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Distribution, morphology, and phenology of *Piper acutistigmum* C. DC. – an endemic species of the Eastern Himalayan region

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Abstract

Piper acutistigmum C. DC. is an endemic species of the Eastern Himalayan region found in northeast India with the adjacent country Myanmar. A study was conducted to examine the distribution, morphology, and phenology of the species, which is an important step towards its conservation. Field surveys were conducted to locate the population, and observations were made on selected plants from three distinct locations. The study revealed that the species is mostly found in the foothills of Arunachal Pradesh and its bordering areas in Assam. The orthotropic and plagiotropic branches show distinct differences in terms of leaf size and shape, petiole, and internodal length. The average sizes of the leaves were 10 × 6 cm and 21.5 × 12.5 cm; petiole length was 3.7 cm and 2.25 cm and internodal length was 17.5 and 6.5 cm in orthotropic and plagiotropic branches, respectively. Leaf flushing occurs between the March and April months, more or less in synchronization with the emergence of the spike bud. The species starts flowering from April until the end of May. The fruiting spikes are observed from July to December. Sterile vines are most dominant in a population with a few fertile (male and female) individuals. The existing natural population is under threat from various developmental activities in and around their habitat and needs immediate attention for conservation.

Keywords

Conservation; morphological variations; occurrence; orthotropic branch; plagiotropic branch; threats

Introduction

The genus Piper of the family Piperaceae consists of approximately 2170 species, making it the second-largest genus of angiosperms (1). It has a pantropical distribution, with the most varied range of the genus occurring in the American tropics and then southern Asian nations (2). Due to the large number of taxa, some of which are difficult to differentiate from one another, resulting in many synonyms, it is challenging to determine the precise number of Piper species and their distribution (3). In addition, the genus exhibits a range of distribution patterns, from locally endemic to widely distributed. Some species are only found in one particular center of diversity, while others are found throughout the Neotropics and Paleotropics (4). Most species exhibit a limited geographic range (5, 2). The Indian species are concentrated almost entirely in northeast and southern India, including Andaman and Nicobar Island. The majority of the species found in

northeast India are endemic to the eastern Himalayan region, which encompasses the neighboring countries of Nepal, Bhutan, China, and Myanmar (6). These species contribute significantly to the composition of tropical and subtropical forests with their disjunct distribution and distinct male and female plants within each population. However, each species-specific distributional pattern and habitat preference are yet to be fully understood.

The genus Piper exhibits a dimorphic branching pattern that has vegetative and reproductive branches. Vegetative branches either trail on the ground as a runner shoots or climb high on the large tree trunks as a climber shoots. Despite the variety of growth forms present in Piper, it has been demonstrated that they are fairly similar in their structure, with the majority of species constructed following Petit's architectural model (7, 8). The upward-growing vertical branches have indeterminate growth and are called orthotropic branches. Simultaneously, they produce numerous lateral pendulous branches that bear reproductive structures in the later stage of life which are known as plagiotropic branches. Even though these two branches come from the same meristematic origins, they grow and look very different because they are oriented differently (vertically and horizontally) and serve different ecological purposes (vegetative and reproductive) (9). Understanding these intraspecific morphological variations is crucial for supporting accurate identification and delimitation of the species and preventing misunderstandings that frequently result in misidentification. In the present study, we have characterized the species to understand the morphological variations for their taxonomic discrimination.

The timing of seed germination and seed dissemination, together with the activities of pollinators, frugivores, and flower and fruit predators, are all directly or indirectly influenced by the seasonal yield of flowers and fruits in the community (10). For plants, flowering and fruiting are significant life phases that have implications for ecology and evolution (11, 12). Phenology is widely understood to be the practice of observing the stages of an organism's life cycle and its activities as they take place throughout the year (13). Plant phenology involves monitoring and documenting the recurring growth phases and analyzing the patterns and relationships between the annual cycles of development and their environmental influences (14). Recurring biological activities in plants include vegetative processes like leaf shedding and flushing as well as reproductive processes like bud formation, flowering, and fruit production (15). Phenology is the easiest to observe and most responsive component of nature to warming (16). Most phenological research on Piper species has been done in the Neotropics (17–20). However, there are few studies (21, 22) that have been carried out in the old world. An in-depth understanding of phenological studies aids in the conservation of species as well as in the formulation of efficient methods for their sustainable cultivation.

Piper acutistigmum C. DC., an endemic species of the Eastern Himalayan region, was first described and reported from Myanmar by De Candolle. (23, 24). The species was first time recorded in India in 2000 in the foothills of Arunachal Pradesh and its adjoining areas (25). Although recently Mukherjee (26) reported the occurrence of the species from Andaman and doubted the identity of the species occurring in Arunachal Pradesh. However, there is no evidence of the occurrence of the species in Andaman, and its occurrence in the northeast was confirmed very clearly (25). The species can be regarded as one of India's rare species because of its restricted distribution and limited population. It is known to have some ethnomedicinal properties that aid in the fast healing of fractured bones (6). The population of this species, which is primarily found along the forest edges, is seriously threatened by the unchecked development and construction taking place in the state. Moreover, there has not been much study done on this species, restricting our knowledge about its ecological or economic importance. The species exhibits a clear branching dimorphism, which sometimes creates confusion in its identification. Phenological studies are found to be significant in understanding the biological changes taking place throughout the year. Considering its ethnomedicinal and ecological values, which have an endemic distribution with a limited known population, the present study has been attempted, which could pave the way for needful management and conservation.

Materials and Methods

Study site

The study was conducted from 2020 to 2022 through an extensive field survey in the states of Arunachal Pradesh and Assam in northeast India. Observations on phenological changes were made for two years, from January 2021 to December 2022, in the Papum Pare district of Arunachal Pradesh. A precursory step of comprehensive study and interpretation of available literature was done before the field visit to understand the distribution and habitat preferences of the species. The field survey was then carried out in different forest areas of the two states to locate the occurrence and distribution of the species. The places where the occurrence of *Piper acutistigmum* populations was observed were recorded, and based on the availability of the species, three different forest areas in the Papum Pare district of Arunachal Pradesh were considered for the convenience of the study (Fig. 1). The selected sites are Rono hills (27˚15′ N, 93˚76′ E, 238 m), Kimin (27˚34′ N, 93˚98′ E, 200 m) and Poma (27˚08′ N, 93˚59′ E, 300 m). These three sites fall under evergreen tropical forests in 100-500 m altitudinal ranges (27). Detailed observations of the morphological and phenological characteristics were made of the selected plants, i.e., 2 (1 male and 1 female) individuals from each study site. Some live specimens were also collected from their natural habitats for *ex-situ* multiplication in the Forest nursery of the North Eastern Regional Institute of Science and Technology (NERIST), Arunachal Pradesh, India.

Study on morphological variations

Before the study, the identification of the species was as-

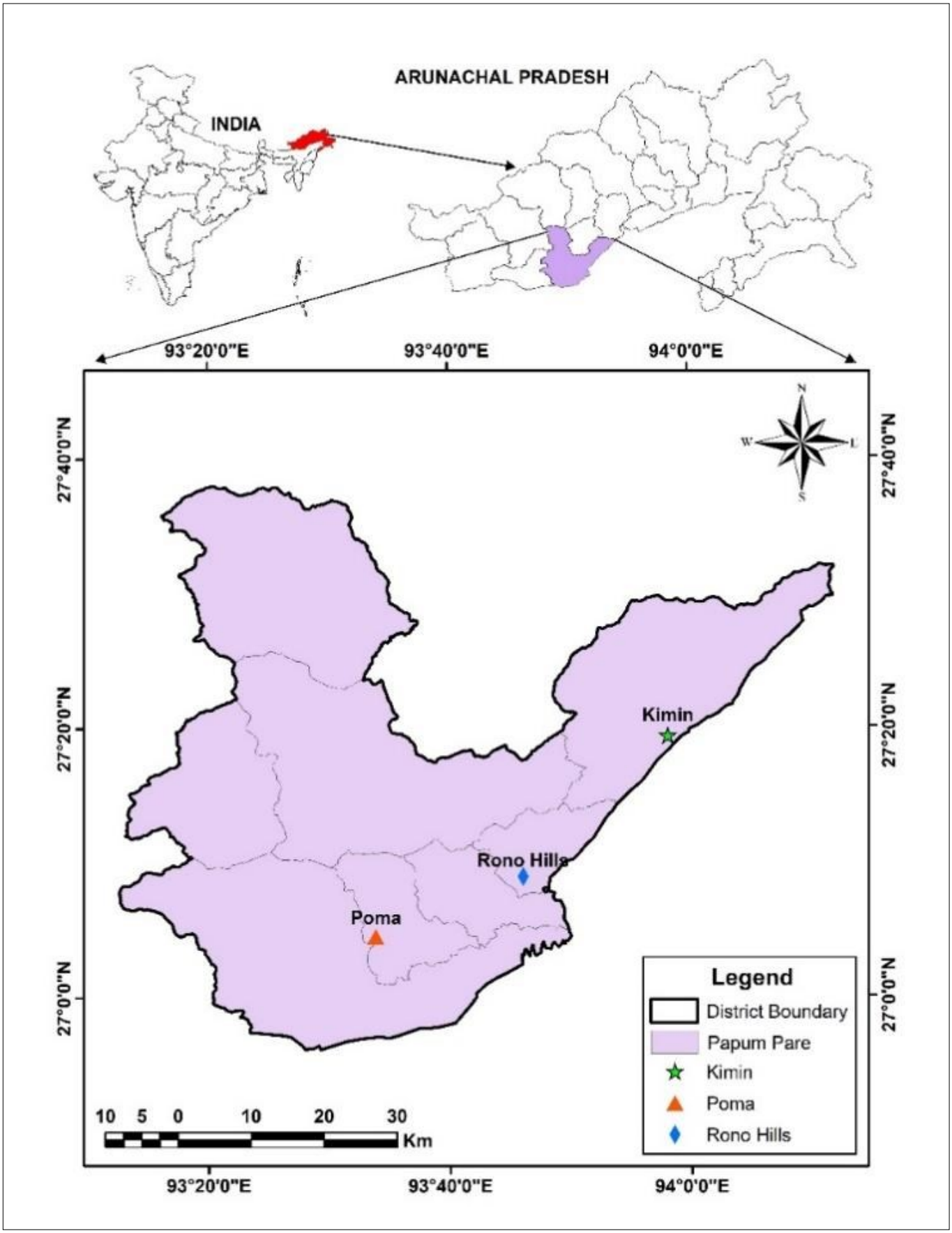

Fig. 1. Map of Arunachal Pradesh marked with Papum Pare district showing study sites.

certained through observations of its morphological characteristics. The senior author (PRG) has been extensively working on Piper taxonomy and has identified the species. The collected specimen was prepared into a mounted herbarium sheet using the standard techniques recommended (28) by drying, poisoning, mounting, and labeling. The voucher specimens were then deposited in the Forestry Herbarium, NERIST, Arunachal Pradesh, India. In the field, specifics about morphological characteristics were noted. To examine the morphological characteristics in greater detail, some samples were brought to the lab, and additional information was gathered. For every plant trait, the

variations in the dimorphic (orthotropic and plagiotropic) branches were quantitatively studied using morphometry. To compare the branches, we considered the characteristics of their stem (node and internode), leaf (shape, size, tip, base, venation, etc.), petiole (length and texture), stipule, and prophyll (shape, size, texture, etc.). We took the average of three measurements to determine the morphometry of all these traits. For leaf characteristics, we selected a well-matured fourth leaf from the top of both shoots for observation (29). Microscopic analysis of the reproductive structures and other plant elements of both branches was examined using a hand lens and a stereo microscope (DIGI510, Dewinter, India), equipped with a digital camera.

Phenological study

Periodic visits to the field and observation of the developments were recorded periodically for two years. A timely observation of the changes in the vegetative and reproductive (female and male) shoot was done at regular intervals following standard protocols (20, 30, 31). All the necessary climatic data have been recorded for the study sites. The phenological observations were made for all three populations in their natural habitat and analyzed. A total of 6 individual plants were tagged, 2 (1 female and 1 male) from each site for timely observation. Considering all the significant biological changes in the plant as the parameter for the study, data for the vegetative, flowering, and fruiting phenophases were recorded accordingly. A list of parameters considered for periodic data collection viz. timing of leaf bud initiation, leaf opening, total numbers of leaves developed, leaves color change, stem elongation, leaf senescence, leaf fall, spike initiation, emergence of flowers in a spike, fruit formation, maturation of fruits, spike dehiscence, the total number of fruits per spike, etc., had been tabulated beforehand (32). Accordingly, the final results have been presented.

Results

Distribution

From the distributional record, it is now confirmed that in India it is only found in Assam and Arunachal Pradesh. Our study revealed that, geographically, the distribution of the species is restricted to the foothills of the Arunachal Himalaya, which have sporadic populations within the altitudinal range of 100–700 m but mostly within 300 m. Our present survey has revealed that the species is distributed in the southern parts of Arunachal Pradesh in the districts of Papum Pare, Lower Subansiri, West Kameng, and Pakke Kessang along the bordering areas in Assam, covering the districts of Sonitpur, North Lakhimpur, Biswanath, and Darrang (Table 1, Fig. 2). The field survey in the different localities of the distribution indicated that normally the population of *P. acutistigmum* is mainly restricted to tropical and subtropical evergreen forests, particularly in the partially shaded humid areas along the forest edges.

Piper acutistigmum is a robust climbing shrub growing up to 20 m with distinct branch dimorphism. They are dioecious, woody, flexuous, and glabrous having distichously arranged leaves. In a population, it has been observed that there exist three different types of vines, i.e., female, male, and sterile vines. In addition to this, it was seen that most of the individuals in a population are sterile vines; that is, most of them do not bear any reproductive structures. During the survey, we found difficulty in differentiating fertile individuals from sterile ones until it came to the flowering or fruiting stage as fertile individuals were

Table 1. Distribution of *Piper acutistigmum* in Arunachal Pradesh and Assam.

S. No	Specific localities	GPS coordinates	Altitude (m a.s.l.)	Districts	States
1.	Rono hills	27°15′ N, 93°76′ E	235		
2.	Kimin	27°34′ N, 93°98′ E	170		
3.	Poma	27°07′ N, 93°56′ E	310	Papum Pare	
4.	Sagalee	27°23′ N, 93°52′ E	562		
5.	Banderdewa	27°09′ N, 93°82′ E	180		Arunachal Pradesh
6.	Yazali	27°40′ N, 93°74′ E	630	Lower Subansiri	
7.	Bhalukpong	27°02′ N, 92°63′ E	180	West Kameng	
8.	Tippi	27°02′ N, 92°61′ E	196		
9.	Pakke Tiger Reserve	27°08′ N, 92°51′ E	350	Pakke Kessang	
10.	Balipara	26°82′ N, 92°77′ E	150	Sonitpur	
11.	Misamari	26°81′ N, 92°56′ E	140		
12.	Balijan	26°85′ N, 93°16′ E	150	Biswanath	
13.	Soibari	26°78′ N, 92°93′ E	150		Assam
14.	Rowta	26°71′ N, 92°21′ E	150	Darrang	
15.	Bhairabh kund	26°87′ N, 92°11′ E	180		
16.	Kakoi Reserve Forest	27°29′ N, 94°15′ E	120	North Lakhimpur	
17.	Padumoni	27°02′ N, 93°97′ E	150		

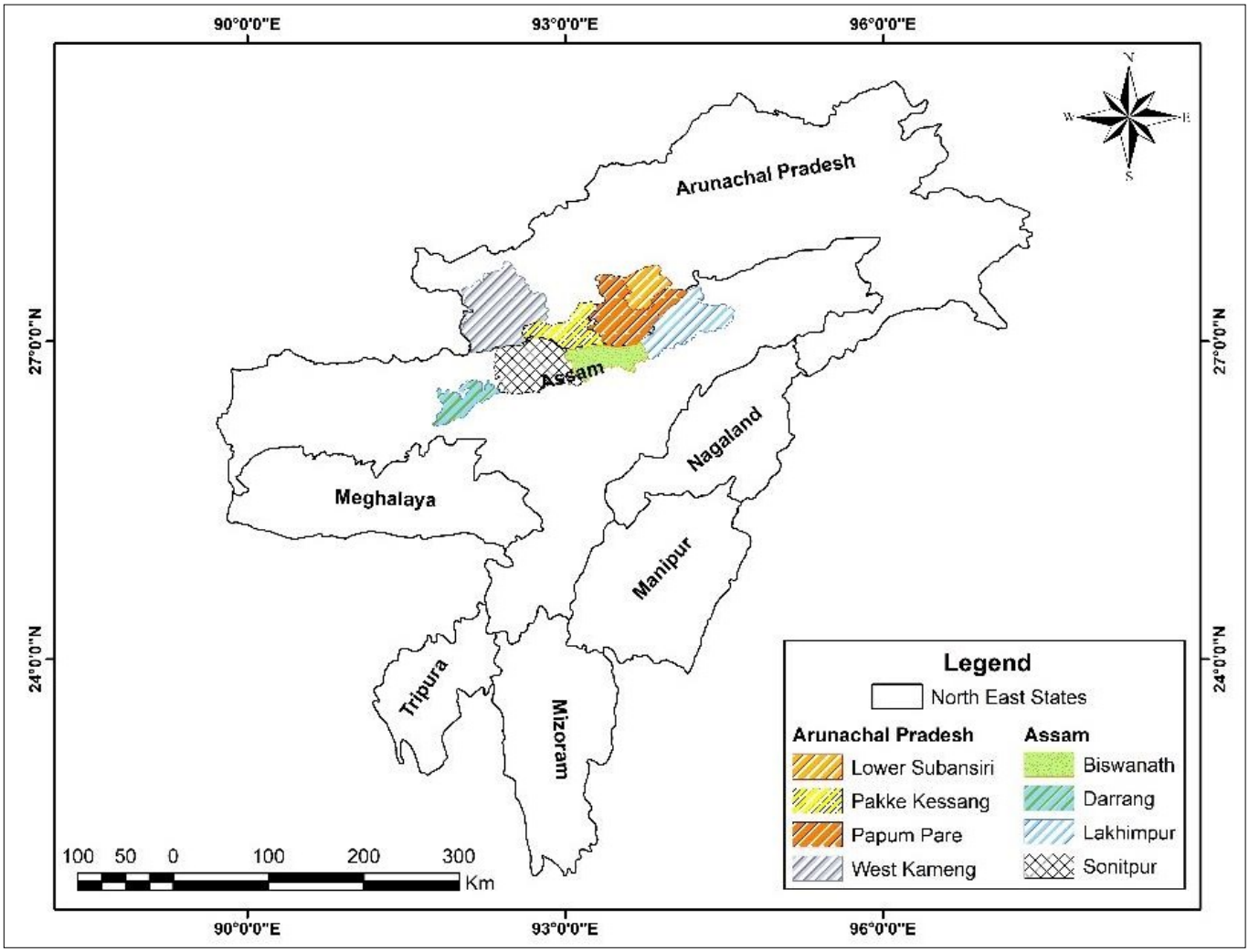

Fig. 2. Map of Northeast states of India highlighting the districts of occurrence of *P. acutistigmum.*

very few in the population. Only very few individuals are fertile and seen to be flowering and subsequently fruiting. It has also been noticed in the study that the internodes of orthotropic branches sometimes have prominent adventitious roots that extend from the nodes. This occurrence of adventitious roots on the internode has not been seen in any other Piper species.

The orthotropic and plagiotropic branches of *P. acutistigmum* manifested some morphological differences in the shape, size, color, texture, etc. in the plant parts of both branches, which are presented in Table 2. Simultaneously, a detailed taxonomic description of the species, taking account of all the recorded characters from both branches, is given in the following paragraph:

Morphological details

Orthotropic branch

Stem- slender, creeping or climbing, light green with reddish brown tinge when young, node with adventitious roots, glabrous; internodes long, sometimes with adventitious roots along the length, 15–20 cm, old stem rope-like, woody, cylindrical, ca. 2–3 cm in diameter, surface rough; *Leaves*- ovate-lanceolate, coriaceous, glossy, 8–12 × 5–7 cm, light green when young to dark green on maturity, apex acuminate, base sub-cordate, margin entire, 3 pairs of lateral veins, 2 pairs arising oppositely from the base and 1 pair from slightly above the base, glabrous; Petiole- 3–4.5 cm long, light green, grooved throughout the length; Stipule- small, 0.5–1 mm, attached at the base of the petiole groove.

Plagiotropic branch

Stem- woody, terete, glabrous, node swollen and scarred without any roots, internodes short, 5–8 cm; *Leaves*- ovate -elliptic, broad on one side of the midrib and narrow on the other side, coriaceous, 15–28 × 7–18 cm, light green when young, turns dark green on maturity, apex acuminate, base sub-oblique, margin entire, 3 pairs of prominent veins, 2 pairs arising oppositely from the base and the anterior pair emerging alternately from 2–5 cm above the base, glabrous, smooth surface; Petiole- 1.5–3 cm long, greenish-brown, shallow groove along the length, Stipule- scaly, conspicuous, 1–2 mm, green color, present at each node near the base of the petiole; Prophylls- 1–1.3 mm, green, present near the base of the peduncle.

Flowering spikes-

Slender, pendulous, densely arranged flowers, green when young and bright yellow upon anthesis, rachis pubescent; Bracts- orbicular, peltate, yellow, non-overlapping arrangement, stalk pubescent at the base. Male spikes*:* 5–8 cm long, filiform; peduncle 1–2 cm, light green; Male flower- 1mm long, stamens 2, anther 4-celled, filaments thick and long. Female spikes*:* 7–9 cm long, filiform; peduncle 1–2.5 cm, light green; Female flower- 1mm long,

Table 2. Morphological variations in Orthotropic and Plagiotropic branches of *Piper acutistigmum.*

Plant parts	Characters	Orthotropic branch	Plagiotropic branch
Stem	Color	Light green with a reddish-brown tinge	Greenish brown
	Texture	Terete, striated, cylindrical	Woody, terete
	Indumentum	Glabrous	Glabrous
	Nodes	With adventitious roots	Swollen and scarred, without any root
Leaf	Color	Light green when young, dark green when mature	Light green when young, dark green when mature
	Shape	Ovate-lanceolate	Ovate-elliptic, broad on one side of the midrib and narrow on the other side
	Size	8–12 × 5–7 cm	15–28 × 7–18 cm
	Margin	Entire	Entire
	Base	Sub-cordate	Sub-oblique
	Apex	Acuminate	Acuminate
	Texture	Coriaceous, glossy	Coriaceous, glossy
	Venation	3 pairs of lateral veins, 2 pairs arising oppositely from the base, and 1 pair from slightly above the base	3 pairs of prominent veins, 2 pairs arising oppositely from the base, and the anterior pair emerging alternately from 2–5 cm above the base
	Indumentum	Glabrous	Glabrous
Petiole	Color	Light green	Light green
	Size	3–4.5 cm	1.5–3 cm
	Texture	Smooth, glabrous	Smooth, glabrous
	Groove	Grooved throughout the length	Shallow groove along the length
Internode	Size	15–20 cm	5–8 cm
	Texture	Striated, glabrous, sometimes with adventitious roots along the length	Glabrous, woody
	Color	Light green with a reddish-brown tinge	Greenish brown
Stipule	Size	0.5–1 mm	1–2 mm
	Color	Light green	Green
	Type	Basal	Scaly, conspicuous
	Position	Attached at the base of the petiole groove	Present at each node near the base of the petiole
Prophyll	Size	---	1–1.5 mm
	Color	---	Green
	Position	---	Near the base of the peduncle

stigmas 4, sessile, ovary globose and large, sunken on the rachis. Fruiting spikes*:* cylindric or twisted, incomplete fruit setting, 12–22 cm in length, drooping, light green turning yellowish green on maturity, reduced bract present; peduncle 1.5–2.5 cm, green. Drupes*:* partially aggregated, globose, sunken on the rachis, ca. 4 × 3 mm, turn orangish yellow on ripening, slightly pungent.

Phenology of the species

In this study, complete phenological data was obtained for the species. The vegetative phenophases and reproductive phenophases for both sexes are presented in Table 3 and Table 4 respectively.

Vegetative phenophases

A frequent field visit and observation of the vegetative phenophases of the species showed that the formation of leaf buds starts more or less from the months of February to March. It was seen that leaf initiation usually takes place earlier in male individuals than the female counterparts. The peak period of leaf initiation was observed to be the month of April. The formation of new leaves or leaf sprouting ceased by the end of April after the completion of 3-4 leaves per branch in male individuals and 5-6 leaves per branch in female individuals. After attaining the number of leaves per branch, leaf flush in the plant undergoes a growth stage and matures over time. The average plant leaf cover is mostly uniform throughout the year except during the leaf-shedding period of December to January. About a month before flowering, new leaves emerge from the tip of the bud in February. All the other vegetative parts, like stem, nodes, internodes, stipules, etc., grow in size simultaneously. The runner shoots grow profusely, proliferating on the ground, and the leaves in the runner shoots spring out all around the year.

Reproductive phenophases

The flowering bud initiation in the species was observed to begin in the month of March. The male spike buds

emerged in early March, i.e., one to two weeks earlier than the female buds, which usually develop in late March. The formation of spike buds is followed by their elongation and maturation. The male flowers mature earlier than the female flowers, but they sustain themselves for a longer time. The spikes, after attaining anthesis, give a bright yellow color because of the flowers. By the end of May, the flowering spikes reach their full length, and this is the peak maturation period for both sexes. The female spikes were noticed to be a few centimeters longer than the male spikes on full maturation. The senescence period of male flowering spikes starts soon after maturation when they get dried off and change their color to dark brown. The fruiting phenophases follow the female flowering phenophases consecutively. Initiation of fruit formation can be seen in the flowering spike in the month of June. The elongation of the fruiting spike as well as the enlargement of the fruit size occurs slowly and continuously in the following months. Eventually, the fruiting spike attains its full maturity in October with a length as long as 20 cm and the fruit changes its color from green to orangish-yellow after maturation. Decaying and dehiscence were completed by the end of December and there are no spikes in January and February.

Table 3. Vegetative phenophases of female and male plants of *Piper acutistigmum*.

Vegetative phenophases		
Observation period	**Female plant**	**Male plant**
3rd week of February	--	Sprout visible
1st week of March	Sprout visible	Leaf initiation in the main axis
3rd week of March	Leaf initiation in the main axis	Leaf flushing in lateral branches
1st week of April	Leaf flushing in lateral branches	Formation of new leaves ceased after initiation of 3–4 leaves per branch
3rd week of April	Formation of new leaves ceased, after initiation of 5–6 leaves per branch	Leaves color change from light green to dark green
1st week of May	Leaves color change from light green to dark green	Leaves get matured (16–18 × 6–8 cm) Internode elongates up to 10 cm
3rd week of May	Leaves get matured (18–20 × 8–10 cm) Internode elongates up to 12 cm	Growth stage

Table 4. Reproductive phenophases of female and male plants of *Piper acutistigmum.*

Reproductive phenophases		
Observation period	**Female plant**	**Male plant**
March	Spike bud initiation in the main axis	Bud's initiation and development of flowers
April	Emergence of lateral spikes and initiation of flowers	Spike elongation with the initiation of anthesis and color changed into bright yellow
May	Inflorescence elongation (8–10 cm) and maturity of flowers. Spike becomes yellowish	Full maturation of male flowering spike and reaches its full length (7–9 cm). Anthesis completed.
June	Maturation of flowering spikes (11–15 cm) and initiation of fruit formation	Decaying starts and Dehiscence occurs
July	The fruiting spike elongates (12–20 cm) and fruiting completed	No spike or inflorescence
August	Enlargement of fruit size (2–3 mm)	
September	Fruiting spike matures continuously	
October	Full maturation of fruits and fruiting spikes (18–22 cm long)	
November	Fruit starts to change color from green to orangish-yellow to black and starts dehiscing	
December	Dehiscence is completed by the end	
January	No spike or inflorescence	
February		

Discussion

Some remarkable differences in the physical and growth characteristics of orthotropic and plagiotropic shoots have been observed and documented during the present study. This study found differences between two different branches of *P. acutistigmum,* which is similar to what another study found about *P. betleoides* and *P. wallichii* (29). The details of the habits, morphological features, and reproductive structures of the species have been understood (Fig. 3). The meristematic parts of orthotropic and plagiotropic shoots are similar, but their growth patterns (vertical and horizontal) and ecological functions (vegetative and generative) are different (9). The study also

found that both shoots had a similar meristematic origin, but they attained different orientations and functions, which resulted in differences in the morphological characters. Apart from bearing flowering spikes in the plagiotropic branch, the shape and size of the leaves are found to be bigger and slightly oblique than the leaves in the orthotropic branch, whereas the size of the petioles and internodes is comparatively smaller. Also, the size and position of the stipules are seen to be varied in both the shoots. The taxa Piper have been regarded as among the most challenging for scientific categorization, due to their varied vegetative characteristics, densely packed spike inflorescences, and minute flowers (33). In this study, the variations in the vegetative characters of both shoots have been documented, which will help in narrowing down the complexity in the identification of the species. The primary reason for the species-poor treatment and much of the current misunderstanding is discovered to be the insufficient taxonomic enumeration, which omitted features from both branches (29). For management, conservation, and domestication, it is essential to comprehend intraspecific morphological variations to prevent misidentification.

In the study, it was also noticed that the fertile individuals of *P. acutistigmum* are very limited in number,

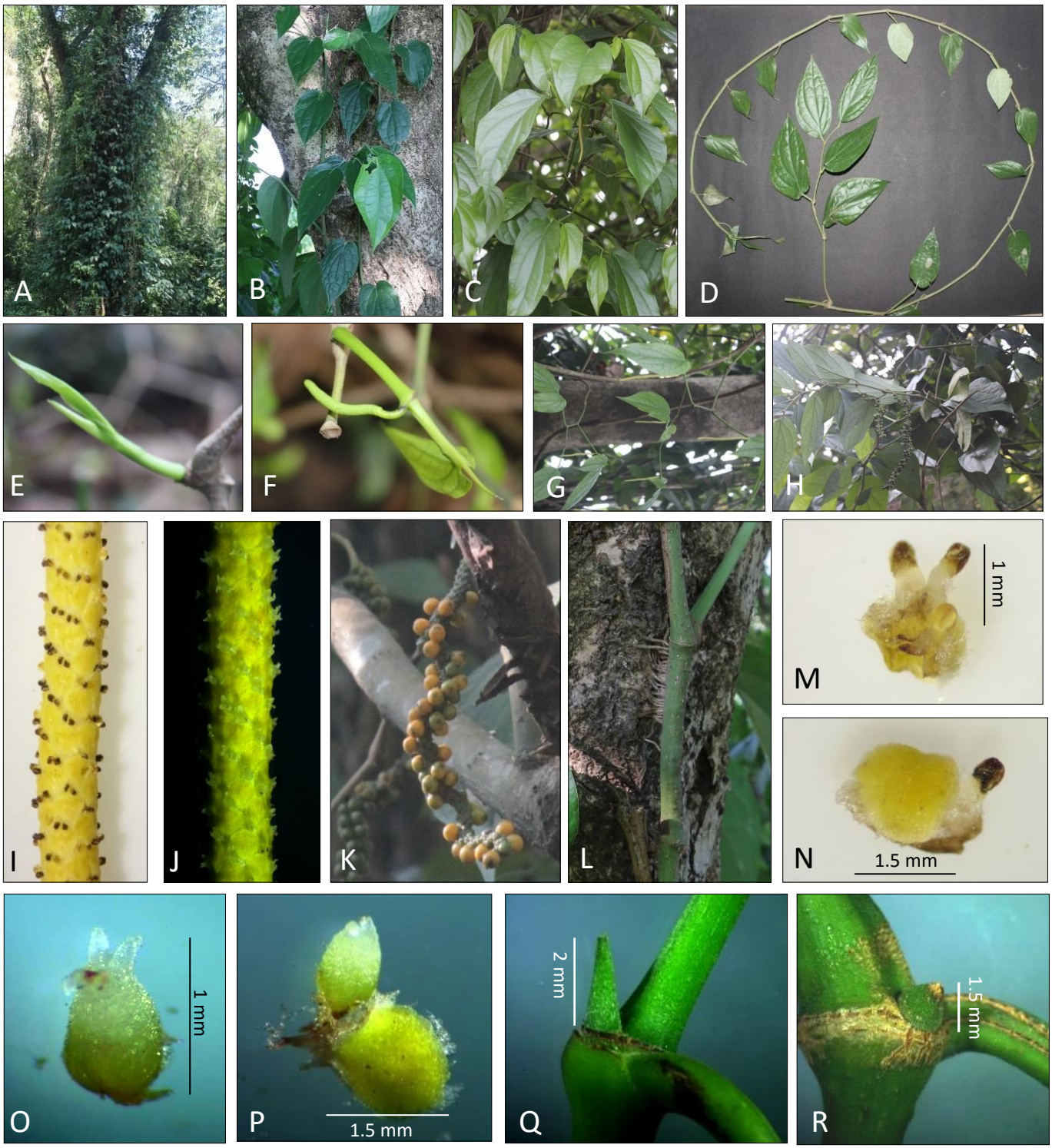

Fig. 3. *Piper acutistigmum* **A.** Habit **B.** Orthotropic shoot **C.** Plagiotropic shoot **D.** Dimorphic branching **E.** Bud initiation **F.** Spike initiation **G.** Male plant **H.** Female plant **I.** Male flowering spike **J.** Female flowering spike **K.** a matured fruiting spike **L.** Internode with adventitious roots **M.** a male flower **N.** a subtended bract of male flower **O.** a female flower **P.** a subtended bract of female flower **Q.** Stipule **R.** Prophyll.

and due to the forest clearing and development taking place in the states, the population is highly threatened and needs conservation. By taking into account harvesting phenology, it is possible to plan out the cultivation of the ethnomedicinally significant wild Piper species using the methods used for well-known cultivated species (34). This work presents details about the seasonal biological changes occurring in the plant for its management. These data are important to understand the timing of recurring biological events throughout the seasons, which include leaf bud initiation, leaf flush, spike formation, flowering, fruiting, etc. The leaf flushing just before flowering reported in our study is a common trend observed in a variety of plant species occurring in various natural environments (22, 35). Besides, the leaf production and flowering in the species occurs annually in a specific period as was observed in *P. sylvaticum* (22), whereas, the finding is in contrast with many bisexual species of Neotropics such as *P. visconum* (20) and almost all *Piper* species of Panama (19), where it occurs throughout the year. In reproductive phenophases, the early flowering of the male spikes and its longer sustenance to facilitate pollen when female flowers attain maturity synchronizes with the reports (22, 36) that some dioecious plant has their male flowering earlier than the female flowering. In nearly all dioecious species, male plants produce more flowers than female plants do (21, 22, 37, 38), but in this study, we have noticed that male spikes are slightly shorter than female spikes and simultaneously produce fewer flowers. The peak flowering period was observed in May for both sexes and usually occurs in the rainy season as seen in Neotropical *Piper* species (39). The longevity of flowers in an inflorescence varies from 10-15 days which is found to be similar to that of *P. nigrum* (40). The fruiting spikes are long, cylindric, and sometimes crooked or spiraling. The fruits are drupe, aggregated and the number varies from 80-110 per infructescence. The fruiting duration ranged from 168-175 days as has been noticed on *P. nigrum* (40). The flowering phenology showed that the species blooms from April to May with fruiting observed from July to December. Complete phenological data have been generated that may be useful for its management and conservation.

Conclusion

The distributional pattern of *Piper acutistigmum* indicates that it thrives best in low altitudinal areas at the foothills of the Himalayas with adequate rainfall and humidity. The research suggests that the differences between orthotropic and plagiotropic branches serve different ecological purposes. For example, orthotropic branches help plants grow and spread vegetatively, while plagiotropic branches have structures that help plants reproduce. The limited occurrence of fertile (male and female) individuals in a population highlights the need for their preservation. Since ongoing development activities in and around their habitats are a threat to the current natural population, management and propagation of fertile individuals are essential. It is even more crucial to preserve the species as it is endemic to the region. To preserve the species both *in-situ* and *ex-situ*, prompt management action is required. *In-situ* conservation can be achieved by creating awareness and controlling the felling of trees in areas where the species is growing. *Ex-situ* conservation can be achieved through vegetative propagation, such as fragmentation or stem cuttings leaving 2-3 nodes for rooting and shooting, and planting them in suitable conditions. The phenological study showed that leaf initiation and spike emergence occur at the onset of spring and start flowering in the rainy season which suggests the best time to do the stem cutting for vegetative propagation.

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Authors contributions

TY carried out the fieldwork and experimental work, compiled all the data, and drafted the manuscript. PRG conceived and conceptualized the study and participated in data analysis, reviewed & edited the original draft. BS supervised and participated in designing the study. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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