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Rattan resources of Manipur: species diversity and reproductive biology of elite species

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Abstract—Rattans, the climbing palms, are one of the most important non-wood forest produce after timber, supporting the livelihood of many forest-dwelling communities in South and South-East Asia. They are known for their strength, durability, elasticity and lightness and are used in making a variety of products. Excessive harvest, loss of habitat and poor regeneration in nature have resulted in the dwindling of the rattan population, much before the existing rattan resources can be identified, thereby resulting in an urgent need to evaluate and conserve the existing rattan resources. This paper studies the species diversity, characteristic features and utilization pattern of the various rattans in the nine districts of Manipur and reproductive biology of elite species.

Key words: *Calamus*; *Daemonorops*; reproductive biology; species diversity.

INTRODUCTION

Rattans, commonly known as canes, are a group of trailing or climbing palms with characteristic scaly fruits. They comprise more than 50% of the total palm taxa found in India [1] and form typical components of the moist forests in the Western Ghats, sub-Himalayan hills, valleys of Eastern and North-Eastern India and in the Andaman and Nicobar Islands. Next to Indonesia, India has the greatest diversity and the richest sources of cane in the world. Over 70 species of rattans from five genera occur in different bioclimatic regions of the country [2]. Out of these nearly 73% of the species are endemic to the country [3].

As the world's demand for rattan and rattan products is increasing, there is a tremendous pressure on the natural population of rattans. Besides extraction pressures, rattans are also severely threatened by changes in land use patterns. The threat is accentuated by the fact that canes, except those of the genus *Korthalsia*, are dioecious and because of their premature harvest, they rarely come to flowering and

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fruiting. Since the reproduction of cane mostly occurs through seeds, the poor seed set adversely affects regeneration of the species. In spite of the increasing concern for rattans, the status of the different species of rattans is far less clear in Eastern Himalayan forests and adjoining areas of the 7 North-Eastern States of India. Precise documentation of the threats to the various species is also compounded by difficulty in identification during the young stages. If conservation measures are not initiated at the earliest possible time, wild stands of rattan may face extinction [4]. In order to conserve and produce genetically improved rattans that are commercially important, basic information on reproductive biology is of utmost requirement [5]. However, detailed information on diversity, and flowering and fruiting biology of rattans of Manipur, a State in North-Eastern India, is lacking, apart from six species sporadically mentioned floras of the region [6]. However, in this paper, we have reported twelve species belonging to two genera, *viz*., *Calamus* and *Daemonorops*. None of the identified species come under the Red List of endangered species. In view of the urgent need for evaluating the rattan diversity, the present study highlights the various rattan species with their characteristic features, utilization patterns and reproductive biology of some elites.

MATERIALS AND METHODS

Surveys for the floristic distribution of rattans were conducted in nine districts of Manipur, namely, Bishnupur, Chandel, Churachandpur, Imphal-East, Imphal-West, Senapati, Tamenglong, Thoubal and Ukhrul (Fig. 1). The vegetative and reproductive parts of the plants were collected, and dried specimens were deposited in the Department of Life Sciences, Manipur University. The colour of the stem, pattern and arrangement of spines, number and arrangement of leaflets, presence or absence of cirrus or flagellum, nature of inflorescence, shape, size and colour of fruit were noted. The thickness of the cane with and without leaf sheath was also recorded. Identification of the different species was done by examining the vegetative and reproductive parts. Specimens at the Cane Herbaria, State Forest Research Institute, Itanagar, Arunachal Pradesh, were also referred for confirmation of identity. Naming of the species was done by referring to Basu [7], Beccari [8–11] and Hooker [12]. Morphological details were drawn after observing the various parts of the plants. Vernacular names (in Manipuri) are given for easy reference. The details of the specimens recorded, were primarily the author's observations in the field conditions. The type of inflorescence, flowering and fruiting phenology, chronology of flower and fruit development, and seed germination of the collected rattan species were studied. The seed germination experiments were conducted in the Experimental Field, Department of Life Sciences, Manipur University by sowing the matured fruits in well-prepared nursery beds. The fruits were divided into three groups: whole fruits, fruits without pericarp and fruits without pericarp and sarcotesta. Each fruit was sown at a spacing of 5 cm $\times$ 5 cm. All the experiments were carried out between 2001 and 2004.

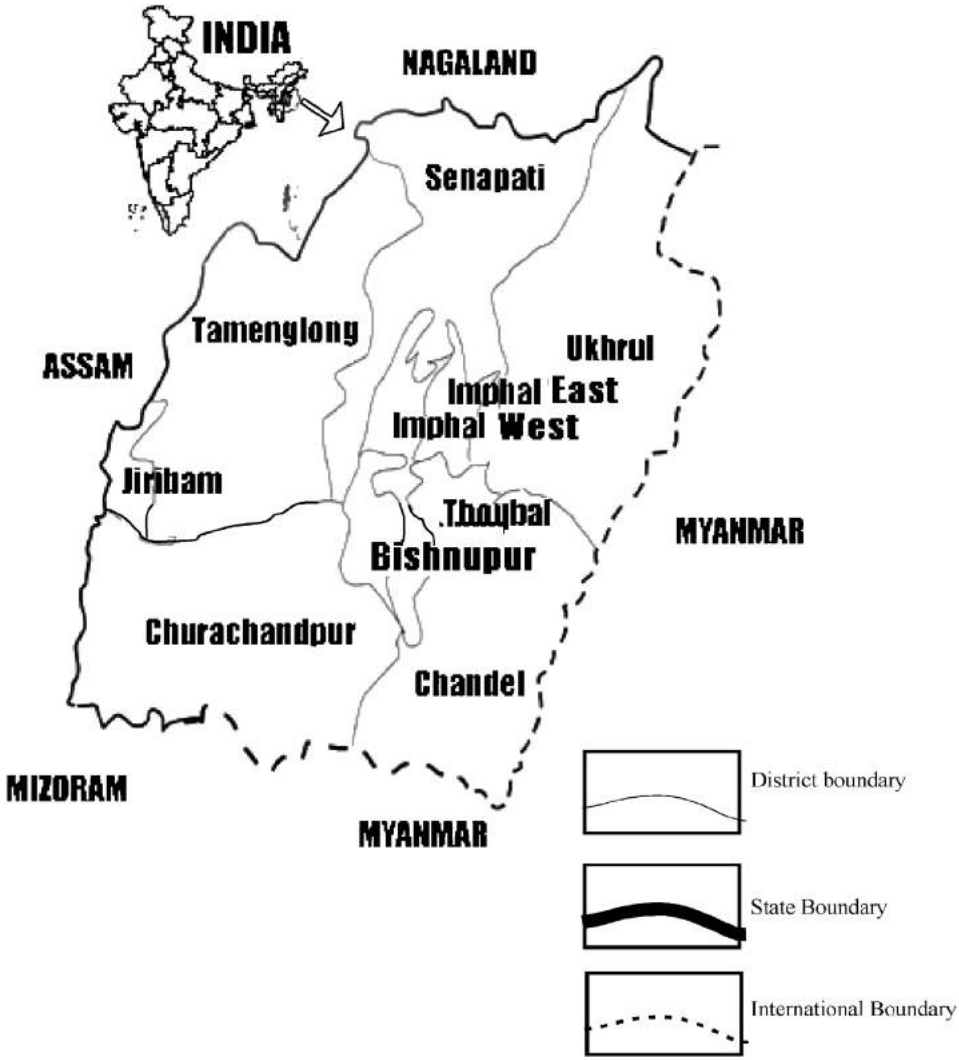

Figure 1. Map of Manipur showing the different districts.

RESULTS

Twelve rattan species, including one variety belonging to two genera, *viz*., *Calamus* and *Daemonorops*, have been collected from the surveys conducted in the nine districts of Manipur. They are identified and named by comparing with other specimens as stated in Materials and Methods. The identified rattans are as follows:

(1) *Calamus acanthospathus* Griff.

(2) *Calamus arborescens* Griff.

(3) *Calamus erectus* Roxb.

(4) *Calamus flagellum* Griff.

Figure 2. Stem of *Calamus acanthospathus* Griff.

(5) *Calamus floribundus* Griff.
(6) *Calamus guruba* (Buch–Ham) ex Mart.
(7) *Calamus inermis* T. Anders.
(8) *Calamus latifolius* Roxb.
(9) *Calamus latifolius* Roxb var. *mormoratus* Becc.
(10) *Calamus leptospadix* Griff.
(11) *Calamus tenuis* Roxb.
(12) *Daemonorops jenkinsiana* (Griff.) Mart.

The specimens are listed alphabetically along with their morphological descriptions. All species collected during the course of study are known through their Manipuri names.

(1) Calamus acanthospathus Griff. (Hunphop)

A moderately robust rattan; stem cluster-forming, with leaf-sheath 5 cm in diameter, without leaf-sheath 2–2.5 cm in diameter, green. Leaves ecirrate, about 1–1.5 m long; leaf-sheath without a conspicuous knee and petiole, heavily covered with small tuberculate spines and broad based single spines; flagellum about 1.5 m long; leaflets 40–45 cm long, 5–6 cm broad in the middle, broadly lanceolate, large, inequidistant, 5–7 costate, costae unarmed on both surfaces, terminal leaflets slightly connate at the base. Fruits and flowers not observed during the study period

Figure 3. Stem of *C. arborescens* Griff.

(Fig. 2). Locality: Jiribam (Imphal East, altitude 40 m asl); used in furniture works and handicrafts.

(2) Calamus arborescens Griff. (Lithit)

A non-climbing rattan, stem erect, 4-6 cm in diameter, internode about 15–20 cm long, leaves arching, leaf-sheath with knee and flagellum, petiole and rachis covered with thick spines, leaflets equidistant, deep-green above, whitish below, spiny at the margins and apices, upper and lower midnerves bristly. Inflorescence longer than the leaves, 2–3 m long, peduncle between the partial inflorescences 30–60 cm long, pendulous, much tapering towards the apex, peduncle green, spiny, elongated, partial inflorescence 8–10, bracts 20–30 cm long, lacerate at the upper part, rachillae 30–32 in number. Male rachilla scorpiod, male flowers in two vertical rows, calyx cup-shaped 0.3 cm long, 3-lobed, corolla acute, valvate, filaments longer than corolla, anthers linear, exerted, pistillode, angular with 3 abortive carpels. Female inflorescence and fruits not seen (Fig. 3). Locality: Andro (Imphal East, altitude 790 m asl); used in making baskets and ropes.

(3) Calamus erectus Roxb. (Tangchaobi)

A non-climbing erect rattan, densely tufted, stem with leaf-sheath 3.5–4 cm in diameter, exposed part of the stem green, leaf-sheath peels off when matured; internodes 5–10 cm long. Leaves ecirrate 200–300 cm long; leaf-sheath without a flagellum, knee absent, armed with black to yellowish, flattened spines of irregular

Figure 4. Stem of *C. erectus* Roxb.

length; ocrea auriculate; petiole 150 cm long, subterete, covered with flat, straight and pale spines in semiwhorls; leaflets 80–82 cm long, linear, equidistant, green on both sides, one nerved, midrib and margins ciliolate; rachis armed below with irregular spines in semi-whorls. Inflorescence 100–105 cm long, compact, non-flagelliform, primary bract elongate, spiny, tubular, lacerate in the upper part, female inflorescence with 8–9 rachillae, rachilla without sterile basal part. Fruit ovoid-oblong, 3 cm × 2 cm (Fig. 4). Locality: Andro (Imphal East, altitude 790 m asl); not much used in furniture industry due to the enlarged nodal regions.

(4) Calamus flagellum Griff. (Lee)

A robust climber, with leaf-sheath 4.5 cm in diameter. Leaves ecirrate; leaf-sheath heavily armed with long and short spines, ocrea marcescent, petiole terete; leaflets equidistant, many in number, green on both sides, uppermost leaflets connate up to the middle, costae and margins bristly, rachis armed with claws at intervals (Fig. 5). Locality: Changjal (Chandel, altitude 1110 m asl); used in furniture and crafts, leaves sometimes used to thatch roofs by tribes of the area.

(5) Calamus floribundus Griff. (Heiri)

A robust climber, stem cluster-forming. Leaves ecirrate, armed with horizontal spines, leaflets not many, lanceolate. 3–5 nerved, upper leaves crowded, terminal leaflets connate at the base. Infructescence rachillae zigzag. Fruits globose, beaked, fruits scales in 10 series, straw-coloured, channeled in the middle, scale tips blackish

Figure 5. Stem of *C. flagellum* Griff.

brown in colour (Fig. 6). Locality: Molcham (Chandel), Noneh (Tamenglong), altitude 960–1440 m asl; the cane is used like other rattan species; the fruits are mainly eaten and offered to traditional deities during Manipuri New Year Day (Cheiraoba).

(6) Calamus guruba (Buch–Ham) ex Mart (Yairi)

A slender thicket-forming, climbing rattan, stem cluster-forming; with leaf-sheath up to 2 cm in diameter; internodes about 25–30 cm long. Leaves ecirrate, leaf-sheath with prominent knee and flagellum armed with recurved, single spines; leaflets numerous, equidistant, alternate to opposite, linear, prominently 3-nerved, green on both sides (Fig. 7). Locality: Phayeng (Imphal West, altitude 780 m asl); used for making ropes, split canes used for binding the bamboo baskets and other cane furniture.

(7) Calamus inermis T. Andersons (Lee-nan)

A robust climbing rattan, with leaf-sheath 5–6 cm in diameter; leaf-sheath smooth with distinct knee; leaflets numerous, linear-lanceolate, costae smooth on the lower surface but spinulose on the upper surface, margins spinulose, length of the leaflets decreases towards the tip (Fig. 8). Locality: Takao forests (Tamei, Tamenglong, altitude 740–1272 m asl); as the cane is robust, it is used as framework of furniture items.

Figure 6. Stem of *C. floribundus* Griff.

Figure 7. Stem of *C. guruba* (Buch–Ham) ex Mart.

(8) Calamus latifolius Roxb. (Lee-ren)

Moderately robust climber; with leaf-sheath about 3 cm in diameter. Leaves cirrate; leaf-sheath with prominent unarmed knee, armed with strongly recurved spines, ocrea strap-shaped, rachis with 2–3 hooked claws on the dorsal side; leaflets not

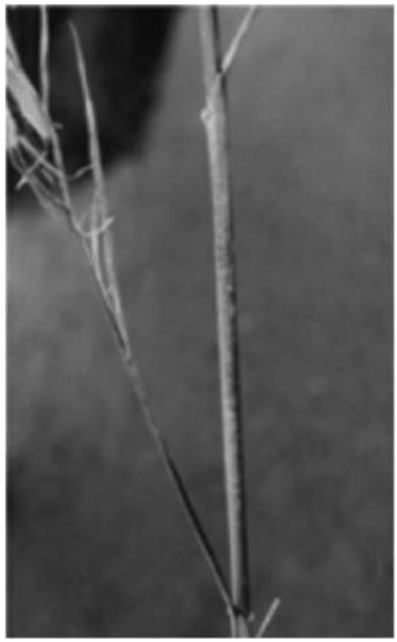

Figure 8. Stem of *Calamus inermis* T. Andersons.

many, interrupted, alternately in clusters of 2–5, broadly lanceolate, 5–7 nerved, glabrous on both surfaces, 4.5 cm wide. Male inflorescence decompound 150–180 cm long, 6–7 in number on a single plant, partial inflorescence branched, 20–24 in number, 30–40 cm long; rachillae 7–8 cm long with 15–20 flowers on each side of the rachillae, the sterile basal part of rachilla enclosed within the respective bracts; male flowers about 5 cm long, ovoid in bud, calyx externally striated upto the middle, forming 3 acute lobes. Female inflorescence decompound, rigid, 100–150 cm long, 4–5 in number; partial inflorescence 4–5 in number on a single plant, 30–35 cm long, with 12–13 rachillae, rachilla 7–8 cm long with 8–10 flowers on each side of the rachilla, each with a sterile male flower, involucre on the involucrophorum visible only by two projecting teeth on the side of the flower; female flowers 5 mm long, calyx unstriated, deeply divided, semiovate, acute, corolla lobes narrower than the calyx lobes. Fruit globose, 1-seeded, dull-brown to yellowish-brown, fruit scales in 10 vertical rows, flattened, scale tips reddish-brown, channeled in the middle, seed roughly pitted. Fruit 4 cm × 3 cm (Fig. 9). Locality: widely distributed in the state at altitudes 790–1520 m asl; most widely used cane in the furniture industry and in religious ceremonies; fruits and tender shoots edible.

(9) Calamus latifolius Roxb. var. mormoratus Becc. (Lee-ren)

Slender climber, with leaf-sheath about 2 cm in diameter. Leaves cirrate, leaf-sheath dark-green with distinct dark-brown patches, prominent knee, variously armed with

Figure 9. Stem of *C. latifolius* Roxb.

small and big spines, rachis with single claws on the dorsal side, leaflets not many, single or paired in 2s or 3s, 5–6 nerved, glabrous, broadly lanceolate, 5–6 cm broad and 20–25 cm long. Male inflorescence decompound, rachillae 5–6 cm long with 10–12 flowers on each side of the rachilla; female inflorescence decompound 50–60 cm long, 1–2 in number per plant; partial inflorescence 4–5 in number, 30 cm long with 10–12 rachillae, rachilla 5–6 cm long with 8–10 flowers on each side of the rachilla. Fruit elongated, 1-seeded, dark-brown to dull-brown, channels distinct (Fig. 10). Locality: Saparmeina (Senapati), Thanga (Bishnupur), Takao Forests (Tamei, Tamenglong), altitude 740–910 m asl; cane used in furniture works like *C. latifolius* Roxb. Fruits edible.

(10) Calamus leptospadix Griff. (Lithit)

A slender cluster-forming rattan; with leaf-sheath 1.5–2.0 cm in diameter, without leaf-sheath 8–10 mm in diameter. Leaf-sheath with a conspicuous knee and flagellum, scurfy, armed with flattened, half-whorled or singly-arranged spines; flagella with a non-spinous base, armed with small claws; ocrea persistent; petiole and rachis armed with deflexed spines, rachis angular, covered thickly with greyish indumentum; leaflets many, closely set, alternate to subopposite upto 30 cm long, middle costae distinct, scurfy on the lower side, uppermost leaflets shorter. Male inflorescence flagelliform upto 1 m long, male rachillae scorpioid, primary bract tubular, rachilla 1–2 cm long with 6–12 male flowers very closely set. Male flowers 4 cm×1.5 cm; calyx tubular, divided into distinct lobes, corolla double the length

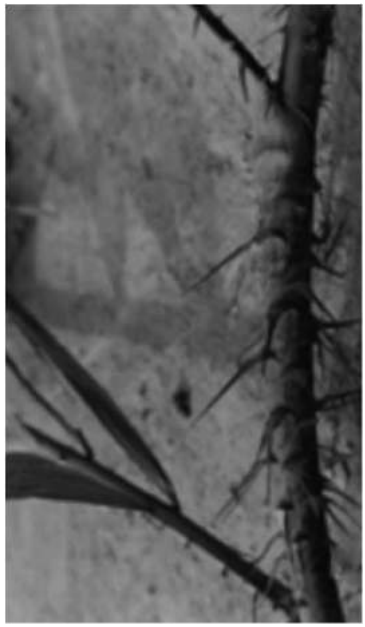

Figure 10. Stem of *C. latifolius* Roxb. var. *mormoratus* Becc.

of the calyx, divided into 3 segments. Female flowers and fruits not seen (Fig. 11). Locality: Baruni Hills (Imphal East, altitude 1113 m asl); the cane is delicate, so it is used in basketry and binding works.

(11) Calamus tenuis Roxb. (Yai-ri)

A slender climbing rattan, stem cluster-forming, with leaf-sheath 1–1.5 cm in diameter, without leaf-sheath 4–5 mm in diameter. Leaves ecirrate, 1 m long; leaf-sheath with conspicuous knee and flagellum, armed with broad-based straight spines confluent at their bases, petiole 15 cm long; rachis armed on the upper side with single, curved spines, spines 0.8–1 cm long with yellow base and blackish-brown tips; leaflets narrowly lanceolate, 35 cm long and 15 cm broad at the middle, gradually smaller towards the apex, uppermost leaflets smallest, spinules on the 3 costae of the leaflet. Female flowers decompound each with a neuter flower. Fruit globose, 10–11 mm in diameter, shortly beaked, fruit scales narrowly channeled at the middle, 1-seeded (Fig. 12). Locality: Kakching (Thoubal), Jiri, Hilghat (Imphal East), Tera (Imphal West), Tongjei Maril (Tamenglong), at altitudes 40–1782 m asl; fruits edible, cane used in furniture works for binding purposes.

(12) Daemonorops jenkinsiana (Griff.) Mart. (Lee-phop)

High-climbing rattan, stem with leaf-sheath 4–5 cm in diameter, internodes 15–20 cm long; leaf-sheath pale-yellow to yellowish-green covered with brown scurf, armed with thin, flattened, deep-brown to black spines in series or scattered;

Figure 11. Stem of *C. leptospadix* Griff.

Figure 12. Stem of *C. tenuis* Roxb.

leaves up to 3 m long, petiole 15–20 cm long, armed with strong, digitate claws and straight spines at the margins; leaflets equidistant, alternate to sub opposite, longest leaflets a little above the base, 40–50 cm long and 2–4 cm broad, ultimate

Figure 13. Stem of *Daemonorops jenkinsianus* (Griff.) Mart.

leaflets rudimentary. Inflorescence inserted above the mouth of the leaf-sheaths, peduncle 3–6 cm long, outer bract open-boat like, reddish-brown in colour. Female inflorescence not flagelliform, rachillae upto 8 cm long; female flowers 6–7 in number on each side of the rachilla, calyx copular, truncate, corolla veined with lanceolate petals, ovary ovoid with 3 stigmas. Fruit globose, 1.8 cm in diameter, fruiting erect, seed about 1 mm in diameter (Fig. 13). Locality: Jiribam (Imphal East, altitude 40 m asl); used in the furniture industry.

REPRODUCTIVE BIOLOGY

Male inflorescences of both *Calamus* and *Daemonorops* found in Manipur have only fertile staminate flowers, while the female inflorescence has pistillate flowers borne in pairs with the sterile male flowers also called the acolyte flowers. Tables 1 and 2 and Figs 14–17 provide detailed information regarding the reproductive biology of *Calamus latifolius*, *C. latifolius* var. *mormoratus*, *C. arborescens* and *Daemonorops jenkinsiana.*

Generally, it was found that the period of inflorescence emergence to fruit development varied from site to site. Small fruits of these two rattans were observed 4–5 months after the emergence of the inflorescence. Size of the fruits increased gradually until the 12th month, when most of the rattan fruits reached their maximum size. The colour changed from dark-brown to pale-yellow. There was a gradual reduction in the number of fruits from December to March–April when the fruits matured. After March–April, there was a sudden increase in the rate

Table 1.
Reproductive chronology of rattans of Manipur (2001–2004)

Species	Inflorescence					Emergence of inflorescence	Flowering season	Fruiting season	Fruits per infructescence	Fruit	
	Length (cm)	Partial inflorescence		Rachilla						Shape	Colour
		No.	Length (cm)	No.	Length (cm)						
C. latifolius Roxb.	150–180	20–24	30–40	25–26	7–8	Oct.–Nov. Sep.–Oct.	Feb.–Mar.	Apr.–May	300–400	globose	dull brown–yellowish brown
C. latifolius Roxb. var. *mormoratus* Becc.	50–60	4–5	25–30	10–12	5–6	Oct.–Nov.	Feb.–Mar.	Apr.–Jun.	130–200	elongated	dull brown–dark brown
C. arborescens Griff.	180–200	8–10	—	20–24	—	—	Feb.–Apr.	—	—	—	—
D. jenkinsianus (Griff.) Mart.	—	—	—	—	—	—	Jul.–Aug.	Apr.	100–120	elliptical	pale green–dark green

Table 2.
Inflorescence emergence to fruit initiation in certain rattans

Species	Emergence of inflorescence stalk	Pre-anthesis stage	Anthesis stage	Post-anthesis stage
C. latifolius Roxb.	Oct.–Nov. Sep.–Oct.	Dec.–Jan.	Feb.–Mar.	Mar.–Apr.
C. latifolius Roxb. var. *mormoratus*	Oct.–Nov.	Dec.–Jan.	Feb.–Mar.	Mar.–Apr.

Figure 14. Flowering chronology in female *C. latifolius* Roxb., emergence stage.

of fruit fall. In *C. latifolius*, flowers were observed to open during the early hours of the day. In *C. latifolius*, seed germination started after about 14 days and continued up to 3 months. Germination was identified by the elongation of the radicle and plumule. Germination rate was calculated by counting the number of seedlings per group. The highest germination rate was observed when the fruits were sown with their pericarp removed (88%). The germination rate decreased to 40% when the pericarp and sarcotesta were completely removed. The fruits sown with their pericarp and sarcotesta intact showed a germination rate of 80% (Table 3).

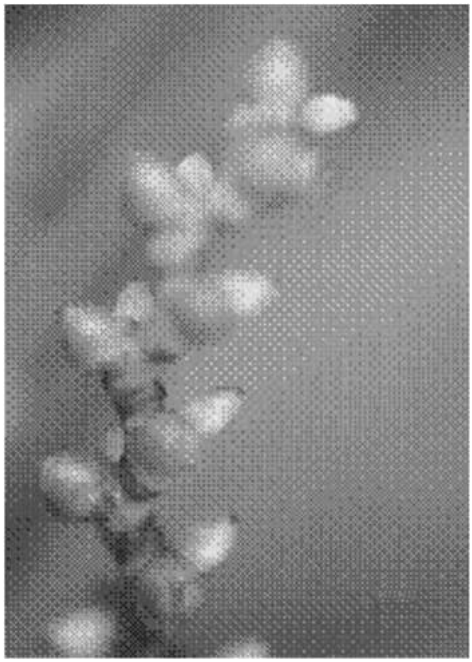

Figure 15. Flowering chronology in female *C. latifolius* Roxb., pre-anthesis stage.

Table 3.
Seed germination in *Calamus latifolius* Roxb.

Mode of sowing	No. of seeds	No. of seedlings germinated	Germination rate (%)
Whole fruit	25	20	80
Fruits with pericarp removed	25	22	88
Fruits with pericarp and sarcotesta removed	25	10	40

DISCUSSION

Being one of the important non-wood forest products, rattans contribute significantly to the socio-economics of the State. The lack of documentation strengthens the fear that sizeable proportions of the endemic species might have been eliminated unknowingly. Only seven species belonging to two genera, viz., *Calamus erectus*, *C. flagellum*, *C. floribundus*, *C. latifolius*, *C. leptospadix*, *C. tenuis* and *Daemonorops jenkinsiana* were reported by Deb [6]. However, during the present study, twelve species including one variety under the genera *Calamus* and *Daemonorops* were collected from Manipur. They have been identified giving proper names by referring to various floras and herbarium specimens.

Rattans have species-specific vegetative characters that enable differentiation between species even when reproductive parts are not available. To date, however,

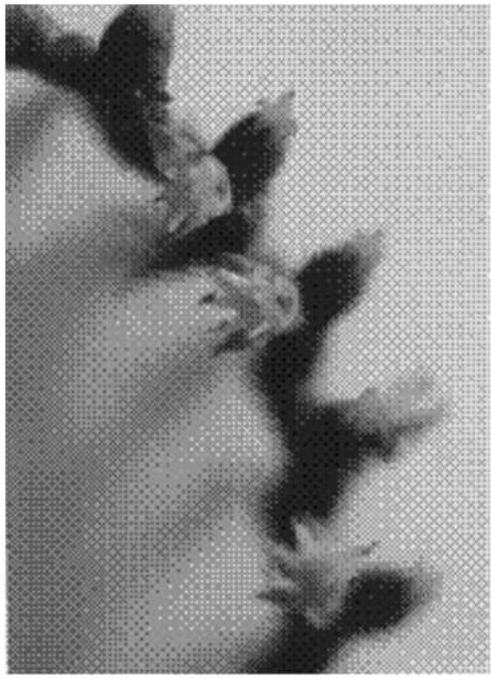

Figure 16. Flowering chronology in female *C. latifolius* Roxb., anthesis stage.

no proper scientific study has been conducted on rattans of Manipur, except for studies related to revenue generation. The present study, hence, highlights the specific characters of the rattans collected during the study period to enable identification by using the morpho-taxonomic characters. Differentiation of species by their fruits and seedlings as well as at maturity is essential since there are many instances where seedlings of commercially unimportant species may at first sight, be closely similar to those of the best species [13]. Interestingly, many species, which were not reported earlier from this area, have been recorded during the study. *C. acanthospathus* identifiable by its broadly lanceolate leaves, heavily armed leaf-sheath and long flagellum has not been reported earlier. It is differentiated from *C. vattaliya* by its heavily tufted-sheath and lanceolate leaflets [14]. *C. latifolius* var. *mormoratus* has been recorded for the first time in Manipur. Earlier studies have not differentiated this variety from *C. latifolius.* However, Basu [7] differentiated it by the presence of slender stem and, the dark and brown patches on the leaf-sheath. *C. arborescens* has distinct knee, rudimentary flagellum, thick spines on leaf sheath, and bristly, equidistant and discolourous leaflets. *C. erectus* can be identified easily by the straight and pale spines in semi-whorls on the leaf rachis. *C. flagellum* has distinct green leaflets which are equidistant and the upper ones are connate while in *C. floribundus* the upper leaflets are crowded. *C. guruba* is a slender thicket-forming rattan with prominent knee, flagellum and recurved single spines on the leaf sheath. *C. inermis* has a distinct smooth stem different from the spiny leaf sheaths of other

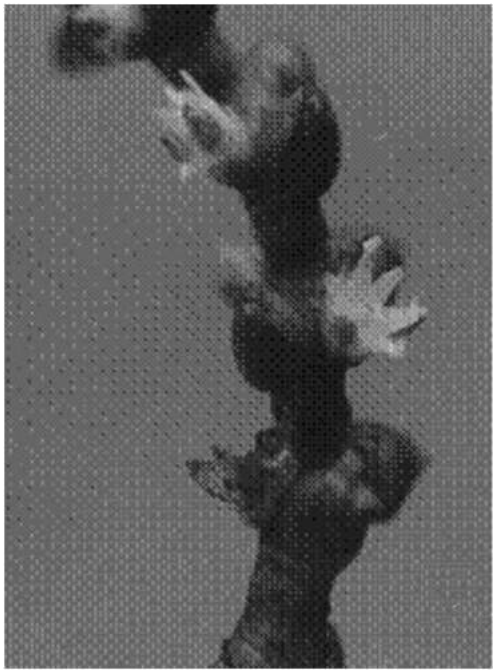

Figure 17. Flowering chronology in female *C. latifolius* Roxb., post-anthesis stage.

rattans. In *C. leptospadix*, the leaf-sheath has half-whorled singly-arranged spines while in *C. tenuis*, the spines are broad-based, straight and confluent at the bases. *Daemonorops jenkinsiana* can be easily identified by the yellowish-green, scurfy leaf-sheath armed with thin, flattened black spines and indistinct knee.

C. acanthospathus, *C. erectus*, *C. floribundus*, *C. gracilis*, *C. inermis*, *C. latifolius* and *D. jenkinsiana* are considered to be under threat due to their indiscriminate exploitation [15]. *C. gracilis* reported earlier could not be relocated during the surveys conducted within the study period. This might be due to over-exploitation and destruction of habitat as in the case of *C. delessertianus* and *C. rheedei* in the Western Ghats [16]. The reduced cycle of shifting cultivation has created environmental hazards like soil erosion and landslides. The natural home of rattans is, thus, being destroyed leading to genetic erosion. Many of the species reported earlier are not present now in their reported localities.

The rattan species best used in the State for furniture industry are *C. latifolius* and *C. tenuis.* Others like *C. flagellum*, *C. inermis*, *C. latifolius*, *C. latifolius* var. *mormoratus* and *C. tenuis* are also used. Most of the rattans supplied to the market come from the natural forests, which is fast-dwindling as the harvesting rate far exceeds the rate of plant regeneration. It is to be noted here that little attention has been paid to the species or variety or quality of rattan extracted but only the bulk supply required for market is taken into account. About 20–30% of the harvested canes are rejected either as waste or as unsuitable raw material. Harvesting

techniques and knowledge of the important species need to be improved to reduce the quantity of waste [17]. In *C. acanthospathus*, *C. inermis* and *C. leptospadix*, the stems are erect in the basal part but gradually bend to become scandent. *C. erectus* and *C. arborescens* are not climbers but have clusters of erect stems. The slender stems of *C. tenuis* and *C. guruba* form large thickets. In the slender species, the diameter varies from 6 to 15 mm. The medium and robust species have a stem diameter varying between 3 and 5 cm. The colour of the naked stem may be green, deep-green, light-green, pale-yellow or deep-yellow. The naked stem of *Calamus* is more glossier than that of *Plectocomia*, *Korthalsia* and *Daemonorops* [7].

C. latifolius and *C. latifolius* var. *mormoratus*, take almost 4 years to flower from the seedling stage. The female plants flowered earlier than their male counterparts. This is similar to the reports of Alloysius [5]. Flowering in rattans is species specific. The first indicator of flowering is a slight inflation of the bracts which ensheath the basal part of the partial inflorescence. The development of the partial inflorescences and the rachilla on it is acropetal. The inflorescence emits a sweet scent. In *C. thwaitesii*, the scent production began on the day prior to the opening of the male flowers and pollen was completely shed by noon [18]. Although the flowering and fruiting periods are annual, there are seasonal variations which occur from species to species. It was found that *C. latifolius* and *C. latifolius* var. *mormoratus* started flowering in February–April with the fruits maturing during April–May of the next year. The seasonal variation in the flowering of *D. jenkinsiana* starting in July–August may be due to a period of relative dryness and, hence, of a higher temperature, followed by a period of heavy rainfall in case of *D. jenkinsiana* [19–21].

Fruiting also varied according to species. Fruits were reported to take up to 14 months to mature after inflorescence emergence. The period of emergence of the inflorescence stalk to the maturity of fruits followed the pattern reported by Alloysius [5]. In semi-domesticated conditions, the number of fruits per plant was found to be more than in the wild conditions. In such conditions, the two rattan species *C. latifolius* and *C. latifolius* var. *mormoratus* bore more fruits in plants growing in large clusters. The same species growing singly often produced less fruits. The number of fruits depended on the number of mature stems. This is in accordance with the reports of Manokaran [22] and Dransfield and Manokaran [13], who correlated the increase in the number of fruits with the increase in the number of matured stems produced.

Germination of rattan seeds fits a type of germination known as adjacent ligular type. The emergence of a short plug from the embryo pit is the first sign of germination. Roots emerged followed by a small bladeless shoot which is then followed by the emergence of the eophyll. Seed germination rate of *C. latifolius* was found highest (88%) when the pericarp was removed but decreased to 40% when both pericarp and sarcotesta were removed. This low germination may be due to the damage of the embryos during the removal process [23]. Sumantakul [24] also reported a low germination rate of 16% for *C. latifolius* when the pericarp

and sarcotesta were removed. It might perhaps be due to the decrease in seed moisture content caused by the removal of the pericarp and sarcotesta. Mori *et al*. [25] reported the importance of moisture content of the seeds during germination. Seeds become non-viable below 4% and germinate when the moisture content is above 60%. The seeds devoid of pericarp and pulp germinated faster when kept in moist sawdust for two weeks before sowing [18]. However, the germination rate of fruits with only the pericarps removed has not been studied earlier. The present study reveals the highest germination rate (88%) when only the pericarps are removed, which may be due to the protrusion of the radicle and plumule made easy by removal of the pericarp and retention of moisture by the presence of the fleshy sarcotesta. By identifying these economically useful species and studying their reproductive biology, the pressure on lesser commercially useful rattans can be relieved. It can further help in preventing the over-exploitation of those species that are less important but nevertheless utilized in the furniture industry.

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