or in the comb. Honey has many uses and anti bacterial properties due to the anti bacterial agent hydrogen peroxide. World demand for honey is high with Japan importing 40,112 tonnes. Major world producers are USSR, China, USA, Mexico, Argentina, Brazil, Canada and Australia. The world price for bulk honey is betwee US$ 1250 up to US$ 2250 per metric tonne with New Zealand claiming the highest price.

Package bees is a growing section of the beekeeping industry in recent years. Health certification is often required and import permits, tariffs may apply in some countries.

Pollen is produced as human food, fed to honey bees, animals and birds. Production can be up to 18 kg per hive per year. Pollen is sold in all countries and export markets are developing.

Pollination is mainly a domestic industry with some beekeepers specialising in the hire of hives to pollinate specific crops. Pollination is of great value to nations' economies as bees are required to pollinate most food crops.

Propolis is produced mainly in countries with a cold climate. Has anti bacterial and fungal properties. Used in cosmetic and medicine, where it is combined with other products. Prices vary from US$ 4.50 to US$ 60.00 per kg. In cold weather propolis is noticed in hives.

The demand for queen bees on the domestic and export markets often exceeds supplies. Queen bees are fairly easy to raise where European races of *Apis mellifera* are present. Export prices vary from US$ 6.00 to US$ 10.50. Canada imports 150,000 queens each year. Queen bees can carry bee diseases and health certificates may be required. Import permits and import duty may apply. Some countries do not allow the import of queen bees.

Royal jelly is produced mainly in countries with cheap labour, because it requires a lot of labour input. Royal jelly is marketed in most countries as a health food or used in cosmetics. The world price is US$ 90 to 100. Approximately, 3500 queen cells produce 1 kg of royal jelly.

This paper explores the production and market opportunities for the various products and income generation using the European races of *Apis mellifera*.

Beeswax

Beeswax is secreted by the wax glands in the abdomen of the adult worker bee, and large amounts of nectar and pollen are consumed to produce it. The beeswax is secreted at small scale. Each hive eats about 10kg of nectar and honey to produce 1kg of beeswax and there are about 1,766,000 scales to every kg of beeswax.

It is a regular by-product of honey production. Beeswax is reclaimed from capping when harvesting honey, comb pieces and rendering of old combs.

Yield

Depending on how well the honey is capped, about one kg of beeswax is marketed for each 50kg of honey. The best grades of commercial beeswax are light yellow and come from fresh honey capping.

Production can be increased by reducing the frames in supers, thus increasing the amount of wax from cappings.

In Australia, income from beeswax can be 5% of total income earned by commercial honey producers.

Composition and Properties of Beeswax

Hydrocarbons	16%
Alcohols	31%
Acids	31%
Diols	3%
Hydroxy acids	13%
Other	6%
Specific gravity	0.95 lighter than water
Melting point	62 - 65°C (expands on heating)
Insoluble in	water
Soluble in	cold alcohol,. (slightly fixed or volatile oils, chloroform, ether, benzene, carbon disulphide (hot)

During storage, wax may develop a powdery substance called "bloom" on the surface. This is not caused by mould. Bloom is not detrimental to the quality of the wax.

Processing

Beeswax must be melted for processing. It is a flammable material and must always be heated with water or in a water jacketed heater. Under no circumstances should beeswax be heated on a direct flame without water. Wax heated in this way will be damaged or even catch fire. Wax may also be contaminated or damaged if it is melted or stored in containers made of iron, zinc, brass or copper. Containers made from plastic, aluminium, nickel, tin or stainless steel can be used safely.

As a natural wax, beeswax can absorb a number of chemicals including many toxic pesticides. On no occasion should wax be stored with or near pesticides other than those recommended for wax moth control.

Cappings produce the best quality wax and they should always be processed separately from old combs and comb pieces. If a cappings melter is used to remove the honey from cappings, the wax may not require further processing.

When draining systems or spin-dryers are used to process cappings, the wax must be further processed by melting and cleaning before it is ready for market. Very efficient cappings melters suitable for use on a commercial scale are available. A simple alternative for smaller quantities is to pack the cappings into a hessian bag with a brick as a weight. Immerse the bag in water and bring it to the boil. The wax melts and escapes from the bag, which serves as a filter for debris. After a suitable time, the water is allowed to cool and the wax solidifies on top of the water and can be collected.

A solar wax melter using the sun's heat can be used to handle small quantities of cappings, but is not suitable for commercial operations.

Comb scraps and old combs are usually processed together. Good combs are an asset, but old or broken combs are a nuisance. About 1kg of wax can be reclaimed from 10 old combs. The process is much more difficult than processing cappings. Small numbers of combs can be handled by a solar wax melter, but once again commercial quantities are not possible.

A Method of Reclaiming Beeswax from Combs

The comb is cut from the frames or removed by dipping the frames in boiling water. The entire comb is melted with water. When the mass is thoroughly melted it is ladled into strainers held suspended inside a steam chest. The strainers can be constructed from old hessian bags or a special bulk strainer can be constructed. A steam chest can be constructed from a 200 litre drum. Steam is applied to the chest for about eight hours. All wax and water contained in the strainer slowly drains into the bottom of the steam chest and the wax can be run off for further refining.

Final refining may not be necessary for some markets. To remove very fine particles of dirt and debris the wax is melted and held at 80o C for 48 hours. After this period most of the dirt will have settled to the bottom of the container and clean wax can be carefully taken off from the top.

A few final cautions on beeswax processing:

(i) never use direct heat, always heat wax with water

(ii) do not boil wax vigorously for too long

(iii) do not fill wax melters to the top. Wax expands on heating and will overflow

(iv) take care not to overheat wax. Consider 85 – 90° C a maximum

(v) never allow bees to rob honey from cappings.

The residues of wax processing and refining are called slum gum. Slum gum contains various substances such as propolis and brood rearing debris and is of little use. However, large quantities may contain some substances of interest to industry and some markets are available for slum gum.

Moulding

After the final process the wax is poured into moulds to set. Many containers make suitable moulds, but black iron copper zinc or brass containers should not be used. Tinned metal plastic stainless steel or aluminium containers are safe to use as moulds.

The best moulds are sloping-sided containers such as bread baking tins. Pouring water into the bottom of the mould reduces sticking.

If top quality moulds are desired, the correct temperature to pour the wax into the moulds can be judged by watching for the formation of a film of wax to set on the surface. After pouring, leave the wax undisturbed and allow to cool slowly. Covering moulds will assist with slow cooling and reduce cracking of the wax.

Solar Wax Melter

The sun's energy can be harnessed to extract small quantities of beeswax. The melter consists of a box with sloping sides and legs to support the box at an angle. The box is painted black on the outside and white on the inside and is fitted with a glass lid. In some designs, two sheets or glass are used.

Inside the melter a metal tray is fitted with an outlet at the lower end. Below this outlet, provision is made for a catching tray. A strainer can be fitted over the outlet to catch larger debris.

The melter is positioned to catch the rays of the sun and the wax is placed on the tray inside. A catching tray or mould is placed under the outlet also inside the melter. Old comb pieces of wax or slum gum can be placed directly in the tray, but a gauze wire strainer should be used under cappings.

Honey should be removed from cappings prior to melting as the temperatures will damage honey if it is left in the melter for any time.

Markets and Uses

(i) Cosmetics and related industries

   (a) The single largest consumer of beeswax is the cosmetics and related industries.

   (b) Beeswax is used in facial beauty creams, ointments, lotions, lipsticks, rouge, cold creams.

(ii) Candle making

This is the largest user of beeswax as a raw material. Pure or mostly pure beeswax candles are required by the Roman Catholic church for use in religious services.

(iii) Beekeeping industry

The third largest user is the beekeeping industry itself for making the beeswax into milled hexagonal stamped beeswax foundation of the drone or worker cell base.

(iv) Pharmaceutical and dental industries

Beeswax is used in these industries in salves, ointments, pill coatings, adhesives, impressions and base plate wax.

(v) Other Uses

Water proofing material, floor and furniture polishes, grinding, polishing optical lenses, children's crayons, candy and chewing gum, inks, nursery grafting, musical instruments, ski and ironing wax, wax for bow strings used in archery and wax threads for sewing.

Demand and Prices

The world demand for beeswax is high, especially if it is free from pesticides.

The United States market demands more beeswax than can be satisfied domestically. Cosmetics consume over three quarters of domestic and imported beeswax . Importers want to process the beeswax themselves, so most beeswax is exported in block form.

Beeswax is often blended with other waxes

Prices have risen over the years with USA beeswax prices on the domestic market increasing from 1989 to 1993 by 30% for dark wax and 36% for light wax over the five years.

In Australia over a six year period from 1990-1996 prices per kg increased from A$ 3.10 (US$ 2.29) to A$ 6.10 (US$ 4.51) — 49% increase (Figure 1).

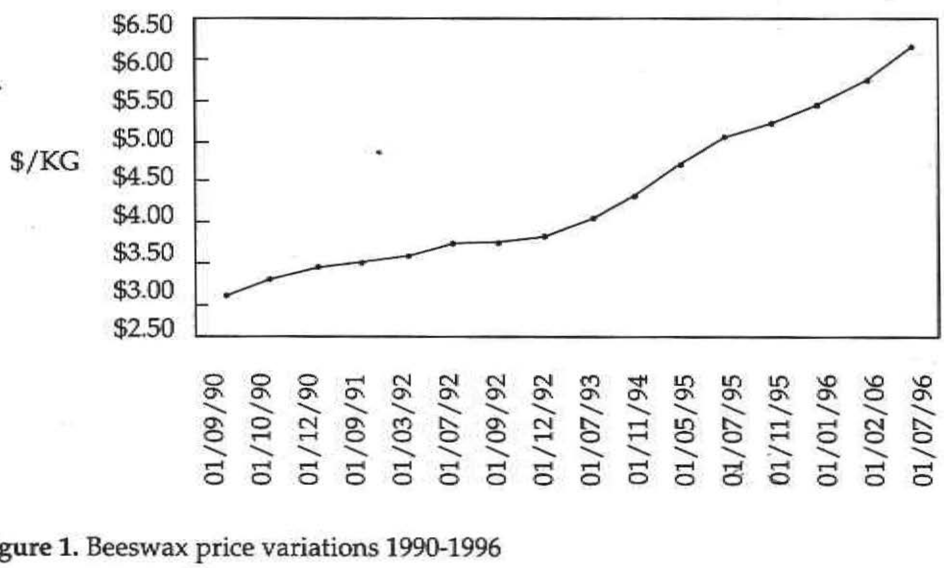

Figure 1. Beeswax price variations 1990-1996

Source: Honey Corporation of Australia

Major exports of beeswax to the US market are China, Canada, Dominican Republic, Netherlands, Germany, France and Australia (Table 1). The US imports about 1000 metric tonnes per year. The European Union imports an average 4000 metric tonnes of beeswax each year coming mainly from Germany, Greece, United Kingdom, Italy and France. EU also imports beeswax from African countries (Table 2).

Table 1. Export of Beeswax from Australia 1994-1995

Destination	Tonnes	$'000
Germany	51.2	235
United Kingdom	49.0	252
USA	42.8	254
Netherlands	33.4	161
France	17.0	79
Malaysia	14.9	87
New Zealand	12.6	71
Indonesia	6.6	44
Other Countries	1.4	10
Total	228.9	1193

Table 2. EU imports of beeswax from African countries in metric tonnes 1992-1993

	Year	
Country	1992	1993
Morocco	67	50
Senegal	18	24
Guinea	15	46
Ghana	2	NA
Central African Republic	50	90
Burundi	6	NA
Kenya	25	5
Tanzania	156	31
Madagascar	53	84
Zambia	40	6
Mali	NA	11
Ivory Coast	NA	26
Total	432	373

Source: EUROSTAT EU External Trade

Trade and Disease Risks to Bees

Beeswax is often imported and re-exported, the world demand is high with prices ranging up to US$ 6.00 per kg. The risk of spreading bee diseases is remote if the beeswax has been melted prior to sale.

Bee Venom

Honey bee venom. It is synthesised by the venom glands of worker and queen bees stored in the venom reservoir and injected through the sting apparatus during the stinging process.

Yield

Using electrical stimulation to force the bees to sting working 10 hives at once should result in the production of approximately 2 gm of venom per 2-3 hr sessions. If 2 sessions are worked per day (6 hr) a daily yield of 4 gm can be anticipated, resulting in a 5-day week of 20 gm.

Composition and Properties

Bee venom is a clear liquid with a sharp bitter taste, an aromatic odour and an acid reaction. Specific gravity is 1.13 heavier than water. Venom dries rapidly at room temperature to about 30 to 40% of its original weight. It contains enzymes such as phospholipase A2 and highly active peptides.

Processing

A technique involving simultaneous electrical stimulation of a large portion of the entire population of worker bees. A queen excluder should be placed above the venom collector which replaces the bottom board so the queen is protected.

The material through which the bees sting, is designed not to retain the sting, the usual loss of bees is less than 1% per session.

Collection power is turned on for 12 min off for 10 min on for 12 min. This is repeated for two to three h to complete a session. Venom is collected by scraping. The venom forms a fine white layer of crystals on the glass collection plate into a sterile container.

Bees do not replenish their venom within their lifespan, so hives should be rotated so that a hive is "milked" twice the same day — only once per fortnight. Bee venom electric collector can cost over US$ 3700.

Bees become extremely excitable and defensive with bees stinging people several hundred metres from the hives supplying the venom.

Markets and Use

A number of therapeutic properties have been attributed to bee venom and a small market is available for this purpose. Bee venom stimulates the heart, it is suitable for treatment of rheumatic diseases like arthritis.

The major use of venom has been in de-sensitisation of people allergic or highly sensitive to bee stings. It is also used, for research for example Melittin, a small protein and major toxin found in bee venom is being used to determine its use to fight malignant cancer cells. Bee venom should only be used under medical supervision. Bee venom in certain cases can have a strong toxic effect on humans.

Approximately 0.5 to 2% of the population is hypersensitive to bee venom. Swelling occurs rapidly and medical attention is required quickly if an allergic reaction occurs.

Price and Demand

The demand is limited, but as research expands the demand may. One gram of venom sells for US$100 to 150.00. Many European and Asian producers are in the market and their prices can be lower.

Venom with a high degree of contamination is easily detected under UV light.

Trade and Disease Risk to Bees

Most countries can produce sufficient bee venom for their own use. Bee venom is not a disease risk.

Brood

Brood is the eggs and juvenile bees (larvae and pupae) from the worker, drone and queen castes in colonies of Apis mellifera.

Yield

Honey bee larvae could be produced on a tonnage basis if a proper market was found.

The average colony can spare about 500 gm of larvae every six days over a period of several months when bees are on a nectar and pollen flow in warm weather.

Composition and Properties

Mature larvae have a fat content of 3.7% and protein of 15.4%. Vitamins A and D in abundance. Bee brood has a good natural nutritional value.

For maximum weight, larvae should be harvested 9-11 days after the queen has laid the eggs.

Larvae are most conveniently removed from the comb before the cells are sealed, but larval weight continues to increase for a day after the cells are capped.

Rapid removal of larvae from the comb can be accomplished either by impact e.g. swinging or the use of a jet of water.

Brood can also be harvested by cutting out a comb section.

Markets and Use

Bee larvae can be marketed as fresh, frozen or dried for human consumption. Bee brood can also be fed to caged birds, reptiles, small mammals, poultry, fish or insects such as lady beetles and lacewings.

Bee brood can also be used as a fish bait. In certain parts of the world, particularly, Africa, Asia, and South America, larval and pupal stages of honey bee brood are consumed as food in certain cultures.

Price and Demand

Demand is limited and the supply is usually plentiful where colonies are kept in framed hives.

Brood from the Giant Honey Bee *Apis dorsata* is popular in Asia, where this bee is present and is usually sold by comb section.

Trade and Disease Risk to Bees

Most brood seems to be sold in the country it is produced as a fresh product. Brood can carry honey bee viral, fungal and bacterial diseases and parasites.

Colonies of Bees

Colony of bees are made up of workers, drones, queens, honey and pollen in a box. International and domestic trade occurs with the selling of established honey bee colonies. The main demand on the international market is for nucleus colonies consisting of three or four frame colonies headed by a young queen bee.

Yield

Depending on floral conditions, established full sized colonies are split up into nucleus colonies and transported in special light weight boxes that hold three or four frames of bees, brood, honey and pollen. In the productive season a strong colony can be split up into six or more nucleus colonies.

Composition and Properties

It is important that the colonies are balanced with worker bees of all ages free of disease and with plenty of stored honey.

Harvesting

Beekeepers usually sell established colonies of bees when fairly full of honey so as to obtain the best price. Prices are highest at the start of the nectar flow season.

Other beekeepers, often queen bee breeders, sell nucleus colonies of bees to beekeepers starting in the beekeeping business or to export markets. They usually remove bees and brood from established hives, introduce a queen bee into the nucleus colony, allowing the nucleus colony to become established, then sell it on the export or domestic market. If exported the nucleus colony is placed into a special light weight box, well-ventilated top and bottom and sometimes on the end as well.

Market and Use

Colonies of bees can be sold as a going unit. The value depends on:

(i) Condition of the material

(ii) Material should be factory made well-painted, free of dry rot to obtain the best price

(iii) Strength of the bees

(iv) Age and quality of the queen

(v) Disease status

Colonies of bees and nucleus colonies are sold for the production of all the products in this paper or for interest or research purposes.

Price and Demand

The domestic market is the best one for established colonies of bees in Australia. Established hives sell as follows depending on condition of material and bees:

(i)	Single	US$37.00 to 26.00
(ii)	Double	US$59.00 to 52.00
(iii)	Triple	US$70.00 to 52.00
(iv)	Nucleus	US$30.00 to 25.00

On the export market mainly to the Middle East three or four frame nucleus colonies sell for up to US$100.00. Domestic markets for established colonies of bees is usually strong. Export demand for nucleus colonies varies a great deal, but the rewards can be worthwhile.

Trade and Disease Risk to Bees

With the transport of established colonies of bees and nucleus colonies transport must be reliable so the hives do not overheat and die.

Disease risk and parasites can be great and most countries restrict the importation of colonies of bees. If they do accept colonies of bees, health inspections and certification will almost certainly be required as will maybe a permit to import into the receiving country. Many countries will not allow the import of colonies of bees e.g. USA, New Zealand, Australia.

Honey and Honey Dew

Honey is defined as the nectar and saccharin's exudations of plants, gathered, modified and stored by honey bees, Apis mellifera. Honey dew, an extra floral sugary exudation of certain species of plants or insects.

Yield

Yield varies a great deal from a few kg per hive to over 400kg per hive. If hives are migrated to nectar flows, a nectar flow is a source of nectar produced from nectaries of flowers. Nectar is then converted into honey by worker bees by reducing the moisture and changing the sugars.

Composition and Properties

The composition of honey varies from one floral source to another. The average composition of Australian honey produced from native and exotic species is moisture 15.6%, sucrose 2.9%, glucose 30.6%, fructose 42.5%, minerals 0.16%, and other constituents 8.24%.

Quality is judged by the honey moisture, colour, flavour, aroma and cleanness.

Properties

Honey sugars are in an unstable form and may with time crystallise. This is referred to as granulation or candying, and depends on ratios of sugars, temperatures, moisture content and particle contamination.

Food value

Honey as a carbohydrate food contains 74% sugar and an energy value ranging from 12.5 to 14.7 kilojoules per kg. The sugars are rapidly absorbed and utilised by humans and it is an excellent source of energy for athletes.

Harvesting

Honey is harvested from hives once the nectar has been ripened by the bees, as indicated by the wax cap the bees place over the cell. It is important that 2/3 of the cells are capped with wax prior to harvesting, so that the moisture content is correct and the honey is therefore unlikely to ferment. In some countries, nectar is harvested and dehydrated to reduce the moisture content to below 20% moisture. Combs of ripened honey are removed from hives. Honey is removed by a honey extractor after uncapping the comb, cleaned and placed into containers for sale to the public or honey packer. The extracting equipment must be clean and hygienic at all times.

Markets and Use

On world and domestic markets honey is graded by colour using a p-fund honey colour grader that costs about US$1500 (Table 3).

Table 3. World grades

Grade	P fund reading
White	Up to 34mm
Extra light amber	34 to 48mm
Light amber	48 to 65mm
Pale amber	65 to 83mm
Medium amber	83 to 100mm
Amber	100 to 114mm
Dark amber	above 114mm

Marketing Requirements

The compositional requirements for honey established by the World Health Organisation and the Food and Agriculture Organisation are as follows:

(i)	Glucose/fructose	not less than 65%
(ii)	Moisture content	not more than 21%
(iii)	Sucrose	not more than 5%
(iv)	Water-soluble solids	not more than 0.1%

(v)	Mineral content	not more than 0.6%
(vi)	Acidity	not more than 40 milliequivalents of acid per kg
(vii)	Diastase activity	not less than 8 on the Goethe scale
(viii)	Hydroxymethylfurfural	not more than 40mg (HMF) per kg

Honey can be sold as liquid, granulated (candy), creamed (honey that has been beaten and air incorporated) or in the comb as a section or chunk.

Use

Most honey is consumed as table honey. It is also used for baking and drinking. Honey has use in the cosmetic industries, an array of products such as vinegar, tobacco and various beverages and the treatment of burns.

Price and Demand

Honey sold in a prepack it is more valuable than if sold in bulk.

Global Honey Trade Patterns

Looking at the major producing and consuming countries in 1993, production fell below the level of consumption for the first time. The trend continued through 1994 and 1995. This was also coupled with a decline in world beehive numbers of 17%, mainly due to mites and use of African bees.

World honey stocks are declining from 192,000 tonnes in 1991 to 100,000 tonnes in 1994 due to increased demand and lower production — this trend is continuing. The average world price of extra light amber honey from all origins in 1993 was about US$800 tonnes, 1995 US$1300 tonnes, 1997 US$1400. The local market is often the best and domestic consumption drives the demand. In Australia consumption is as shown on Table 4.

Table 4. Consumption of honey in Australia (comparisons in the last 5 years)

Year ended	Australian total sales in tonnes	Imports tonnes	Usage tonnes	Mean population '000	Per capita kg
30/6/91	15,404	62	15,466	17,217	.8983
30/6/92	15,309	76	15,385	17,417	.8833
30/6/93	15,503	74	15,577	17,569	.8866
30/6/94	15,547	81	16,628	17,843	.8759
30/6/95	16,262	82	16,294	17,938	.9083

Source: Australian Bureau of Statistics

Table 5. European Buyers' Quotations

US$ per metric tonne C&F Europe, July 1997

Origin	UK	Germany
Australia	1300-1450	1300-1450
China	1200	1200
Argentina (White)	1250-1290	1250-1290
Argentina 34mm	1280-1290	1280-1290
Mexico (Yucatan)	1270	-
Chile	-	-
Vietnam	1180	1180
Cuba	-	1300-1400
Eastern Europe		1300-1400

Table 6. USA Buyers' Quotations July 1997

Origin	US $
Argentina	1270-1300
China	-
Australia	-
Mexico	1350

Table 7. World Honey Markets

	World honey production thousand metric tonnes				
Continents	1991	1992	1993	1994	1995
Africa	109	117	129	131	191
North and Central America	222	216	223	207	207
South America	87	87	95	102	105
Asia	334	328	326	321	324
Europe	180	182	181	178	183
Oceania	29	29	30	30	31
Total	1189	1172	1215	1189	1199

Table 7 Cont.

	World honey production thousand metric tonnes				
Country	1991	1992	1993	1994	1995
China	70	92	96	102	87
Argentina	47	55	55	62	63
Mexico	50	36(37)	36(35)	90(30)	25(30)
USA	5	10	4	4	10
Canada		11	8	8	15
Others	82	56	57	11	66
UE Extra	8	11	11	8	11
UE Intra	18	18	21	22	22
Total	280	289	288	307	299

Source: Eurostats

Trade and Disease Risks

World prices have tended to ease in the last few months but it is expected they will rise again in September (Tables 5 and 6). Chinese and Argentina stocks are high (Table 7). Mexican honey has been rejected by Germany, because of antibiotic residues in the honey.

Honey can carry bee diseases that do not affect humans, so as a result, many countries require health certification or honey heat treatment prior to entry. Some countries require import permits to be issued prior to export and tariffs may also apply. If exporting prepacks, label and container sizes must be considered as many countries have set standards. Honeydew is popular in some European countries.

Package Bees

A package of bees consists of worker bees and queen, housed in a gauze cage. They are sold by weight.

Yield

Live bees are shaken from established hives in most cases 1.35 kg — 3lb of bees are shaken from a strong double hive. If the whole hive is shaken, it is possible to obtain 4 kg of bees. Ten thousand bees are equal to 1kg.

Composition and Properties

The shaken bees, should be well-balanced in age from nurse bees to old bees and a young queen, so they can establish a colony when placed on drawn combs.

Harvesting

Established colonies are placed on a light nectar and heavy pollen flow conditions, which are suitable to build up hive strength.

Harvesters smoke the hive entrances with the lid ajar, so that the smoke forces the bees from the brood nest into the super.

The lid and frames covered with bees in the super are then shaken through a funnel into a large gauze cage. From the gauze cage the bees are shaken into a wooden gauze package bee cage about 30cm long, 14cm wide, 21cm high weighted and a feeder of sugar syrup included and a queen bee in a cage. The packages must be kept cool, after harvesting and can be held in a cool room at 10°C (50°F).

The packages can then be shipped to the domestic or export markets. After shaking, the colonies should be fed sugar syrup.

Markets and Use

Package bees are used to establish new colonies for pollination or the production of hive products. Cold countries often do not overwinter colonies preferring to restock with package bees each year, e.g. Canada and Korea.

Reliable cool rooms and air transport is essential to be able to export.

Price and Demand

Demand in February through to May in Korea and Canada usually exceeds supply. Australia ships over 30,000 packages annually to Korea and Canada and this has been a growth sector of the Australian beekeeping industry. Packages 1.35kg can be worth US$100.00 to some markets.

Trade and Disease Risks to Bees

Not all countries allow the importation of package bees, because of disease risks associated with imports. Package bees can carry brood diseases and parasites.

Import tariffs can apply and permits to import and health certification. To export, air freight must be reliable at transhipping points. Air freight is expensive as bees (animals) carry a freight surcharge .

Pollen

Pollen is the male reproductive cells of plants and is found on the antlers of flowers. Pollen, from the bees point of view, is the most important product they collect as it supplies the bees nutrients. Pollen is collected on the bees body hairs and pollen baskets on the bees hind legs.

Yield

Depending on the pollen flow condition over a 12 month period, in Western Australia, average production can be 12 to 18 kg of pollen per hive.

Composition and Properties

Bee collected pollen varies a great deal between plant species. Protein is the major component with an average of 24% variation from 4 to 43% occurring with Australian pollen. Carbohydrates constitute about 27% of bee collected pollen, mainly simple sugars, fructose and glucose. Some pollen contains up to 18% starch by weight. Average fat content is about 5% in pollen, which also contains substantial quantity of potassium, calcium and magnesium as well as high levels of iron, zinc, magnesia and copper with low levels of sodium. It is rich in B vitamins and variable levels of vitamin C, D and E. It is low in calories.

Each grain is like a finger print and the species it is collected from can be identified.

Properties of pollen make it a useful human, insect and animal food.

Harvesting and Processors

Pollen is collected by placing a trap on the hives. When the worker bees return to the hives the bees are forced to go through two screens of 5 mesh wire, separated by 5mm. A protective screen of 6 to 8 mesh wire allows the trapped pollen to fall into a collection tray and prevents the bees re-collecting it.

Traps remove about 60% of the pollen collected by the bees and should only be harvested when a surplus is available. The collection trap must be water proof and the pollen removed from the collection tray each week. Traps must have drone escapes to prevent drones from blocking up traps. Ants must be controlled as they will quickly remove all pollen collected. Once collected the pollen should be cleaned then frozen or dried.

Warm air at 45°C is used to reduce the moisture content to between 2-5 and 10%. The pollen is then stored in airtight containers.

Markets and Use

Pollen is sold as human food with the allegation that it boosts the immune system, builds strength, stamina and vitality. It is also used in creams to rejuvenate and sooth skin. Claims are also made pollen has ability to protect against the adverse effects of Xray. Pollen has also been used to reduce the symptoms of hay fever, ulcers and colds. The common adult dosage of pollen granules is 1/8 to 1/4 of a teaspoon once a day, with dosage increased to 1-2 teaspoons three times a day.

Pollen is also available in gelatine capsules, tablets, mixed with honey, candy bars, a liquid tincture cream or salve. There can be adverse reactions where pollen has been consumed including stomach and gastrointestinal upset or allergic reactions to oral ingested pollen.

Pollen can also be used as feed in beehives, on pollen deficient nectar flows or to queen cell builders. It must be harvested from disease free hives as pollen can carry bee diseases.

Pollen can be used to rear insects and feed birds or animals e.g. race horses.

Price and Demand

Figures concerning worldwide production are difficult to obtain. Major producers are USA, China, former USSR, Mexico, Argentina, Australia and Spain. China produces between 3000 and 5000 metric tonnes annually. The price varies from US$4 to 15 per kg, depending on quality; light coloured pollen is the most valuable.

The production of pollen for human consumption has been growing at a rapid rate. Prices of pollen vary a great deal, but can often yield high profits for the producer. Some beekeepers specialise in pollen production only in parts of Australia and other countries.

Trade and Disease Risk to Bees

There is a large world trade in bee collected pollen. It is often imported in bulk and processed into tablets and exported as a value added product.

Trade restriction exists in some countries as bee pollen can carry bacterial and fungal bee diseases if fed to bees. All pollen should be irradiated using Cabot 60 to kill these diseases. This does not affect its nutritive value. It can also carry fire blight, a disease of fruit trees and ornamentals not present in all countries.

In Australia, all pollen sold for human consumption must carry the warning "This product may cause severe allergic reaction" on all labels.

Pollination

Pollination is the transfer of pollen from the male part of the flower (anther) to the female part (stigma) in the same species. Many plants will not set seed or fruit if their flowers are not pollinated. Large numbers of bees do the best job. Honey bees play a major roll in the transfer of pollen when they visit flowers for food for their own use.

At least 90% of crops depend on honey bees for pollination.

Yield

Honey bees are in most cases species-specific on the same field trip for pollination to take place, whereas moths, flies, animals, wasps, visit different crops on the same trip, thus pollination is unlikely.

Honey Bee Pollination in Australia

The financial estimates of the value of pollination to the seed and food crops of Australia were determined in 1981 by Dr Roderick Gill from the University of Armidale to be worth between 600 million to 1-2 Billion A$. This is a potential reminder of bees' value to a nation, for example lucerne seed yields can increase from 250 to 1000 kg per hectare. Faba bean yields increased by 24%. Pollination also benefits fruit quality and uniform crop maturity.

Colonies

Colonies used for pollination must be strong in bee numbers and have a high desire to rear brood, thus increasing the colony demand for pollen. Colonies can be migrated in large numbers to crops requiring pollination.

Market and Use

Beekeepers need to manage hives for pollination and in most cases, little surplus nectar is harvested.

The demand for bees as pollinators is increasing and depending on the crop, the price per hive paid to Australian beekeepers — for stone and pome fruit pollination is US$ 24, faba beans US$ 26 and lucerne US$ 26. Contracts are important to protect both parties.

In Australia, some beekeepers derive 50% of their income from pollination contracts. Examples of contracts are given in Appendix I:

The crops (Table 8) benefit from crop pollination and stocking rate.

Table 8. Hives per hectare for pollination of crops

Crops	Hives per hectare	Crop	Hives per hectare
Fruit crops		**Seed (vegetable) crops**	
Almond	5-8	Asparagus	2+
Apple	3-5	Broadbean	2+
Apricot	2-3	Broccoli	2-8
Asian pear (nashi)	2-4	Brussel sprout	2-8
Avocado	2-7	Cabbage	2-8
Blackberry	2-3	Cauliflower	2-8
Blueberry	5-8	Celery	1+
Boysenberry	2-3	Garlic	5-10
Cherry	3	Leek	1+
Gooseberry	1	Onion	4-10
Kiwi-fruit	8	Parsnip	1+
Loganberry	2-3	Sweed	2+
Passionfruit	1	Turnip	2+
Peach (some only)	2		
Pears	2-3	**Seed (field) crops**	
Persimmon	2-3	Canola (rapeseed)	1-2
Plum	2-4	Clover - white	2
Quince	1-2	Faba bean	0.2-0.5
Raspberry	2-4	Flax	2-3
Strawberry	1-10	Lucerne	5-8
		Lupin	1-2
Vegetable crops		Sunflower oil crop	1-2
Cucumber (gynoecious)	2-4	Sunflower seed crop	3-6
Cucumber (monoecious)	3-6	Sweet clover	2-5
Marrow	2-4	Treefoil	2-6
Pumpkins	2-4	Vetch	5-8
Rock melon	2-7		
Squash	2-7		
Water melon	2-7		
Zucchini	2-7		

Trade and Disease Risk to Bees

Hives should be disease free when hired for pollination, because the disease fire blight of fruit and ornamentals can be transferred by honey bees.

Propolis

Propolis is a resinous exudate collected from trees by honey bees which they use to seal their hives. Propolis is collected and carried to the hive on the pollen baskets on the worker bees hind legs.

Components of propolis can be traced to the trees, from which the propolis is collected. Bees frequently visit conifers, poplars, alders, birch, hazel, oak and willows, to collect resins from the tree bark or buds, mainly in autumn.

Yield

The Caucasian race of European honey bee is regarded as more likely to collect the most propolis. Most propolis is produced in cold European countries.

Yields per hive can vary from a few grams to over 1kg.

Composition of propolis and properties:

(i)	Waxes	30%
(ii)	Resins and balsams	55%
(iii)	Ethereal oils	10%
(iv)	Pollen	5%

Note: Composition varies from sample to sample depending on the source.

Propolis has anti bacterial and anti fungal properties. Appears not to be toxic to humans and mammals unless very large quantities are taken. It can, over time, become extremely irritating to a beekeeper's hands causing painful cracks in the skin.

When cold propolis is brittle, it melts at 40°C, is partly soluble in alcohol, readily dissolves in ether and chloroform. Can be removed from hands with washing soda. Colour of propolis ranges from yellowish-green, reddish to dark brown.

Harvesting and Processing

Commercial production of propolis is usually time consuming. To obtain the highest grade and purity, special "inserts" are placed into the hives.

The inserts mimic holes or cracks, thereby encouraging the bees to fill them with propolis.

Hive scrapings where propolis is seen is another method from frames, entrances and holes. This method can result in the propolis being contaminated with wood, chips, beeswax and paint and is of lower value. At times bees collect paint, tar and sealants and use them the same way they would use propolis.

Markets and Use

The main use of propolis are in natural supplements and herbal medicines, where the propolis is combined with a variety of ingredients.

Propolis is also used as an additive to skin lotions, beauty creams, soap, shampoos, lipsticks, chewing gums, toothpaste, mouth washes, sun screens, tinctures for treating sore throats, cuts, skin rash, in varnish and as an animal growth stimulant. Many other uses have been researched by using propolis to treat tuberculosis, immune boosting, internal sores and cure bacterial infections going back 2000 years.

Price and Demand

The world demand for propolis products seem to be increasing with strong demand from some Asian countries.

Propolis prices vary a great deal from country to country:

(i) USA prices vary from US $4.50 to 13.00 per kg.

(ii) New Zealand US $57.00 per kg

(iii) Australia US$60.00kg

Trade and Disease Risks

Many countries require warning labels on products containing propolis eg Australia requires for oral use the following:

"WARNING — Propolis may cause allergic reactions. If irritation or swelling of the mouth or throat occurs discontinue use."

for dermal use:

"WARNING — Propolis may cause skin irritation. Test before use."

In Australia all products containing propolis are therapeutic goods, except propolis flavoured confectionary.

Propolis is not at risk of carrying bee diseases.

Queen Bees

The queen bee is one of the three castes in the honey bee colony. She normally produces all the eggs, from which other members of her colony develop. She is the focal point of her colony and helps maintain colony cohesion.

Production

A number of beekeepers throughout the world specialise in the production of queen bees.

They require special equipment as they have to remove young larvae from worker cells (grafting) and place the larvae into queen cells in specially prepared colonies of bees, to start and feed the larvae in the queen cells.

Prior to hatching of the queen cells they are placed into smaller colonies (nucleus) that are queenless. The queen cells hatch, the virgin queens mate in the first 10 days of their life and are then caught and sold as mated queens.

It is also possible to artificially inseminate queen bees and initiate queen bee breeding programmes, to increase productivity. The time frame is as follows:

Day 1	Graft 3 days old larvae into queen cells
Day 10	Remove the mature queen cells and place them into small queenless colonies.
Day 11	The queen cells should hatch.
Day 21	The queens mating should be completed and eggs should be present in the combs of the nucleus colony.
Day 31	Queens can be caught and marketed.

Markets and Use

A queen bee can lay 2000 eggs per day and it is normal for beekeepers in most countries to requeen each colony each year.

A number of colonies are requeened more than once a year because the colony is susceptible to diseases, hive is queenless, to queen a drone layer, colony is savage and colony is not performing.

As well as a domestic market being available in all countries where bees are kept, international markets exist in the Middle East, Asia, Europe and Canada.

Queen bees can be exported by air freight or regular mail service in small wooden or plastic cages or included with export package bees.

Price and Demand

The world demand for queen bees is strongest in the Middle East in November/ December, Asia in February/March/April and Canada April to May. From Australia the export demand often exceeds the supply from February to May.

Prices vary from country to country and the landed export price should reflect the domestic price for queens being used to stock productive colonies.

e.g.

(i)	Canadian prices	$US 8.00 to 10.00
(ii)	Korean prices	$US 6.60 to 9.00
(iii)	Middle East	$US 8.50 to 10.50

Breeder queen bees attract a premium export price.

Canada imports 150,000 queen bees per year from Hawaii, New Zealand and Australia.

Trade and Disease Risk

Tariffs can apply where queen bees are exported and imposed by the importing country. Also health certification may be requested to export queen bees into some countries and import permits may be required prior to export. Reliable transport by air is often required where queens are exported or sent over long distances.

Queen bees and worker escorts can carry parasites of bees and queen candy made on honey can carry brood diseases unless the honey in the candy has been irradiated. Some countries will not allow the importation of queen bees e.g. USA, New Zealand and Solomon Islands.

Royal Jelly

Royal jelly is a milky white substance secreted from the hypopharyngeal glands of nurse worker bees and used to feed developing larvae particularly queen larvae.

Yield

Royal jelly is produced by raising queen cells. The maximum yield is obtained when the queen cells are three days old. The yield is as follows:

Age of cell (days)	2	3	4
Average jelly yield per cell (mg)	147	235	182

Composition and Properties

The royal jelly contains the following:

(i)	Water	66%
(ii)	Protein	15%
(iii)	Fat	4%
(iv)	Sugar	12%
(v)	Ash minerals	1%
(vi)	Unknown	2%

Royal jelly is rich in vitamin B and contains vitamins C and D, but is lacking in vitamin E. It has antibacterial properties.

Production

Royal jelly is produced in colonies maintained for the purpose of using either queenless or queen right colonies. Queen cells are grafted and the started queen cells harvested at day three, when royal jelly is at its maximum.

The larvae are removed from each queen cell and the royal jelly collected either with a wooden spoon or a soft suction tube. A good cell will yield 200 to 300 mg of royal jelly. Once collected, the royal jelly can be stored in an air tight container in the refrigerator for several months, frozen or freeze dried until used.

Markets and Use

Main markets are in the cosmetic industry which uses royal jelly in moisturising, skin cream and added to a variety of other cosmetic products. Royal jelly's anti-bacterial, cleansing and textural properties account for its cosmetic popularity.

Royal jelly is also marketed as a health food and is often added as a supplement to other ingredients and vitamins which are taken as either capsules or as part of a beverages in confectionaries or mixed with honey as a spread. Claims are also made royal jelly boosts the immune system, strengthens nails, improves skin and hair.

Royal jelly as human food or cosmetic additive has been promoted as a "miracle food" or medicine, but there is no clear cut evidence of therapeutic value. However, humans have used it for centuries.

Royal jelly is also used by beekeepers to prime queen cells before grafting.

Prices and Demand

The largest producers of royal jelly are China, Japan and Korea; China produces up to 360 metric tonnes. Production is labour intensive and Japan and Korea are also importers. Thailand is emerging as a producer. Royal jelly is often exported and processed. Australia produces very little royal jelly, but imports royal jelly from Thailand and China and exports it after processing into cosmetics or tablets. One kg of royal jelly sells for US$90–100. The world seems to have a surplus supply at present — by value adding a kg can be worth over US$300.

Trade and Disease Risk

Some countries are concerned that royal Jelly may cause allergic reactions in humans. The Australian Federal Government classifies royal jelly as drug and food and has warned asthma and allergy sufferers to avoid royal jelly. All royal jelly products must carry warning labels in Australia stating. "Royal Jelly may cause an allergic reaction."

Royal Jelly can also carry viral, bacterial and fungal brood diseases of bees at very low risk.

Marketing Considerations

Before entering into a market consider the following:

(i) Its size and reliability

(ii) Can the market expand

(iii) Are there any deficiencies in the existing market

(iv) Is the supply and demand seasonal or year round

(v) Can the product be marketed in its raw state or processed

(vi) What technology is required for processing

(vii) Is the price - stable or subject to supply and demand

(viii) Will you market direct to the consumer or need levels of selling, processors, wholesalers, retailers.

(ix) What are the legal implications of producing and marketing.

(x) What licenses are required Are these health, regulatory, what requirements do you need to process the product.

(xi) How much of the product can you market. What will this do to your existing resources. What other commitment do you have for these resources. Are you prepared to invest in this enterprise. How will you fare if the market collapses.

(xii) Can you get permits to import and health certification if required for the product.

(xiii) Is transport available and reliable.

(xiv) Do tariffs and import duty apply.

(xv) If exporting ensure you have a letter of credit before consigning goods.

(xvi) Know any label requirements. Ensure you can produce quantities or obtain quantities of the product and make a profit.

(xviii) Ensure you quality assurance product meets customer specifications.

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Hive and Honey Bee

Beekeeping

Department of Agriculture Victoria.

Appendix I

Pollination Agreement for Season 19 ....

The beekeeper

Name ....

Address ....

Telephone ....

The grower

Name ....

Address ....

Telephone ....

Number of hives ordered ....

Date of delivery ....

Minimum hive strength:

As a minimum, bee colonies shall have six combs of brood well covered with bees.

If colony strength is in dispute, with 5 days of delivery the grower or beekeeper may request an inspection from a State government apicultural authority or by such person mutually agreeable to both parties. Should any colony be found to be under minimum strength, the beekeeper shall pay any inspection cost. Should the colony meet or exceed the minimum standard, the inspection cost shall be paid by the grower. Should a hive be found to be less than minimum strength then either:

(a) a replacement hive shall be provided, or

(b) the hive may be removed and no fee shall be payable.

Crop name	Crop fee
1	$ ....
2	$ ....
3	$ ....
Total	$ ....

(Separate fee is payable for each named crop)

Location of crop

The grower agrees:

1. To give .... days notice to bring colonies into the crop.

2. To give .... days notice to take colonies out of the crop.

3. To pay in full within .... days after the completion of pollination period, or pay deposit of $ .... within .... days of placement of hives in the orchard and the remainder within .... days of the completion of the pollination period.

4. To use no chemical without notifying the beekeeper at least 48 hr in advance.

5. To provide an uncontaminated water supply.

6. To assume liability for damage to hive material, vandalism or theft whilst in the crop.

7. To not move or handle hives without the permission of the beekeeper.

8. To allow the beekeeper unrestricted access to property for hive management.

9. To assist the beekeeper with transport and organisation in the distribution and removal of hives in the crop when requested.

The beekeeper agrees:

1. To ensure that colonies are properly maintained in good condition whilst pollinating the crop.

2. To open and demonstrate the strength of hives randomly selected by the grower.

3. To leave the bees in the crop for a period for effective pollination estimated to be approximately .... days but not later than date ...., after which day the bees will be removed or the contract be extended at $ .... per day.

Signed .... Date ....

Grower

Signed .... Date ....

Beekeeper

RELATIONSHIP BETWEEN QUEEN REMOVAL AND QUEEN REARING BEFORE AND DURING THE HONEY FLOWS IN ASSIUT, UPPER EGYPT

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Abstract

The behaviour of queen rearing in F_1 Carniolan bees after queen removal was studied before and during the honey flows from clover and cotton. The maximum rate of construction of queen cells and queen cups was on the first day after queen removal before honey flow. It occurred on the 2nd and 3rd day during honey flows from clover and cotton.

Before the honey flows, nurse bees significantly selected younger larvae and eggs than during the flows. The sealing of queen cells began on the 4th day when queens were removed before the flows, but on 3rd day during the flows. No eggs deposited by queens were observed in queen cups after queens were removed during the cotton flow. Before the flow, no eggs of laying workers were observed in queen cups during the seven days after queen removal. During the flows, such eggs were observed on the 5th day after queen removal. The ovarian development of worker bees during active season was discussed.

The best time for natural queen rearing, to obtain good quality of queens, is considered to be April or before the clover flow, but not during either the clover or cotton flow.

Introduction

The simplest way to rear honeybee queens is to remove the queen from the colony. Beekeepers often utilize queen cells built spontaneously by bees in queenless colonies. Certain worker larvae are selected by nurse bees and reared to produce queens. The aim of this work was to find the best time for the natural rearing of queens in honeybee colonies, in the area of study.

Materials and Methods

This work, was conducted in the Department apiary during two successive seasons at three periods: before the clover honey flow (last week of April), during clover flow (last week of May) and during cotton flow (August).

The four F_1 Carniolan colonies used were of equal strength (9 combs covered with bees, and including six combs of brood at different developmental stages), and were headed by sister queens, i.e. 24 colonies during the two years. The number of queen cells constructed, normal queen cups, abnormal queen cups (destroyed cups and those containing eggs of laying workers), and the stage of development of larvae chosen by nurse bees for queen rearing, were recorded daily for a week after queen removal. The age of larvae was estimated according to their shape, size and length, following Jay (1963) and Laidlaw (1979).

A factorial design and comparisons between means by least significant difference method were used.

Results and Discussion

Tables and Figures 1 to 3 give mean values for the following each day after removal of the old queen, before the flows, and during the two flows:

(i) percentage of queen cells constructed.
(ii) number of queen cells found in the colony.
(iii) number of queen cells constructed.

The greatest numbers of queen cups were constructed two days, and the greatest percentages two or three days after queen removal. The numbers of sealed queen cells rose consistently between day 3 and day 7 after removal. The number of queen cells sealed before the honey flows was significantly lower than the number sealed during the cotton flow.

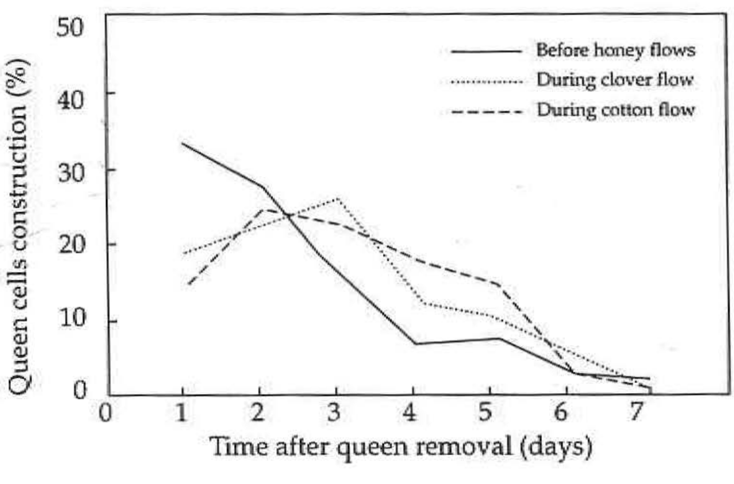

Figure 1. Daily per cent of queen cells construction before and during honey flows

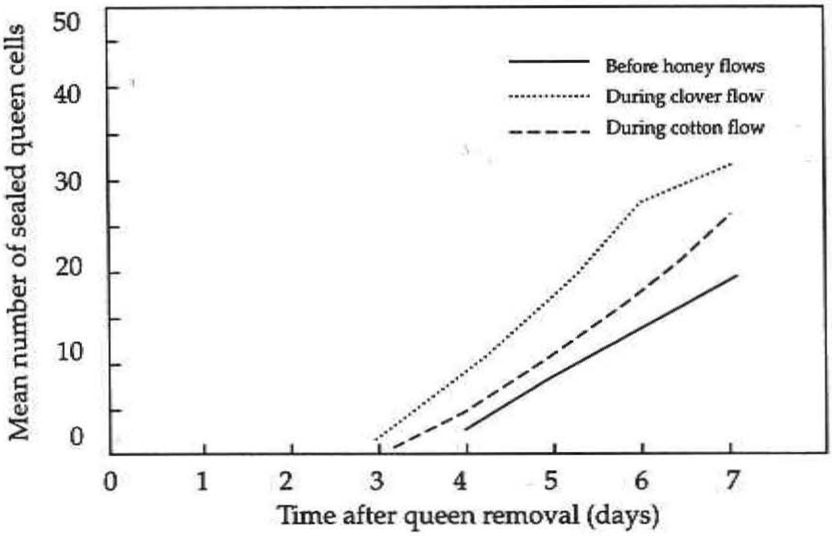

Figure 2. Daily number of sealed queen cells before and during honey flows

The number of queen cells constructed (Table 1) and the number sealed (Table 2) were significantly higher in 1987 than in 1986.

Table 1. Mean number of constructed queen cells/colony before honey flow (I), during clover honey flow (II) and during cotton honey flow (III)

Days	First season			Second season			Mean			Combined
queen removal	I	II	III	I	II	III	I	II	III	mean
1	6.75	6.25	4.25	9.50	4.50	10.25	8.13	5.38	7.25	6.92 a
2	5.75	8.25	7.25	7.25	8.75	9.75	6.50	8.50	8.50	7.83 a
3	4.00	5.75	9.25	3.75	9.75	10.40	3.88	7.88	9.88	7.21 a
4	0.50	6.75	4.00	3.00	6.00	5.75	1.75	6.38	4.88	4.33 bc
5	2.25	1.50	4.00	1.50	9.00	4.50	1.88	5.25	4.25	3.79 c
5	0.75	1.25	1.00	1.00	1.25	3.75	0.88	1.25	2.38	1.50 de
7	0.50	0.00	1.00	0.75	0.75	0.00	0.63	0.38	0.50	0.50 e
Mean/ flow period	2.93	4.25	4.39	3.82	5.71	6.35	3.38 B	5.02 A	5.36 A	4.58
Mean/year		3.86 (B)			5.29 (A)			4.58		

Values with the same letter do not differ significantly at 0.05 probability level.

Table 2. Mean number of queen cells sealed per day per colony before and during honey flow

Days queen removal	First season			Second season			Mean			Combined mean
	I	II	III	I	II	III	I	II	III	
1	0	0	0	0	0	0	0	0	0	0 f
2	0	0	0	0	0	0	0	0	0	0 ef
3	0	0.50	0.50	0	0	2.50	0	0.25	1.38	0.54 def
4	2.50	4.00	3.75	3.25	4.25	12.00	2.87	4.13	7.87	4.96 c
5	5.00	4.75	8.25	6.50	9.00	8.75	5.75	6.87	8.50	7.04 ab
5	4.75	5.50	9.75	6.00	9.25	10.00	5.38	7.38	9.87	7.54 a
7	5.25	6.00	3.75	6.25	9.50	4.50	5.75	7.75	4.13	5.87 bc
Mean/ flow period	2.50	2.96	3.71	3.14	4.57	5.38	2.82	3.77	5.54	3.71
Mean/year		3.06 (B)			4.36 (A)			3.71		

Values with the same letter do not differ significantly at 0.05 probability level.

A highly significant negative correlation ($r = -0.796^{**}$, $t = 5.736^{**}$) was found between the number of queen cells constructed and the number sealed.

Table 3 shows the mean number of queen cups constructed per colony before and during the honey flow. The mean number of queen cups was greatest two days after dequeening before and during clover flow, and one day after dequeening during cotton flow. In general, more cups were constructed during the flow than before it. During the cotton flow, cups were made even on cells containing pollen or honey. No significant difference was detected between queen cup construction in the two seasons. Daily mean number of constructed queen cups before and during honey flow is illustrated graphically in Figure 3. About 30% of the cups constructed before and during the clover flow were used as queen cells; this rose to 37% in the cotton flow, apparently due to the abundant food provided by this flow.

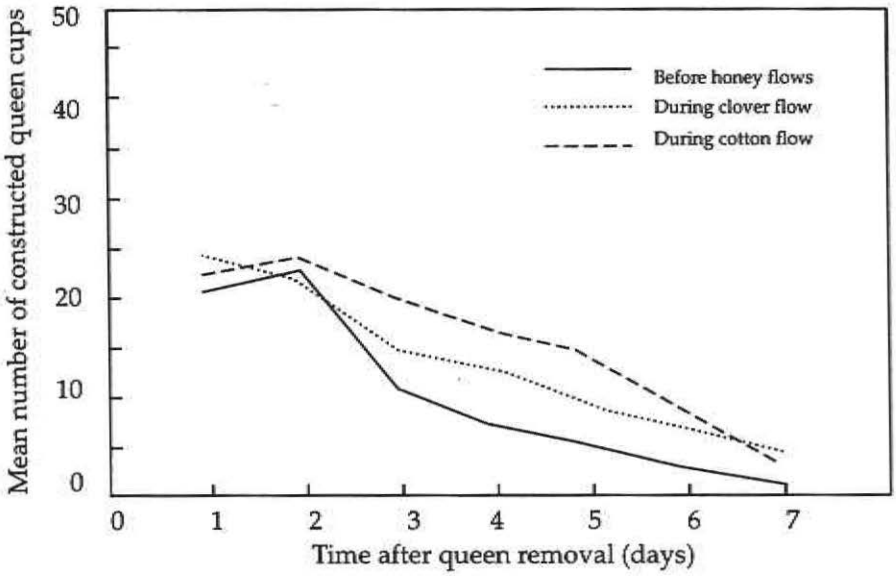

Figure 3. Daily number of constructed queen cups before and during honey flows

Table 3: Mean number of queen cups constructed per colony per day before and during honey flow

Days queen removal	First season I	II	III	Second season I	II	III	Mean I	II	III	Combined mean
1	22.25	25.00	32.75	21.50	23.50	18.00	21.87	24.13	25.38	23.79 a
2	20.25	23.85	28.20	28.00	26.75	18.50	24.13	25.25	23.50	24.29 a
3	14.00	18.25	20.00	9.50	23.25	12.25	11.75	20.75	16.13	16.21 bcd
4	9.75	17.00	17.00	6.75	18.00	11.50	8.25	17.50	14.25	13.33 cd
5	7.50	15.50	13.25	5.25	15.00	6.25	6.38	15.25	9.75	10.46 de
5	4.00	10.75	11.25	3.00	7.25	3.25	3.50	9.00	7.25	6.58 ef
7	3.50	2.25	7.50	2.25	5.00	1.00	2.87	3.63	4.25	3.58 f
Mean/ flow period	11.61	16.06	18.56	10.89	16.96	10.11	11.25 B	16.50 A	14.36 AB	14.03
Mean/year	15.41 (A)			12.65 (A)			14.03			

Values with the same letter do not differ significantly at 0.05 probability level.

Table 4. Mean number of eggs and larvae per colony (primary material) used for queen rearing before and during honey flow

Stages of Development	First season I	II	III	Second season I	II	III	Mean I	II	III	Combined mean
Eggs										
1 day larvae	2.25	1.50	0	3.25	1.50	0	2.75	1.50	0	1.42 de
2 day larvae	9.75	8.75	2.50	13.50	10.25	14.00	11.63	9.50	8.25	9.79 bc
3 day or more	7.75	14.5	20.250	8.50	15.75	28.75	8.13	15.13	24.50	15.92 a
larvae	1.75	8.50	11.25	2.00	13.50	9.25	1.76	11.00	10.25	7.71 c
Mean/ period	5.38	8.31	8.50	6.81	10.25	13.00	6.10 B	9.28 A	10.75 A	8.71
Mean/year	7.40 (B)			10.02 (A)				8.71		

Values with the same letter do not differ significantly at 0.05 probability level.

Table 4 and Figure 4 show that eggs were used for queen rearing before and during the clover flow, but not during the cotton flow. More 1-day old larvae were used before the flows, than during the flows, but more larvae, 2 and 3 days old (or more) were used during the flows than before them. More larvae were being reared during the flows.

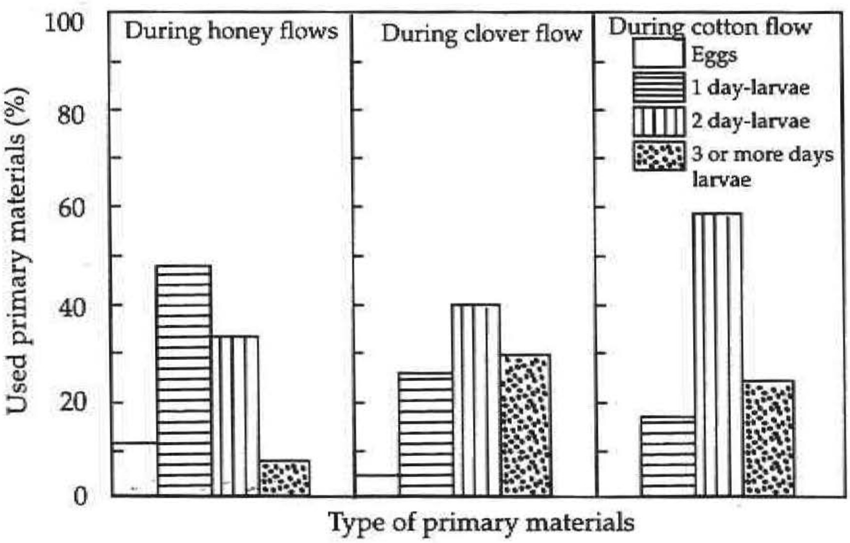

Figure 4. Percentage of used primary material for rearing queens, before and during honey flows

York (1975), Ruttner (1980) and Örösi-Pál (1960) have reported similar results obtained in other countries. Woyke (1971) reported that use of older larvae for queen rearing, not only reduces the queenless period, but tends to reduce queen viability. Also, Ruttner (1980) concluded that a higher rate of queen rearing during honey flow, reduces the quality of queens.

Abnormal queen cells were counted during the work. Eggs from laying workers were observed 5 days after dequeening, and higher numbers of them during the cotton flow Figure 5.

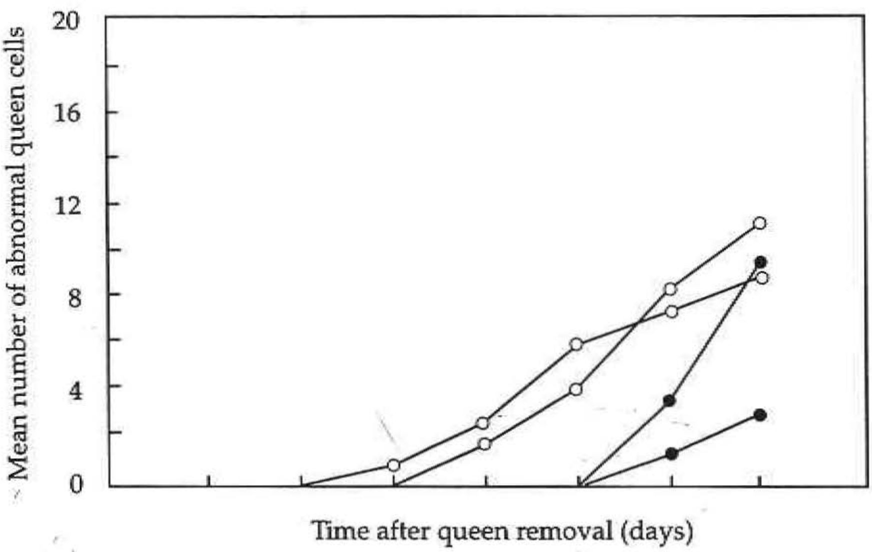

Figure 5. Daily number of destroyed cups during clover flow (o—o) and cotton flow (o-----o) and cups containing eggs of laying workers during clover flow (•—•) and cotton flow (•----•)

In the USSR, Koptev (1957) found that normal colonies had 7-45% anatomically laying workers at the end of a honey flow. In the Netherlands, Velthuis (1985) observed a duration of laying worker phase that was much influenced by conditions inside and outside the colony. In active period, the maximum number of ovarioles occurred in summer bees and were recorded during June in Assiut area by Khodairy (1990).

The higher number of ovarides recorded during (May-June) probably related to the fluctuation in the amount of pollen brought in the colony and its protein content, and the variations in ratio of nurse bees to the unsealed brood number. The high protein content of stored pollen was recorded by Omar (1989) during this period in the same area.

It can be concluded that, under the conditions in Assiut, more queens are reared, and older worker larvae are used, during the clover and cotton flows than beforehand, and that the queens reared are of a lower quality.

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SESSION VI

ECOSOCIAL MARKETING

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The concept of ecosocial marketing is based on the sustainable use of resources, to allow economic growth while protecting the environment and preserving cultural identity. The goal is capacity building while installing a chain of partnerships between producers, distributors and consumers, involving great responsibility for each other. Consumers today know that the decisions they make at the point of purchase can have an impact thousands of miles away. In a sense they are voting with their wallets, with a direct impact on the global economy and Consumers are becoming conscious of where and how goods are produced.

Other than the marketing rules, the unique spiritual propositions, including the background information of goods, with an answer to today's P2s menaces,will make the products and distributors in terms of marketing, including public relations, and will help to reach new national and international markets. The development of a strategy for marketing honey and beehive products taking into account the specific circumstances of the different regions needs an interactive communicaton between the partners and will take part in four different phases:

- Research and evaluation
- Organization and coordination
- Operational aspects
- Monitoring and coaching

SERICULTURE IN UGANDA: PAST, PRESENT AND PROSPECTS FOR THE FUTURE

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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. Systematic development of the industry, however, started about 10 years ago. Mulberry growing and silkworm rearing have started in 24 districts. Silk cocoons are being produced and exported. A brief account of the status of the Uganda sericulture industry and prospects for the future are presented in this paper.

Introduction

Uganda is one of the most favoured countries in the African region in rainfall, temperature, humidity, sunshine and soils for mulberry cultivation and silkworm rearing. The climate is equatorial, with two well-marked rainy seasons. The peak of the first rains usually occurs in April and May, and of the second rains in September, October and November. Rainfall is low in June and July over the regions near the equator, but further north, its distribution tends to be unimodal with no well marked dry period during these months. Most of the land receives an average of between 750 and 1250 mm of rainfall. Mean temperatures are for the most part between 21 and 25°C. Climatic variations are less marked. These favourable climatic conditions make Uganda a comfortable home of diverse insect fauna and associated flora. Most of the known silkworm food plants like mulberry, castor and *Bridelia* are found growing luxuriantly all over the country throughout the year. Many species of wild silkworms are also known to occur in Uganda.

Mulberry for silk production has been planted in 32 districts. Silkworm rearing and silk cocoon production has started in 24 districts. More than 5000 farmers have planted mulberry, but only 400 of them are producing silk cocoons.

Since 1992, a total of 35,203 kg of fresh cocoons have been produced and 8752 kg of dry silk cocoons worth US $ 110,440 have been exported (Tables 1 and 2).

The focus on sericulture development is now to increase production and productivity. This paper reviews the work done in the past and highlights the current situation, activities achievements and future prospects.

Historical Perspectives

Many species of wild silkworm are reported to occur in Uganda. Gowdey (1911) recorded some of these as *Anaphe infracta* Wals, *A. moloneyi* Duce, *Hypsoides milleti* de Juan and *Mimopacha gerstakaeri* Dew. The food plants of *A. infracta* and *A. moloneyi* are recorded to be *Bridelia micrantha* (*Katazamiti*), *Cynametra alexandra* (*Nongo*) and *Triumfeta macrophyla*. Anaphe silkworms were reported to be more abundant than the others.

Table 1. Fresh Cocoon Production

Year	Quantity (kg)	% Increase
1992	432	0
1993	8332	1800
1994	8480	2
1995	8508	0.3
1996	9451	11
1997	10872	15
Totals	46075	

Table 2. Dry Cocoon Exports

Year	Quantity (kg)	CIF Value	Grade
1993	1660	22,576	2A
1994	3332	45,315	2A
1995	1800	24,480	2A
1996	0	0	-
Totals	6792	92,371	

Current Situation and Activities

Sericulture has been singled out in the countrywide campaign to reduce poverty in rural areas and diversify foreign exchange earnings. The implementation and development of the sericulture programme and projects is now the mandate of the Department of Entomology in the Ministry of Agriculture, Animal Industries and Fisheries.

Anaphe silk was one of Uganda's exports in the period 1910 - 1945. Despite the fact that *B. micrantha* is found growing luxuriantly in most parts of the country, all the anaphe silk was being collected from Kakumiro county in the now Mubende District. Attempts were made to introduce mulberry sericulture in the 1920s. Silkworm eggs were imported from Europe and Madagascar; unfortunately the eggs always hatch on the way. This problem was overcome by importing hibernating eggs. However, the young larvae which hatched from the eggs were eaten by ants in the hut in which they were being reared. Further attempts were hampered by lack of silkworm eggs, trained indigenous manpower and the speculation that synthetic fibres would out-compete natural silk.

During the early 1970s, attempts were again made to introduce sericulture. Mulberry plantations were established at Kawanda Agricultural Research Station. The work was concentrated on mulberry propagation and planting techniques, but got stuck in 1975 because of lack of silkworm eggs and trained manpower. The project was later abandoned and the mulberry was uprooted during 1982.

In 1985, the Indian government and the Swiss Development Corporation provided a training opportunity to Uganda and one person was trained for 8 months at the International Centre for Training and Research in Tropical Sericulture, Mysore.

Sericulture activities resumed in June 1986, immediately after the training. A mulberry variety Kanva-2 and Bivoltine breeds NB4D2, NB18, NB7 and KA and multivoltine breeds PM and HM, were introduced from India. Local mulberry varieties were collected and planted and evaluated together with Kanva-2. Kanva-2 was selected and recommended for multiplication and release to farmers.

The bivoltine breeds were evaluated together with hybrids imported form Japan namely Shuko x Rhyuhaku and Kinshu x Showa. The hybrid Kinshu x Showa was selected and recommended. Farmers started planting mulberry in 1991 and rearing of silkworms started in 1992.

Sericulture Situation and Activities

More than 5,000 farmers have planted mulberry and about 8% are rearing silkworms and producing silk cocoons. The low number of rearers is mainly due to inadequate extension services including lack of inputs, like silkworm eggs, appropriate rearing houses and equipment. Farmers production costs are high because recommendations and techniques being adopted by farmers are not appropriate, since they have been developed in sericulturally advanced countries. The farmers who are able to produce silk cocoons rear very small quantities of silkworms. Cocoons production per case of 20,000 eggs varies from 10 - 40 kg. It has been demonstrated that one hectare of mulberry can yield leaves to feed 10 cases of worms. However, it seems that production per unit area of mulberry field is decreasing with time. The low productivity is considered to be due to inadequate training in silkworm rearing and mulberry cultivation techniques and high incidence of silkworm diseases.

Table 3. Sericulture Farm Income and Productivity (per cycle)

Year	Egg cases/ family	Cocoon production/ family (Kg)	Gross production/ case (Kg)	Gross income per case (US$)	Gross income family (US$)
1995	0.70	11	17	46	30
1996	0.80	15	20	55	41
1997	0.60	13	25	67	37

Most farmers have planted Kanva-2 with recommendation based on the limited germplasm available at the time. Todate 22 mulberry varieties have been introduced. The variation in productivity could also be due to mulberry varieties as the different varieties are planted anywhere without due consideration for agro-ecological adaptability.

About 15 - 20% of the cocoons produced by farmers are unreelable or of low quality and cannot be exported. There are no reeling or spinning facilities in Uganda. The low quality cocoons have been stored by exporting companies since 1992, because of lack of processing facilities. Farmers are now being advised to destroy the "waste" cocoons. The quality of the cocoons produced is generally grade 2A with a raw silk of 38 - 40% and reelability is around 70%.

Dry silk cocoons have been exported to Japan and India. There are possibilities of exporting high quality raw silk to a wider market including Europe once reeling facilities are established. The traditional high quality raw silk producers like Japan and Korea can no longer produce large quantities of high quality cocoons, because of heavy industrialisation and increase in labour costs. Clearly, this is an opportunity for Uganda and other developing countries to exploit.

The government has planned to remove identified constraints and to assist rural farmers to increase cocoon production, productivity and incomes over the next 5 years to about 600 tons of fresh cocoons, 26 kg/case of eggs and the quality to Grade 3A, through development and transfer of appropriate technology. Minimum cocoon production per worker is targeted at 50 kg/cycle and the number of cycles per year 6. Average size of a family in Uganda is 7 people. The targeted production, productivity and quality improvement are considered to be the minimum for a farmer to rely on sericulture for cash income and the basis for expansion and development of a competitive industry.

Bridelia trees which are the food plants for anaphe silkworms are abundant in most parts of the country. The trees are mainly used for firewood. The leaves could be converted into silk through anaphe culture which requires fewer inputs than mulberry sericulture. Two acres of Bridelia have been planted at NSDC as the first step towards non-mulberry sericulture resource conservation and utilisation.

The government is establishing an institutional mechanism to overcome the above constraints and achieve the set objectives and targets. A national sericulture development centre (NSDC) and regional centres are being established. The NSDC will be constantly engaged in overcoming hardships and taking advantage of favourable circumstances through development of appropriate technical and managerial systems.

Specific functions of the NSDC are to establish and maintain a national germplasm of sericulture resources and to develop techniques to exploit the various stocks. The following supportive infrastructure is being established: laboratories for silkworm/mulberry pests and diseases; silk reeling, spinning technology and quality control; regional sericulture centres for technology development and transfer to decentralised districts in different ecological zones. Other functions include collaboration with districts in training programmes for extension staff and farmers; preparation of manpower development plans; provision of advisory services; collaboration with international organisations, local NGOs and private sector associations; collection and collation of data.

Development of intensive mulberry cultivation and silkworm rearing techniques, and pests and disease control techniques appropriate for Uganda are on-going activities. Regional sericulture centres are being established to assist the decentralised districts and extension personnel in appropriate technology transfer to cater for differences in agro-ecological and socio-economic variations through adaptive studies and practical demonstrations.

District sericulture training and demonstration centres are also being established. Entomologists have been recruited and mulberry plantations planted in most districts for healthy seed multiplication and training in sericulture technology. Funds are, however, limiting all these activities.

Young silkworm production centres are being established in various districts to provide relatively developed easy to handle third instar larvae to farmers. The national programme has trained district entomologists to provide the necessary supervisory and backstopping services to the young silkworm centres. Plans have been made to establish more young silkworm rearing centres and adequate extension services.

Prospects for the Future

Mulberry grows luxuriantly throughout the year and silkworms can also be reared to ensure regular and continuous monetary incomes to underprivileged rural populations. Some farmers have been able to rear and produce silk cocoons 10 times in a year as compared to 1 - 2 crops for most of the traditional crops.

About 90% of the population is employed in agriculture mainly on small land holdings. Most of the agricultural employment is household farming, which is based on a very high labour intensity. The labour force supports a large population which is unable to undertake any productive work. The dependency ratio is over 100%. The incidence of wage labour in rural areas is low. Casual and short term contract workers account for a very high proportion. The incidence of permanent workers is very low. This is because most of the members of the rural labour force are predominantly occupied with work on their own farms. Very few are available for employment on a long term basis. The people are unskilled and the work in their household farms is the most convenient and remunerative occupation.

The current policy of restructuring in the public and private sectors has left many civil and military servants and employees of parastatals and private companies jobless. The reduction of the public service was based on the understanding that the remaining service should be well renumerated, and therefore, more productive to restore the culture that supports hard work. However, this has not been the case, because of budgetary constraints and those who have not been retrenched/retired are forced to indulge in other activities or reduce their effectiveness at work. Many graduates from the universities, secondary and tertiary institutions join the jobless every year.

There is therefore need to encourage programmes which can offer alternative employment and income on a regular basis to which the retired personnel are used and which is also needed for modernisation of rural areas. Sericulture is such an activity and competes favourably with other non-traditional income generating activities being promoted by government. The all year round production is expected to make sericulture one of the most efficient industries in terms of employment and wealth generation in rural areas. The success of the sericulture industry, however, is subject to timely removal of identified constraints and establishment of necessary infrastructure and systems which will be constantly involved in anticipating and overcoming hardships and exploiting favourable conditions.

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CONCEPTS OF SERICULTURE DEVELOPMENT IN DEVELOPING COUNTRIES

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Need to Identify Cost Centres

Once we call this industry, every activity in sericulture development shall be viewed through cost benefit analysis by establishing cost centres at each stage.

Creating such cost centres would contribute not only to making each centre cost effective, but will also lead to self sustenance on long term basis without financial support on continuous basis from funding agencies.

In other words, each centre has to earn for itself through optimization of results with cost control, when initial financial support is provided by the funding agencies/or corporations.

Phases of Silk Production

Production of silk is basically conversion of nutrients of mulberry lead to silk, wherein silkworm eats the lead and converts the nutrient into silk. The whole operation is an eco-friendly process.

The litter of the silkworm and wasted leaf and wood stock are useful for generation of biogas and power generation and the resultant mass is used as farm yard manure. The entire operation of cocoon production takes the nutrition from the land and returns it to the land.

Soil fertility is increased through application of natural fertilizers conserving environment and totally avoiding pollution in the entire process. Thanks to the rich foliage and repetitive blooming, mulberry is ideal as an excellent green cover and contributes to social forestry in an immense measure.

This agro-based industry transfers purchasing power from those rich who can afford to buy expensive quality silk to the farmers who grow mulberry in economic limits of cultivation. Not only does this economic activity add to national income and wealth, it is also a path breaker in agro-operation and promotion environment of conservation.

Sericulture therefore, enhances the income levels of the the grassroots community, when compared to the other agro-based products. At the same time and the income levels development of this activity is directly in proportion to the scientific inputs we administer, so as to get optimum returns on a commercial scale. Sericulture development is technology driven.

The demand and consumption for silk is on the rise particularly in India and other Asia and European countries, at middle level of society as income levels are on the rise. Silk fabric is luxurious, casual wear and for special occasions.

Now the point to ponder by everybody at this conference is how we harness this activity in developing countries in a systematic, self regulated manner without regimentation, giving scope for free market forces to play across the globe.

Silk to Silk

Development of pre-cocoon technology with a linkage to post-cocoon technologies as an integrated system, can be considered as an overall industrial activity under "Soil to silk" concept If this concept is accepted, developing countries have to clearly identify what these technologies are and how to develop them under a national policy for sustanianble growth. At this stage it is essential to come back to the cost centres for silk production with suitable technologies.

Cost Centres

I would suggest the following areas which can be identified as cost centres:

(i) Germplasm stations and grainages with stabilized races suitable to different seasons

(ii) Mulberry plantations

(iii) Irrigation facilities

(iv) Chawky (young silkworm) rearing centres

(v) Adult silkworm rearing houses

(vi) Demonstration farms

(vii) Technical training centres at field level

(vii) Field research stations with training facilities

(ix) Cocoon markets with grading facilities

(x) Filature reeling units operation with optimumefficiency level with continuous supply of quality cocoons

(xi) Twisting facilities.

To this stage the cost centres are meant for producing raw silk with an integrated approach.

Subsequent activity of weaving is considered as a special activity for meeting the consumers' needs throughout the globe with varying preferences from country to country and also to meet the domestic market requirement.

Factors of Production

To achieve maximum results from these cost centres, I consider the following factors of production which become critical, while evolving policies by a developing nation.

(i) Material is worked upon to get the finished product in each cost centre

(ii) Labour which works on the material to get the finished product

(iii) Capital in the form of tools and implements and facilities used for working on the material to convert them into finished product

(iv) Entrepreneur co-ordinating the other factors to achieve production.

(v) Technology necessary to produce quality products with a competitive edge

(vi) Infrastructure (power, transport, communication) without which modern day production and distribution is impossible

(vii) Market which creates demand for the Goods and services enabling sales promotion

(viii) Government which ultimately rejuvenates the economy or messes it up by its policies and administration.

I would like to elaborate each of the above vital aspects of integrated development of silk"under soil to silk" concept.

Quality Seed from Grainages

Quality seed is the backbone of sericulture industry. Basic seed technology is still kept as a secret by most of the sericulturally advanced countries like China and Japan.

Today most of the developing countries are dependant for supply of hybrid seed from outside sources. In some of the developing countries like India, Brazil, Thailand, the situation is quite different as they are in position to maintain their own breed stock stations, with continuous upgradation of races, in order to achieve greater stability and productivity of crops at commercial rearing level.

In India, this is met with limited success, while in Brazil and thailand they are self sufficient, matching international standards with seed of the same quality and race being supplied to their farmers on continuous basis, to produce better quality of cocoons and giving international grade of raw silk of more than 2A grade.

It may be worthwhile for sericulture developing countries in Africa to try to associate with some of these developing countries for supply of quality eggs on continuous basis at the same time, simultaneously strengthening their basic seed activity through applied research. Any investment on grainages without building up infrastructure in the direction of mulberry gardens, rearing and reeling facilities could be unproductive, as these counties can ill afford to waste their scarce resources.

It may also be worthwhile to go into this activity, if funding from international funding agencies is over a long period with a clear objective to achieve economic self sustenance of grainages.

Reeling Facility

This should be to develop as a clear cut strategy as a national policy for development of sericulture. First, developing countries should decide whether they would like to produce only cocoons or they would like to produce raw silk. China for example is the largest silk producing country exporting raw silk and made up fabric.

India is second for silk production and exports are increasingly rapid. However, lack of quality consciousness in the silk production is hampering the growth of silk industry. There is also a tendency to import raw silk on continuous basis from other countries to meet the silk demand in the domestic market.

Brazil and Vietnam have developed sericulture only for the purpose of exporting of raw silk. Japan and Korea are not increasing the production of raw silk, because of high cost of production.

Developing stations introducing sericulture activity should also aim for the global market from the very beginning to produce better quality of raw silk within their own countries with a competitive edge to sell their products in international market. Otherwise they will have a serious marketing problem of raw silk.

This applies to countries which propose to produce only raw silk. The strategy of the countries which propose to produce not only silk, but also the fabrics, have advantage of better cost effectiveness in the respective cost centres to promote production, either for domestic or export markets.

So this policy has to be decided at the beginning and suitable mechanisms created for an integrated development under "soil to silk" concept.

It should be clearly understood that consumption of silk, fabrics and madeups is concentrated in the developed countries like USA, Japan and Western Europe. If suitable technologies are developed by the developing countries, whole silk industry could shift to the developing nations, for production of raw silk and quality fabrics.

The question arises as to how to co-ordinate the sericulture development by promoting transfer of the technology to respective developing countries that are interested in sericulture industry as a long term capital investment project.

This needs the following aspects to be co-ordinated:

(i) To raise manpower

(ii) Mulberry and chawky field rearing centre management

(iii) Adult silkworm centre and reeling units management

(iv) Creating skilled workforce for weaving line for fabrics and design centres

(v) Evolving suitable pricing policy for eggs supplied to farmers and fixing cocoon price under a grading system and raw silk price at internationally competitive rates.

Extension Networks

The extension network for mass production, education, demonstration and field visits are essential for transfer of technology at the field level to produce better quality of cocoons. This is possible only if the grainage are continuously supplying same quality of silkworm eggs to the rearers.

The cocoon producers should follow and realize the importance of package practices for rearing the silkworms on a continuous basis, giving quality cocoons to the reeling units under a pricing formula. If the cocoons that are coming into the market are not of the same grade, the raw silk production is not effective in terms of quality standards and becomes less effective against competition in international market.

Producers Association

It may be worthwhile to consider from the very beginning creation of cocoon producers association with linkage to grainage unit and facilities to create extension network to farmers cooperatives, for suitable transfer of scientific technology.

At the same time, reelers association should also associate themselves with cocoon producers association for suitable pricing policies at all the levels envisaged earliar.

Conclusion

Dedication to duty at all levels is the need of the hour, if at all we have to develop sericulture activity in a systematic way. We will have to adopt a better work culture aiming at improved productivity and ensuring high quality.

We will have learnt the lesson not only from advanced sericulture countries of west, but also from nations like Japan and China, which have earned the name as "Asian Tiger" by virtue of their phenomenal economic development.

In sericulture development, there is no short cut to progress. We will have to take the route of hard and work discipline. This calls for:

(i) Silkworm egg breeding, indentificaton , re-production, quality control and distribution

(ii) Increase in mulberry production and silkworm disease control

(iii) Establishment of pricing policies for cocoons, raw silk and silk fabrics

Any tendency for short cut at any of the above mentioned levels of operation will hamper the growth and development of silk industry, particularly in developing countries, as they can ill afford to waster, their scarce resources.

UGANDA NATIONAL POLICY FOR PROMOTION AND DEVELOPMENT OF APICULTURE AND SERICULTURE FOR RURAL FARMING COMMUNITIES

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Abstract

The paper outlines policy issues, which have in recent years influenced Uganda government to review her National Agricultural Policy. As indicated, the Ministry of Agriculture, Animal Industry and Fisheries stands for its organizational structure, objectives and roles. It outlines the ministry's future direction and strategies for promoting apiculture and sericulture as sustainable high income family generating agricultural enterprises for rural farming communities. The paper provides data on the economics of apiculture and sericulture farming in Uganda and indicates how these two agricultural enterprises are targeted by the government to alleviate rural poverty.

Introduction

Peasantry agriculture by small scale holders is the backbone of Uganda's economy with women producing between 85-95% of family food requirements and also contributing from approximately 60-75% of cash crops for both domestic consumption and export markets.

Uganda's rainfed agriculture is characterized by use of simple production tools, mainly the hand hoe and to small extent ox-ploughs. A good percentage of the planted hectarage is attacked by agricultural pests and diseases, while the crop is still in the fields and between 20-30% is further made unavailable as postharvest losses.

Traditional cash crops like cotton and to a lesser extent coffee are labour intensive and because of low fluctuating world market prices, are becoming less appealing to farmers. This has necessitated government to review her agricultural policy and to set new priorities as to what crops must be grown and where, to target zonal production

National Policy Issues which have in Recent Years Influenced Government Policy Review on Agriculture

(i) The Civil Service reform and Rationalization Programme. In order to professionalise the traditional civil service and for government to initiate a progressive time frame action plan, towards payment of a minimum living wage and introduce a Result-Oriented Management (ROM) Policy Strategy, there has been down-sizing of the civil service and the armed forces.

(ii) Divestiture and liberalization of the economy has meant that government has delegated some of its previous responsibilities to the private sector.

(iii) Decentralization of political power to the local district councils and urban authorities similarly meant that services and roles hitherto handled by central government were handed over to local governments.

(iv) The 1996 Uganda constitution under specific activities and schedule made further provisions which handed over service and delegated other roles to local administrations at district level.

(v) All these policy formulation changes and others dictated that the Ministry of Agriculture Animal Industry and Fisheries, out of necessity, had to review and internalize its rule within a changed environment.

The Ministry of Agriculture, Animal Industry and Fisheries (Maaif) Mission Statement

It may be said that the, ministry now exists to promote increased production, on sustainable basis, of quality crops, livestock and fisheries for domestic consumption and export market.

The ministry's new roles within a new policy framework may also be summarized as:

(i) Agricultural policy formulation and planning

(ii) Supervision, monitoring and evaluation of agricultural implementation progress by district local governments

(iii) Regulations relating to agricultural policy and their appropriate enforcement

(iv) Capacity building at all levels of headquarter technical agricultural extension staff.

Maaif's Structure (Organogram)

The government's roles within the agricultural sector are to be implemented by three Directorates, namely:

(i) Directorate of agricultural extension (one director) supported by:

- (a) Department of animal production
- (b) Department of crop production
- (c) Department of training and information

(ii) Directorate of Crop Resource (one director) supported by:

- (a) Department of crop production
- (b) Department of land resources and development.

(iii) Directorate of animal resources (one director) supported by:-

- (a) Department of veterinary services
- (b) Department of fisheries
- (c) Department of entomology

There is a department of agriculture planning and one for finance and administration. All are supervised by the executive composed of the permanent secretary and minister.

Department of Entomology Mandate

The department of entomology in the Ministry of Agriculture, Animal Industry and Fisheries is mandated:

(i) To co-ordinate, supervise, monitor and evaluate the field implementation progress of the national tsetse and biting flies of livestock Tabards control programme

(ii) To promote or popularise the development of Apiculture and Sericulture as sustainable high income generation of agriculture enterprises to rural family communities

(iii) The department is responsible for the generation and transfer of appropriate apiculture and sericulture technologies to small scale farming communities.

Ministry of Agriculture, Animal Industry and Fisheries Specific Objectives

The ministry's specific objectives are to:

(i) Ensure national food security

(ii) Diversify the national agriculture economic base through introduction and promotion of non-traditional cash crops, high yielding seed germ plasma and high value agricultural enterprises.

(iii) Target zonal production of such high value crops, high yielding seeds and agricultural enterprises, taking into consideration Uganda's ecological zones.

(iv) Gradually modernize agriculture through increased quality agricultural production and productivity.

Promotion and Development of Apiculture and Sericulture in Uganda

Traditional bee farming is an old industry in Uganda although all modern apiculture was introduced in the mid 1970s. Silkworm farming on the other hand dates as far back as between 1910-1945 when Anaphe silk was one of Uganda's exports for world war I and II for making military parachutes.

Modern silk production was introduced in Uganda in 1986 by the Ministry of Agriculture. Animal industry (now Ministry of Agriculture, Animal Industry and Fisheries). Silk production is a rural based agro-industry with potential to create employment and generate income for rural poor communities. Silk itself is a high value product with world trade in silk goods exceeding US $ 20 billion.

In Uganda targeting agriculture zonal production puts emphasis on those high yielding crops and agricultural enterprises, which can generate a minimum family income of US$1000 per hectare per annum in order to alleviate rural poverty.

Apiculture and sericulture have in this respect been identified as promising agro-enterprises which meet this criterion in the countrywide campaign to create employment and reduce poverty.

The Economics of Apiculture and Sericulture Farming by Rural Communities in Uganda

Mulberry has been planted by more that 3000 farmers in Uganda in 32 districts and silkworm cocoon production has started in 24 districts. Economic analysis of available data on average provides the following information:

(i) Sericulture

One hectare planted with approximately 8500 mulberry plants at 1.5 x 0.8 spacing density and with ten months production cycle, will produce 1500 kg of silkworm cocoons valued at US$4900 per year.

(ii) Apiculture

One hectare of open Savannah woodland will on average accommodate 200 Kenya top bar hives. Each hive will harvest a minimum of 40 kg of honey in a year, giving a total and annual harvest of 8000 kg of honey. Presently, Uganda honeybee keepers association is paying US$0.8 per kg of honey in a comb. Expected family income from this level of farming is US$6400.

Future Strategies for Promotion of Apiculture and Sericulture Development in Uganda

In summary, it is planned that the following intercessions and strategies will be put in place to strengthen the implementation of Ministry of Agriculture. Animal Industry and Fisheries' objectives and achievements of the mission statement on Apiculture and Sericulture:

(i) National apiculture and sericulture centres with associated laboratories for disease pest control and quality assurance will be established.

(ii) Regional apiculture and sericulture demonstration and farmer training centres will be developed and equipped with honey collection, processing and cocoon silk reeling facilities.

(iii) Undertake and strengthen capacity building of technical extension and managerial staff in relevant fields of apiculture and sericulture entomology, technology and management.

(iv) Introduce cost recovery at an appropriate time and open up revolving bank accounts for the two enterprises.

(v) Collaborate with relevant research and training institutes within the region and overseas.

(vi) Closely liaise with the Uganda national Bureau of Standards and the Uganda quality products for export market, to provide market information to farmers.

POTENTIALS OF APICULTURE IN ETHIOPIA

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Background

On the horn of East Africa, Ethiopia occupies a land area of 1.1 million sq. km. bordered by Sudan to the north and west Kenya to the south, the territory of Affairs and Issas and Somalia to the east and southeast. Eriteria is to the northeast and across Eritrea and the Red Sea is the Arabian Peninsula. Ethiopia occupies a land area from latitudes 3 and 16°N and longitudes 32 and 48°E.

Ethiopia is a land of contrast. Whilst in some areas the land is 250 feet (75 m) below sea level, its highest mountain towers to 14929 feet (4553 m) above sea level. The variety of landscape from raggedness to undulating plain, with relatively wide north-south latitude and east-west longitude differences, has given the country a contrast in climate and consequently a variety of seasons and rich biodiversity.

Beekeeping seems as old as time itself to Ethiopians, who cannot think of a period in the country, history without "tej" the local alcoholic drink made only of honey. It is similar to that known as mead in other parts of the world. In fact, it has long been a national beverage, where no birth burial, wedding or other social event can take place without it.

Since the forth century, during the time of king Ezana, christianity with a strong emphasis on a monastic culture contributed a lot to the intensive growth of beekeeping, because of the need for wax for religious ceremonies. In addition, the farming community had to supply the nobility and the social elite with honey for making traditional beverages.

Some authorities speculate that bees came to Ethiopia from Egypt along the Nile Valley, and that the same bees were also taken to Somalia and other East African countries. Smith (1960) includes Ethiopia as one of the homes of *Apis mellifera adansonii*. The *adansonii* bee is the common race of honeybee in tropical Africa, extending from the Sahara in the north to Cape Town Province in the south and from the east to west coast. Although most, and often all the workers in the colony may show the characteristic *adansonii* coloration, yellow bands on the first three abdominal segments, yellow scutellum and yellow hairs, there are also darker individuals. At the higher altitudes, where the climate is cooler and occasionally on the coast, darker varieties occur. The darkest variety having no yellow on the abdomen, but usually with the yellow scutellum and yellow hairs, was called frieset by Buttel-reepen. The drones of otherwise normal *adansonii* colonies may be yellow-banded or quite dark. There is no evidence of any difference between the varieties, other than the tendency for the bees to be darker in the mountainous areas.

In his recent paper on "African races of *Apis mellife*", Smith indicates that the bee samples which he received from Ethiopia differ in characters from the *adansonii* bees (Gebreyesus, 1988). In another analysis done by Rutthner, of bees sent from experimental station in Debre Zeit to Germany, similar conclusions have been indicated. No differences in the haemoymph protein spectra were found between the bee samples obtained from Ethiopia and European races. I discovered such differences in *A.m. capensis* from South Africa and *A.m. adansonii* hybrids from Brazil, originating also from South Africa. Ruttner explained also in Grenoble that the description of the race is adansonii derived from bees from Senegal. Perhaps the South African as well as the Ethiopian honeybees are indeed different races and need a new taxonomic name (Gebreyesus, 1988).

Recently, Fichtl and Adi(1994) reported that in Ethiopia at least three geographical areas are confirmed to be present. The Ethiopian bees are *Apis m. yemenitica*.

Traditional Management of Bees in Ethiopia

The long tradition of beekeeping has not involved anything more than the materials involved in a given environment in Ethiopia. Bees are kept in cylindrical hives made of the bark of a tree, hollowed-out logs, bound reeds, bamboo, woven cane wicker or earthenware. It has been estimated that there are over three million of these cylindrical hives, and one million farmer-beekeepers, in Ethiopia today. The manner in which the hive and the colony of bees are handled varies greatly from one part of the country to the other, even within a few kilometers. One can in general classify beekeeping practice in two major categories.

(i) Beekeeping as practised in the western and southern parts of Ethiopia.

(ii) Beekeeping as practised in the rest of Ethiopia.

Beekeeping in Western and Southern Ethiopia

In western and southern parts, bees are found in abundance. The climate in general is wet and warm throughout the year, with much sunshine. A wide variety of natural vegetation covers this area, with plenty off lowering plants throughout the year as a rule.

The natural conditions are so well suited to bees, that hives put in position will be occupied within a matter of hours. The practice of bee management here is to let the bees live in the wild state, once the cylindrical hives are hung up in trees. Many tales have been told regarding the bees in this part of Ethiopia. Management of bees in south-west Ethiopia by the Majangir people is worth mentioning.

Majangir acquire large amounts of honey by apiculture. They gather very little honey from wild bees' nests, but depend instead on honey produced in hive (dance, sing), which they make, place in trees, care for, and visit regularly to remove honey. The hives are made from hollowed-out logs, about five feet long and a foot in diameter, taken from certain softwood trees, especially *Cordia africana*. The finished hive is pulled up to the high branches of a tree. Majangir believe that bees like height, and that it also makes the theft of honey more visible and difficult.

As most hive are higher than fifty feet, climbing to them is risky. Despite the dangers of falling, Majangir show no fear. A man visits each of his hives several times a year, not only to remove honey, but to renew the ropes fastening the hive to the tree, and remove the leaves stopping the entrance and the charred wood on the inferior of the hive. A hive that is not tended will eventually lose its bees and fall to the ground to be destroyed by termites (Gebreyesus, 1998).

In areas where honey production is not the only cash earning farm produce, the colonies are treated in a cruel way. Cylindrical hives hung in high trees, suspected to contain honey, are cut and allowed to drop on the ground, thereby destroying the whole colony of a few kilogrammes of honey. In areas where the value of honey plays a significant economic role in the home economy, however, bees are tended well. At times they are allowed to live as members of the family in the same hut(s) or house(s), but still in the cylindrical hive, which is suspended from the roofing of the hut or from wooden poles set up for the purpose

The behaviour of bees is dependent on the environment to which they are exposed. In situations where man and nature are cruel, the bees are aggressive and the slightest provocation is tantamount to a declaration of war. In places where they have been well looked after, the bees are reasonably gentle and easy to manage.

Regarding production, the yield per hive in western and southern Ethiopia is quite low: estimates and sample surveys show only 4-9 kg per hive. This of course includes the wax, which is crushed and mixed with the honey.

Beekeeping as Practised in the Rest of Ethiopia

Beekeeping in the rest of Ethiopia is similar, but with a few exemptions, dictated by environmental peculiarities. Notes on bees and beekeeping in Abyssinia by Giavarini (1973) as quoted by Gebreyesus (1988) at the 5th National Congress of Italian Beekeepers in Bargamo had this to say:

> "The methods used by the natives are usually primitive The hives, as Morton reports, are generally cylindrical in shape and are covered with palm or banana leaves and plastered with mua, cow dung and straw. These hives are equipped with a handle by which the native carries them, and either hangs them on the wall of "tukul' or supports them by forked sticks near the dwellings, or else, and most frequently, suspends them on trees"

The inhabitants of Tigrai use a somewhat more sophisticated method: the hives are divided into two parts by means of a perforated wooden partition; one-part serves as a honey chamber, the purpose of the division being to facilitate extraction.

Morton regards the Abyssinian hive as the oldest in existence, since in its general shape it resembles the hives constructed by the Egyptians. Padre Bellani, who lived in East Africa for more than 25 years, records that in the neighbouring territories of Kenya, Uganda and Tanganyika, he never saw hives constructed like those of Abyssinia, which suggests that Abyssinian apiculture has its origins in Egypt. This would support my theory stated earlier, about the probable existence of *A.m. fasciata* in Abyssinia. Honey is usually harvested twice year, before and after the rainy season.

The native's method of extracting is generally primitive. The keeper removes the bees from the hive by means of smoke, and then quickly takes out the combs, which have superficially been cleared of bees and larvae, and places them in suitable containers.

The combs are squeezed by hand, and honey is achieved summarily extracted. A further extraction of honey is achieved by washing the compressed combs. Honey extracted in this way will naturally contain pieces of comb and often also larvae, it is kept in suitable then vessels?

Traditionally bees are handled as all other domestic animals by the farmer. Bees are kept in an apiary yard, usually located near the living quarters of the farmer. The necessary protection against ants, honey badgers, birds and the like is provided in all organized and timely fashion. It is also not uncommon for farmers to place water near the apiary during the dry period and pollen substitutes (such as roasted pea, bean and other flour), during periods of pollen shortage.

The cylindrical hives used in this part of Ethiopia are normally bigger than those used in western and southern parts. The size is increased or decreased, as the case may be, after the honey harvest or when the climatic conditions are too dry for plants to exist and flower, as beekeeping is directly related to the season. In order to describe the seasons of Ethiopia, the following facts need to be known. Three zones of altitude and climate "Kolla" "Woina Dega" and "Dega" distinguish Ethiopia. The Kolla includes regions up to 1600 to 1700 m where *Acaeia, Albizzia, Combretum, Comminphora* and *Croton* are the natural vegetation. The rainfall is from nil to 200 mm yearly, and at higher levels from 600-800 mm. The temperature varies from 20-26°C. The Woina Dega is the intermediate zone, at an altitude of up to 2200 m and 2400 m and with a yearly rainfall of 1000 to 3000 mm. The natural vegetation here includes *Acacia, Coffea, Combretum* sp. *Croton, Guizotia, Trifolium* spp., *Vernonia, Dombeya, Olea, Rosa abyssinica* and *Euphorbia*. The Dega, the temperate zone of the highlands which starts at an elevation of 2400 m is mostly treeless, and is a cold area where the temperature sometimes falls below freezing point. The natural vegetation in these areas includes *Olea, Rosa abyssinica, Albizzia sp., Guizotia, Acanthaceae* composite and *Compositae*.

There are important variations every year from one part of the country to another, but generally two rainy seasons. The short rains, which often vary in intensity and length and normally occur some time between mid-February and April, are usually intermittent showers that interfere very little with the daily sunshine. The long rains which occur in most parts of Ethiopia from mid-June or early July to September, provide about 80% of the country's rainfall. The striking relief features of Ethiopia greatly affect the distribution of rainfall and accounts micro-climatic conditions. Rainfall usually increases with altitude and is affected by the path of the most air stream. The latter is the main reason for the relatively high rainfall recorded in the southwestern parts of the country, such as Illubabor (7-9°N, 33-37° E) and Kefa (5-9°N, 35-38°E).

Towards the end of the rainy seasons, about September and April, just before the flowering periods, the beekeeper farmer goes out for his swarm catching. The cylindrical hive is smeared with wax (usually at the inner top side), so that the colony can start building the combs. One hole, about an inch in diameter, is left in the cylindrical hive for the entrance of the swarm initially and as the flight entrance once foreign and other activities start. The hive is then hung in a tree in areas where swarms are expected and it may be occupied within a few hours or days. The new colony is usually allowed to settle into its new home before it is transferred to the backyard of the farmer's home. In a situation where there is swarming from the beekeeper's own apiary, the manner of handling and catching of the swarm is different. When a swarm leaves a cylindrical hive and settles on a branch of a tree or bush, the beekeeper then searches for the queen. By placing her in a queen cage made out of bamboo cane, the swarm is easily hived. Once comb building has started, the queen is released from her cage.

At the end of the next honey flow season, the beekeeper will open the cylindrical hive for honey, using smoke. At the beginning and end of every flowering period (honey flow), the beekeeper inspects his hives, not only for honey, but also for the well-being of the colony.

If due to a poor climatic or flowering season the bees have been unable to occupy all the combs and there is reason to believe that it will be attacked by wax moth, the beekeeper removes and cleans the space, to allow for its fresh preparation for the next reason. Where there is an abundance or food production in the cylindrical hive, the beekeeper removes any building up that is considered likely to cause swarming and overgrowth of the colony. As this method does not allow the rearing of new queens, the old queen will be allowed to remain in the colony. As the seasons come and go and the queen gets older her capability to maintain her colony will falter. While some colonies do manage to replace their queens, others will fail as a result of the beekeeper's direct and constant interference in their natural development. The beekeepers of Ethiopia do not fully understand the need for a new queen in a colony, and much effort will be required to inform and teach them this fact, which cannot be acquired from either traditional or practical experience.

View Point

Ethiopia is a heaven for bees, and among those engaged in beekeeping at present are those who might like to start it on a commercial scale. The diversity of climate, natural landscape, natural and cultivated vegetation, coupled with its very co-operative people, could make commercial beekeeping an undertaking of great benefit to an investor and to Ethiopia indirectly, should a programme the field get underway in the immediate future. At present, there are estimated to be three million hives among beekeeper farmers in Ethiopia. Honey production is estimated at 26547 tons per year. About two-thirds of it goes into tej making in the homes of farmers or in urban areas, while the remainder goes for home consumption and export. The export of honey is however very small, only 10-15 tons per annum, mainly to Saudi Arabia and Yemen. Ethiopia at present ranks as the largest exporter of beeswax in Africa, and fourth largest exporter in the world. Approximately 500 tons of beeswax is exported to USA, Europe and Asia. An unknown quantity of beeswax is also used in the production of church candles (there are over 15,000 churches in Ethiopia) and for home consumption. Honey harvesting by the traditional beekeeper includes removing combs from hives and crushing them before the honey is sold in the market. The honey sold contains the wax from the crushed combs. In the preparation of the tej, the removal of this wax is undertaken in a fashion that is very tiring and time-consuming way to the tej producers. The wax so obtained is sold in lumped cakes to exporters. The exporters, who have the advanced machinery, have to purity the wax further prior to its shipment to foreign markets.

Utilization of Honey in Ethiopia

The honey produced in Ethiopia is utilized: (a) in the preparation of honey wine (tej) by local tej houses; (b) for home consumption; (c) for processing table honey and (d) or export. The local demand for pure honey is extremely high. Consumers are willing to pay high price for locally produced honey, provided they are convinced that it is pure. However, the honey produced by beekeepers using simple hives is prepared in a very crude manner. It has either been spoilt by the presence of unripe honey, by pollen combs being included, by heating or even by addition of water, some of which may have been observed from the atmosphere. The containers in which the honey is usually kept and transported to the market place is made of skin. This skin bag spoils the honey still further. Honey kept in the skin bags, is used for the production of honey wine only. Thus, a great deal of honey is spoiled due to lack of knowledge of proper handling.

Export of Honey

A very small amount of honey is exported, mainly to Saudi Arabia. Aden and Yemen as these is a huge domestic demand and market.

The honey is bought in the local market, packed in 26 kg tin containers and exported. Unfortunately it tends to granulate on the way and since buyers did not like the honey in granulated form, demand has decreased or ceased over time.

Export of Beeswax

Ethiopia is one of the world's largest exporters of beeswax with an annual average export of 500 tons a year. Its export in 1978 for example, was 557,321 kg worth Ethiopian Birr 5,141,844 (about USD$ 2.6 million).

In modern beekeeping with a movable - frame hive the exact measurements must be respected, the quipment is expensive and there should be the know-how. Combs can be used every year, and the centrifugally extracted honey is a marketable product. Bees wax being conserved will reduce the cost of production per hive or frame.

In a country like Ethiopia, with an established tradition of fixed-comb beekeeping in cylindrical hives, wax is produced for sale easily over much of the year. There is no economic reason why movable frame beekeeping for honey production could not exist side by side with fixed-comb beekeeping for wax production.

Beekeeping Development

Little attention has been paid to the possibilities of beekeeping in the past. It has been looked upon as a small, insignificant industry, playing a doubtful part in the overall agricultural sector. This possibly has been due to the fact that beekeeping was a family business, and the techniques passed from one member to the other with little outside interest.

This situation has changed. Honey production can be a large and attractive business. The place of the honey bee in pollination is now recognized. Trained experts are to be found in almost all countries. It is high time that this information was adapted to the developing area.

The Advantage of Beekeeping

The advantages of developing the honey and beeswax production are immense and may be summarized as follows:

(i) the capital need is very small

(ii) a reserve of experience and skill exists in villages and can be harnessed without much difficulty

(iii) it reduces unemployment, stops labour migration to cities and stabilizes rural economy

(iv) with very limited labour/time input, a peasant farmer will get higher income than his usual full-time farming output

(v) it may enhance imports substitution in the national economy and contributes to the overall economic growth of a nation

Beeswax is a minor, but by no means negligible product. The high and steady oversees demand for beeswax would appear to be adequate incentive for Ethiopia to develop it. Honey and beeswax production could very well be a major enterprise in Ethiopia and could provide both food and income for thousands of people living in the low income sectors.

ICIPE Ethiopia Activities

Considering the potentials of apiculture and sericulture as income generating undertakings in Ethiopia, ICIPE has initiated a pilot apiculture and sericulture project. The IFAD supported commercial insects project of ICIPE has provided 100 modern movable-frame hives to be tested in Southern Ethiopia, Sodo-Bedessa, Gurage Zone, Tigrai Region, Tekezze River Valley (Fig. 1) and at the Biofarm located at the outskirts of Addis Ababa). In each location, 25 hives have been used to train, evaluate and validate the appropriate technology. Currently, the average production per hive per harvest ranges between 23-26 kg.

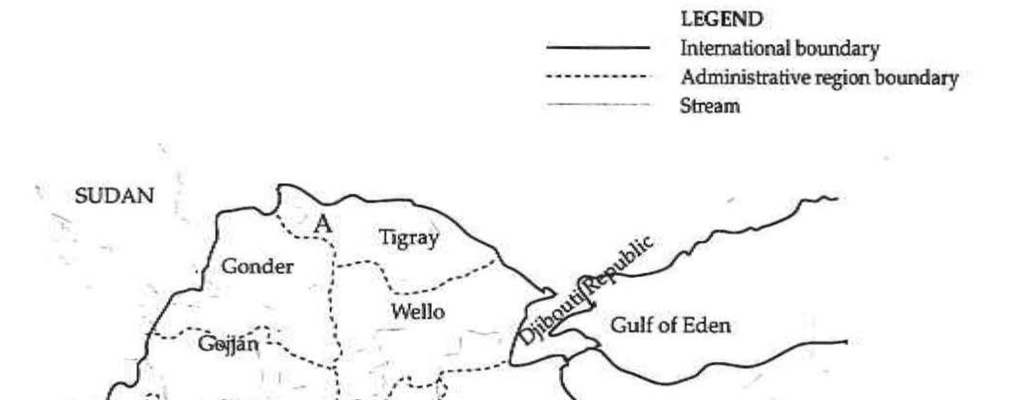

Figure 1. Areas where marble-frame hives are being tested in Ethiopia with ICIPE and IFAD support

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RESOLUTIONS

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Summary

1. The workshop participants resolve to express gratitude to ICIPE and IFAD for bringing together the wealth of expertise that has made an important contribution to the exchange of information in the last four days.

2. That the proceedings of the workshop are published and given the widest possible circulation.

3. That there should be further communication between ICIPE and IBRA with a view to exploring areas of mutual co-operation particularly in the field of dissemination of information on all aspects of apiculture.

Concluding Remarks

Four hundred years ago an English poet said:

"No man is an island entire unto itself".

Today, throughout the world we have "islands of knowledge". This workshop has brought some of those islands together. Knowledge on its own means very little. It is the sharing of knowledge and the building that can take place on shared knowledge that is important. We can only share knowledge if we are prepared to be truthful. Information, figures and data must be accurate and honest. Our knowledge comes to nothing if it is not shared with integrity.

There are changes from state led models to those that rely on market and sector. This applies to much of the economy including apiculture and sericulture.

This means that markets are now judged as better indicators for allocating resources than public administration, a radical change in roles. It demands accuracy, truth, integrity.

During this conference, many figures have been used — figures have to be accurate so as not to build up false hopes of income to producers and a source of supply to buyers. Overestimation of potential is as harmful as not realising the potential that is available.

Another English poet, — well known I think in former British colonies, wrote the poem "If". In that poem he says;

"If you can talk with crowds and keep your virtue

Or walk with kings nor lose the common touch

If neither foes nor loving friends can hurt you

If all men count with you, but none too much"

I believe this is very good advice and I would like to think that it applies to all us.

Our work this week has not only provided a resource, I hope it can be a catalyst for development and for promoting sustainable economic growth as well as maintaining biodiversity in East Africa.

In the Book of Solomon it says:

"Give a wise man knowledge and he will be yet wiser"

Here there are wise men and women seeking knowledge of beekeeping and sericulture. I hope we have provided a start and will continue to share our knowledge with those who will go out and make a success of commercial ventures with silkworms and honey bees. This is just the end of the beginning. Go out and put science into practice and make a real contribution to the East African economy.

Good luck.

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