

Original Research Article

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***Colophospermum mopane* – A Potential Host for Rearing Wild Silk Worm
(*Gonometa rufobrunnea*) in Arid Rajasthan**

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India is the biggest consumer of raw silk and silk fabrics and second largest producer of raw silk after China. There are two types of silk viz., mulberry silk and vanya silk (non-mulberry silk). India has vast potential for production of vanya silks which plays a major role in rural livelihood security. Vanya silk can also be produced from the cocoons of wild silkworm, *Gonometa rufobrunnea* insect. The main food plant of *Gonometa rufobrunnea* is *Colophospermum mopane* commonly called as mopane. Mopane is a xeric species of South Africa and introduced in India for sand dune stabilization. The review discuss about the possibility of rearing *Gonometa rufobrunnea* in already available mopane plantations in arid regions of the country to increase production of vanya silk and to improve the rural economy in arid regions of India.

Introduction

Silk is a textile fibre produced by insects and commonly called as “Queen of Textiles”. Since ages, silk and silk products have attracted humankind and have found their place among the most esteemed and rich human fabrics. India is the world's second biggest producer of raw silk and contributes 15.5% of world silk production. India imports more than 8,500 MT/yr because of increased demand of 25,000MT/yr. By the year 2025 it is expected to increase to 45,000 MT/yr (Kshirasagar, 2006). So, silk generation has enormous potential in India, which could give extra employment opportunities for upto 6 million rural people mostly women folk

(Ahmed and Rajan, 2011). It is agricultural output based enterprise viz., cocoons and cottage based labour intensive in nature. The silk enterprise includes reeling the cocoons for unwinding the silk filament, weaving, silk knitting, silk wet and processing comprising of degumming, dyeing, printing and finishing other than cloth manufacturing.

The very nature of this industry with its rural based on-farm and off-farm activities and huge employment generation potential has involved the attention of the planners and policy makers to perceive the industry among one of the most appropriate avenues for socio-

economic development of rural economy like India (Gangopadhyay, 2008). For increasing the silk production we require highly productive and also tolerant silkworm races to adverse climatic conditions and diseases. The wild silkworm (*Gonometa rufobrunnea*) is one of the silk producing insect which feeds only on mopane (*Colophospermum mopane*) can be a best addition to already available other non-mulberry silkworms to meet the domestic demand of raw silk. An extensive review on *Colophospermum mopane* and *Gonometa rufobrunnea* has been carried out to explore the possibilities of growing wild silkworm in mopane plantation established for sand dune stabilization and afforestation of degraded lands in arid regions of Rajasthan.

Type of silks

India is a home to a huge variety of silk producing fauna which also includes an remarkable diversity of silk moths. This has made India to achieve the unique distinction of being a maker of all the five commercially traded varieties of natural silks. These are divided into two categories viz., Mulberry silk and Vanya or Non mulberry silk. Those silks produced from the *Bombyx mori L.* silkworm, which solely feeds on the leaves of the mulberry plant are called as mulberry silk. Most of mulberry silk produced in the world comes from this variety. In India, 92 per cent of the country's total mulberry silk production comes from the states Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu and Kashmir together. Non mulberry silk consists of all the other varieties of silk except mulberry silk. Non-mulberry sericulture is generally known as forest or wild sericulture. Tropical and temperate tasar eri and muga are the major non-mulberry silks. Other varieties i.e. fagara, coan, mussel and spider silks are limited interest. Tasar silks alone contribute nearly 95% of the global production of non-mulberry silks.

Tasar silk is copperish and coarse textured, secreted by the tropical tasar silkworm, *Antheraea mylitta* which thrives on Asan and Arjun trees (*Terminalia* sp.) and is mostly used for furnishing and interiors (Gangopadhyay, 2008). Oak tasar is a finer variety of tasar secreted by *Antheraea proylei*, the temperate tasar silkworm, which nourishes on wild oak plants (*Quercus* sp.) and is found in large quantity in the sub-Himalayan belt. Eri silk is a silk spun from open-ended cocoons and produced by the domesticated silkworm, *Samia cynthia ricini* that feeds mostly on castor leaves. Mugasilk is an exclusive produce of India and preferred attire during festivities especially in Assam. It is golden yellow in colour secreted by *Antheraea assamensis*. Som (*Persea bombycina*) and Soalu (*Litsea polyantha*) are the two major host plants of muga silkworm (Handique and Singh, 2014).

Vanya silk industry in India

History

Vanya sericulture remained obscure for quite a while as a selective art of tribal and hill folks inhabiting the Central and North Eastern India. It is in the recent past that this tribal tradition got significance and attracted attention at National level. The eco-friendly nature of the production processes, high production potentialities within the country, enduring interest for vanya silk products outside, women involvement, promoted commercial exploitation of this art, which culminated in the transformation of this age old custom to an industry of enormous potentiality. Vanya silks have been commercially exploited route back in seventeenth Century. The Western World attracted for these alien shaded silks in mid-1800 when a widespread silkworm disease affected the whole European sericulture industry. Asia could not supply enough

mulberry silk to meet the requirements of Europe and North America, accordingly making a market opportunity for vanya silks (CSB, 2017).

Status of vanya silks in India

Production trends

Among the different varieties of silk produced in 2015-16, mulberry accounts for 71.79% (20,478 MT) followed by tasar 9.88% (2,819 MT), eri 17.74% (5,060 MT) and muga 0.58% (166 MT) of the total raw silk production of 28,523 MT. During 2015-16 over 2014-15 vanya silk has achieved 9.9% growth (Table 1) (DGCIS, 2017).

Marketing of vanya silk cocoons and products

In the last two decade steps has been taken to help in marketing of vanya silk cocoons and products viz., establishment of Raw Material Banks (RMB) in vanya sector by Central Silk Board (CSB), Cocoon markets by Department of Sericulture and State government marketing agencies viz., Sericulture Federation (SERIFED), Khadi Village Industries Commission (KVIC) and Tribal Federation (TRIFED). Because of these agencies the bargaining power of primary cocoon producers has been improved. The vanya silk products mainly sarees and fabrics for dress material and furnishings are being marketed by participating in various exhibitions all over India mainly by manufacturers and traders (CSB, 2017).

Export and import of silk goods

Major markets for Indian silk goods are USA and European countries and also exported to small markets of Asia Region. Fabrics, made-ups and readymade garments which account for about 95% of the total silk goods exports of the country are the major items of India's

silk exports. The export earnings from silk goods during 2015-16 were Rs.2495.99cr and Rs. 2829.88 cr. in 2014-15 (Table 2) (DGCIS, 2017). The vanya silk fabrics are being exported mainly from Kolkota, Bhagalpur New Delhi, Mumbai and Bangalore by the established exporters. Vanya silk product contributes approximately 10% of share of export earnings out of total export of natural silk goods.

India also imports natural silk yarn and silk fabrics apart from raw silk. The import value of silk and silk goods during 2013-14 and 2014-15 are given in table 3. 98% of the total imports include raw silk, silk yarns fabrics and made-ups. During 2014-15, the value of silk goods imports was Rs. 1356.73 cr. compared to Rs. 1357.48 cr. in 2013-14, indicating a decrease of 0.06% in Rupee terms. Marginal increase of 7.02% from 3260 MT in 2013-14 to 3489 MT in 2014 has been observed in raw silk import (CSB, 2015).

Moreover, among the non-mulberry varieties, eri has the limitation of higher cost of productions. Tasar is gifted by nature with enormous potential. However, over exploitation and deforestation brought about depletion of non-mulberry food plants. One should not overlook that non-mulberry sericulture holds prodigious potential for the world forestry as a supplementary activity. Vanya (or) Non-mulberry sericulture is a forest based industry specifically suited to the economy and social structure of developing nations on account of its low investment requirement, foreign exchange earning potential and high employment opportunities.

Taxonomic status of the *Gonometa rufobrunnea*

The genus *Gonometa* has two silk producing species of commercial value, *Gonometa postica* and *Gonometa rufobrunnea*. In spite a few experts believe *G. rufobrunnea* to be just

a subspecies of *G. postica*, *G. rufobrunnea* is recognizable from *G. postica* at every phase of the life-cycle and the larvae feed only on mopane which is rejected by *G. postica* larvae. *G. rufobrunnea* (Scholtz and Holm, 1985; Hartland-Rowe, 1992) belongs to the order lepidoptera and Family lasiocampidae (Nagaraju and Jolly, 1988). The cocoons of both species are viewed as a profitable natural resource. Notwithstanding comparable cocoon attributes, there are marked differences between the two *Gonometa* species. The distributions of the species also differ (Pinhey, 1975). Adult male and female moths of *G. postica* have brown forewings, while those of *G. rufobrunnea* are red (Pinhey, 1975). Although the general biology of both species is reasonably known (Pinhey 1975; Scholtz and Holm, 1985; Hartland-Rowe, 1992), an extensive study on ecology of neither species has been carried out.

Lifecycle of *Gonometa rufobrunnea*

The moth has reddish-brown wings looking exactly like dead leaves of mopane. The female is corpulent and twice the size of male. It is nocturnal, lacks functional mouthparts and has short life span of three to five days, maximum of nine days. The egg stage takes 10-11 days to complete. The eggs are unique, spherical, white in colour with a dark micropyle and a diameter of around 1 mm. The eggs are laid in clusters of 2 - 25 eggs (averaging 6 eggs) not generally on the mopane but rather on thin stems of grass or other herbage near mopane trees, however once in a while a cluster is laid upon a mopane leaf. Every female lays around 200 eggs (Hartland-Rowe, 1992).

In order to investigate the deterministic nature of the choice of pupation site, the between-host plant and within host plant distribution of *G. postica* and *G. rufobrunnea* pupae was quantified in Africa. The distribution of both species at these scales was observed to be

extraordinarily non-random, with pupae generally preferring toward particular tree attributes and micro-sites. These outcomes now give the premise to suggesting a suitable utilisation strategy for Africa's wild silk moths. In light of the spatial and temporal variability in pupal abundance observed, a stable and predictable cocoon supply for natural harvesting is unlikely. Long-term, broad-scale documentation of *Gonometa* species population cycles may make it feasible to foresee cocoon availability in the future. Until such research is done, it is prescribed that the current practise of only gathering cocoons from which moths have emerged be continued with (Veldtman, 2005).

Climatic factors

Climate plays a vital part in regulating the population density of this species. Not only do they directly control the moth emergence timing and the induction and termination of diapause but also affects the timing of availability of food indirectly. Continuous drought can also affect the population by affecting the host plant (Hartland-Rowe, 1992).

Colophospermum mopane

Botanical description

G. rufobrunnea, feed on *Colophospermum mopane* (Kirk ex Benth.) J. Leonard, a multipurpose tree commonly called mopane, mopanie, rhodesian ironwood, turpentine tree, butterfly tree, red Angolan copal belongs to legume family (Fabaceae). Meaning of this genus is 'oily seed' and refers to the distinct turpentine smell of the oil contained in the seeds. It is one of the most important tree species of the hot and dry areas of southern Africa. Colophon in Ionia was celebrated for its resin; it was the origin place of Homer, so the name connects this African genus with one of the world's great brave stories. The

particular name, 'mopane' is derived from a Bantu common name for the tree (Van Voorthuizen, 1976). It has been planted in western Rajasthan for stabilizing sand dunes and it performs well in silvopastoral system also.

C. mopane is a deciduous shrub or medium-sized to tall tree from 4m to 18m tall, normally 10 m, with single or several stems from the base and sparse branches developing upwards. Trunks of large trees have diameters up to 1m, with bark dull dark to blackish, profoundly and vertically fissured and flaking in limited strips (Timberlake, 1995). Leaves look like camel footprints or butterflies; composed of two asymmetric leaflets, each with a straight inner margin and a curved outer margin, kidney-shaped. *C. mopane* trees grows in area receives a summer rainfall of 100 mm and 800 mm per year and a dry season ranging from 5 to 10 months with a mean annual temperature of -3 to 50 deg. C (Palmer and Pitman, 1972). It grows on a wide range of soils, but is commonly found on alluvial soils and on alkaline and poorly drained soils, which it tolerates better than many other species and has a wide altitudinal range (200-1200 m) (Orwa *et al.*, 2009; Timberlake, 1995).

Uses

C. mopane is a multipurpose trees planted in agroforestry for, soil improvement, fuel wood, fodder, shade, shelter, rehabilitation of degraded soils and stabilization of dry, alkaline soils and sand dunes. The tree regrows after felling and the chemical present in mopane give resistant against termites and borers which increase its preference in construction purposes. The internal barks are utilized for making ropes, while the external barks are utilized for fuel. High wood density of (1200 kg/m³) the mopane makes the species durable (Goldsmith and Carter, 1981).

The wood cell of *C. mopane* is stuffed with crystals of calcium oxalate, which results in a dense wood (Prior and Cutler, 1992). Likewise, the secondary metabolites by and large known as extractives, adds to the final density of wood. As *C. mopane* grow in harsh environments, those environmental conditions favours high substance of extractives in the plant. Mopane wood stripped of bark is used with other commonly available tree species to build a variety of structures, including traditional huts (walls and roof structures), grain stores, fences, chicken pens and kraals (Mashabane *et al.*, 2001). It is used for building timbers, flooring, exterior fittings, fences, railway sleepers and furniture, as well as round wood, posts, pit props, and tool handles. Wood is excellent firewood, it burns easily, even when green (Liengme, 1983). It is reported to burn slowly with the remaining coals emitting a lot of heat which is good for long periods of cooking. The ash is used as fertiliser, although this was found not to be a common practice (Madzibane and Potgieter, 1999). A small fibre is said to be obtainable from the bark of this tree. *C. mopane* is also used for treatment of various animals and human diseases. Seeds are consumed by humans as famine food.

C. mopane taps underground water, which help to break dormancy to produce fresh leaves and consequently making it an important fodder species in times of grass shortage. Crude protein content is 11% when the leaves are reddish-brown in colour and animals relish the leaves at this stage. Fallen leaves contain crude protein content of around 4%. Old leaves are picked from the ground and eaten. Fresh leaves are not palatable as it contains higher crude protein (13%) and have a laxative effect on cattle and also have high tannins (Orwa *et al.*, 2009). Feeding fresh leaves of *C. mopane* is possible in goats but it can be fed at 35-40 percent of whole ration. The palatability of mopane dry leaves was

low and decreased with progress of feeding from 15 to 5 per cent from first to fifth week (Mathur *et al.*, 2007). New leaves are utilized to treat animals with sores on their ankles (Mashabane *et al.*, 2001). *C. mopane* is host tree of mopane moth or head moth (*Gonimbrasia belina*) caterpillars which feed on its leaves (Ditlhogo *et al.*, 1996). In southern Africa the mopane worms are consumed (Palgrave, 1983) as a nutritional food (Mpuchane *et al.*, 2001) and also provides income through the sale (Shackleton *et al.*, 2000; Kozanayi and Frost, 2002; Gondo *et al.*, 2010) because of rich source of protein. Crude protein content in the caterpillars is assessed at 47.5% (Orwa *et al.*, 2009).

Silvicultural practices

C. mopane is a drought tolerant species limited to regions of alluvium and colluvium soils with low to modest precipitation. It grows quickly both vegetatively and by seed. Seeds orthodox in nature yet seeds are sometimes viable for more than one year under natural conditions. Central Arid Zone Research Institute (CAZRI), Jodhpur, Rajasthan reported failure in germination with 8-year-old *C. mopane* seeds (Orwa *et al.*, 2009). Without any seed treatment the seeds grow readily however 24 hours water soaking speeds germination. Seeds can be sown in the polybag in the nursery or directly sown in the pits in the field. *C. mopane* is the only tree species which exhibited natural regeneration in afforested areas under arid conditions (CAZRI, 1979).

Tree spacing of 5 x 5 m is suitable for agroforestry system and 10 x 4 m for restoring degraded rangeland. Weeding should be done in the initial few years as the young trees are susceptible to competition. More number of coppice shoots was observed in trees cut at 1m over the ground level than

10 cm high after three years of planting. However seedlings may have height increments of around 10 cm per year and grow slowly (Timberlake, 1995). Musvotu *et al.*, (2006) recorded 5-10 t/ha/yr of biomass production in acacia and mopane mixed woodlands with a coppicing cycles of 10-20 years, however more long term research is required on coppice management in mopane plantations. He also observed a significant increase in flowering and fruiting due to thinning as it reduces the inter-tree competition. Root system of *C. mopane* are shallow (30–120 cm deep) and extensive as an adaptation to survive in the arid condition. The roots can take up water from drier soil than contending grasses. The leaves join together and hang straight down under more daylight or water stress conditions (Hocking, 1993).

Pests and diseases

There are no major diseases in arid regions of the country. In Africa, it is regularly defoliated by larvae of Anomalous emperor moths. 'Mopane bee' additionally makes harm the species to some degree. In some places young seedlings were attacked by termites. In case of such issues, Aldrex powder, BHC or Gammexane ought to be applied in the pits before planting operations (Orwa *et al.*, 2009).

***Colophospermum mopane* in arid Rajasthan**

Many authors evaluated and reported the performance of *Colophospermum mopane* in arid western Rajasthan. Among fourteen tree species investigated *Prosopis cineraria*, *Colophospermum mopane* and *Hardwickia binata* which lead to higher built of amino acids, amino sugars, hydrolysable NH₄ -N and total hydrolysable N are likely to be more useful to the companion crop than rest of the

species evaluated (Burman *et al.*, 2002). Increase in organic matter, available nitrogen, phosphorus and micronutrients were observed in in silvo pasture plantations of *Acacia tortilis*, *Colophospermum mopane*, *Hardwickia binata* with *Cenchrus ciliaris* in degraded lands in arid India (Aggarwal *et al.*, 1978). Production potential of silvipastoral systems involving two trees, viz. *Colophospermum mopane* and *Hardwickia binata* with buffel grass (*Cenchrus ciliaris* L.) and sewan grass (*Lasiurus indicus* Henr.) and fodder sem (*Lablab purpureus* L.) as legume were assessed with and without N application. Significant variation in the growth of *Colophospermum mopane* was observed due to cropping systems. The average plant height and survival percentage of *Colophospermum mopane* were higher than *Hardwickia binata* (Patidar *et al.*, 2008).

Colophospermum mopane was planted in agri-horti-silvi system with citrus and shisham and with intercrops viz., mungbean and cluster bean at CAZRI, Bikaner under sprinkler irrigation system. *Colophospermum mopane* recorded highest leaf water potential of -6.99 MPa and both intercrops recorded maximum leaf water potential in *Colophospermum mopane* intercrop plot (Yadava *et al.*, 2013). Growth of *Colophospermum mopane* was better with intercrops than the sole trees (without intercrops) but it affected the yield of intercrops due to more competition for moisture with intercrops. The maximum stem girth (78.00 cm; 74.33cm) and tree canopy (25.10²; 24.53 m²) was recorded by *Colophospermum mopane* respectively when intercropped with mungbean and clusterbean (Yadava *et al.*, 2013).

Litter decomposition of different tree species viz., *Acacia senegal*, *Acacia tortilis*, *Colophospermum mopane* and *Dalbergia sissoo* were studied by litterbag technique in between the tree stands at CAZRI, Bikaner.

Among all species the C/N ratio was highest in *Colophospermum mopane* and the N concentration in the leaf litters was 0.99%. Compared to other species the lignin content (34.1%) was highest in the *Colophospermum mopane* which makes the litter resistant to decomposition because it binds strongly to organic-N (e.g. aminoacids and proteins) in litter (Palm and Sanchez, 1991). The result indicated that for 99% decay, litter of *Colophospermum mopane* would require 588 days at field capacity and 746 days at 50 % field capacity which is the maximum among all the species studied (Soni *et al.*, 2016). In order to rehabilitate the mining area *Colophospermum mopane* and few other arid tree species were planted at Lignite Mining Backfill in Barmer, Rajasthan Survival of species planted at lignite mine spoil was 82.82% (Moharana *et al.*, 2016).

In another experiment three tree species, viz. *Emblica officinalis*, *Colophospermum mopane* and *Hardwickia binata*, were planted at AFRI, Jodhpur in agroforestry system with mungbean as intercrop. *Colophospermum mopane* recorded the second highest intercrop yield of 330 kg ha⁻¹ (ICFRE 1995). Singh and Singh (2015) reported 51% more height in *Colophospermum mopane* in agroforestry than in the alone tree plots. Collar diameter was greater by 63% in tree-integrated than in the alone tree plots. Maximum crown diameter was recorded by *Colophospermum mopane* compared to other tree species. He also observed that the roots of 18-year old *Colophospermum mopane* were more confined to top 80 cm soil layer and almost parallel to soil surface and appeared to be more competitive in agroforestry system at Jodhpur, Rajasthan. Average total dry biomass ranged between 5.91 to 130.41 kg per tree. Biomass accumulation in stem was 28.6%, whereas contribution of foliage to the total biomass was 40.2%.

To study the effect of tree integration and

cropping pattern on land productivity *Colophospermum mopane* plants were intercropped for seven years. In the tree-integrated plots soil organic matter was increased and available PO₄ [sbn] P, NH₄ [sbn] N and NO₃ [sbn] N were decreased. Added litters and nutrient uptake are the major reasons for these changes. Conclusively, *Colophospermum mopane* enhances land productivity through increased system production and agriculture yield in the initial 4 - 5 years. In order to reduce the competition for the resources at higher age canopy restructuring and root trenching should be carried out (Singh and Rathod, 2006).

Silk of mopane silk worms

Gonometa rufabrunnea silk is marginally coarser than *B. mori* silk, yet finer than other

wild silk moth species (Hartland-Rowe, 1992; Freddi *et al.*, 1993). *G. rufabrunnea* silk dyes very well and has characteristic gold shading (Hartland-Rowe, 1992). As the silk strands are produced from hatched cocoons they are environment cordial and their production does not trade off biodiversity at all.

Opportunities

It is hoped that the collection and processing of the wild silk moths' cocoons will do much in providing people with an income. And because the cocoons are collected only when the moths have already emerged, the moth population is not affected – unlike the mulberry silk industry, which has led to overexploitation of the insects. The wild silk moth nonetheless has the potential to make as great an economic impact as mulberry silk worm.

Table.1 Raw silk production in India

	2013-14	2014-15	2015-16	2016-2017*
Mulberry silk	19,476	21,390	20,478	7,085
Vanya silk	7004	7318	8045	2242
Total	26,480	28,708	28,523	9,327

*up to August, 2016

(DGCIS, 2017)

Table.2 Export earnings from silk and silk goods (Value: Crore Rs.)

Items	2013-14	2014-15	2015-16	2016-17
Natural Silk Yarn	36.25	25.40	30.32	4.27
Fabrics and Made-up	1455.63	1465.40	1280.60	186.74
Readymade Garments	874.00	1214.01	1078.39	470.01
Silk Carpet	15.71	15.97	16.88	1.63
Silk Waste	99.30	109.12	89.80	43.98
TOTAL	2480.89	2829.88	2495.99	706.63

(DGCIS, 2017)

Table.3 Value of Import of silk and silk goods during 2013-14 and 2014-15
(Value: Cr. Rs.)

Items	2013-14	2014-15	% increase/Decrease
Raw Silk	896.44(3260 MT)	970.82(3489 MT)	8.30(7.02)
Silk Yarn	100.07	103.78	3.70
Fabrics and Made-up	315.32	239.16	-24.15
Readymade Garments	16.07	16.63	3.47
Silk Carpet	0.62	0.43	-30.21
Silk Waste	28.96	25.91	-10.54
TOTAL	1357.48	1356.73	-0.06

Note: Figures in parenthesis indicate quantity of raw silk imported.

(CSB, 2015)

The multipurpose tree species *C. mopane* is the best tree species with lot of economic potentials to grow in arid regions and to improve the rural livelihoods. *C. mopane* plantation can be raised in community land with the cooperation and management of local people. This can be achieved through formation of community co-operatives. After establishment of the plantation, mopane silk worms can be introduced and members of the community co-operatives can be involved in collection of the cocoons, which will then be sold to the silk enterprises. Already available *C. mopane* plantations in afforested areas, sand dune stabilized areas can also be used for growing mopane silk moth. With this initiative *C. mopane* tree will act as an important source of income for rural communities of arid Rajasthan through collection, cleaning and degumming of the mopane moth's hatched cocoons apart from greening the arid regions of the country.

Future research need

Bombyx mori L. the domesticated silkworm species, evolved nearly 4600 years prior from the *Bombyx mandarina* Moore, a wild species, which is a local of China and Palaearctic region (Hampson, 1892; Hirobe, 1968). The eggs of *B. mori* were initially

brought from China into Japan and Korea in the first century and consequently into Middle Eastern and European nations and later into the adjoining nations around China in the 6th century. The chronicled foundation of silkworm passage into India is still a puzzle; and the verifiable proof shows that a prospering silk trade was practicing amongst India and Rome/Greece during Kaniska period (56 B C) (FAO, 2003). Amid eighteenth century, the British control in India, many univoltine and bivoltine silk worm races were introduced from Italy, France, Russia and China, and the races were reproduced and maintained by the farmers (Krishna Rao, 1997) and few of them persisted under Indian climatic condition. Likewise presence of mopane silkworms in Indian condition can be surveyed and multiplied or possibilities for the introduction of mopane silk worms from Africa can be initiated. Further, biology of mopane silkworms, the conditions which must prevail for the growth of the mopane silkworms, successful method of seeding populations, captivity rearing, the factors which induce or terminate diapause, methods to increase cocoon productivity, management techniques for mopane trees, pest-management measures against various pests of mopane and silkworms, formation of village co-operatives

for growing of mopane silk worms and development of better marketing conditions are the major researchable issues to be considered to increase the wild silk production from mopane and to improve the livelihood status of rural communities in arid Rajasthan.

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