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Article *in* Current science · October 2006

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Role of lac culture in biodiversity conservation: issues at stake and conservation strategy

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Lac insects are exploited for their products of commerce, viz. resin, dye and wax. Cultivation of lac not only provides livelihood to millions of lac growers, but also helps in conserving vast stretches of forests and biodiversity associated with lac insect complex. The lac ecosystem is a complex multi-trophic web of flora and fauna; of the 87 species falling under nine genera recorded from the world, 19 species belonging to two genera, namely *Kerria* and *Paratachardina* are found in India. Lac insects thrive on more than 400 plant species generally growing in the forests which have varied economic, medicinal and social significance. Twenty-two species of lac predators, 30 species of primary and 45 species of secondary parasites, besides several fungal pathogens, represent a rich biodiversity of this ecosystem. Moreover, this natural lac complex also maintains a variety of other tree flora, macro fauna and soil microorganisms. Several of the insect fauna associated with lac insects are species-specific (exclusive to the ecosystem) and hence, loss of even one species of lac insect poses a danger of losing many other related species. Many lac insects and associated fauna have become endangered where lac cultivation has been abandoned or habitat destroyed. Promoting and encouraging lac culture will not only check environmental degradation but also conserve associated fauna and flora for posterity.

Keywords: Biodiversity, conservation, lac culture, *Kerria lacca.*

LAC insects, the crowning glory of India's rich insect fauna (representing 21.8% diversity of the known lac insect species) are exploited for their products of commerce, viz. resin, dye and wax. Our country is the largest producer of lac (a resinous compound secreted by lac insect while feeding on phloem sap of certain plants called lac hosts) in the world, accounting for about 50–60% of the total world lac production. At present, production of raw lac in India is approximately 20,000 metric tonnes per year. The major lac-producing states are Jharkhand (57% of the country's production), Chhattisgarh (23%), West Bengal (12%), while Orissa, Gujarat, Maharashtra, Uttar Pradesh, Andhra Pradesh and Assam are minor producers. Over three million tribals inhabiting these states are engaged in lac cultivation. Lac insects and their host plants play an important role in economics of lac growers[1]. About 20–38% of the total agricultural income of the tribal growers of Jharkhand is contributed by lac[2]. Nearly one million mandays per annum are generated by the industries engaged in post-harvest processing of lac. Besides, India fetches approximately Rs 120–130 crores of foreign exchange through export of lac every year. Lac resin being natural, biodegradable and non-toxic, finds applications in food, textiles and pharmaceutical industries in addition to surface-coating, electrical and other fields and provides immense employment opportunities.

The lac insect ecosystem is a complex multi-trophic web of flora and fauna. It represents a rich biodiversity, which includes besides lac insects, lac-host plants, several predators of lac insects, beneficial parasites, harmful parasites, microbes and a variety of pests of host plants. The lac host plants constitute the first trophic level, pests of host plants and the lac insects make the second, predators along with primary parasites the third and parasitoids of lac predators constitute the fouth trophic level.

Biodiversity in lac insect ecosystem

Lac insects and host plants

Lac insects require plant species for survival. More than 400 lac hosts have been observed to carry lac insects throughout the world[3–6]. Of the nine genera and 87 species of lac insects reported from the world, two genera and 19 species are found in our country[7]. Species belonging to genus *Paratachardina* produce a hard, horny substance, which is insoluble in alcohol. These are uni-voltine and are generally treated as parasites of economically important plants such as tea and sandal. However, recently, *Paratachardina* spp. have been found to be potential biocontrol agents for managing weeds[8] and need to be nurtured as such. Lac insects under genus *Kerria* are generally bi-voltine except *K. lacca mysorensis* found on *jalari* (*Shorea talura*) and *K. sharda* on *kusum* (*Schleichera oleosa*) and raintree (*Albizia saman*), which are tri-voltine[9]. Indian lac insect, *Kerria lacca* (Kerr), the most important and widely exploited insect for lac cultivation can further be distinguished into two strains or infra subspecies forms, the *rangeeni* and *kusmi* on the basis of differences in life cycle, host preference and quality of lac produced. *Rangeeni* strain is characterized by unequal dura-

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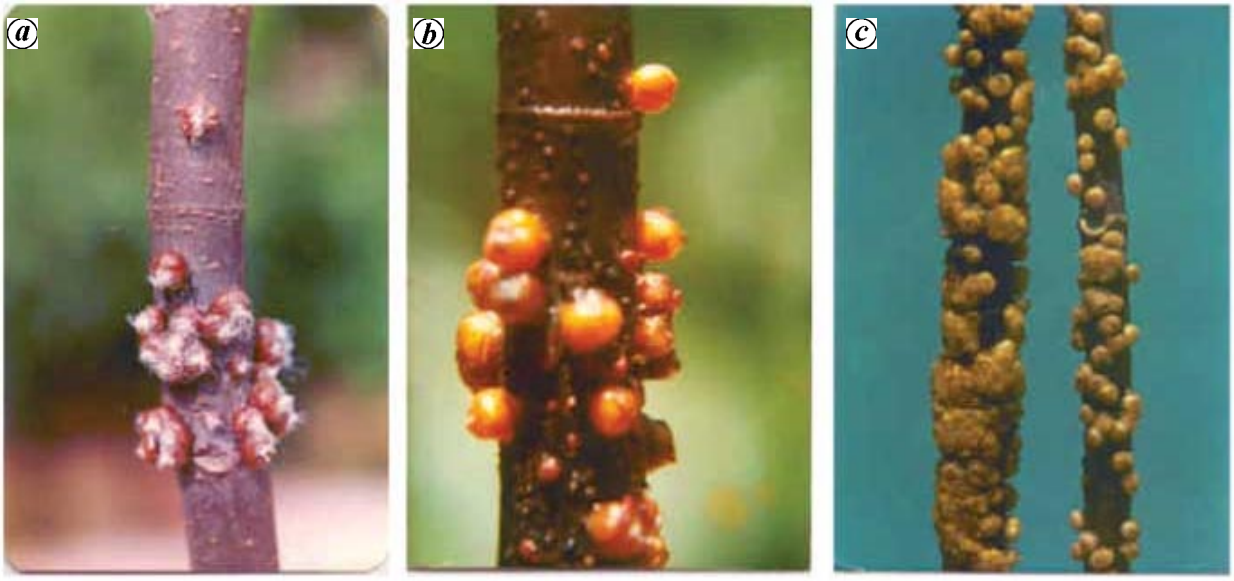

Figure 1. ***a***, Crimson lac insect: body colour crimson, resin colour yellowish orange. ***b***, Yellow lac insect: body colour changes to yellow, resin colour remains yellowish orange. ***c***, Cream lac insect: both body as well as resin colour are creamish.

tion of bi-voltine life cycle and non preference of *kusum*, as a host, whereas *kusmi* strain by a more or less equidurational life cycle and preferring *kusum* as a host. Quality of resin produced by *kusmi* lac insect is superior in comparison to *rangeeni* lac insect. Significant quantitative and qualitative variation in various biological attributes of the lac insect, viz. yield of resin, fecundity, sex ratio and body colour have also been reported[10–14]. The pigment present in the lac insect haemolymph (laccaic acid or lac dye) is non-toxic and finds numerous applications in textile, pharmaceutical and food industry. Qualitative and quantitative variations in lac insect dye have been observed showing crimson, yellow, albino and cream body colour (Figure 1 *a–c*).

Similarly, quantity of lac dye present in the resin (erythrolaccin) also varies depending upon the lac insect and the host plant on which the insect is reared. Lac host plants can be divided into various categories based on the degree of the preference of the lac insects for the various hosts, and the abundance and quality of lac obtained by infection upon the host (Sharma, unpublished). It is possible to divide hosts into further categories. First, there are species which are excellent hosts throughout the year and wherever they occur. Secondly, there are those species which are good hosts in certain restricted regions of the country, whereas in other regions they are either indifferent or do not take lac cultivation at all. Thirdly, there are hosts which are major for certain specific purposes and in certain specified seasons. Again, while one race or variety of host species is a good host, another (which may not be botanically distinguishable from the first) may be a non-host. Several examples from this type are well known lac hosts, e.g. *kusum* (*S. oleosa*), *palas* (*Butea monosperma*) and *Ficus* spp.[3].

Considerable inter-specific and intra-specific lac host variability vis-à-vis lac insect like density of settlement, initial mortality, sex ratio, size and weight of the insect cell has also been observed[15,16].

Lac insect associated fauna

The soft-bodied lac insects produce a resinous secretion, which protects them from adverse environment. In spite of this protective covering, the insects due to their sedentary habit are always a sitting prey to predators and parasites. Twenty-two lac insect predators, 30 primary parasites, 45 secondary parasites[17,18] and several fungal pathogens of lac insects as well as lac hosts[19,20], besides several other associated insects visiting lac insects for honey dew represent a rich biodiversity of this ecosystem. Moreover, natural lac insect complex maintains a variety of other tree flora, macro fauna and soil micro-organisms.

Issues at stake and conservation strategy

Not long ago, cultivation of lac was carried out practically throughout the country. Shrinking economic returns from lac cultivation due to varied reasons and changing socio-economic conditions have, however, eroded the area under lac cultivation. Lac cultivation is now restricted only to certain pockets of Jharkhand, Chhattisgarh, West Bengal, Orissa, Maharashtra, Madhya Pradesh and Gujarat. Punjab, Rajasthan, Karnataka and Tamil Nadu

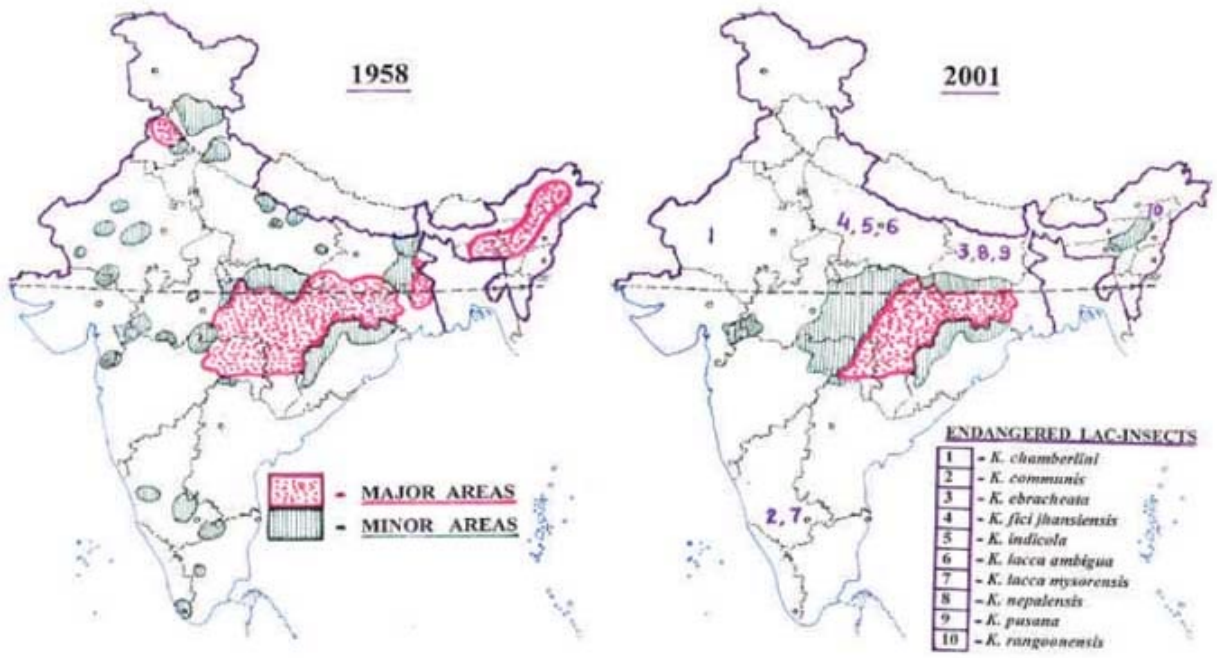

Figure 2. Lac-growing areas of the country showing distribution of endangered species of lac insects.

Table 1. Important lac-growing regions (states) of the country and various lac hosts exploited for lac cultivation

Area	State	Important lac hosts reported
Major lac-growing region	Jharkhand	*Butea monosperma*, *Croton oblongifolius*, *Ficus* spp., *Protium serratum*, *Schleichera oleosa*, *Ziziphus mauritiana*
	Chhattisgarh	*Acacia catechu*, *B. monosperma*, *S. oleosa*, *Z. mauritiana*, *Z. xylopyra*
	West Bengal	*B. monosperma*, *Ficus* spp., *Samanea* (=*Albizia*) *saman*, *Z. mauritiana*
Minor lac-growing region	Orissa	*S. oleosa*, *Z. mauritiana*
	Maharashtra	*Acacia catechu*, *A. nilotica*, *B. monosperma*, *S. oleosa*, *Z. mauritiana*
	Gujarat	*A. catechu*, *B. monosperma*, *Z. mauritiana*
	Uttar Pradesh	*A. nilotica*, *B. monosperma*, *Z. mauritiana*, *Z. xylopyra*
	Assam	*Albizia lucida*, *Cajanus cajan*, *Grewia* spp., *Ficus* spp., *Flemingia macrophylla*, *Kydia calycina*, *Leea crispa*
	Andhra Pradesh	*B. monosperma*, *Albizia saman*, *Peltophorum ferrugenium*
Negligible contribution presently	Rajasthan	*Acacia* spp., *B. monosperma*, *Ficus* spp., *Z. mauritiana*
	Punjab	*A. nilotica*, *Ficus* spp., *Z. mauritiana*
	Karnataka	*Acacia* spp., *Ficus* spp., *Shorea talura*
	Tamil Nadu	*A. nilotica*, *B. monosperma*, *S. talura*, *Z. mauritiana*

earlier contributed significantly to national lac production, but now their share is almost negligible. As a result, many species of lac insects reported from these places have either become extinct or are in the 'waiting list' of extinction (Figure 2). With abandoning of lac cultivation, unutilized lac hosts are frequently cut for timber and fuel wood, etc. Out of more than 400 plants on which lac insects have been observed, only about two dozen are utilized for lac production as commercial lac cultivation on other plants is economically not viable. Moreover, lac host plants exploited for commercial production of lac vary from region to region (Table 1). Danger looms large on other host plants whose economic importance remains to be realized.

The future of various flora and fauna associated with lac is thus intricately linked to the fate of lac cultivation. Fast shrinking area of lac cultivation is a serious threat to biodiversity of the lac insect ecosystem.

Some of the important issues at stake are as follows:

- Of the 19 species of lac insects reported from the country, mainly *K. lacca* is exploited for commercial production of lac. *K. chinensis* in the northeastern states and *K. sharda* in coastal regions of Orissa and West Bengal are also cultivated to a certain extent. Potential of other lac insect species reported from the country remains to be exploited. Wild lac insects are principally distributed in the forest and sub-forest regions. Thus, the future of lac insects is intricately linked to the fate of the forests. Fast depleting forest cover of the country is a serious threat to the biodiversity of lac insects as well as their host plants. In the absence of human intervention, the unattended species of lac insects and their host-plant might be lost.
- Fluctuating prices of lac and over dependence on foreign buyers leading to shrinking economic returns from lac cultivation has eroded the lac cultivation area. Orissa, Gujarat, Assam, Punjab and Uttar Pradesh earlier contributed significantly to lac production but now their share is almost negligible as cultivation of lac has been abandoned. Many species of lac insects reported from these places have thus become endangered.
- Lac insects infesting economically important plants, viz. litchi (*Litchi chinensis*), mango (*Mangifera indica*), *ber* (*Ziziphus mauritiana*), sandal (*Santalum album*), etc. are the direct targets of pest management leading to erosion of biodiversity of lac insects and associated fauna.
- Species belonging to *Paratachardina* do not produce true lac of commercial importance and are pests of such important plants as sandal (*Santalum album*) and tea (*Thea chinensis*) and hence are deliberately destroyed.
- Some of the insect fauna associated with the lac insects are species-specific (exclusive to the ecosystem) and hence loss of even one species of lac insect poses a danger of losing many other related species (Table 2).
- In agriculturally advanced states like Punjab and Haryana, *ber* in the wild has been replaced by high-yielding fruit varieties. The trees are regularly pruned and subjected to pest management measures, which have led to the loss of lac insects.
- In drought-prone states like Rajasthan and Gujarat, twigs of lac host trees such as *Butea monosperma* (*palas*), *Albizia saman* (raintree) and *Ficus* spp. are utilized as cattle fodder during adverse conditions, thus preventing natural multiplication of lac insect populations.

Once lac cultivation is abandoned, its re-initiation is difficult because: (i) broodlac (akin to seeds in other crops) cannot be stored for more than a week and its availability becomes a major constraint in starting lac cultivation afresh; (ii) multiplication ratio in lac culture is low (1 : 3–7), i.e. for every 1 kg of broodlac used we get only three to seven kg; (iii) life cycle of lac insect is long, it takes 4–8 months to complete one generation; (iv) no open/organized market is available to lac growers, and (v) pests and diseases do cause substantial damage to the culture. These biotic factors are manageable, but tribal lac growers are so poor and ignorant that they are unable to take any control measures. Keeping in view the importance of lac cultivation, there is a need for properly identifying, documenting and conserving the lac insects and associated fauna.

The steps which merit immediate attention are:

(i) There is need to undertake extensive surveys of the country and abroad to know the present status of the lac insects and their plant host biodiversity. The reported species of lac insects do not give any idea, hitherto, of unreported species and more importantly, the infra-specific genetic diversity of these species of economic value. There is need for properly identifying, documenting and conserving (*in situ* and *ex situ*) the diversity of lac insects.

(ii) Action needs to be initiated to build a strong infrastructure to develop field germplasm bank to conserve at one suitable place, all the recorded lac insects and host plants. Protected lac insect and hosts habitats on the pattern of sanctuaries and wild life parks in different agro-climatic zones are needed to conserve the precious wealth of our country.

Table 2. Species-specific/important insect pests exclusive to lac ecosystem

Insect	Family
Primary parasites	
**Aprostocetus* (Syn. *Tetrastichus*) *purpureus* (Cam.)	Eulophidae
Coccophagus tschirchii Mahd.	Aphelinidae
Erencyrtus dewitzi Mahd.	Encyrtidae
**Eupelmus tachardiae* (How.)	Eupelmidae
**Marietta javensis* How. (=*M. leoperdina*)	Aphelinidae
Parechthrodryinus clavicornis Cam.	Encyrtidae
Tachardiaephagus tachardiae How.	Encyrtidae
T. somervilli Mahd.	Encyrtidae
Predators of lac insect	
Eublemma amabilis Moore	Noctuidae
Pseudohypatopa (=Holcocera) *pulverea* Meyr.	Blastobasidae
Secondary parasites	
Apanteles tachardiae Cam.	Braconidae
A. fakhrulhajiae Mahd.	Braconidae
Aphrastobracon flavipennis Ashm.	Braconidae
**Brachymeria tachardiae*	Chalcidae
**Chelonella cyclopyra* Franz.	Braconidae
Elasmus albomaculatus Gahan	Elasmidae
E. claripennis Cam.	Elasmidae
Eurytoma pallidiscapus Cam.	Eurytomidae
Perisierola (=*Goniozus*) *pulveriae* Kuerten	Bethylidae
Pristomerus sulci Mahd. & Kolub.	Ichneumonidae
**Trichogrammatoidea nana* Zehnt.	Trichogrammatidae

*Not species-specific but with very narrow host range.

(iii) Integrate lac culture with agriculture and include multi-purpose lac host plants in social forestry programmes of, at least, those states where lac cultivation is/was carried out, as it will not only diversify land use for increased productivity but also help save lac insects and associated flora and fauna.

(iv) *Paratachardina* spp., though do not produce lac of commercial importance, are potential natural control agents for perennial weeds and need to be nurtured as such by making them a component in integrated pest management schedule as bio-control agents for managing weeds.

(iv) Develop a database on all aspects of lac production, processing, product development, export, employment generation, etc. for better policy planning.

Conclusion

Most of the lac host trees are confined in forest areas, thus making them the storehouse of lac insect diversity. Cultivation of lac not only provides livelihood to millions of lac growers but also helps in conserving vast stretches of forests, lac insects and associated biota as most of the lac hosts are in forest areas and farmers resist felling of these trees and protect them for lac cultivation. Thereby, lac culture plays a vital role in the protection of our bio-resources. Growing lac hosts for timber and fuel yields revenue in cycles of long years, whereas cultivation of lac on these trees gives a return almost every year. Thus, lac growers give more importance to regular income from cultivation of lac over the years to one-time income from timber or fuel. Average net profit from one tree is Rs 109 for *palas*, Rs 202 to 1060 for *ber* and Rs 1320 for *kusum* per crop cycle. Thereby, lac-culture plays a vital role in protection of our bio-resources. Lac also provides sustained high economic returns, generates employment opportunities and has potential to pave a strong foundation for lac-based rural cottage industries. About one million man-days are generated in the existing lac-processing factories. With increasing demand for natural products, e.g. in fruits and vegetable coating and as food colour, the time is ripe to introduce lac culture in the farming system and on idle lac host trees in the forests. It is evident from the foregoing account that promoting and encouraging lac culture will not only check environmental degradation and help rebuild the ecological balance, but also conserve endangered lac insects, associated fauna and flora for posterity.

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Received 21 March 2005; revised accepted 1 June 2006