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Actinidia strigosa Hook. f. & Thomson (Actinidiaceae): A Future Plant with Higher Economic Importance in Hilley-Barsey Sanctuary, Sikkim, India

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Abstract

The present study was conducted during the period August, 2021 to March, 2023 in Sikkim state of Northeast India. *Actinidia strigosa* Hook. f. & Thomson (Theki Phal/wild kiwifruit) is a temperate climbing shrubby plant species, collected from the Hilley-Barsey Sanctuary, West Sikkim, India. It has been observed that this plant is associated with the daily needs of the locals and used for various economic purposes, such as fresh fruit for table purposes, fodder, medicine, and for the preparation of fruit wine. During the field survey in 2021, the plant species *A. strigosa* was collected from Ribdi (2203 m) to Hilley (2679 m) within the Hilley-Barsey Sanctuary for further study. The distribution of *Actinidia strigosa* is confined to the Eastern Himalayas, specifically in Sikkim (West, South and East districts), West Bengal (Darjeeling hills), and eastern Nepal, at an altitudes of 2100-2600 m. It has the potential to be used in the kiwifruit breeding industry as gene source to enhance cold tolerance and expand kiwifruit cultivation to high altitudes in the Himalayan regions. Due to its economic importance and limited distribution, conservation is essential, as the plant is vulnerable to uprooting and injury, especially in areas like the Hilley-Barsey Sanctuary in West Sikkim. Being endemic to its area of occurrence with maximum diversity in its morphology at Hilley-Barsey Rhododendron Sanctuary, West Sikkim, the sanctuary must be recognised a biodiversity hotspot for *A. strigosa*.

Keywords: Hilley-Barsey, Himalayan, India, wild kiwifruit, Theki Phal, West Sikkim

1. Introduction

The Hilley-Barsey Sanctuary is situated in the West Sikkim district of Sikkim State, Northeast India, within the geographical limits of 27° 11' 39" N latitude and 88° 07' 06" E longitude. It covers an area of approximately 10,400 hectares (104 sq. km) within the altitudinal range of 2000–4100 m above mean sea level (msl), receives an average annual rainfall of more than 250 centimetres, covering Hilley, Okhrey, Ribdi, and Bhareng villages within the sanctuary premises. The sanctuary is primarily dominated by East Himalayan Moist Temperate Forest, covering 55.50% of the area, followed by Rhododendron Forest at 23.77%, Degraded Forest at 6.66%, and Hemlock Forest at 0.78%. Of the sanctuary's total geographical area of 120 km², 28.45% exhibits very high plant richness, while 50.84% shows high richness, 6.96% medium richness, and 13.75% low richness (Kushwaha et al., 2005).

During the field survey in the year 2021, the plant species *Actinidia strigosa* was collected within an altitudinal range from the lowest location Ribdi (2203 m) to the highest location Hilley (2679 m) above msl for further study purposes. It was also observed in the West, South, and East districts of the Sikkim and extended its distribution up to the Darjeeling hills of West Bengal. The natural occurrence of *A. strigosa* was earlier reported from the Ribdi- Bhareng village of West Sikkim and Gorkhey-Samanden village of Darjeeling district, West Bengal based on the surveys conducted in the Barsey Rhododendron Sanctuary and Singalila National Park within India's Khangchendzonga landscape (Chettri et al., 2021). In addition to the northeastern hills of India's Himalayas, *A. strigosa* is also found in the Himalayas of Nepal, where it is locally known as 'Theki Phal' (Bhandari et al., 2021). Among the underutilized or minor edible fruit crops of the Northeast region is *A. strigosa* from Sikkim, commonly known as wild kiwi

(Deka et al., 2012; Patel et al., 2010). It has been reported as a shrubby climber with edible fruit in the hills of the Darjeeling district, West Bengal (Ghosh et al., 2020) and the red panda (*Ailurus fulgens*) eats the ripened fruits as its feed. It is found at elevations between 1800 and 2850 meters in Sikkim and Northern West Bengal, including Darjeeling (Badhwar and Fernandez, 2013). However, a recent study has documented the natural occurrence of *A. strigosa* in the humid tropical to temperate forests of Arunachal Pradesh, where its fruiting season extends from October to December (De, 2017).

Actinidia strigosa is a large, deciduous climber known for its strigose branchlets and reddish-brown, densely hispid new shoots, which gradually become smoother as they mature. The young branchlets have a rough surface with occasional elongated lenticels. Over time, this vigorous vine develops into a thick, woven liana, often dominating the canopy of the trees it climbs, such as native pine (*Pinus wallichiana*), bamboo, and rhododendron. At optimal maturity, the fruit has a dark green outer pericarp, light green inner pericarp, and greenish-white core. As the fruit ripens, the flesh color changes from green to light yellowish (Padhan et al., 2023). The leaves are ovate to long-ovate, with an obtuse to rounded, sometimes oblique base, and an acuminate to long-acuminate apex, featuring dark green, lustrous, and glabrous upper surfaces with sparse pubescence along the veins, and lighter green, glabrous lower surfaces with sparse setose hairs (Huang, 2016). The fruits are found to be ovoid or egg-shaped, approximately 3 cm long and mucilaginous (Badhwar and Fernandez, 2013), with pigmentation on fruit's skin is quite common which is influenced by environmental conditions (Huang et al., 2004).

2. Materials and Methods

The present study was conducted during the period August, 2021 to March, 2023 in Sikkim state of Northeast India. The collected plant specimens were carefully dried, pressed, and mounted as per the known herbarium practices given by Jain and Rao (1976). The specimen was identified as *Actinidia strigosa* Hook. f. & Thomson through perusal of literature and herbarium consultation at BSI, Gangtok, Sikkim (BSHC).

2.1. Description

Actinidia strigosa Hook.f. & Thomson in J. Proc. Linn. Soc., Bot. 5: 55.1860. TYPE: Sikkim, J.D. Hooker *s.n.* (Holotype, K; Isotype, GH).

Large, deciduous climbing, branched shrub, 20–60 m long; stems reddish-brown, dense hispid hairs (Figure 1). Leaves ovate to long ovate, 7.6–15.56×4.07–12.37 cm, obtuse to rounded or sometimes oblique at base, acuminate to long acuminate at apex, minutely serrate or entire at margins, dark green on upper surface, light green and glabrous on lower surface, with sparse setose hairs; lateral nerves 5–7 pairs; petioles short, stiff, 1.89–3.97 cm long (Figure 1, 1a, 2a). Flowers white, 1.45–2.67 cm across. Sepals 5 or 6 among the group, ovate, 4–6 mm, glabrous. Petals 5.5–6.5×8, 6–8 among the group, obovate, 7–12 mm long (Figure 1a,1b,1c,1d,1e). Styles varied from 21–38 across female flowers, 1.5 mm long (Figure 1b); stamens varied from across the male flowers; anthers yellow, 1–1.5 mm long (Figure 1d). Ovary globose, hairy. Fruits oblong, elliptic or obovate among the groups, 1.47–3.72×1.46–26.12 cm, with 2.46–14.93 grams fresh weight; stalk length 1.12–2.38 cm long; seeds more than 100, small, black to reddish (based on specimen studied and as per our own observations) (Figure 3a,3b,3c).

2.2. Location

(Figure 1).

Figure 1: Herbarium sheet of *A. strigosa* [BSS (01)]

2.3. Flowering period

April–June (As per our own observations) (Figure 1a)

2.4. Fruiting period with harvesting maturity

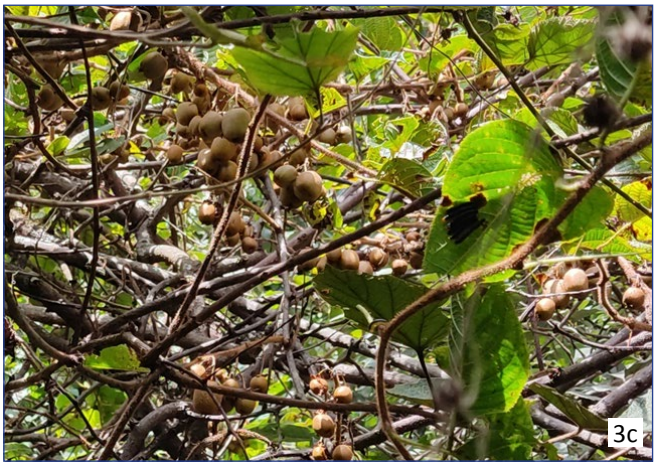
August–October (As per our own observations) (Figure 3c)

2.5. Specimens examined

West Sikkim, Sikkim, 27° 11' 9.024'' N, 88° 7' 20.244'' E, 2621 mtrs, Hilley, 09/07/23, *Abhilash Padhan* 01 [(1a male, 1b female) (BSS)].

2.6. Key to identification

1. Climbing shrub, glabrous to hairy, presence of simple or stellate hairs .....*Actinidia*



Figures (*Actinidia strigosa*): 1a: Flowering stage (female), 1b: Female flower (front view), 1c: Female flower (back view), 1d: Male flower (front view), 1e: Male flower (back view), 2a: Leaves with young shoot, 3a: Depicting length and width of fruits, 3b: Flesh of fruits, 3c: Female vine in fruiting stage

Figure 2: Wine made from the fruit juice of *A. strigosa*

2. Branches and stems with strigose hairs, Upper leaf surface is dark green, lustrous, glabrous and sparsely pubescent, flowers white..... *A. strigosa*

3. Stem glabrous, conspicuous on branches, dense lenticels present, leaves ovate to elliptic with parallel cross bars on veinlets, glabrous upper surface.....

..*A. callosa*

4. Leaves glabrous on upper surface, strigillose on lower surface .....*A. callosa* var. *strigillosa*

3. Results and Discussion

3.1. Biochemical analysis

The fruit of *Actinidia strigosa* has been analysed and found to be highly nutritious. Its total soluble solids range from 12.3–20.7 °Brix, with titratable acidity between 0.4–1.5%. The total sugar content varied from 3.5–9.09%, while the ascorbic acid (Vitamin C) content ranged from 30–125 mg 100 g-1 of fresh weight. Additionally, the total phenol content ranged between 23–45 mg GAE (gallic acid equivalent) g^{-1} fresh weight, indicating a rich profile of beneficial compounds (Padhan et al., 2023).

Uses of *Actinidia strigosa* Hook. f. & Thomson:

3.2. Ethnomedicinal properties

The stored fermented juices of the fruits are used against colds and fevers. A topical application of a decoction made from the roots of the wild *A. strigosa* is used for the treatment of musculoskeletal disorders such as bone fractures, dislocations, muscular swelling, and sprains (Bhandari et al., 2021).

3.3. Fresh fruits

The fresh fruits are used for table purposes and in preparation of juice and brewed items (Ghosh et al., 2020; Hazarika and Pongener, 2018). The wine made from the fruits (Figure 2) are sold in local shops and provide a source of income to the locals. In addition to being eaten raw, the ripen fruits are used to extract juice, which is bottled for fever remedies (Padhan et al., 2023).

3.4. Green fodder

The leaf, branch, flower and fruits of A. strigosa are utilized as fodder for domestic animals. The leaves and fruits are used as one of the major feeds of red panda (*Ailurus fulgens*), an endangered animal of the Sikkim-Himalayan region. In Ribdi-Bhareng village of Sikkim and Gorkhey-Samanden village of West Bengal, leaf and branches is used as green fodder with moderate preference among the local communities (Chettri et al., 2021).

3.5. Kiwifruit breeding industry

The wild kiwifruit (*A. strigosa*), characterized by its distinctive flavour and aroma, showcases remarkable resilience to cold temperatures and a broad spectrum of biotic and abiotic stresses. These commendable traits present an opportunity for the infusion of novel characteristics into present-day kiwifruit (*A. chinensis*) cultivars through strategic crossbreeding. Moreover, it holds promise as cold-resistant rootstocks, offering a foundation for the development of new cultivars with enhanced cold tolerance (Arora, 2014). It will be further helpful in increasing kiwifruit cultivation to higher altitudes (2000–3000 m above msl) in the Himalayan region. The fruits derived from *A. strigosa* are not only delicious but also encompass a myriad of nutritional and medicinal properties. Given the escalating global demand for diverse kiwifruit varieties, there exists significant potential to optimize the commercialization of this species (Padhan et al., 2023).

3.6. Threats and conservation

The distribution of *Actinidia strigosa* is in the Eastern Himalayan region comprising the states of Sikkim and West Bengal of India and adjoining areas of Eastern Nepal at an altitude of 2100–2600 m above msl. Due to its higher economic importance and being endemic to a confined area, conservation of this plant is highly required. The vines grow in abundance of sunlight and support of woody perennials, making it a common sighting on both the sides of roads and pathways within the Hilley-Barsey Sanctuary. However, it is prone to being uprooted and physical injury by humans as a result of maintaining road cleanliness. Conservation of the vine is necessary to protect it from human intervention. The propagation of the vine can be done either through seeds, hard wood cuttings or dormant bud grafting. The seeds require 8-10 weeks of sand stratification to break the seed dormancy during the months of December to February. After that, the seeds are sown into pots filled with soil, sand, and organic compost during mid-February, at a depth of half to one inch. The seeds of Actinidia strigosa takes 3 to 4 months period for germination and giving rise to seedlings. The hard wood cuttings collected during the month of early February are used for propagation with at least 4 to 6 dormant buds in each cutting. The hard wood cuttings of 15 to 20 cm in length are dipped into 2000 ppm IBA (indole-butyric acid solution) and inserted 3 to 4 inches into the soil, sand, and vermicompost (2:2:1) mixture media during the month of March. The vegetative buds (eyes) present in the cuttings are grafted into the one-year-old kiwifruit (*A. chinensis*) seedlings using the tongue grafting method to propagate the plant.

4. Conclusion

Actinidia strigosa Hook. f. & Thomson is vital for food, fodder, and medicine and holds significant economic value in the North Eastern Himalayan region of India and Eastern Nepal. Due to its restricted natural range and notable morphological diversity in Hilley-Barsey Sanctuary, this area should be designated as biodiversity hotspot for *A. strigosa*. As a wild kiwifruit species, the role of *A. strigosa* is crucial towards breeding and development of cold-hardy kiwifruit cultivars.

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