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Indigenous lac culture and local livelihood: a case study of *Karbi* community of Assam, North-Eastern India

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The indigenous lac culture of *Karbi* community inhabiting West Karbi Anglong district of Assam is highlighted in this paper. A total of 114 knowledge holders were identified through chain referrals method from three representative villages of Ameri Block for the study. *Karbis* reared lac insects twice in a year on naturally growing host plants either in the forest areas or in homegardens. A total of eight unique host plants except *Ziziphus mauritiana* and *Ficus religiosa* were observed to be used by the community for rearing lac insect. They preferred bigger host plants such as, *Ficus benghalensis*, *F. religiosa* and *Albizia lucidior* due to higher lac yield and lesser labour requirement. An individual *F. religiosa* and *F. benghalensis* tree could produce about 120-200 kg of sticklac in a season. The average annual household production of sticklac ranged from 679 to 776 kg in the studied villages and contributed to about 25-30% of annual household income. *Karbis* traditionally use lac as natural dye, binding agent, polishing earthen pots and also as medicine for chest and joint pains. Factors like uncertain production, high fluctuation in market prices and unorganized nature of the venture have been identified as the major constraints for the sustainability and up-scaling the practice.

Keywords: Host plants, Indigenous knowledge, Livelihood, Market value, Non Timber Forest Product, Sticklac

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Lac is a resinous secretion of certain scale insects belonging to the family *Kerriidae* and considered as one of the non timber forest products[1,2]. Processed lac (shellac) is used as raw material in the manufacturing of products such as paints and varnishes, glazing of fruits, coating of medicines, electronic appliances, hair lacquer, nail polishes, jewelry, sealing wax and confectioneries[3-6]. Shellac demand has been increasing in these industries since last few decades due its eco-friendly and nontoxic properties[5-7]. Lac is mainly produced in Asian countries and India produces the highest amount of lac followed Bangladesh, Myanmar, Thailand, China, Vietnam and Mexico[8]. India contributes about 50-60% of the world's total lac production[9]. In India majority of lac is produced in Jharkhand, Chhattisgarh and West Bengal states, while Orissa, Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Andhra Pradesh and Assam account for smaller quantities[9,10].

In Assam which is one of the largest eight states in North-Eastern India falls in Indo-Burma biodiversity hotspot, lac culture is traditionally practiced in some pockets of Karbi Anglong, Kamrup, Marigaon, and Nagaon districts[10,11]. Karbi Anglong district is historically a major lac producing area in the North Eastern India from where lac used to be exported to China and Japan during 17th and 18th centuries[10,12].

Among the several indigenous communities inhabiting Karbi Anglong district, for *Karbis* rearing of lac insects (*Kerria lacca* Kerr), locally called *Laha*, on naturally growing host plants in forests and on pigeon pea (*Cajanus cajan*) plants in their shifting cultivation (*Jhum)* fields is a traditional practice[13,14]. Documentation on conventional lac culture (commercial lac culture practiced in other parts of India), modern techniques in lac culture and its role in livelihood earnings of local communities have been reported from different parts of India[9,15-18]. However, indigenous methods of lac culture on naturally growing host plants and its traditional uses have been rarely documented and reported so far. Present study attempts to fill the knowledge gap by documenting various aspects associated with indigenous lac culture and its role in livelihood among the *Karbi* community

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of West Karbi Along district of Assam. The study will also help in the preservation of traditional knowledge of lac culture of the community amidst fast occurring changes in socio-economic spheres including in climate in present times.

Socio-economic profile of the Karbis

Karbi is one of the major indigenous communities of the North-East India inhibiting East Karbi Anglong, West Karbi Anglong districts and few pockets of Dima Hasao, Kamrup, Morigaon, Nagaon, Sonitpur districts of Assam and Ri-Bhoi district of Meghalaya state[19]. The population of the community is 430452 in Assam[20]. Shifting cultivation (*Jhum*) is major livelihood activity of the upland *Karbi* people and settled wet rice cultivation in the low lands[21]. Ginger, turmeric, taro and broom grass are the major cash crops of the community. *Karbis* collect a range of wild edibles which not only help them in securing nutraceutrical benefits but also in augmenting household income[22]. In some pockets of West Karbi Anglong, the community earns part of its household income through indigenous lac culture.

Materials and methods

Study area

The study was carried out during September 2016 to June 2018 in the Ameri Block of West Karbi Anglong district of Assam state of North-Eastern India (Fig. 1). In most of the villages of the Block, *Karbi* community practices traditional lac culture. To achieve the objectives of the study, three representative villages, viz., Kolabari, Doloigaon and Engtithengkiri were selected (Fig. 1). The population of the selected villages ranged from 147-200 and number of households from 19 to 34 (Table 1).

The vegetation of the study area is characterized by tropical wet evergreen and tropical semi evergreen forest types[23]. The area experiences sub-tropical monsoon climate and as recorded during last four decades (1981-2017), receives an average annual rainfall of 1203 mm. About 74% of the total rainfall occurs during May through September months (Fig. 2). During winter season (November-January) temperature ranges from 6 to 12°C while it remains 23-32°C in summer (June-September) season (www.karbianglong.nic.in).

Table 1 — Number of households and population of the studied villages in West Karbi Anglong district, Assam, India

Village	Households	Male Population	Female population	Total population
Doloigaon	34	122	84	206
Engtithengkiri	19	79	68	147
Kolabari	19	88	70	158

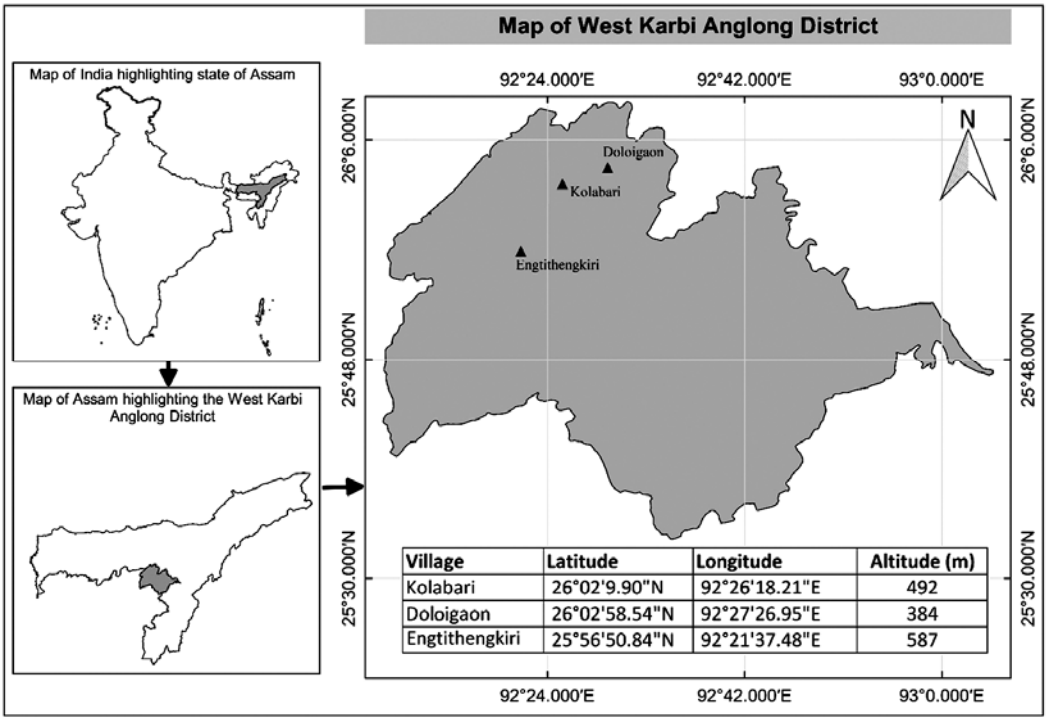

Fig. 1 — Location of the study area (Doloigaon, Engtithengkiri and Kolabari villages in West Karbi Anglong district of Assam, India).

Data collection

A considerable time was spent in the selected villages to convey about the objectives of the study. To develop a thorough trust with the community following key elements of participatory research were followed: (a) secured prior permission from the Assam State Biodiversity Board for conducting the research (b) remained sensitive to community's social customs and norms and (c) allowing more verbal responses using local translators with minimal requirement of responding via writing/reading to ensure smooth communication. Keeping the aforesaid elements constantly in mind, based on secondary literature (which included web based search and locally available records from forest department) and with the help of Key Knowledge Holders (KKHs), we documented the details of the indigenous lac culture and its traditional uses in the study area.

The process of data collection was taken up between September 2016 and June 2018. A total of 114 KKHs (68 male and 46 female) of different age groups (35-80 years) which included lac farmers, headmen of the villages, executive members of the traditional institution (*Mei*), church committees and local NGOs were identified through "Chain Referrals" method[24]. Focus group discussions (FGDs) were conducted with KKHs using semi-directive interview method[24]. The interviews were conducted based on an open-ended, discovery-oriented, and semi-structured questionnaire and also free flowing discussions to understand and document a whole lac rearing practices pertaining to host plant selection, inoculation and infestation of the lac insect, management, harvesting and marketing. Apart from semi-directive interviews and FGDs, the collaborative field work with select number of lac farmers and KKHs was also conducted to validate the documented information and also the practical knowledge. Photographs and specimen of lac host plants were collected during the field survey and were identified with the help of Assam's Flora[25] and Flora of Assam[26].

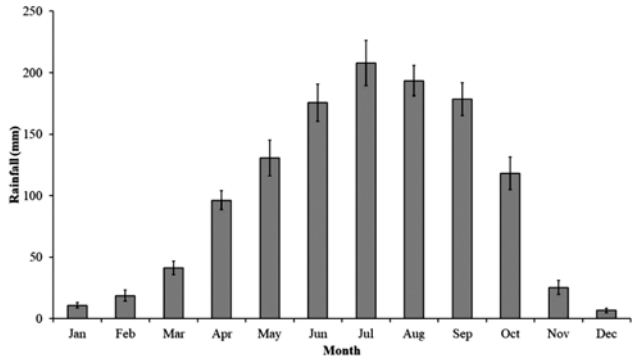

Fig. 2 — Average monthly rainfall during January 1981 to December 2017 in West Karbi Anglong district (source: India Meteorological Department, Regional Meteorological Centre, Guwahati Assam).

Results and discussion

Indigenous lac culture

Karbis rear lac insects twice in a year (April-October and October-April) on a total of eight host plants, *viz*., *Albizia lucidior, Cajanus cajan, Ficus benghalensis, F. religiosa, Grewia* sp., *Leea crispa, Trema orientalis* and *Ziziphus mauritiana* growing naturally either in their homegardens or forests near *jhum* (shifting agriculture) fields (Table 2, Fig. 3). About 67% of the informants reported October-April as the most preferred season for lac culture due to favourable climatic condition (less rainfall and optimum temperature) and lesser work load in agriculture (Fig. 4a). About, 72% farmers reared lac insect on host plants growing in forest areas while the others on those growing in or around their homegardens (Fig. 4b). Farmers may either inoculated

Table 2 — Host plants used by the *Karbi* community for lac culture in the study area

Scientific Name	Local Name	Family	Habit and Occurrence
Albizia lucidior (Steud.) Nielson	Inghok	Fabaceae	Large tree (height up to 25 m), grows in the forests, roadside, homegardens and roadside
Cajanus cajan (L.) Mill sp.	Thekek	Fabaceae	Shrub (height up to 2.5 m), cultivated in *jhum* and homegardens
Ficus benghalensis L.	Chirijangphong	Moraceae	Large tree (height up to 35 m), grows in the forests, roadside and occasionally in homegardens
Ficus religiosa L	Hotachiri	Moraceae	Large tree (height up to 30 m), grows in the forests, roadside and occasionally in homegardens
Grewia sp	Singnam longdak	Tiliaceae	Small tree (height up to 4 m), grows in *jhum* fallows and roadside
Leea crispa L.	Sopleple	Leeaceae	Shrub (height up to 2.5 m), grows in *jhum* fallows
Trema orientalis (L.) Blume	Senamlongdak	Ulmaceae	Medium sized tree (height up to 8 m), grows in the forests and jhum fallow lands
Ziziphus mauritiana Lam.	Bukuri	Rhamnaceae	Small tree (height up to 15 m), grows in the forests and homegardens and occasionally along roadside

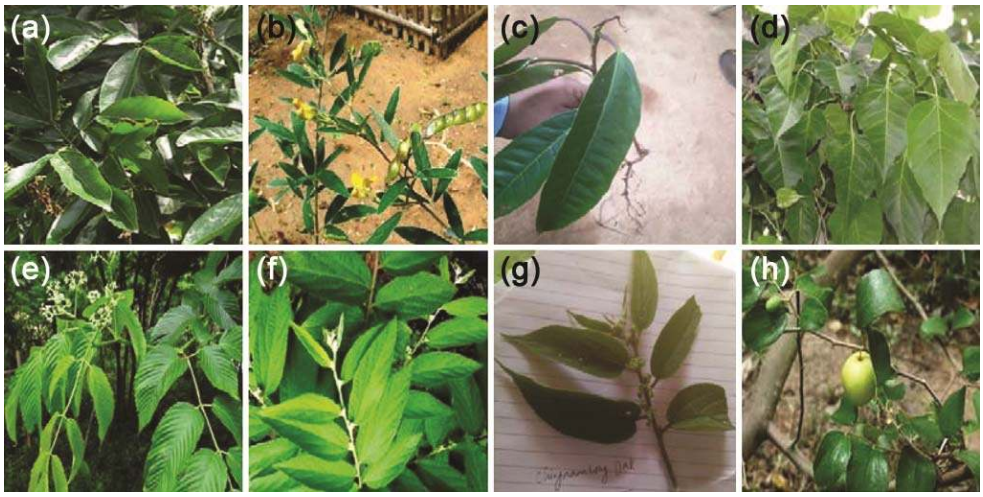

Fig. 3 — Host plant species used by *Karbis* for lac culture in Karbi Anglong district of Assam (a) *Albizia lucidior* (b) *Cajanus cajan (*c) *Ficus benghalensis* (d) *Ficus religiosa, (*e) *Grewia sp* (f) *Leea crispa* (g) *Trema orientalis* and (h) *Ziziphus mauritiana.*

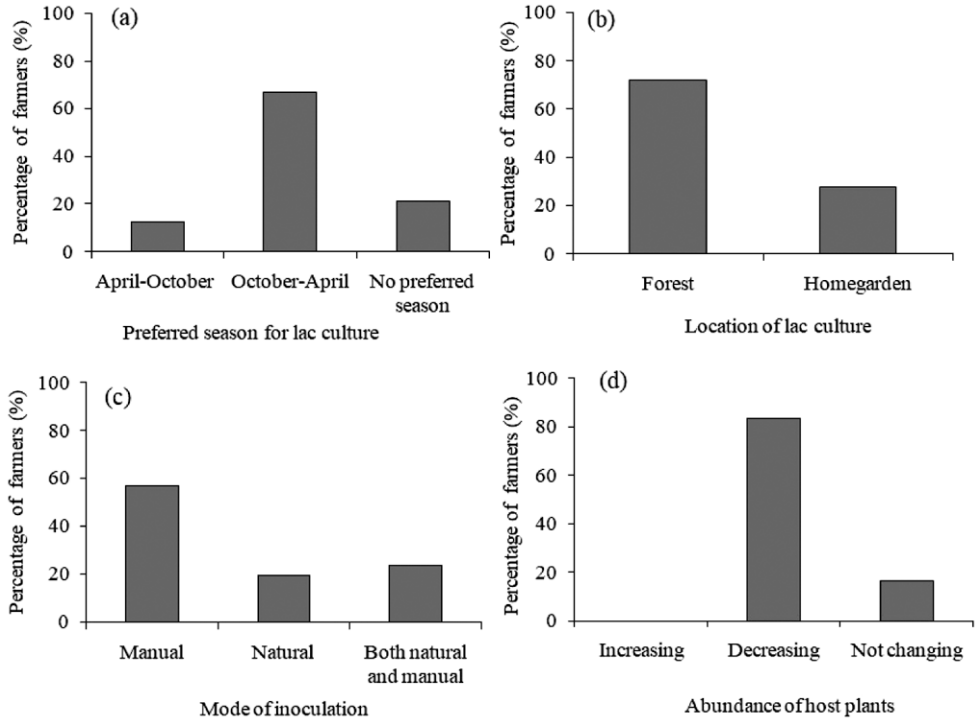

Fig. 4 — Responses of the informants on (a) preferred season for lac culture, (b) preferred location for lac culture, (c) preferred mode of inoculation and (d) abundance of host plants.

lac insects on host plants manually or these got infested naturally. A total of 43.4% of the farmers inoculated lac insects using broodlac while 18.5% reported natural infestation during the study period. About 38% farmers reported both natural infestation and manual inoculation of lac insects on the host plants (Fig. 4c). According to the KKHs, natural inoculation takes place where lac culture was practiced in the previous season. However, infestation and productivity of the naturally inoculated lac insects remain uncertain and hence, a sizable proportion of farmers depended on both natural and manual inoculation methods. All the farmers reported that repeated lac culture on the same individual host plant reduced the lac yield every successive season. Therefore, after 2-3 successive cultures, they inoculated new host plants. For inoculation of the lac insects, farmers used 3-5 cm long broodlac in a small

bamboo made basket locally called *laha-atum* and hung it around majority of the second and third order branches of the host plants (Fig. 5a). In case of small sized host plants, the broodlac was tied with the trunk with the help of bamboo string or fibre extracted from banana sheath (Fig. 5b). Depending on the species and size of the host plants, the farmers had sufficient knowledge on manual inoculation to manage the levels of infestation of lac insect in order to avoid excessive infestation. As per the KKHs mortality due to excessive infestation sometimes observed when the host plants got infested naturally.

Once the inoculation was completed, the lac insect infested all the second and higher order braches within 15-20 days, but seldom infested the main trunk of the larger host plants. After inoculation, the only activity of the farmers was to protect foraging by squirrels and birds upon the host plants using traditional bows and mud palates as deterrents (Fig. 5c). Farmers protected the lac insects from red ants (*Myrmica rubra* L.) also that forage upon lac insect by removing the red ant nests from the host plants whose eggs and larvae are edible for the community. Unlike in conventional lac culture, *Karbis* never applied fertilizer, pesticide and irrigation on the naturally growing host plants (Table 3).

Harvesting was done in the months of October-November every year by pruning the lac bearing branches of the host plants (Fig. 6). The pruned branches were again cut into small pieces of 20-35 cm

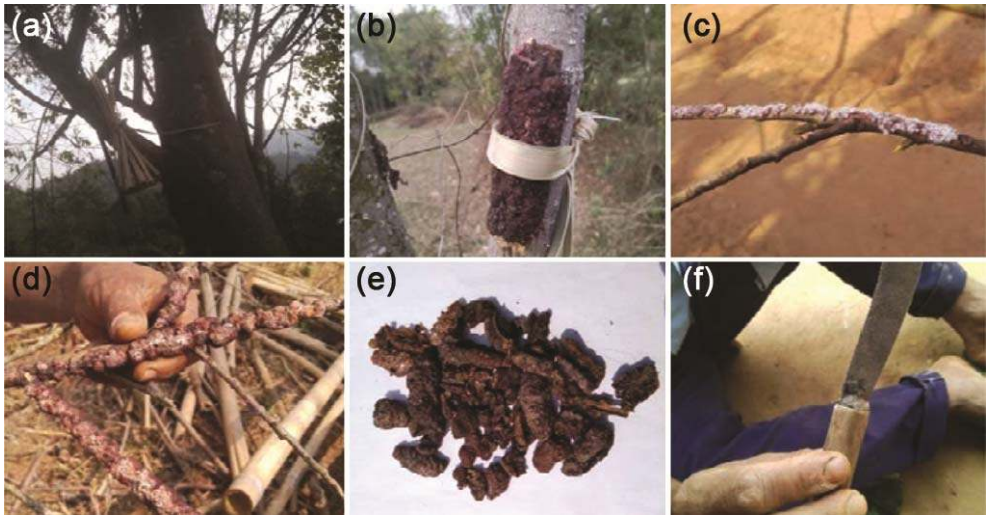

Fig. 5 — Photographs of traditional lac culture by *Karbis* (a) inoculation of lac by *laha atum*' on host plants (b) inoculation by binding the brood lac on the branches of the host plants (c) natural spreading of the lac insect population after inoculation (d) harvesting of sticklac (e) lac after scrapping (f) use of lac as binding agent in traditional sickle.

Table 3 — Features of conventional and indigenous lac culture of *Karbi* community of West Karbi Anglong district of Assam, India

Activity	Conventional lac culture in India	Indigenous lac culture of *Karbis*
Major host plants	*Butea monosperma*, *Schleichera oleosa*, *Flemingia semialata* and *Ziziphus mauritiana*	*Ficus religiosa, Ficus benghalensis, Albizia lucidior, Leea crispa* and *Cajanus cajan*
Plantation of host plants	Host plants are planted for rearing lac insects after proper land preparation and digging of pits	Host plants are naturally growing near shifting cultivation fields (*Jhum*) or homegardens except *Cajanus cajan* which is cultivated in the *jhum* fields
Inoculation season	January-February July-August	April-May October-November
Inoculation	Broodlac is inoculated with net bag of 60 mesh size	small bamboo baskets locally called '*laha atum*' are used for inoculation
Weeding and hoeing	Weeding and hoeing are carried out after 30-40 days of inoculation	Weeding is carried out occasionally
Application of fertilizer	Fertilizers are applied	Not applied
Pesticide Application	Chemical pesticides such as endosulfan, dichlorvos, cartap hydrochloride and ethofenprox are applied 2-3 time each cropping season	Not applied
Irrigation	Irrigation is given frequently	No irrigation

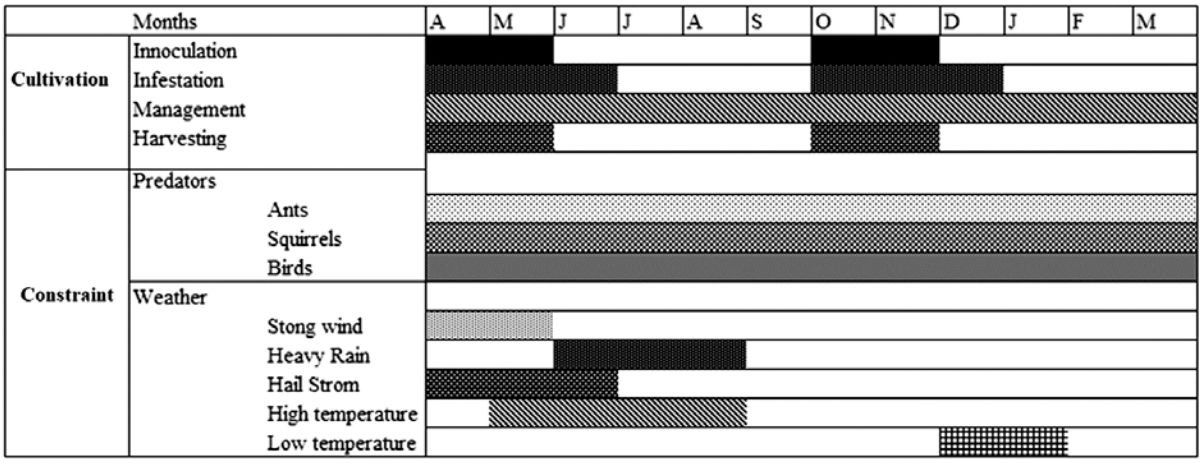

Fig. 6 — Different phases of traditional lac culture and constraints faced by *Karbi* farmers in different months of the year.

long called sticklac which can either be sold directly to local traders or stored for self-use (Fig. 5d, e).

Processing of the sticklacs for self-use was carried out mostly by the *Karbi* women. The sticklac was dried for about 3-5 days depending upon the moisture content of the lac. According to *Karbi* women, over drying of the sticklac may lead to change in colour from reddish to black which is considered inferior in quality for dyeing traditional yarns. After proper drying, lac was scrapped from the sticks manually or with the help of a small knife. A woman scrapper can scratch 8-10 kg of lac in a day. The scrapped lac was cleaned manually by removing the bark of the branches. The cleaned lac may be further sun dried if the scrapping person feels that the lac has still some moisture or stickiness to avoid chances of clotting during storage. The cleaned and dried lac was wrapped in cloth and kept inside a *buruk* (a bamboo made basket) and hanged on the house walls near traditional hearths. According to KKHs through this method the lac could be stored for 2-3 years beyond which the quality starts deteriorating in terms of its colour and binding capacity.

Host plants for lac culture

A total of aforementioned eight host plant species were observed to be used by the *Karbis* for lac culture (Table 2, Fig. 3). All of these, except *Z. mauritiana* and *F. religiosa* were different from the host plants used in the conventional lac culture[15-18,27]. Around the globe, more than 400 plant species have been reported which can be used as host for lac culture[28-30]. The host plants used by the *Karbis* were the common plant species in the forests of the study area. According to the farmers (83%), due to frequent use of forest areas for *jhum* cultivation, abundance of these species is decreasing in present times. As a result about 17% of the farmers have started planting few of them viz., *F. religiosa, F. benghalensis, A. lucidior* and *L. crispa* in their home gardens.

Of the eight host plant species, most of the households (95%) used not more than two species simultaneously for rearing lac insect in a season while others used three to four species. *F. religiosa* and *F. benghalensis* were the most preferred species for the lac culture among the *Karbis*. About 58-68% of farmers used *F. religiosa* as host plant while *F. benghalensis* was used by 21-26% of the farmers (Table 4). On average 3-5 trees of *F. religiosa* and 2-3 trees of *F. benghalensis* were used by each farmer for lac culture in a given season. Average 7-8 trees of *A. lucidior* were used by 12-32% farmers and 7-9 trees of *T. orientalis* by 8-21% of farmers as host plants. *L. crispa, Z. mauritiana* and *Grewia* sp were occasionally used by 5-15% farmers (Table 4). As per the account of the KKHs, they preferred large host plants (*F. religiosa, F. benghalensis*, *T. orientalis* and *A. lucidior*) as these required less care, less land area, high production per tree and fewer chances of foraging (Table 5). However, the only disadvantage of rearing lac insect on large and tall host plants was that women farmers were unable to participate in inoculation and harvesting activities.

Rearing of lac on winged bean (*C. cajan*) plants in *jhum* fields was a common practice among the upland *Karbi* farmers in the study area until last decade. However, the practice has now been abandoned due to requirement of large number of host plants, higher maintenance and less productivity. Lac culture on

Table 4 — Proportion of host plants species used by the farmers for lac culture in Doloigaon (D), Engtithengkiri (E) and Kolabari (K) villages in West Karbi Anglong District, Assam, India

Host plants	Percentage (%) of lac farmers using different host plants			Number of host plants used/household			Yield of sticklac (kg/tree)
	D	E	K	D	E	K	
Albizia lucidior	8.82	36.84	31.57	8.33 ± 0.55	8.20 ± 0.95	7.83 ± 0.39	50-80
*Cajanus cajan**	-	-	-	-	-	-	0.5-1
Ficus religiosa	67.65	57.89	63.16	4.43 ± 0.57	5.45 ± 0.93	3.50 ± 0.54	120-200
Ficus benghalensis	23.53	26.32	21.05	2.75 ± 0.30	1.5 ± 0.13	2.5 ± 0.54	120-200
Grewia sp	5.88	15.79	5.26	7.0 ± 1.41	7.5 ± 0.71	19.5 ± 0.32	5-7
Leea crispa	5.88	10.53	15.79	36.50 ± 0.61	27.5 ± 3.41	6.67 ± 0.66	1-3
Trema orientalis	14.71	31.58	36.32	7.20 ± 0.25	8.25 ± 0.51	9.0 ± 0.89	30-50
Ziziphus mauritiana	8.82	5.26	5.26	3.67 ± 0.20	4.50 ± 0.16	5.33 ± 0.13	20-25

* Not used as host plant in present time

Table 5 — Farmers perceptions on advantage and disadvantages of the host plants used for lac culture in West Karbi Anglong, Assam, India

Preference	Host plants	Advantages	Disadvantages
1 Most preferred	1 *Ficus religiosa* 2 *Ficus benghalensis*	1 Higher yield per tree 2 Less care and labour requirements 3 Negligible chances of browsing by domestic or wild animals	1 Women cannot be involved actively in lac culture 2 Need to climb greater height for inoculation and harvesting
2 Preferred	3 *Albizia lucidior* 4 *Trema orientalis*	4 Medium height tree and hence easier to climb during inoculation and harvesting 5 High occurrence in forests 6 Lesser chances of browsing by domestic or wild animals	3 Lac production is less than *Ficus* spp 4 Women cannot be involved actively in lac culture
3 Less preferred	5 *Cajanus cajan* 6 *Grewia* sp 7 *Leea crispa* 8 *Ziziphus mauritiana*	7 Both men and women can be involved in lac culture as these are small trees/shrubs 8 *Cajanus cajan* cultivated for both as a pulse crop and at the same time used to be a host for lac insects more than a decade ago	5 Required larger land area 6 Higher chances of grazing/browsing by livestock/wild animals 7 Demand active management and protection against grazing. 8 Thorns on *Ziziphus mauritiana* trunks and branches make harvesting and scraping of lac a bit cumbersome

C. cajan has also been reported from various provinces of China[31-33].

Traditional uses of lac

Lac used by the *Karbis* as natural dye for coloring yarns for preparing traditional dresses (e.g., *Choy-Aan, Rekong-ke-Er, Dokherso pi-sharpi, Poho* and *Wankok*) and bags (*Jambili*). This practice of coloring yarns was common among the *Karbi* women. According to the women, the coloring of yarns with lac lasts longer and the clothes do not loose luster. However, such dyeing practice has been declining in recent times due to the availability of synthetic or chemically colored yarns in the local market.

All *Karbi* households used lac as binding agent to fix handles of agricultural implements especially the *dao*- a multipurpose tool/dagger (Fig. 5f). It was also used in polishing both outer and inner sides of the new earthen pots (*Tibuk*) bought from the market for storing water. However, with declining use of earthen pots, use of lac for this purpose has also declined. In Kolabari and Engtithengkiri villages, respectively, 14% and 16% of the informants reported medicinal value of lac in curing cough, chest and joint pains. In case of cough and chest pain, a small piece of lac is mixed with lukewarm water by crushing and a glass of such water is drunk daily to get relief. Lac is also used by local people to get relief from a variety of joint pains by massaging lac powder mixed with mustard oil on the afflicted areas of the body. Use of lac in Unani medicine has been reported for curing a whole gamut of health conditions such as obesity, hyperlipidemia, renal, jaundice, ascitis, back ache, premature ejaculation, leprosy, cough, hemiplegia, asthma, haemoptysis, epilepsy, chicken pox, ulcerations, worm infestation and palpitation[33-34].

Lac production and marketing system

According to the farmers, lac culture from an individual tree of *F. religiosa* or *F. benghalensis* may

yield 120-200 kg of sticklac. Similarly, yield of sticklac was reported as 50-80 kg/tree for *A. lucidior*, 30–50 kg/tree for *T. orientalis*, 20-25 kg/tree for *Z. mauritiana* and 5-7 kg/tree for *Grewia* sp (Table 4). In earlier studies from India, average yield of sticklac on an individual tree of *Schleichera oleosa* (6–10 kg), for *Z. mauritiana* (1.5–6 kg) and for *Butea monosperma* (1–4 kg) was recorded in Bihar[35]. Similarly, sticklac production from an individual tree was recorded as 10 kg for *B. monosperma,* 20 kg for *Z. mauritiana,* 12 kg for *Acacia catechu,* 8 kg for *Acacia nilotica* and 80 kg for *Samanea saman* in Rajshahi division, Bangladesh[36]. Thus sticklac yield from individual *F. religiosa* and *F. benghalensis* tree reported by farmers in the present study was significantly higher than those reported for other host plant species[35-36]. However, the yield from individual trees of *A. lucidior*, *T. orientalis*, *Z. mauritiana* and *Grewia* species was comparable with that of host plants used in the conventional lac culture[35-36].

Household sticklac production varied from 80 kg to 2650 kg in each season depending on the species and number of host plants used by individual household. At village level, average annual household sticklac production was estimated to be 776.32, 679.41 and 694.74 kg, respectively, in Doloigaon, Engtithengkiri and Kolabari villages (Fig. 7). Higher sticklac production in Doloigaon may be due to occurrence and use of higher number of large sized host plants (*F. religiosa* and *F. benghalensis*) by most of the farmers (68%) of the village than Kolabari and Engtithengkiri villages (Table 4).

The marketing system for lac in the study area could be grouped into three units, viz., lac producers, procurement units and processing units (Fig. 8). The procurement of the freshly harvested sticklac was mostly done locally by primary purchasers who came from the nearby plain areas of the state. Sometimes these traders informally appointed local agents in villages to collect sticklac. The primary purchasers scrapped the sticklac and sold it to the wholesalers called *Mahajan* residing in nearby townships located in the plains. The *Mahajan* supplied it to processing units located in distant urban areas outside Assam through the agents of the industries.

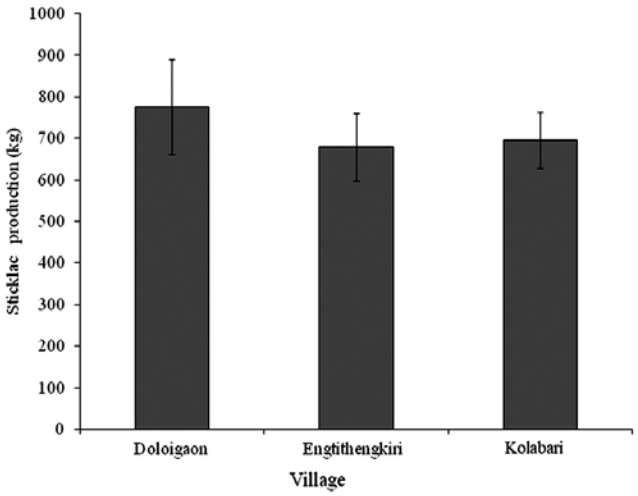

Fig. 7 — Average annual household sticklac production in Doloigaon, Engtithengkiri and Kolabari, villages, West Karbi Anglong, Assam, India.

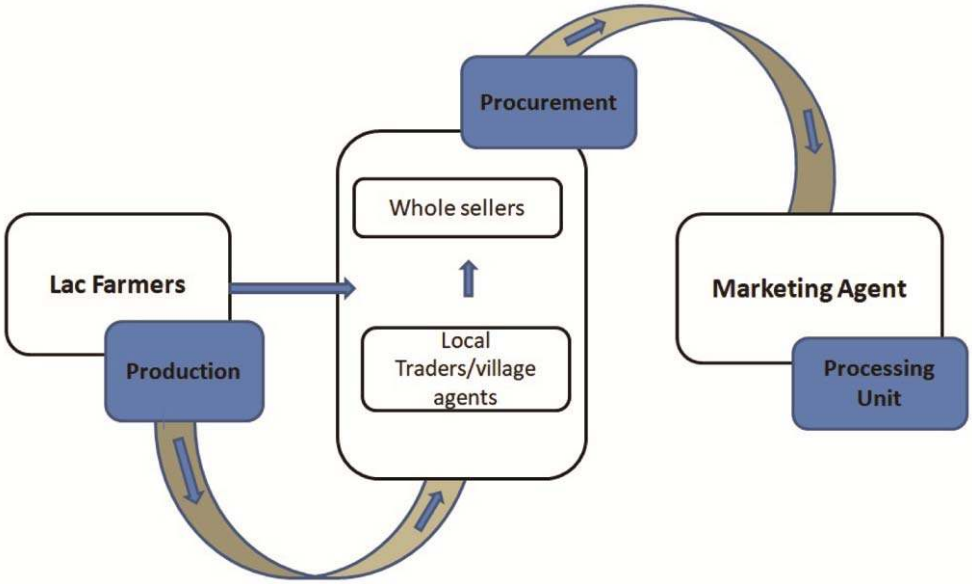

Fig. 8 — A schematic diagram showing existing lac marketing systems in West Karbi Anglong district, Assam, India.

The price of sticklac varied from ₹ 10- 40/kg in different years. According to the informants, through lac culture, they could earn INR (₹) 20000-25000 (₹ 71.33= US $1) annually which was estimated to be 25-30% of their total household income as also was the case with more than 3 million people belonging to socio-economically weaker sections of the society in other parts the country[15]. Lac culture has high potential of generating income and employments for both men and women in the country[8].

Constraints in lac culture

Farmers reported some constraints in indigenous lac culture. In the initial three months (inoculation and infestation period), they faced problems from predators such as squirrels, birds and ants. Sometimes predation may lead to complete failure of the lac production. Besides, unfavourable weather conditions such as heavy rains, very high or low temperatures, strong winds and hail storms also posed pronounced threats to lac culture and can affect it at any stage[8,37-38] (Fig. 6). In the studied villages, about 11% of the farmers reported failure of their lac culture due to heavy rains and hail stones during infestation period in the year 2012.

Farmers (15-21%) reported that increasing uncertainty of weather in most recent times has been discouraging them to remain engaged in lac culture. Combination of biotic and abiotic stresses influenced the growth of the lac insects and could lower the lac production up to 80%[2,38-39]. About 90-95% *Karbi* farmers stated that uncertain production while 15-26% farmers reported lack of organized market system as discouraging factors (Table 6). According to the Plant Resins and Gums Statistics of India (2016), the price of sticklac varies year to year basis depending on the fluctuating market conditions[10]. Despite increasing use in various industrial products, about 26-42% of the farmers in the study area reported that availability of alternatives was the another factor for lack of interest in lac culture among the new generation (Table 6).

Suggestions and way forward

Relevant line agencies such as state forest department, agricultural department and directorate of employment and craftsmen training may help building the capacities of local farmers to improve the efficiency of traditional lac processing and storage methods and in local value addition by establishing micro industrial units in the area for realizing higher income. Farmers may be suggested using modern practices and tools in their lac culture to minimize human drudgery. For example, use of modern broodlac placement-cum-removal tools during inoculation will help them to avoid climbing the tall host trees and also save time[40]. Similarly, the efficiency of indigenous lac scrapping process can be enhanced significantly from 8-10 kg of lac per day to 20 kg lac per hour by using improved lac scrapers such as hand/ pedal or power operated[41]. The knowledge about hitherto unknown parasitoids like wasps, moths and fungi that have been reported from various parts of India causing 35-40% reduction in lac production[42-43] may also be disseminated among the *Karbis* and other lac rearing indigenous groups to keep them prepared to face the likely challenge in future. The wasps and moths can be controlled by using of 60 mesh synthetic bags (brood bag) during the inoculation of the lac insect instead of traditional *laha-atum*[44].

Awareness needs to be raised on growing national and international demand of shellac in multiple industries especially paints and varnishes, pharmaceutical and electronics in most recent times[3-7]. Further, mechanisms are required to be explored that help adoption of modern practices of lac culture, provide minimum support price and insurance to indigenous lac farmers, develop organized marketing system[45] and mobilize farmers to plant host trees in *jhum* fallows in order to ensure the socio-economic and environmental sustainability of traditional lac culture in general and that of the *Karbis* in particular. At the same time the formal lac culture practices may benefit from the traditional knowledge of *Karbis* by integrating the

Table 6 — Farmers' responses for prevailing factors responsible for dwindling lac culture among the *Karbi* community in West Karbi Anglong district, Assam, India

Villages	Factors responsible (% age of farmers' responses) for dwindling lac culture				
	Fluctuation in market price	Informal/unregulated marketing system	Uncertain production	Availability of alternatives	Increasing weather uncertainty
Doloigaon	91.18	26.47	79.41	35.29	17.65
Engtithengkiri	94.74	21.05	84.21	42.11	21.05
Kolabari	89.47	15.79	94.74	26.32	15.79

new host plants and inoculation methods for increasing the lac production in the country.

Conclusion

Karbis used eight naturally growing host plant species either in forests or homegardens for lac culture which are unique except *Z. mauritiana* and *F. religiosa.* Traditionally, they used lac as natural dye, medicine, binding agents and polishing earthen pots. The yield of lac from *F. religiosa* and *F. benghalensis* trees was reported to be significantly higher than that of conventional and other traditional host plant species. Lac culture was found contributing nearly one quarter of the household income among the *Karbis* of the studied villages. However, uncertain production, high year to year fluctuations in market price and unorganized/informal market system have been found to be discouraging factors for this forest based traditional livelihood earning practice. Increasing use of lac particularly in electronic appliances and pharmaceutical industry may enhance its market value in near future. The study would help in preservation and protection of traditional knowledge and may contribute in informed policy making that help promote forest based livelihood earning practices among local communities.

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