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AN ASSESSMENT OF THE POPULATION STATUS OF THE THREATENED MEDICINAL PLANT *ILLICIUM GRIFFITHII* HOOK.F. & THOMSON IN WEST KAMENG DISTRICT OF ARUNACHAL PRADESH, INDIA

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COMMUNICATION

An assessment of the population status of the threatened medicinal plant *Illicium griffithii* Hook.f. & Thomson in West Kameng District of Arunachal Pradesh, India

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Abstract: *Illicium griffithii* Hook.f. & Thomson, a medicinal plant of the family Schisandraceae, is an Endangered species listed by the IUCN. A decline in population of this plant due to climate change as well as increasing human influences on the natural resources has been a matter of great concern among the researchers. In order to estimate the existing population of this plant, a field-based study employing linear transect method was conducted in four phases, May–June 2017, May–June 2018, April–May 2019, October–November 2019 covering an area of 700km² (approx.) in West Kameng District of Arunachal Pradesh that lies within the Himalayan biodiversity hotspot. The study recorded 3,044 live individuals of *I. griffithii* including 1,372 seedlings, 1,358 saplings, and only 314 mature trees. Additionally, 126 dead trees were also recorded. The study confirmed that the plant has a good regeneration rate but with a poor survival rate of saplings. Besides, large-scale collection of its fruits for trade and anthropogenic disturbances in the study area appears to be the major threat to its existing population. Therefore, proper training of the local people on large-scale cultivation of this plant together with awareness towards judicious harvesting of fruits from the wild may be the significant approach to conservation.

Keywords: Endangered species, regeneration, survival, risk assessment.

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Author contribution: Both the authors have contributed to the conception and design of the study. Tashi Dorjee Bapu collected, tabulated, and analyzed the field data and wrote the first draft of the manuscript. Dr. Gibji Nimasow helped in data analysis, interpretation of the results and commented on the first draft, then endorsed the final manuscript.

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INTRODUCTION

People largely depend on plants for food security and a multitude of plant products, from medicine to fibre. In short, plants are vital to our existence, which enhances our lives in innumerable ways. Medicinal plants are an important source of raw material for traditional medicines and a large number of people derive employment and income from collection, processing and trade of these plants (Sarma & Sharma 2014; Bapu & Nimasow 2019). Today biodiversity and ecosystems (home to medicinal plants and other raw materials) are facing threat from over exploitation, habitat loss and fragmentation (Bapu & Nimasow 2018), climate change, pollution and invasion of alien species (IUCN 2003) and disturbance of community structure (Novacek & Cleland 2001).

The present population and regeneration status largely determines the existence of the species and is significant in conservation management. The regeneration status of a species is usually assessed from the population dynamics of seedlings and saplings in a forest community (Duchok et al. 2005). The age and diameter of a plant have been the basis for the prediction of regeneration status of tree species according to several researchers (Pritts & Hancock 1983; Khan et al. 1987; Bhuyan et al. 2003; Duchok et al. 2005). The presence of sufficient seedlings, saplings and young trees and the ability of the seedlings and saplings to survive and grow largely portray the successful regeneration of the species (Good & Good 1972; Saxena & Singh 1984). Although the species habitat changes over time naturally, the exposure to human interference and other causative factors largely influence the species structure and regeneration. The number of seedlings and saplings in an area allows assessing the regeneration potential of a species (Saxena & Singh 1984).

Illicium griffithii Hook.f. & Thomson belongs to the family Schisandraceae (Kew Science 2019). It is distributed sporadically in Bhutan, Hongkong, Vietnam, and India (Dung et al. 1995; Mukhia 2006). In Arunachal Pradesh, it occurs mostly in subtropical and temperate broad-leaved forests of West Kameng, Tawang, Lohit, and Lower Subansiri districts (Paul et al. 2013) and in very small numbers in Pakke Tiger Reserve of East Kameng District (Tag et al. 2012). It is an important medicinal plant of the temperate broad-leaved forests of northeastern India (Saha & Sundriyal 2010) with an average life span of 25–30 years (IUCN). This species is observed to be present in the second and third storey in the forest stratification in Arunachal Pradesh (Kaul & Haridasan 1987). It is known by different names in different places, most commonly as 'Lishi' / 'Lissi'. It is called "Dombursheng" and "Munsheng" by Monpas of West Kameng and Tawang, "Taihelang" by Apatanis, Loshsing/Loshu by Membas (Paul et al. 2013) and "Anasphal" in Hindi. The fruits are star-shaped, consisting of 7–13 follicles / carpels, containing one seed each. These seeds in the fruits contains shikimic acid which is used for manufacturing antiviral / anti influenza drug Tami flu (Ghosh et al. 2012; Cui et al. 2014; Candeias et al. 2018). About 41 constituents of essential oils have been identified from the fruits and seeds that consists mainly of 4-methyl-6-(2-propenyl)-1,3-benzodioxole, linalool, p-methoxy phenyl acetone, terpinen-4-ol, limonene and safrole (Dutta et al. 1997; Saraswathy et al. 2010), for which it has high demand in the spice and perfumery industries. Recently, scientists have also found cancer fighting properties especially against lung cancer cells (Vijayakumar et al. 2012). Traditionally, the carpels of fruits are used for flavouring butter-salted tea (Inchaa-Jhaa/Tsaajhaa) and to increase the potency of 'Ara' (local wine) by 'Monpas' of West Kameng and Tawang districts of Arunachal Pradesh (Bapu & Nimasow 2017). It is also used as medicine to cure cough, toothache, abdominal pain and food poisoning by the local people and is considered carminative, stomachic, and galactagogic (Hung et al. 2016). *Illicium* flowers from January to April and fruiting occurs by the end of April (Saha & Sundriyal 2010) and it matures by September end.

International Union for Conservation of Nature and Natural Resources (IUCN) reported a decline in the habitat of *I. griffithii* due to land use changes and unregulated collection of seeds, fruits and tree felling. Further, the experts in Conservation Assessment and Management Plan (CAMP) workshop, 2003 reported a decline of more than 60% of its population over 84 years (three generations length). Hence, the species has been enlisted as Endangered in IUCN Red Data Book (Saha et al. 2015). It is reported to be Critically Endangered in Meghalaya and Near Threatened in Arunachal Pradesh (Ved et al. 2003, 2005). Paul et al. (2013) reported that the plant is found growing abundantly in the natural forests of Arunachal Pradesh, but raised concern about its endangerment due to localized distribution, occurrence in unprotected areas with high anthropogenic disturbances and adverse impact of climate change. Further, the local people used to collect its fruits from the forests for their nominal source of income (Duchok et al. 2005; Bapu & Nimasow 2019) and fell the trees for fuel wood and other purposes (Bapu & Nimasow 2017). Therefore, in the present study, an attempt has

been made to examine the current population structure and regeneration status of *I. griffithii* in the wild so as to understand the future prospects of its regeneration.

STUDY AREA

The study was carried out in West Kameng District of Arunachal Pradesh (Figure 1) covering an area of about 700km² out of the total 5,013km². The study area is located in between 27.083–27.833°N & 92.083–92.416°E. The district shares an international boundary with Bhutan in the west and is bordered by Sonitpur and Darrang districts of Assam in the south, East Kameng District in the east and Tawang District in the north. The topography of the district is mostly mountainous and its greater part falls within the higher mountain zone, consisting of tangled peaks and valley. The study area was selected on the basis of the reports of large-scale exploitation of *I. griffithii* (Image 1) for medicinal purposes from the district in the past decades (Kalita & Khan 2013).

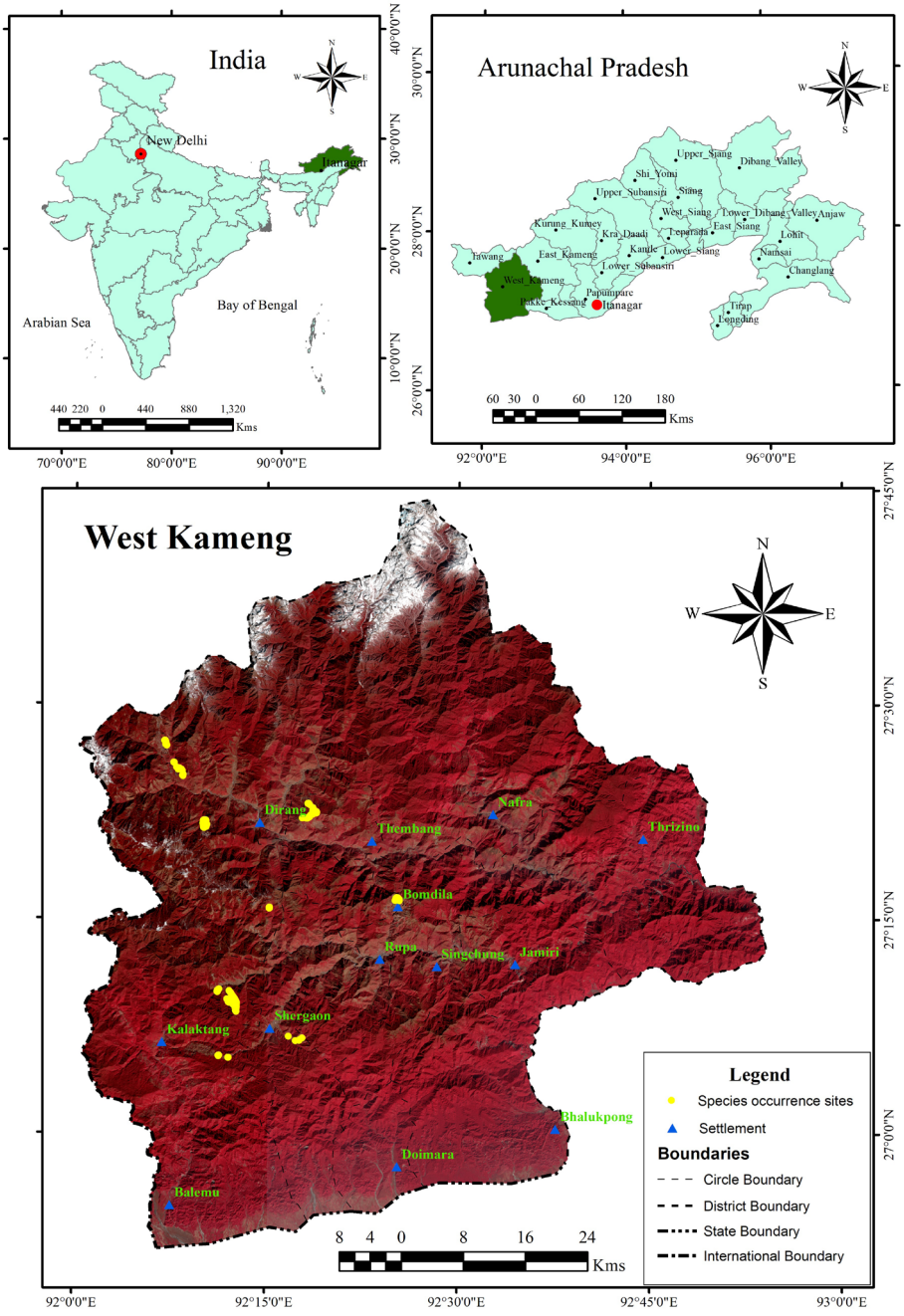

Figure 1. Study area (ArcGIS 10.3)

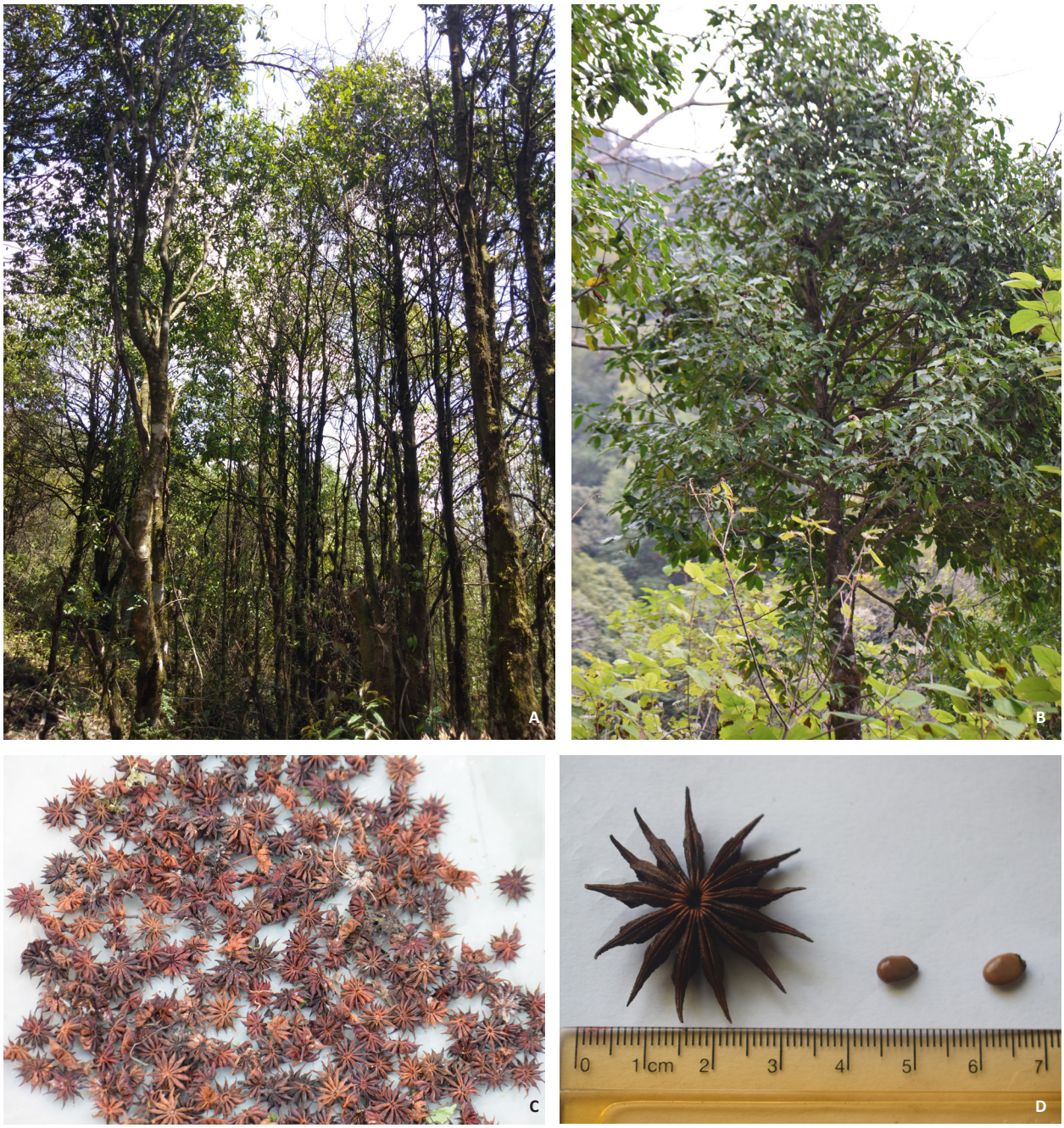

Image 1. *Illicium griffithii* Hook.f. & Thomson: A,B—tree | C—fruits | D—fruits and seeds. © Tashi Dorjee Bapu.

Database and Methodology

Database

1. Toposheets of survey of India for delineation of study area.
2. Shuttle Radar Topographic Mission Digital Elevation Model (SRTM DEM) for selection of study sites based on altitude.
3. Garmin Global Positioning System (GPS) for locating the species occurrence.
4. Camera to substantiate the field study.

METHODS

Field method and data collection

Since the population size of *I. griffithii* is not known, non-probability sampling technique was used. Based on previous site history on availability of *I. griffithii,*

proximity of camping and other human settlements, human use, closeness to nearby forest area and reports from the local people on occurrence, a purposive sampling technique was applied to select the sites. The site selection, however, was primarily based on altitude viz. below 1,000m, 1,000–1,500 m, 1,500–2,000 m, 2,000–2,500 m, 2,500–3,000 m and above 3,000m. In total 10 sites, namely, Morshing, Sanglem, Bomdila, Namshu-Chander, Lubrang, Nyukmadung, Senge, Mandala Phudung, Shergaon, and Tenzingaon, were selected from various altitude categories and linear transect survey was carried out. The plants along the line transect were recorded in GPS in three categories based on girth (circumference) at breast height (gbh), i.e., seedlings (<5cm), saplings (5–10 cm), and tree (>10cm). The distance covered in a line transect was purely based on the natural barrier and distance covered in a specific period of time in each site with an average distance of 6.42km. The minimum and the maximum distances covered were 2km and 64.2km, respectively. The distance covered was classified into three classes for better analysis and representation, viz., <5 km, 5–10 km and >10 km (Table 1). Further, the plants located in the study sites were categorised into various altitudinal zones (Table 2). The population status was studied by observing and recording the number of individuals of the species during 2017–2019 in four different time periods, viz., May–June, 2017, May–June 2018, April–May 2019, October–November 2019 based on phenological cycle of the fruit. Further, the information on medicinal plants extraction and trade were collected through open-ended participatory discussion with the local informants (Joshi & Edingtong 2010; Bapu & Nimasow 2017). The collected data was represented with suitable tables and graphs.

RESULTS AND DISCUSSION

Linear transact survey carried out at 10 sites recorded 3,170 individuals of *I. griffithii*, out of which 1,372 were seedlings, 1,358 saplings, 314 mature trees, and 126 were dead plants. The population structures of the live plants found in these sites along the line transect have been presented in Table 1. The number of plants recorded in 10 sites varies from 38 to 852 individuals. Out of the total 3,044 live plants, the mature trees were only 314. The Namshu-Chander site recorded the highest with 105 individuals whereas Tenzingaon recorded the lowest with only two mature trees. Out of the total number of 1,358 saplings, Namshu-Chander had the highest number of individuals (319) whereas Tenzingaon had the lowest number of individuals (11). Out of the total 1,372 seedlings, the highest number of individuals was recorded in Morshing (518) followed by Namshu-Chander (259), Lubrang (157) and the lowest in Shergaon (21). Overall, the number of live plants was highest in Namshu-Chander as the area is located relatively away from the settlements. Further, the Namshu Village Council has imposed a ban on the felling of *Illicium* for the last 30 to 35 years which is also a contributing factor for the abundance of the species in the wild. Morshing area recorded higher numbers of seedlings and saplings which may be attributed to the decline in fruit collection thereby allowing regeneration of the species. Moreover, recently the village council has also imposed certain restrictions on the felling of trees. Among the mature trees, the largest girth was recorded in Namshu-Chander site (1.80m gbh) followed by Morshing (1.55m gbh). The plant was found scattered and isolated in Tenzingaon and Shergaon areas. In the Tenzingaon area, large-scale land fragmentation and land conversion is taking place for agriculture and horticulture purposes leading to loss of species or habitat. The respective village councils of Senge and Lubrang have also banned the felling of *Illicium* recently. During the field survey frequent occurrence of stump sprouting was observed which reflects the coppicing ability of the species.

The distribution of various girth classes, i.e., seedlings (<5 cm), saplings (5-10 cm) and trees (>10 cm) of the species showed significant difference among the sites (Figure 2). The individual girth class followed the trend: seedlings > saplings > trees in the >10km distance category. The trend in <5 km and 5–10 km distance categories, however, were: seedlings < saplings > trees (Table 1 & Figure 2). The overall trend in terms of number of individuals in different category of growth was: seedlings (1,372) > saplings (1,358) > trees (314). So, the regeneration status of *Illicium* appears to be satisfactory in contrast to the poor regeneration of the species as reported by Duckhok et al. (2005). The difference in findings may be attributed to the declining trend of fruit collections compared to the late 1990s and early 2000s period. Because large-scale collection of *Illicium* fruits was reported from Arunachal Pradesh during 1990 till early 2000 which restricted the natural growth of the plant (Paul et al. 2013). The potential of species regeneration can be understood by the presence of seedlings and saplings in an area (Saxena & Singh 1984). The survival rate of the seedlings was found to be high in the study area which is in agreement with Paul et al. (2013) but in contrast to the findings of

Table 1. Population structure of live *Illicium griffithii* and distance covered in 10 sites.

Distance category	Site	No. of seedlings (<5cm gbh)	No. of saplings (5cm-10cm gbh)	No. of trees (>10cm gbh)	Total	Distance covered in a transect (km)
>5 km	Mandala Phudung	67	53	21	**141**	2
	Tenzingaon	25	11	2	**38**	2.9
	Sanglem	50	12	3	**65**	2.3
	Senge	124	238	9	**371**	2.9
5–10 km	Shergaon	21	29	11	**61**	5.8
	Bomdila	116	149	18	**283**	5.3
	Lubrang	157	251	17	**425**	5.1
<10 km	Nyukmadung	35	70	20	**125**	12.8
	Namshu-Chander	259	319	105	**683**	11.9
	Morshing	518	276	58	**852**	13.2
Total		**1372**	**1408**	**264**	**3044**	**64.2**

(Source: Field survey, 2017-19)

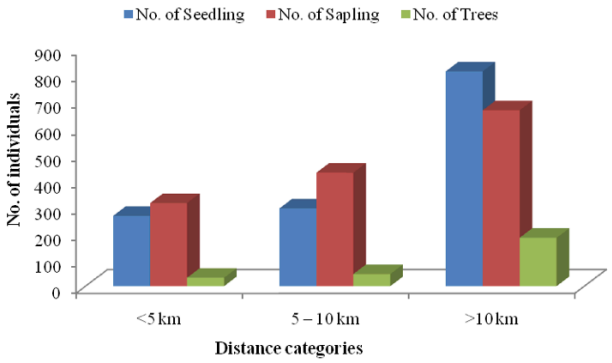

Figure 2. Population structure of *Illicium griffithii* (distance surveyed).

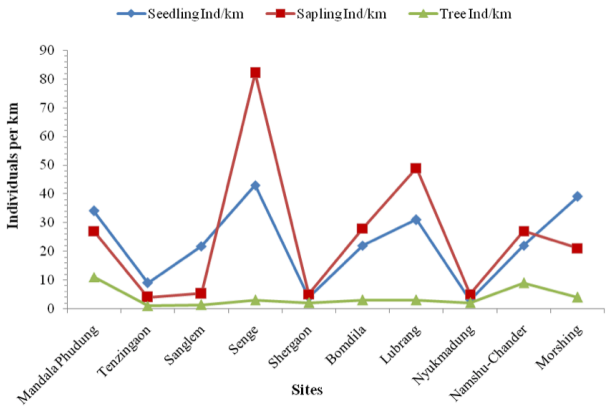

Figure 3. Number of individuals per km in the study sites. Source: Field survey 2017–2019.

Duchok et al. (2005). This might be due to a decline in the collection of *Illicium* fruits, thus contributing to its natural regeneration since 2010. Nevertheless, the establishment of saplings in comparison to number of trees present was very poor (trees < saplings) due to selective felling of larger girth trees for creating fields of plantation crops and other agricultural purposes, construction related activities, and for fences and fuel wood which are the underlying factors hindering the survival rate of saplings. Thus, the variations in number of individuals among different classes may be ascribed to the prevailing environmental factors and degree of disturbances (Duchok et al. 2005). The villagers informed that *Illicium* bears fruit in alternate annual cycles resulting in good production in a particular year but poor production in the next year. Similar finding has also been reported by others (Ved et al. 2003). People of Nyukmadung and nearby areas also informed that a huge forest area, mostly dominated by *I. griffithii* was gradually converted to pasture land in Nyukmadung after the establishment of a Yak Farm in 1989.

The survey revealed that the maximum occurrence of *I. griffithii* (1442 individuals or 47.37%) was observed in the altitudinal range of 2,600–2,800 m followed by 2,400–2,600 m (741 individuals), 2,800–3,000 m (636 individuals), 2,200–2,400 m (209 individuals), and 2,000–2,200 m (16 individuals) (Table 2). It was further observed that the species was growing abundantly in the altitudinal range of 2,500–2,750 m. Although, the present study found that the species was growing between 2,000–3,000 m (± 20 m), some earlier studies found it to be growing between 1,600–2,500 m (Hussain & Hore 2008), 1,700–3,000 m (Paul et al. 2013), 2,000–2,800 m (Gajurel et al. 2015). Such variation might be due to the tolerance level of the species or to a bio-climatic zone which is favourable for its growth.

It is reported that the price of the fruits ranged

Table 2. Altitude-wise population structure of live *Illicium griffithii*.

Altitude range (in m)	No. of seedling	No. of sapling	No. of trees	Total
2,000–2,200	10	6	0	**16**
2,200–2,400	107	78	24	**209**
2,400–2,600	330	339	72	**741**
2,600–2,800	652	650	140	**1442**
2,800–3,000	273	335	28	**636**
Total	**1372**	**1408**	**264**	**3044**

(Source: Field survey, 2017-19)

Table 3. Proximity, altitude, habits and threats to *Illicium griffithii*.

Site	Proximity to settlement	Altitude range (m) (+ - 20m)	Parts Used	Types of threats
Mandala Phudung	Nb	2,890–2,910	fr, lv, st	Tr, HoP, Df, Tp
Tenzingaon	Nb	2,230–2,280	St	HoP, Df
Sanglem	Nb	2,650–2,680	fr, st	Tr, HoP, Tp
Senge	Nb	2,810–2,910	fr, lv	Tr, Tp
Shergaon	F	2,120–2,760	fr, st	Tr, HoP
Bomdila	Nb	2,620–2,800	St	HoP
Lubrang	Nb	2,490–2,730	fr, lv, st	Tr, HoP, Tp
Nyukmadung	MF	2,380–2,730	fr, lv, st	Tr, HoP, Df
Namshu-Chander	VF	2,460–2,740	fr, st	Tr, HoP
Morshing	F	2,240–2,880	fr, st	Tr, HoP, Tp

Proximity to settlement: Nb—nearby (<1 km from settlement) | MF—moderately far (1–3 km from settlement) | F—far (3–5 km from settlement) | VF—very far (>5 km from settlement). **Parts used:** fr—fruits | lv—leaves | st—stems. **Types of threats:** Tr—trade | HoP—harvested for other purposes (e.g., fence, pole, construction) | Df—deforestation | Tp—trampling.

from Indian Rupees (INR) 120–150 per kg (Paul et al. 2013) and INR 100–200 during the early 2000 (Bapu & Nimasow 2017), which went down to INR 50 per kg during 2010, leading to less interest in fruits collection (Bapu & Nimasow 2019). *Illicium* fruits are mainly marketed through middlemen from the district which are sold at nearby markets at higher prices (Paul et al. 2013; Bapu & Nimasow 2017, 2019). Further, the local people informed us that the demand for fruits of *Illicium* was high during 2002–2007 (Bapu & Nimasow 2017) and fetched around INR 10,000–15,000 annually to a household (Bapu & Nimasow 2019). They also informed that the demand in the market has gone down, and therefore the price of the *Illicium* fruits is as low as INR 40 at present, however, interactions with the Range Forest Officer, Bomdila revealed that the low market demand is mainly due to the monopoly in the market. The actual rate in international market is as high as INR 700–800 per kg and around INR 400 in Mumbai, Maharashtra (Tsering Dorjee Megeji pers. comm., Range Forest Officer, Bomdila). The collection and trade of *Illicium* fruits in the district is regulated by issuing permit to the traders by the forest department. Some years back, however, the officials of Bomdila Forest Division reportedly seized *Illicium* products owing to improper documents for trade.

Many studies on population and regeneration status of a specific species have focused mostly on the number of individuals in a unit area (Dhar et al. 1997; Duchok et al. 2005; Paul et al. 2019) and number of individuals along linear transects (Nimachow et al. 2010). On an average, 32 individuals of *I. griffithii* in 1.0km linear transect was recorded in West Kameng District. The average number of seedlings, saplings and trees in the linear transect were 23, 24, and 5 individuals per km, respectively. The total number of seedlings (per km) ranged from 3–43, saplings 4–82 and trees 1–11. The maximum number of seedlings (per km) were recorded in Senge (43 individuals), followed by Morshing (39), Mandala Phudung (34), Lubrang (31) and lowest in Nyukmadung (3). The highest saplings (per km) was also reported in Senge (82) followed by Lubrang (49),

Mandala Phudung and Namshu (27) and lowest in Tenzingaon (4). The number of mature trees (per km) was recorded highest in Mandala Phudung (11) followed by Namshu-Chander (9) and the lowest in Tenzingaon and Sanglem (1 each). The sites located far away from the human settlements recorded a higher number of plants whereas the sites located near the settlements had a lesser number of plants owing to the higher rate of anthropogenic influences, as presented in Table 3. The local communities use *Illicium* mostly for pole, fences and others. Currently, the major threats to the species were deforestation, harvest of trees for various purposes including construction work and erection of fences, etc. and trampling of plants by bovines. Looking at the multiple uses of the plant, plantation and other conservation measures are essential for sustainability of the plant. The Bomdila Forest Division had ventured and planted *I. griffithii* in around one hectare of land at one mile area near Bomdila during 1990–1991 which was found to flourish during the field survey. Hence, more such efforts by the governmental and non-governmental organizations with community participation might be helpful in regeneration and conservation of the plant.

CONCLUSION

A comprehensive study to understand the existing population status of a species is considered to be the most important in order to effectively protect the species from extinction (Vischi et al. 2004). The present study provides comprehensive information on population structure, regeneration status and distribution of *Illicium griffithii* Hook.f. & Thomson in West Kameng District of Arunachal Pradesh (India). The plant was found growing between altitudinal range of 2,100–2,930 m but showing its abundance between 2,500–2,750m. The study found a good number of *I. griffithii* in natural stand but only in a limited area. The dominance of saplings and seedlings over trees at all the sites was recorded which indicates its good regeneration potential. Adding to this, the localized distribution of the species, excessive extraction of large trees for various purposes and changing global climate has put a pressure on the population of the species. Although, the collection of fruits has declined in recent years, the silent illegal trade from deep inside of the forest cannot be ruled out. Cultivation and awareness on the value of such species can play an important role in the livelihood strategies of the local people in the study area. Therefore, proper awareness with regards to importance and market value of the species in particular and maintenance of the ecosystem as a whole is the need of the hour. The government and other organizations should encourage cultivation of *Illicium* and other important medicinal plants as a part of agroforestry, which in turn will help in conservation of these plants. Further, imparting proper training to the villagers on scientific way of fruits collection could ensure the sustainable utilization of the plant and its products. Finally, the present study opens up scope for further research on habitat suitability and impact of climate change of this endangered medicinal plant.

REFERENCES

Bapu, T.D. & G. Nimasow (2017). Extraction of important medicinal plants and the need for conservation strategies in Eastern Himalayan Region, pp. 177–181. In: Kaur, K. & S.A. Khan (eds.). *Development of Nations: interplay of Economics, Politics and Society*. Madan Publishing House, Patiala, India, 338pp.

Bapu, T.D. & G. Nimasow (2018). Land cover change assessment of Pakke Tiger Reserve (PTR), East Kameng district of Arunachal Pradesh. *Journal of Remote Sensing & GIS* 9(1): 26–33.

Bapu, T.D. & G. Nimasow (2019). Medicinal plants as a source of livelihood in Arunachal Pradesh, pp. 127–136. In: Nayak, S.K., L. Nochi & M. Lama (eds.). *Hill Economies and Sustainable Development in India: Emerging Realities*. Concept Publishing Company Pvt. Ltd., New Delhi, India, 308pp.

Bhuyan, P., M.L. Khan & R.S. Tripathi (2003). Tree diversity and population structure in undisturbed and human-impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas India. *Biodiversity Conservation* 12: 1753–1773. https://doi.org/10.1023/A:1023619017786

Candeias, N.R., B. Assoah & S.P. Simeonov (2018). Production and Synthetic Modifications of Shikimic Acid. *Chemical Reviews* 118(20): 10458–10550. https://doi.org/10.1021/acs.chemrev.8b00350

Cui, Y.Y., C. Ling, Y.Y. Zhang, J. Huang & J.Z. Liu (2014). Production of shikimic acid from Escherichia coli through chemically inducible chromosomal evolution and cofactor metabolic engineering. *Microbial Cell Factories* 13(1): 1–11. https://doi.org/10.1186/1475-2859-13-21

Dhar, U., R.S. Rawal & S.S. Samant (1997). Structural diversity and representativeness of forest vegetation in a protected area of Kumaun Himalaya, India: implications for conservation. *Biodiversity & Conservation* 6(8): 1045–1062. https://doi.org/10.1023/A:1018375932740

Duchok, R., K. Kent, A.D. Khumbongmayum, A. Paul & M.L. Khan (2005). Population structure and regeneration status of medicinal tree *Illicium griffithii* in relation to disturbance gradients in temperate broad-leaved forest of Arunachal Pradesh. *Current Science* 89(4): 673–676.

Dung, N.X., T.D. Chinh & P.A. Leclercq (1995). Volatile constituents of the fruit oil of *Illicium griffithii* Hook. f. et Thoms. from Vietnam. *Journal of Essential Oil Research* 7: 451–452. https://doi.org/10.1080/10412905.1995.9698561

Dutta, S.C., B.N. Saha, M.G. Pathak, P.B. Kanjilal & R.K. Mathur (1997). Essential oil of *Illicium griffithii* Hook. f. & Thoms. *Journal of Essential Oil Research* 9(2): 227–228. https://doi.org/10.1080/10412905.1997.9699466

Gajurel, P.R., K. Ronald, R. Buragohain, P. Rethy, B. Singh & S. Potsangbam (2015). On the present status of distribution and threats of high value medicinal plants in the higher altitude forests of the Indian Eastern Himalaya. *Journal of Threatened Taxa* 7(6): 7243–7252. https://doi.org/10.11609/JoTT.o4041.7243-52

Ghosh, S., Y. Chisti & U.C. Banerjee (2012). Production of shikimic acid. *Biotechnology Advances* 30(6): 1425–1431. https://doi.org/10.1016/j.biotechadv.2012.03.001

Good, N.F. & R.E. Good (1972). Population dynamics of tree seedlings and saplings in a mature eastern hardwood forest. *Bulletin of the Torrey Botanical Club* 99(4): 172–178.

Hung, N.V., D.N. Dai, B.V. Thanh & I.A. Ogunwande (2016). Constituents of essential oils from *Illicium micranthum* Dunn and *Illicium griffithii* Hook.f. & Thoms. *Journal of Medicinal Plants* 4(6): 80–84.

Hussain, S. & D.K. Hore (2008). Collection and conservation of major medicinal plants of Arunachal Pradesh. *Indian Forester* 12: 1663–1679.

IUCN (2003). Guidelines for Application of IUCN Red List Criteria at Regional levels: Version 3.0 IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. https://www.iucn.org/content/guidelines-application-iucn-red-list-criteria-regional-levels-version-30.

Joshi, A.R. & J.M. Edington (1990). The use of medicinal plants by two village communities in the central development region of Nepal. *Economic Botany* 44(1): 71–83. https://doi.org/10.1007/BF02861069

Kalita, J. & M.L. Khan (2013). Medicinal plants from the high altitudes of the western part of Arunachal Pradesh, India and their trade. *International Journal of Conservation Science* 4(3): 337–346.

Kaul, R.N. & K. Haridasan (1987). Forest types of Arunachal Pradesh-A preliminary study. *Journal of Economic and Taxonomic Botany* 9(2): 379–389.

Kew Science (2019). Royal Botanical Garden Kew. https://www.kew.org/science. Accessed on 21 January 2019.

Khan, M.L., J.P.N. Rai & R.S. Tripathi (1987). Population structure of some tree species in disturbed and protected sub-tropical forests of northeast India. *Acta Oecologica* 8: 247–255.

Mukhia, P.K. (2006). Management Guidelines for *Illicium griffithii* for Community forests of Bhutan, Participatory Forest Management Project Report 32, Social Forestry Division, Department of Forests, Ministry of Agriculture, Thimbu, Bhutan. https://www.academia.edu/603439/Illicium_griffithii_Management_Guidelines.

Nimachow, G., J.S. Rawat & O. Dai (2010). Status of Himalyan yews in West Kameng district of Arunachal Pradesh. *Current Science* 98(11): 1434–1347.

Novacek, B.P. & E.E. Cleland (2001). The current biodiversity extinction event: scenarios for mitigation and recovery. *Proceedings of the National Academy of Science of the United States of America* 98(10): 5466–5470. https://doi.org/10.1073/pnas.091093698

Paul, A., J. Kalita, M.L. Khan & O.P. Tripathi (2013). *Illicium griffithii* Hook. f. & Thoms. – A potential source of natural off-farm income to the rural people of Arunachal Himalaya, India. *Indian Journal of Natural Products and Resources* 4(2): 131–137. http://nopr.niscair.res.in/handle/123456789/19909

Paul, S., S.S. Samant, M. Lal & J. Ram (2019). Population assessment and Habitat Distribution Modelling of high value *Corylus jacquemontii* for *in-situ* conservation in the state of Himachal Pradesh, India. *Proceedings of the Indian National Science Academy* 85(1): 275–289. https://doi.org/10.16943/ptinsa/2018/49507

Pritts, M.P. & J.F. Hancock (1983). The effect of population structure on growth patterns in the woody goldenrod *Solidago pauciflosculosa*. *Canadian Journal of Botany* 61(7): 1955–1958. https://doi.org/10.1139/b83-210

Saha, D. & R.C. Sundriyal (2010). Stand structure, phenology and fruit yield *of Illicium griffthii* in western Arunachal Pradesh, Northeast India. *Indian Journal of Forestry* 33(4): 475–488.

Saha, D., D. Ved, K. Ravikumar & K. Haridasan (2015). *Illicium griffithii*. *The IUCN Red List of Threatened Species* 2015: e.T50126617A50131370. Downloaded on 30 April 2017. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T50126617A50131370.en

Saraswathy, A., R. Shakila, S.M. Lavanya & A. Arunmozhidevi (2010). Essential oil constituents of *Illicium griffithii* and its antimicrobial activity. *Pharmacognosy Magazine* 6(23): 208. http://doi.org/10.4103/0973-1296.66938

Sarma, J. & P. Sharma (2014). A checklist of medicinal flora in West Kameng district, Arunachal Pradesh, India. *NeBIO* 5(2): http://nebio.in/2014/04/22/nebio-52-april-2014/

Saxena, A.K. & J.S. Singh (1984). Tree population structure of certain Himalayan forest associations and implications concerning their future composition. *Vegetatio* 58*:* 61–69. https://doi.org/10.1007/BF00044928

Tag, H., L. Jeri, T. Mingki, J. Tsering & A.K. Das (2012). Higher plant diversity in Pakke Wildlife Sanctuary and Tiger Reserve in East Kameng district of Arunachal Pradesh: Checklist – I. *Pleione* 6(1): 149–162.

Ved, D.K., G.A. Kinhal, K. Haridasan, U. Ghate, V. Sankar & J.H. Indresha (2003). Report of the Conservation Assessment and Management Prioritisation for the medicinal plants of Arunachal Pradesh, Assam, Meghalaya and Sikkim. Foundation for Revitalisation of Local Health Traditions (FLRHT), Bangalore, India, 153pp.

Ved, D.K., G.A. Kinhal, K. Ravikumar, R.V. Sankar & K. Haridasan (2005). Conservation Assessment and Management Prioritisation (CAMP) for wild medicinal plants of North-East India. *Medicinal Plant Conservation* 11: 40–44.

Vijayakumar, A., V. Duraipandiyan, B. Jeyaraj, P. Agastian, M.K. Raj & S. Ignacimuthu (2012). Phytochemical analysis and in vitro antimicrobial activity of *Illicium griffithii* Hook.f. & Thoms extracts. *Asian Pacific Journal of Tropical Disease* 2(3): 190–199. https://doi.org/10.1016/S2222-1808(12)60045-0

Vischi, N., E. Natale & C. Villamil (2004). Six endemic plant species from central Argentina: an evaluation of their conservation status. *Biodiversity & Conservation* 13(5): 997–1008. https://doi.org/10.1023/B:BIOC.0000014465.31740.9b

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