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Assessment of Lac Diversity and Indigenous Technical Knowledge in North East Region of India

A. Mohanasundaram, K.K Sharma[1], T. Kandasamy[1], V.D. Lohot[1] J. Ghosh[1] and P. Das[2]

ICAR- National Research Centre for Banana, Tiruchirappalli-620 102, India
[1]ICAR-National Institute of Secondary Agriculture, Namkum, Ranchi-834 010, India
[2]Assam Agricultural University, Jorhat-785 013, India
E-mail: entosundaram@gmail.com

***Abstract*:** Lac insects are commercially harnessed for economically important resin, dye and wax. Of the nine genera and 102 species of lac insects reported from all over the world, two genera and 22 species are found in India. Natural populations of *Kerria spp.* are distributed throughout the country and NE region houses valuable lac insect genetic resources in the country. Hence, surveys were carried out for lac associated faunal and floral diversity from seven states in North East India. Lac insects and associated fauna (predators and parasitoids) were observed and collected from Assam, Manipur, Meghalaya, and Nagaland on various lac host plants, *viz., Acacia auriculiformis, Cajanus cajan, Ficus spp, Mallotus philippensis, Malvaviscus penduliflorus* and *Ziziphus mauritiana.* Distinct lac host species were also reported in NE region. Lac insect from Manipur was recorded as morphologically new species, *Kerria manipurensis.* Lac insects collected from Manipur, Assam and Nagaland revealed 89–97% homology with both LIK31 and LIK23 (both *K. chinensis* lines) through molecular analysis. Different ant species *viz., Crematogaster spp* and *Technomyrmex albipes* were also found associated with lac insect. *The occurrence* of lac host plants, *viz., Acacia auriculiformis, Albizia lebbek, A. lucida, A. saman, Butea monosperma, Cajanus cajan, Ficus spp., Kydia calycina* (Boldubak), *Macaranga denticulate* (Chhagru), *Mallotus philippensis, Malvaviscus penduliflorus, Ziziphus mauritiana,* and the perennial Red gram variety were also collected during the survey. Indigenous Technical Knowledge (ITK) information related to lac was also collected from north-east India during the survey. These ITK's were used in lac culture as well as medicinal purposes. It is envisaged that the distinct lac insect and host *species* would be a valuable resource in developing new lac insect + host plant combinations for enhancing lac productivity of the country.

***Keywords*:** Lac insects, Lac hosts, Diversity, ITK and North East India

Lac-insects (Tachardiidae) are commercially harnessed for economically important resin, dye, and wax. India is the world's richest lac biodiversity nation containing 21.8 per cent diversity (Sharma et al 2006). The Indian lac-insect, *Kerria lacca* (Kerr) is the most important and widely exploited insect for lac cultivation. More than 400 lac host plants have been observed to carry lac insects throughout the world. Major host plants of *K. lacca* are *Butea monosperma* Lam. (*palas*), *Schleichera oleosa* (Lour.) Oken. (*kusum*), *Ziziphus mauritiana* Lamk (*ber*), *Ficus spp.*, *Cajanus cajan* (L.) *Mill* sp. (Red gram*),* and *Flemingia spp.* Lac cultivation is prominent in Jharkhand, Chhattisgarh, West Bengal, and Odisha, mainly using *K. lacca*. Natural populations of *Kerria spp*. are distributed throughout the country (Mohanasundaram et al 2018). Lac was widely cultivated in North-East India even before the 19th century, but its production contribution at present is insignificant. North eastern region particularly Assam is one of the biodiversity hotspots with approximately 4000 species of plants but exploitation of these natural flora for commercial production of lac is very limited (Rahman et al 2021). *Kerria chinensis*, which is the Chinese commercial species and also the major species of lac insect cultivated in Thailand (Chen et al 2011), is cultivated to a certain extent in the northeastern states of India. The lac insect ecosystem is a complex multi-trophic web of flora and fauna. It represents a rich biodiversity, which besides lac insects, lac-host plants includes several predators of lac insects, beneficial parasites, harmful parasites, etc. (Sharma et al 2006). The NE region has valuable lac insect genetic resources in the country. Hence, surveys were carried out for collecting biodiversity of lac associated fauna, flora diversity and studying the Indigenous Technical Knowledge (ITK) in lac field. Populations of collections from NE states were cultured at the National Lac Insect Germplasm Centre at ICAR-National Institute of Secondary Agriculture (NISA), Ranchi for morphological, biological attribute studies.

MATERIAL AND METHODS

Survey and collection of lac insects and lac host plants: To know the availability of lac insect species, extensive surveys were carried out in seven states *viz.,* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and

Tripura, covering 30 districts. Surveys were undertaken during February 2013, October 2013, 2014, & 2016 and November 2009, 2010 & 2018 and February 2020. Before, undertaking the survey, information on the occurrence of lac insects was acquired from organizations *viz*., Agricultural Universities, State Forest Department and Local *Krishi Vigyan Kendra* about lac insect/host plant availability. The lac insect populations were located through visual observations and through binoculars, especially on reported lac host species in the peripheral area. The presence of lac insect was located by the blackish appearance or dried twigs or branches of lac host plants nearby waterlogged areas, either by eye sight or through binoculars. If lac insects were noticed, then the branch/ twigs having the lac insect colonies were cut and covered with moistened cotton plugs at both ends to avoid dehydration and kept in the 60 mesh synthetic net with proper label. Altitude, latitude and longitude of the location were marked using GPS (GARMIN OREGON® 550). If, proper lac insect stage (larviposition) was not observed, visits were made subsequently to the respective places for collection and its conservation at appropriate stage. Collected lac insects were brought to ICAR- National Institute of Secondary Agriculture (ICAR-NISA), Ranchi and inoculated live on potted plants of *Flemingia macrophylla* (Willd.) Merr. in National Lac Insect Germplasm Centre (NATLIGEC) for further study. Lac insect sample collected from Manipur was identified at ICAR-Indian Agricultural Research Institute (IARI), New Delhi, on morphological basis. Evaluation of biological attributes of lac insects collected from North East India *viz*., Assam, Manipur, Meghalaya and Nagaland for *rangeeni baisakhi* (summer season) and *katki* (rainy season) crop during two consecutive years, 2014-15 and 2015-16.

Molecular characterization of newly collected lac insects: Lac insect samples collected from Manipur, Nagaland, Assam on different host plants were characterized using *cox1* marker. For characterization of housekeeping genes, DNA was isolated from lac insects and amplified with cytochrome oxidase gene specific primers. The amplified products were checked on 1% agarose gel and sent for sequencing.

RESULTS AND DISCUSSION

Lac host plants: Seven states *viz.,* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, covering 30 districts were surveyed in the peripheral areas and a numbers of host plants were observed (Table 1). Lac host plants *viz., Acacia auriculiformis* Benth*., Albizia saman* (Jacq.) Merr*., B. monosperma, C. cajan, Calliandra surinamensis* Benth*., Ficus religiosa* L*., Grewia multiflora* Juss*., Jacaranda mimosifolia* D. Don*, Leea crispa* L*., Malvaviscus arboreus var. penduliflorus* (DC.) Schery*,*

Table 1. Lac host plants/ floral diversity in North East India during survey

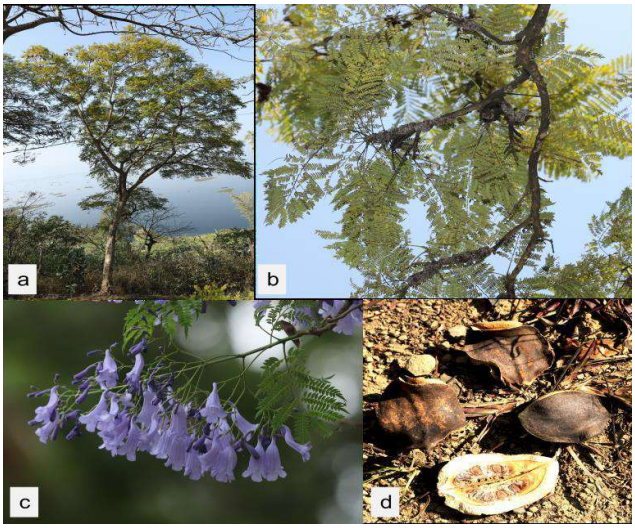
Place (State)	Lac host plants	Year
Imphal (West), Bishnupur, Churandpur, Senapati and Ukhrul (Manipur)	*Acacia auriculiformis, Cajanus cajan, Calliandra surinamensis, Ficus religiosa, Malvaviscus penduliflorus, Mallotus philippensis* and *Ziziphus mauritiana*	November 2009 and February, 2013
Dhalai, Sipahijala, Khowai, gomati, Unakoti, North Tripura, South Tripura and west Tripura (Tripura)	*A. auriculiformis, Albizia saman, A. lebbek, Ficus* spp, *Peltophorum ferrugenium* and *Z. mauritiana*	November 2010
Aizawl, Champhai &Kolasib (Mizoram)	*A. auriculiformis, A. saman and A. lebbek*	November 2010
Dispur, Marigaon, Nagaon, Kharbiolong, Diphu & Golaghat (Assam)	*A. auriculiformis, Butea monosperma, A. lebbek, Albizia lucida, A. saman, C. cajan,Ficus sp, M. penduliflorus* and *Z. mauritiana*	October 2013
Dimapur, Wokha (Nagaland)	*A. lebbek, A. saman, C. cajan Ficus sp,* Litchi*, M. penduliflorus,* Tokho, Tsolong and *Z. mauritiana*	October 2013
Ribhoi, Shillong (Meghalaya)	*C. cajan, Ficus* sp *M. Penduliflorus* and *Sohtharnu*	October 2013
Guwahati, Goalpara (Assam)	*Z. mauritiana, A. lebbek, A. saman, Ficus sp, B. monosperma, P. ferrugineum* and *A. auriculiformis*	October 2014
West Garo, East Garo hills (Meghalaya)	*Z. mauritiana, Ficus sp,* Litchi*, G. multiflora, C. cajan* and *Leea crispa*	October 2014
West Tripura, Khowai, Unokoti, North Tripura, Dhalai, Gomati, South Tripura and Shipahijala. (Tripura)	*A. saman*, *P. ferrugenium Ficus* spp*, Z. mauritiana M. philippensis, C. cajan* and *M. penduliflorus*,	October 2016
West Siang, Siang, Upper Subansiri, Lower Siang and surrounding hilly areas in Arunachal Pradesh	*L. crispa*, *Ficus semicordata, Z. mauritiana, A. saman, F. bengalensis*, and *F. religiosa*	November, 2018
Lokhtak lake, Imphal (Manipur)	*J. mimosifolia*	February, 2020

Mallotus philippensis (Lam.) *Müll. Arg., Litchi chinensis* Sonn., *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne and *Ziziphus mauritiana* were observed in surveyed areas of North east India. Some of the lac host plants *viz*., *C. cajan, G. multiflora, J. mimosifolia, L. crispa, M. penduliflorus, M. philippensis, L. chinensis, are* very specific to surveyed areas of the NE states of India. *Among these, M. penduliflorus, M. philippensis* and *J. mimosifolia* were recorded as new lac insect host plants in Manipur (Fig. 1), apart from these lac host plants, *Macaranga denticulate* (Chhagru), *Kydia calycina*. (Boldubak) and the perennial red gram variety were also collected during the survey and added to our lac host plant gene bank at ICAR- NISA, Ranchi. Major lac host plants, *viz*., *S. oleosa*, *B. monosperma and Z. mauritiana* were found in Jharkhand, Chattisgarh, Odisha, West Bengal, rain tree in southern parts of India (Mohanasundaram et al 2018) and *Ficus* spp in Rajasthan, Haryana (Meena et al 2020). *M. arboreus var. penduliflorus* is cultivated in ornamental, flowers used for worship and distributed throughout India. *M. arboreus* cav. is a perennial plant belonging to Malvaceae family, having culinary and medicinal properties. It is an erect, deciduous herb or shrub, commonly known as Turk cap or sleeping hibiscus as its flowers never fully opens. *M. penduliflorus* identified as a promising lac host for *K. chinensis* (Mohanasundaram et al 2022). *M. philippensis* belongs to the family Euphorbiaceae. The kamala tree is found throughout India and in use as a medicinal tree in India for ages. The tree can grow up to 10 meters tall. Alternately arranged, ovate or rhombic ovate leaves are rusty-velvety. Male and female flowers occur on different trees. Female flowers are borne in lax spike like racemes at the ends of branches or in leaf axils. Three male flowers occur together in the axils of small bracts. The capsule is trigonous-globular, covered with a bright crimson layer of minute, easily detachable reddish powder. Kamala is the source of Kamala dye, which is used in coloring silk and wool and an antioxidant for ghee and vegetable oils. Oil is used as a hair-fixer and added to ointments. Seed oil is used in paints and varnishes. Seed cake is used as manure. (Web reference Flowers of India). *J. mimosifolia* comes under the family: Bignoniaceae. It is a magnificent deciduous tree with its clusters of fragrant blue trumpet-shaped blooms. In April the entire leafless tree is covered with blue flowers, turns the ground below into blue carpet. It is a very popular tree among gardens and along roadsides as an ornamental tree. He bark is brownish and peeling off in small thin flakes. The foliage of jacaranda consists of fern-like bipinnate compound leaves, leaflets 12-20 pairs per pinnae, narrowly elliptic. Flowers appear from March to April, in terminal racemose panicles, and bluish in colour. Fruits appear from April to May, ellipsoid-orbicular in shape and woody in nature. Origin of this tree is South America. *J. mimosifolia* was first reported as lac host for *rangeeni* strain of *K. lacca* Kerr. by Kapur in 1954 from Jamshedpur, India and lac encrustation on this tree was sparse to moderately thick. Later on was able to successfully infect lac on Jacaranda at ICAR-NISA (Lohot et al 2020).

Lac insect and associated fauna: A natural infestation of the lac insect was on different host plants, viz., *C. cajan*,

Malvaviscus penduliflorus a) Plant b) Lac encrustation

Mallotus philippensis a)Tree b) Bark c) Seeds d) Lac encrustation



Jacaranda mimosifolia a) Tree; b) Lac encrustation; c) Flowers; d) Pods with seeds

Fig. 1. New lac insect host plants discovered in Manipur

Ficus spp, *G. multiflora*, *J. mimosifolia*, *L. chinensis*, *M. penduliflorus*, *M. philippensis, and Z. mauritiana*. Lac encrustation covered with an ant nest made of mud slurry was observed on *M. penduliflorus* and *M. philippensis* at Manipur. This was a very peculiar characteristic, i.e., the symbiotic relationship between lac insects and ants. Ants are fed on honey dew secreted by lac insects, and lac insects protect the ants from parasitoid and predator attack. Lac insect collected from Manipur on *M. penduliflorus* was new species, *Kerria manipurensis* (Ahmad et al 2013). Collected ant species were also identified as *Crematogaster flava Forel, Crematogaster rogenhoferi Forel, C. rothneyi Forel,* and *Technomyrmex albipes Smith.* No lac insect species was observed in surveyed districts of Mizoram and Tripura probably due to high rain fall and humidity throughout the year in these states. Lac insect parasitoids, (*Aprostocetus purpureus* Cam.*, Tachardiaephagus tachardiae,* How.) and predators (*Pseudohypatopa pulverea,* Meyr., *Eublemma amabilis* Moore) were also recorded from the collected lac insect samples (Table 2, 3).

Similar survey work was reported by various authors in different parts of the country, incidence of a lac insect was observed infesting *arhar* (*C. cajan*), *peepal* (*F. religiosa*) and *champak* (*Michelia champaca*) at Nongmeibung, a locality in Imphal East District at Manipur (Devjani and Singh 2012). Lac insect along with more ants but without nest was found on the ornamental plant, *Amherstia* nobilis, in Kerala. Natural infestation of lac insect covered with wax secretions was found *A. saman* and *F. religiosa* in Tamil Nadu (Mohanasundaram et al 2018). Naturally occurring lac was found in large quantities on *peepal* and Litchi tree during the survey period of 2017 and 2018 in Assam (Anonumous 2018). *Ficus* and *M. penduliflorus* are the most productive hosts in Manipur; Litchi in Nagaland, Arunachal Pradesh and Mizoram and *Ficus* in Meghalaya (Sigh et al 2020). Good encrustation of lac was seen on *A. auriculiformis*, *Annona reticulata*, *Calliandra calothyrsus*, *Ficus religiosa*, *F. racemosa*, *F. tsiela*, *Peltophorum ferrugineum*, *Pithecellobium dulce* and *Samanea saman in the* western plains of India (Meena et al 2020). *Ficus spp., Z. mauritiana, A. saman, and B. monosperma are the important host plants throughout India for the naturally occurring lac insect. (*Monobrullah and Kishor 2020, Gupta et al 2020, Bhatnagar et al 2022)

Biological attributes: Evaluation of four lac insect stocks

Table 2. Lac insects in North East India during survey

Place (State)	Host plant	GPS	Date of collection	Remarks
Imphal West (Manipur)	*M. penduliflorus* *C. cajan* *M. philippensis*	*M. penduliflorus* : 24° 44.727'N 093°49.394'E and elevation 771m *C. cajan*: 24° 44.751'N 093°49.350'E and elevation701m *M. philippensis* : 24° 44.813'N 093°49.194'E and elevation 751m	06-02-2013	Live, mature and crimson coloured lac insect at Heigrujam
	Z. mauritiana	Patsoi: 24° 47.710'N 093°52.520'E and elevation 776m Khaidem : 24° 45.084'N 093°49.797'E and elevation 770m Khumbong : 24° 46.341'N 093°49.994'E and elevation 771m	06-02-2013	Live, mature and crimson coloured lac insect at Patsoi, Khaidem and Khumbong
	F. recemosa	24° 46.336'N 093°49.971'E and elevation 782m	06-02-2013	Live, mature and crimson coloured lac insect at Khumbong and Near PWD, Imphal
	J. mimosifolia	24° 31.05'N 093°47.41"E and elevation 778m	04-02-2020	Live, immature lac insect at Sendra Park, Lokhtak lake, Imphal
Bishnupur, Manipur	*M. penduliflorus*	Tronglaobi : 24° 28.707'N 093°45.119'E and elevation 793m Kwatha : 24° 26.660'N 093°43.638'E and elevation 799m Naranseina : 24° 31.159'N 093°45.417'E and elevation 770m	07-02-2013	Live, mature and crimson coloured lac insect at Tronglaobi, Kwatha and Naranseina
Dimapur, Nagaland	*L. chinensis*	25° 45' 24" N 93° 50' 20" E and elevation 295 m	21-10-2013	Live, immature and crimson coloured lac insect at ICAR NEHR RC, Jarnapani
Wokha, Nagaland	*Z. mauritiana*	26° 09' 24" N 94° 00' 54" E and elevation 241 m	23-10-2013	Live, mature and crimson coloured lac insect at Lio Wokha Old
Karbi Anglong, Assam	*F. religiosa*	26° 12' 55" N 93° 34' 31" E and elevation 970 m	25-10-2013	Live, mature and crimson coloured lac insect at Doloigaon
Ri-bhoi, Meghalaya	*Ficus spp*	25° 54' 03" N 92° 08' 17" E and elevation 783 m	27-10-2013	Live, mature and crimson coloured lac insect at Sonidan
West Garo Hills Meghalaya	*C. cajan*, *L. chinensis*, *G. multiflora*	Bawegre : 25° 41' 01" N 90° 22' 09" E and elevation 634 m Tapragre : 25° 40' 43" N 90° 20' 55" E and elevation 708 m Chiokgre : 25° 41' 13" N 90° 21' 17" E and elevation 674 m	10-10-2014	Lac insect (Mature) at Bawegre; Tapragre and Chiokgre

collected from the NEH region (Assam, Manipur, Meghalaya, and Nagaland) was carried out during summer season crop in two consecutive years, 2014-15 and 2015-16 on *F. macrophylla*. Pre-harvest parameters, *viz*., settlement density, initial mortality, and sex ratio, were studied. Average settlement density was 51.4 per sq cm, with 26.59 per cent mortality and 100 per cent male population recorded. Subsequent observations could not be taken from Manipur stock due to 100 per cent male lac insect populations. The summer generation normally contains higher proportion of males. The average density of settlement ranged from 61.42 to 68.96 per sq cm, with 13.22 per cent significantly lower mortality on Nagaland stock. The male/female ratio was higher than optimal in all three stocks, ranging from 62 to 79 per cent. Postharvest parameters, *viz*., fecundity, cell number, and resin weight, were also studied. Average fecundity was significantly higher at 290.35 numbers in Assam stocks, with no significant difference in cell weight or resin weight from all three stocks (Table 4). Evaluation of lac insect stocks collected from the NEH region (Assam, Meghalaya, and Nagaland) was continued during *katki* (rainy season) crop during 2015 and 2016. Average settlement density was significantly higher (120.55 per sq cm) with less initial mortality (7.12 per cent) in Meghalaya stock. On all stocks, the male/female ratio ranged between 46.46 and 51.28 per cent. Average fecundity, cell weight and resin weight were not significantly different among the three stocks (Table 5). Assam stock was showed more potential for the *rangeeni* summer season crop, whereas Meghalaya stock indicated more potential for the *rangeeni* rainy season crop. In both seasons, there was a high average density of settlement with low mortality in both stocks (Assam and Meghalaya). In cell weight and resin weight, no significant difference was observed among the stocks studied. Although there is no significant variation observed, further intensive studies may be required to identify the best performing line. Rahman et al (2021), studied productivity linked parameters and the life cycle of the lac insect, *K. chinensis,* on eight different lac hosts: *Flemingia semialata* Roxb.*, Flemingia strobilifera* (L.) W.T.Aiton*, Indigofera teysmannii* L.*, F. religiosa, Z. mauritiana, Litchi chinensis* Sonn.*, Hibiscus rosa-sinensis* L. and *C. cajan.* Among the eight lac hosts, the highest density of crawler settlement with the lowest mortality, the maximum cell weight and fecundity were recorded on *F. semialata*.

Molecular analysis: Lac insects collected from Manipur on *Z. mauritiana* tree revealed 97% homology with both LIK31 and LIK23 (both *K. chinensis* lines). Lac insects collected from *F. religiosa* were found to have 90% homology with LIK31 and 89% with LIK23. Lac insects collected from *M. penduliflorus* from Imphal West, Manipur showed 97% homology with both LIK31 and LIK23. The cox1 product of lac insects collected from *Malvaviscus* from Bishnupur, Manipur showed 98% homology with both LIK31 and LIK23. In case of

Table 3. Lac associated faunal diversity in North East India during survey

Place (State)	Host plant	Lac associated fauna
Lio wokha old Nagaland	*Z. mauritiana*	Nil
Sonidan, Meghalaya	*Ficus sp*	*Aprostocetus purpureus, Eublemma amabilis*
Doloigoan, Assam	*Ficus sp*	*A. purpureus, Pseudohypatopa pulverea, E. amabilis*
Jarnapani, Nagaland	*Litchi*	*Tachardiaephagus tachardiae*
Heigrujam, Manipur	*M. penduliflorus*	Nil
Imphal West, Manipur	*M. penduliflorus*	*Crematogaster flava, C. rogenhoferi, C. rothneyi* and *Technomyrmex albipes*

Table 4. Biological parameters of lac insect collected from NEH region of India during summer season crop during 2014-15 to 2015-16 (Pooled)

Name of the lac insect stock	Pre-harvest productivity parameters			Post-harvest productivity parameters		
	Settlement density (Nos. / cm^2)	Initial mortality (%)	Sex ratio (% Male)	Fecundity (nos./Female)	Cell weight (mg)	Resin weight (mg)
Assam	68.96 (8.30)	19.41 (4.38)	62.43 (7.88)	290.35 (17.02)	12.19 (3.49)	10.49 (3.24)
Meghalaya	61.42 (7.82)	28.60 (5.34)	77.09 (8.77)	253.01 (15.89)	11.83 (3.44)	9.84 (3.14)
Nagaland	66.48 (8.11)	13.22 (3.62)	79.17 (8.90)	229.85 (15.13)	12.54 (3.54)	10.06 (3.17)
CD (p=0.05)	NS	0.361	0.342	1.20	NS	NS

*Figures in parentheses are square root √ (X+0.5) transformation values; Means are significant at p< 0.05

lac insects collected from *M. philippensis* there was 97% homology with both LIK31 and LIK23. Lac insects collected from Nagaland (on *L. chinensis)* revealed 95% homology with both LIK31 and LIK23. Lac insects collected from Assam (on *F. religiosa*) showed 99% homology with LIK31 and 98% with LIK23 (Table 6). All of our collections from NEH region matched with *K. chinensis* lines. *K. chinensis*is also having peculiar characteristic i.e the aleuritic acid content was maximum 19.81 per cent with 98.78 per cent purity (Ali *et al*. 2021). Mohanasundaram et al (2018) earlier study found that the molecular analysis based on the COX1 sequence classified the collected lac insects from Tamil Nadu and Kerala under the *Rangeeni* strain clustered with *K. lacca* in the phylogenetic tree.

Indigenous Technical Knowledge

Lac insect and its products: Indigenous Technical Knowledge (ITK) information related to lac was also collected from North East India during the survey. Bamboo cages and Banana leaves are used for collection, carrying and inoculation of lac insect broodlac and preservation of broodlac, respectively; during lac production operations. Scraped lac is used for fixing *dauli (long sickle)* at ChiokTferagre, West Garo Hills district in Meghalaya. Lac is also used as curative medicine against rheumatic and other body pain in East Karbi Anglong district and against itching at Merapani, Golaghat district of Assam. Lac dye is used for coloring Eri silk cloth at Umsning, Ri-Bhoi district, Meghalaya.

Bamboo cage: Bamboo nodes are made into a cage-like structure. This bamboo cage is being used for collecting and carrying the lac insect brood. It is used to avoid the falling of broodlac and easy *phunki* collection.

Banana leaves: Banana leaves are cut according to the broodlac quantity. Broodlac is kept inside the banana leaves before folding and tying the banana leaves along with the broodlac, then keeping the folded banana leaves containing the broodlac above a wet place at home. When the crawler's emergence starts, broodlac will be used for inoculation. It is used to preserve broodlac for further inoculation.

Lac resin and Lac dye at West Garo Hills, Meghalaya: The lac insect was collected or harvested from the lac host trees. Afterwards, scrapped lac was taken, and the same was washed with water to remove the lac dye. The lac dye was then used to colour Erisilk cloth. In this process, lac resin was separated out and melted by heating. That lac resin was used to fix the sickle and fix the iron blade in the bamboo to make *dauli* (*long sickle*).

Lac cell in East Karbi Anglong district of Assam: Approximately one gram of fully matured lac cells are taken and put the pre-weighted lac cells in a bamboo pot / pipe. A glass of water is added to the bamboo pipe. The mixture is boiled under high flame till lac cell completely is dissolved in

Table 5. Biological parameters of lac insect collected from NEH region of India during rainy season crop during 2015 to 2016 (Pooled)

Name of the lac insect stock	Pre-harvest productivity parameters			Post-harvest productivity parameters		
	Settlement density (Nos. / cm^2)	Initial mortality (%)	Sex ratio (% Male)	Fecundity (nos./Female)	Cell weight (mg)	Resin weight (mg)
Assam	85.87 (9.22)	7.50 (2.73)	46.46 (6.79)	241.00 (15.51)	20.92 (4.55)	17.46 (4.15)
Meghalaya	120.55 (10.95)	7.12 (2.62)	51.28 (7.15)	277.17 (16.60)	24.87 (4.98)	20.43 (4.51)
Nagaland	79.08 (8.85)	15.04 (3.87)	49.65 (7.04)	256.86 (16.01)	21.55 (4.64)	18.18 (4.25)
CD (p=0.05)	1.15	0.46	NS	NS	NS	NS

*Figures in parentheses are square root √ (X+0.5) transformation values; Means are significant at p< 0.05

Table 6. *cox1* based sequence homology of newly collected lac insect samples

Location	Host plant	Code	Product length (bp)	% Homology	Matching with
Assam	*Ficus religiosa*	AsA1	530	99/98	LIK0031/23
Manipur	*Z. mauritiana*	MaB	517	97	LIK0031/23
Manipur	*F. religiosa*	MaF	583	90/89	LIK0031/23
Manipur	*Hibiscus*	MaH	598	97	LIK0031/23
Manipur	*Malvaviscus*	MaM	594	98	LIK0031/23
Manipur	*M. philippensis*	MaU	594	97	LIK0031/23
Nagaland	*Litchi chinensis*	NL1	510	95	LIK0031/23

water, and then the total volume of the mixture to be reduced to a quarter of the initial volume under low flame. The content is kept aside for cooling under shade. Finally, the mixture is divided into three parts and one part may be taken a day against rheumatic and other body pain. The actual amount to be administered may vary according to the body weight and intensity of pain. Lac encrustation is boiled in water; allowed to cool, and the extract is applied to the body to soothe itchy skin.

CONCLUSION

ICAR-NISA, Ranchi has a mandate of collection and conservation of lac insects of the country and implements through network mode (All India Network Project on Conservation of Lac Insect Genetic Resources (NPCLIGR)). Lac insect is primarily cultivated in Jharkhand, Chhattisgarh, Odisha, and West Bengal in scientific manner. In the past, lac insect cultivation was prevalent in some places of the NEH region. But today it is not popular because of unawareness of scientific lac cultivation methods and natural lac resin is being replaced by synthetic ones. The present study revealed that there is vast diversity in lac host plants and lac insects which are specific to NEH region. It is envisaged that the distinct lac insects and host *species* would be valuable in developing new lac insects + host plant combinations for enhancing the lac productivity of the NEH region. Appropriate conservation initiatives are also needed for conserving the valuable lac-associated faunal and floral diversity in NE region. Plenty of lac-based ITKs are also available which are not well documented and should be evaluated scientifically and promoted among the lac growers. Awareness should be created among the lac growers as well as in the general public about the values, advantages, and usage of natural products with regards to lac insect products.

AUTHOR CONTRIBUTION

Dr. A. Mohanasundaram: survey, lac insect maintenance, biological characterization of lac insect, experimental design, data analysis, manuscript writing. Dr. K.K Sharma: Lac insect maintenance, guided in the experimental plan, manuscript writing. Dr. T. Kandasamy: Molecular characterization of lac insect, experimental design and editing of manuscript, Dr. V.D. Lohot: Survey, Lac host maintenance, experimental design and editing of manuscript. Dr. J. Ghosh: Survey, Lac host maintenance and experimental design. Dr. P. Das: ITK's of lac insect and its products and editing of manuscript.

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