ECOLOGICAL AND CONSERVATION STUDIES OF *ABUTILON RANADEI* WOODR. *ET* STAPF[1]

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Abutilon ranadei Woodr. *et* Stapf is one of the critically endangered plant species of the Western Ghats in India. It is endemic and restricted to four districts of Maharashtra State. Ecological and conservation studies revealed that the species is more restricted to moist deciduous forests in the Western Ghats. The plant suffers from a number of pests and diseases, and poor fruit set. It can easily be propagated by vegetative propagation through the air layering technique.

Key words: *Abutilon ranadei*, conservation, ecology, Western Ghats, threatened, critically endangered.

INTRODUCTION

The genus *Abutilon* Mill. belongs to Family Malvaceae and is represented by about 150 species. India is home to 12 species, 2 subspecies and 5 varieties (Paul 1993; Woodrow 1897). Of these, two species and four varieties are endemic to India. The genus is distributed mostly in the tropical or subtropical parts of the world. Many species are commercially important as they are highly ornamental.

Abutilon ranadei Woodr. *et* Stapf was first collected by N.B. Ranade, ex-keeper of the herbarium at the College of Science, Pune. Woodrow and Stapf (1894) described it as a new species and named it after Ranade. It is an endemic, known so far only from four districts of Maharashtra State. According to Cooke (1901), it is a rare plant. Due to its narrow range of distribution and extreme rarity, the species has been declared as endangered (Nayar and Sastry 1987; Venkanna and Das Das 2000) or even presumed extinct (Ahmedullah and Nayar 1986). However, it was recollected from its type locality after a lapse of almost 95 years (Mistry and Almeida 1989; Almeida 1996; Walter and Gillett 1997). Since then, the species has been collected from six new locations in Pune, Kolhapur and Satara districts (Table 1).

Abutilon ranadei is one of the most critically endangered plants of India (Mishra and Singh 2001), on the verge of extinction. Its survival in its natural habitat is further complicated by habitat fragmentation and habitat loss. It is a priority species for research and conservation. The present study was taken up with a view to understand the autecology and conservation related aspects of the species with special reference to wild and cultivated plant populations.

METHODOLOGY

The study was conducted between June 1997 and March 2002. The study area comprised mainly of three localities - Torna, Shilim and Amboli. The authors made regular field trips in different seasons to different localities and studied various ecological aspects of wild populations. Information on the phenology, association, pollinators, and seed setting were collected during field surveys. Simultaneously, aspects related to conservation, such as propagation techniques, cultivation practices, pests and diseases were also studied for wild and cultivated plants/ populations.

Habitat specificity: According to Blatter, the species is found only in Konkan. However, all the reported localities of the species, including the type locality, are from the southern Western Ghats in *madhya* (= central) Maharashtra (Almeida and Almeida 1989).

Geography: The species is distributed between 19°-16.4° N and 72° 6'-74° E; that is, between Shilim on the northwest of Pune to Amba Ghat near Kolhapur, covering an area of *c.* 500 sq. km (Fig. 1). The area of occupation is below 12 sq. km.

Geology & soils: Structurally, the natural locations of the species are a part of the Deccan trap, and the geological formations are of basaltic origin, with an abundance of silica, alumina and iron oxides. The soils are brownish to reddish in colour, poor in nutrients and slightly acidic (pH 5.5-6.5).

Vegetation, altitude & rainfall: The species is found at the edges of moist deciduous forests, on gentle hill slopes between 600-1,000 m above msl. All these regions receive high rainfall from the southwest monsoon. Annual rainfall

Table 1: *Abutilon ranadei* Woodr. *et* Stapf. – Ecology and Distribution

Locality	District	Forest type & Association	Number of individuals	Reference
Amba Ghat	Kolhapur	Mixed deciduous	Few	Woodrow (1894)
		Moist deciduous	7	*Mistry & Almeida (1989)
		—	19	*Diwakar & Moorthy (2001)
Radhanagari		—	—	Yadav & Sardesai (2002)
Vasota Fort	Satara	Moist deciduous *Carvia callosa* (Nees) Bremek.	50	Bachulkar & Yadav (1997)
Amboli	Sindhudurg	Moist deciduous *Carvia callosa* (Nees) Bremek. *Barleria* spp.	7	**Tetali (1998)
Shilim	Pune (Mulshi)	Moist deciduous *Carvia callosa* (Nees) Bremek. *Terminalia elliptica* Willd. *Kydia calycina* Roxb. *Xantolis tomentosa* (Roxb.) Raf.	250	Punekar *et al.* (2001)
		Sterculia guttata Roxb. ex Dc.	280	Lakshminarasimhan, Diwakar & Prasanna (2001)
Torna	Pune (Velhe)	Moist deciduous	175	*Punekar *et al.* (2000)
		Carvia callosa (Nees) Bremek.	40	**Tetali & Thopte (2000)
		Ziziphus rugosa Lam. *Woodfordia fruticosa* (L.) Kurz. *Atalantia racemosa* Wight	140	*Lakshminarasimhan, Diwakar & Prasanna (2001)
Rajgad	Pune (Velhe)	Moist deciduous *Carvia callosa* (Nees) Bremek. *Vernonia divergens* (Roxb.) Edgew. *Rhinacanthus nasuta* (L.) Kurz. *Pentanema cerunum* (Dalz.) Ling. *Vigna khandalensis* (Sant.) Raghavan & Wadhwa	45	*Datar Mandar & C.R. Jadhav (2002)

* Personal communication, unpublished data, year of observation is given in parenthesis.
** Senior authors field survey observations, noted from field note book.

ranges between 4,000 mm to 7,000 mm.

Population size: The natural distribution is highly fragmented and the plant is not found in abundance anywhere. Population size (mature individuals) at different localities ranged between 7-280. Some of these localities are adjacent to private land. The natural habitat suffers a variety of depredations due to human interference.

Association: *A. ranadei* populations were discovered in moist deciduous forests. In almost all localities, they grew among thickets of *Carvia callosa* Bremek.

Description & Ecology: Undershrub, or large shrub, up to 2.5 m tall. Plant parts densely and minutely stellately hairy. Leaves ovate to round-ovate, apex acute to acuminate, base cordate, margin crenate to dentate.

Flowering: *A. ranadei* is a fast growing plant. Flowering normally commences in plants about 7-9 months old. Flowers bisexual. Calyx campanulate. Lobes 2-2.7 cm long, connate in the middle, stellate-hairy and glandular. Corolla campanulate with pale purple prominent veins on orange-yellow petals, tips prominently yellow. Petals 1 to 2 times longer than the calyx. Staminal column 20-35 mm long, glabrous, reddish, filaments white, with reddish base, 3-5 mm long. Upper part of the filament sparsely covered with dumbbell shaped glandular hairs. Anther kidney-shaped, initially green, turns dark rose at maturity and brownish violet at dehiscence. Carpels 5. Styles as many as carpels, up to 7 mm long, sparsely hairy (Fig. 2).

Floral biology: Flowering begins in the second week of November and continues till the end of March. Flowers axillary, solitary, pedicels up to 8 cm long, jointed in the upper half. Opening of flowers begins in the afternoon. Maximum flowers open between 12-15 hours (68%). Individual flowers have 3-5 days for pollination. The process of floral development, from opening of flower to pollination, takes place in four stages (Fig. 3).

Paint brush stage (Stage 1): During this stage, floral parts are enclosed in a swollen calyx tube, which is green and glandular. A few bearded white filaments with immature white anthers protrude conspicuously among the yellow tips of the petals. Petals are almost equal or slightly longer than the calyx tube. The flower bud appears like the head of a

paintbrush.

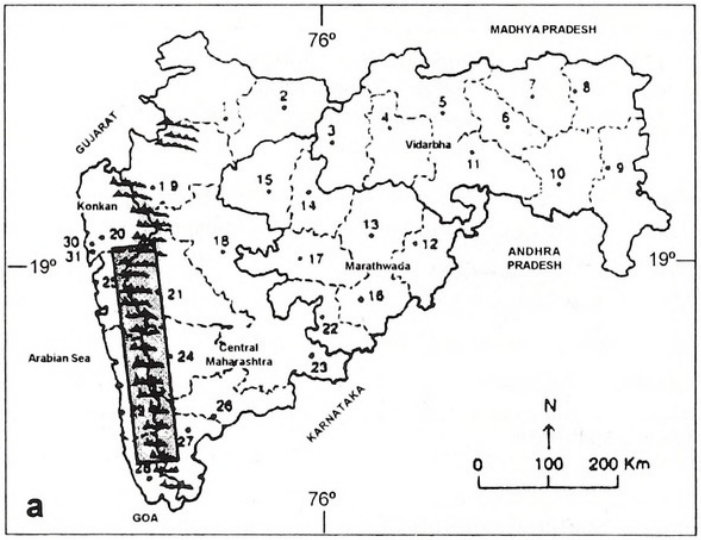
Trumpet stage (Stage 2): At this stage, a number of modifications of floral parts occur, to attract pollinators. It begins with the enlargement of petals and staminal tube. Petals grow longer and wide at the base (length: from 2.5 cm to 3-6 cm; wide: up to 2.5 cm). Two thirds of the proximal end of petals turns light purple, while the distal end turns orange yellow. Whitish veins are more prominent. The spacing between two petals widens. From the almost contorted and overlapping stage, the distance between petals increases to about 2.5 cm towards the distal end. This facilitates a wide open corolla mouth. The yellow region of the petals slowly turns backwards and the corolla resembles a trumpet. Simultaneously, the staminal column with anthers also increases in length (from 2 to 4.5 cm long). The column becomes shining, turns dark purple or reddish-brown. The filaments increase in length from 0.3 cm to 0.5 cm. They are positioned perpendicularly, and hairs on the filaments are more conspicuous.

The white anthers turn reddish-brown or brick coloured. Dehiscence occurs during daytime with increasing temperatures. Anthesis does not take place on the same day, but in phases for about two days. Pollen yellow, spherical, size 55-57 μ diameter, single colpate, echinate, aperture 5-8 μ wide (According to Nair 1962, average size 76 μ; range 74-77 μ). Exine 4.2 μ thick. Basal cushion of spinules not formed (Fig. 4). Styles 5, distinct, 0.5 cm at the time of anther dehiscence. Stigma capitate.

Pollination stage (Stage 3): During this stage, the glandular hairs on the calyx tube emit a strong odour, like curry leaves. The secretion of nectar follows this. Nectaries are located at the base of the petals. The staminal tube twists slightly during or after anther dehiscence. Style length increases on the second day from 0.5 cm to almost 1.5 cm. Styles turn backward into an inverted 'C' shape. Odour from the calyx tube, colour of the corolla and nectar attracts insect visitors belongs to the families. The insect visitors were mostly nectarivorous.

The floral biology and the timing of anthesis indicate that the species prefers cross-pollination. Flowering may not necessarily result in fruit formation.

Observations to identify pollinators were made consecutively for three years. Night observations had to be abandoned due to practical difficulties (especially inaccessibility) in working in natural habitat. Observations were carried out from dawn to dusk. The floral nectar fallen



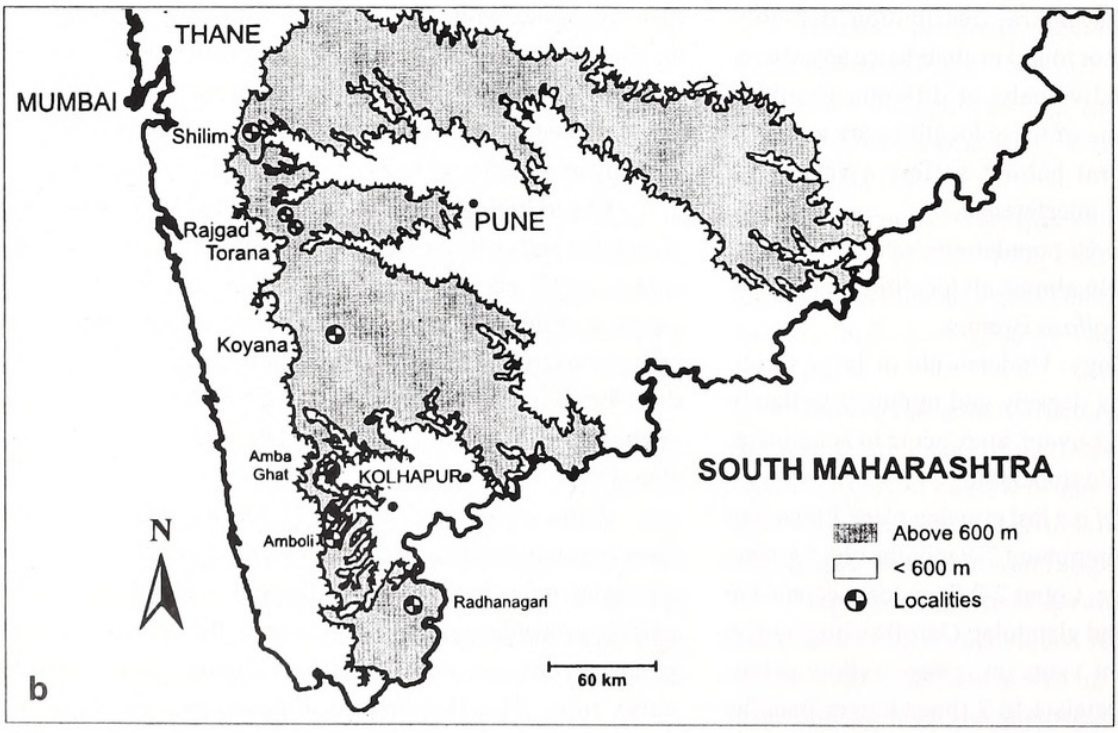


Fig. 1: *Abutilon ranadei* Woodr. *et* Stapf,

a. Distribution map, Maharashtra,
b. Locality map, south Maharashtra

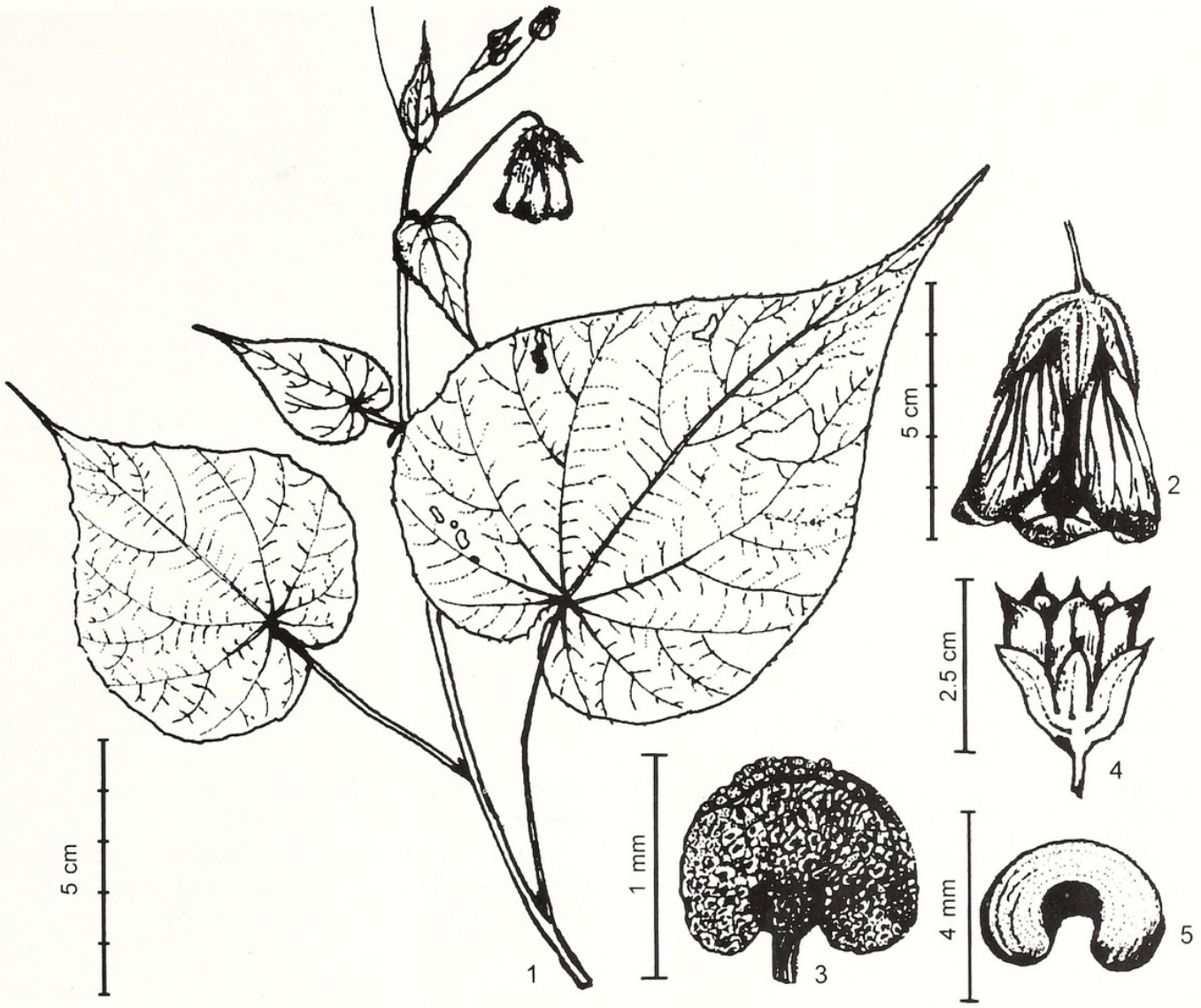


Fig. 2: *Abutilon ranadei* Woodr. *et* Stapf, 1. Habit, 2. Flower, 3. Anther, 4. Fruit, 5. Seed

on leaves and other vegetative parts was seen to attract flies and other insects. Despite thorough observations, no pollinator was seen during the first two years of our study. This, and other factors such as trumpet shaped flowers, odoriferous calyx, colours of the corolla, and secretion of nectar at the base of petals indicate that moths or other nectar-drinking insects might be the true pollinators. No conclusions, however, could be made, due to lack of evidence. Other factors, such as small population size and the resultant scarcity of forage plants (pollen) or nectar may have contributed to the absence of pollinators. Curiously, in the third year, at the end of the flowering season we noticed insects visiting the flowers. A detailed record of the insects, their flower visiting behaviour and food preferences were recorded. The peak period of flowering was only for two days. The insects stopped visiting the plants, as the number of flowers per plant drastically decreased. During the entire study we observed two insect species visiting flowers. Among the insect visitors, Honeybees (*Apis mellifera*), the occasional visitors, may not contribute in pollination. They were seen feeding only on pollen. Bees generally ignore or cannot recognize the flowers of *A. ranadei*. A frequent visitor was *Anthophorus zonata* (Family Anthophoridae, Order Hymenoptera), a fast flying insect and mostly a nectar feeder. The size of the insect and staminal column length indicates that it may not be a true pollinator, but an optional pollinator. A detailed record of the behaviour of *Anthophorus zonata*, flower visiting pattern and food preference were recorded (for two days only). The results showed a positive relation between number of visits and average time spent on each flower from morning to noon. Number of visits and average time spent collecting nectar dropped from 12 a.m. to 2 p.m. In the later part of the day, the number of visits gradually reduced and the average time spent for collecting nectar greatly

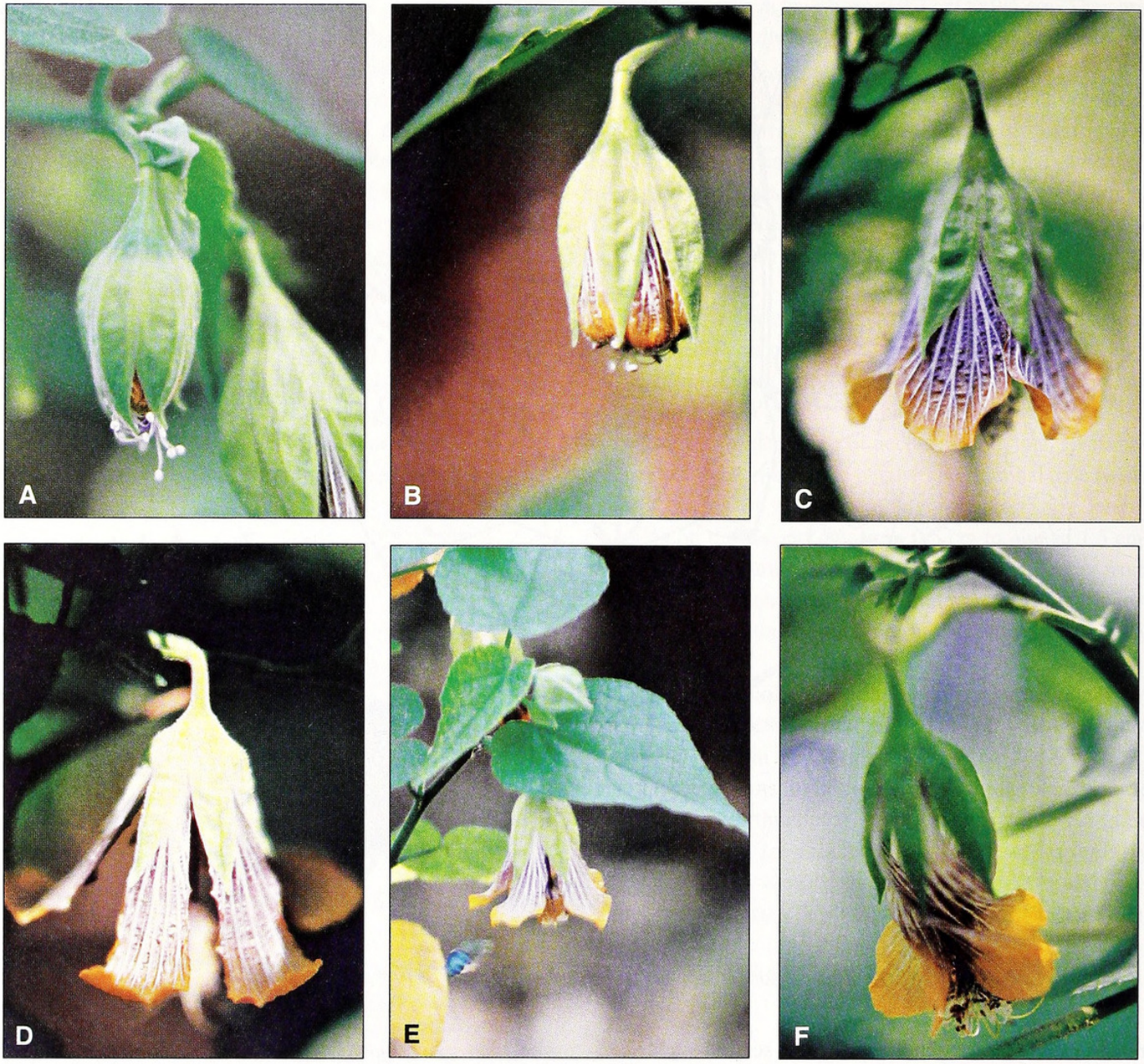


Fig. 3: *Abutilon ranadei* Woodr. *et* Stapf, Floral biology: A & B. Paintbrush stage, C & D. Trumpet stage, E. Pollination stage, F. Contorted corolla stage

increased (Fig. 5). On the third day, the number of insects visiting flowers declined sharply. We observed a positive correlation between insects visiting flowers and pod formation. Further studies are also required to identify the pollinators, and minimum number of mature plants required to attract pollinators. It is not clear whether it is the pollen or the nectar or both, that mainly attract pollinators.

Flowering may not necessarily result in fruit formation. Gregarious flowering was never noticed. On any given day during the flowering season, about 2-12 open flowers are observed on each plant. The total number of flowers set in a season by healthy and mature individuals range between 20-340.

Contorted corolla stage (Stage-4): In this stage, the corolla becomes twisted, mostly on the fourth or fifth day. The corolla shrinks slowly before it falls off. The corolla of the pollinated flowers contorts around the staminal column and blocks the entry of insects or other visitors.

Field observations showed that 60-90% of the flowers fall off without any sign of fruit formation. The calyx tube turns yellow and becomes detached from the pedicel after the corolla tube is shed. The flowers offer pollen as well as nectar in large quantities. Anther dehiscence does not take place instantly. Anthers of some flowers dehisce in more than one phase, preferably in two phases. Location of nectar and flowering time tentatively indicates that flowers may be

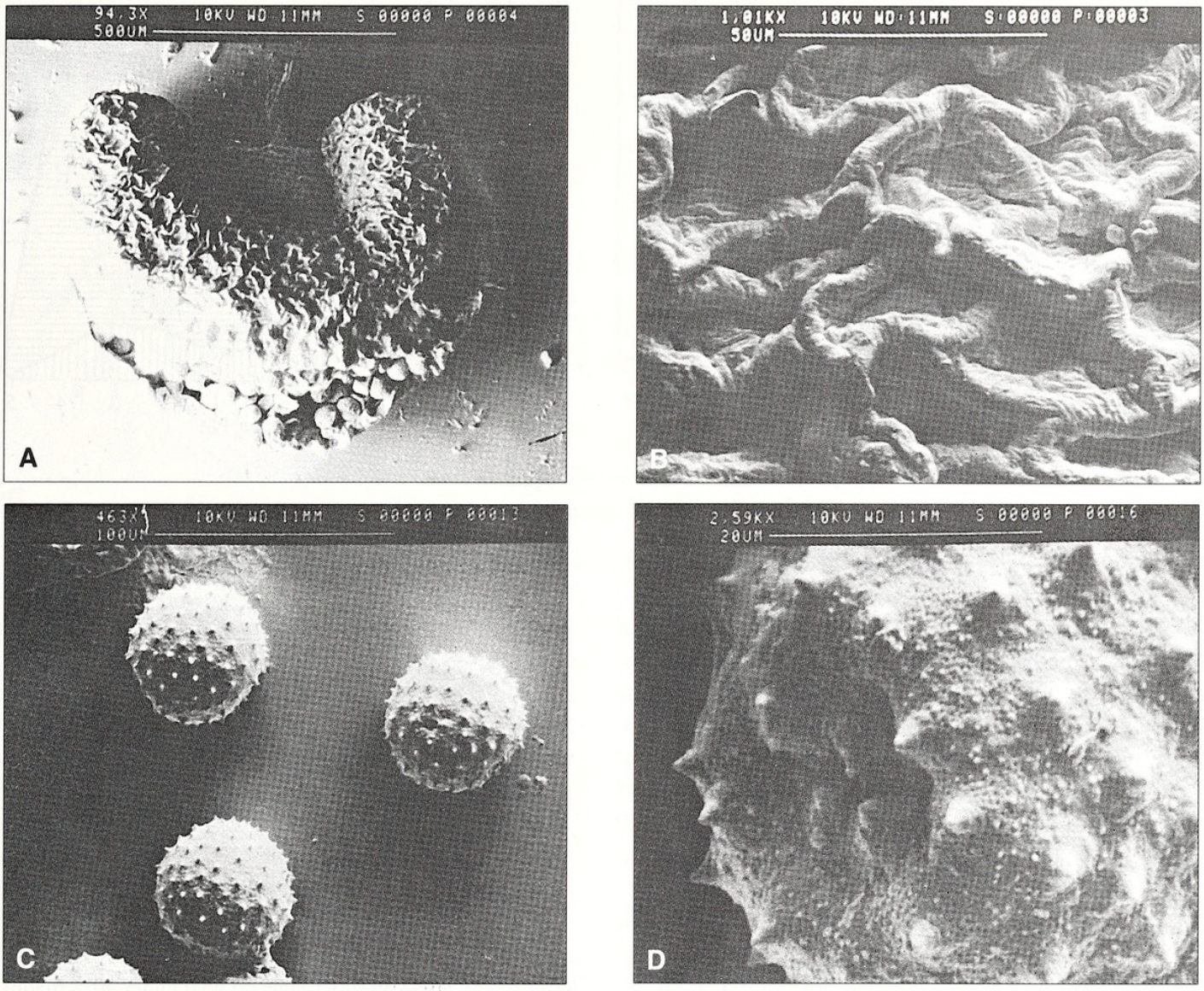


Fig. 4: *Abutilon ranadei* Woodr. *et* Stapf, Scanning Electron Microscope photographs of anther and pollen: A. Single anther, B. Monothecous anther, C. Echinate pollen, D. Pore

pollinated by nectar feeding insects, probably moths.

Seed set: Only 4-20% flowers develop into mature fruit. Fruit a schizocarp, seeds 2-3 per mericarp, brownish-black, kidney-shaped. Fruit formation begins in December and continues till the end of April. Number of fruits per plant range from almost nil to 27.

Seed germination: Depending upon the location, percentage of germination varied from 2%-35% (Table 2).

Propagation: *A. ranadei* can be propagated by seed as well as vegetative propagation.

a) Seed: Germination tests were conducted under nursery conditions. Seeds were sown in net pots and plastic trays. The percentage of aborted seed in this method is very high as the seeds are generally shriveled, small and nonviable. The seeds germinate very slowly, taking a minimum of 20 and a maximum of 30 days to germinate. Net pots are ideal for sowing. Germination takes up to three months in net pots. Seedlings prefer shade (under 90% shade nets). Details of the seed characteristics are presented in Table 2.

b) Vegetative: Poor fruit set and high percentage of non-viable seeds led to the trial of various vegetative propagation techniques at our research farm. Air layering was found to be the most successful method of vegetative propagation. In this method, a girdle was made on a branch not less than 5 mm thick, at about 20-30 cm from the tip. About

Table 2: Seed characteristics of *Abutilon ranadei*

Character	Range	Mean
Number of seeds/ pod	3-15	5.4
Seed weight	0.014 – 0.020 mg	0.016 mg
Seed length	0.384 - 0.520 cm	0.45 cm
Seed diameter	0.353 - 0.464 cm	0.434 cm

• Number of pods studied – 20; Number of seeds studied: 100.

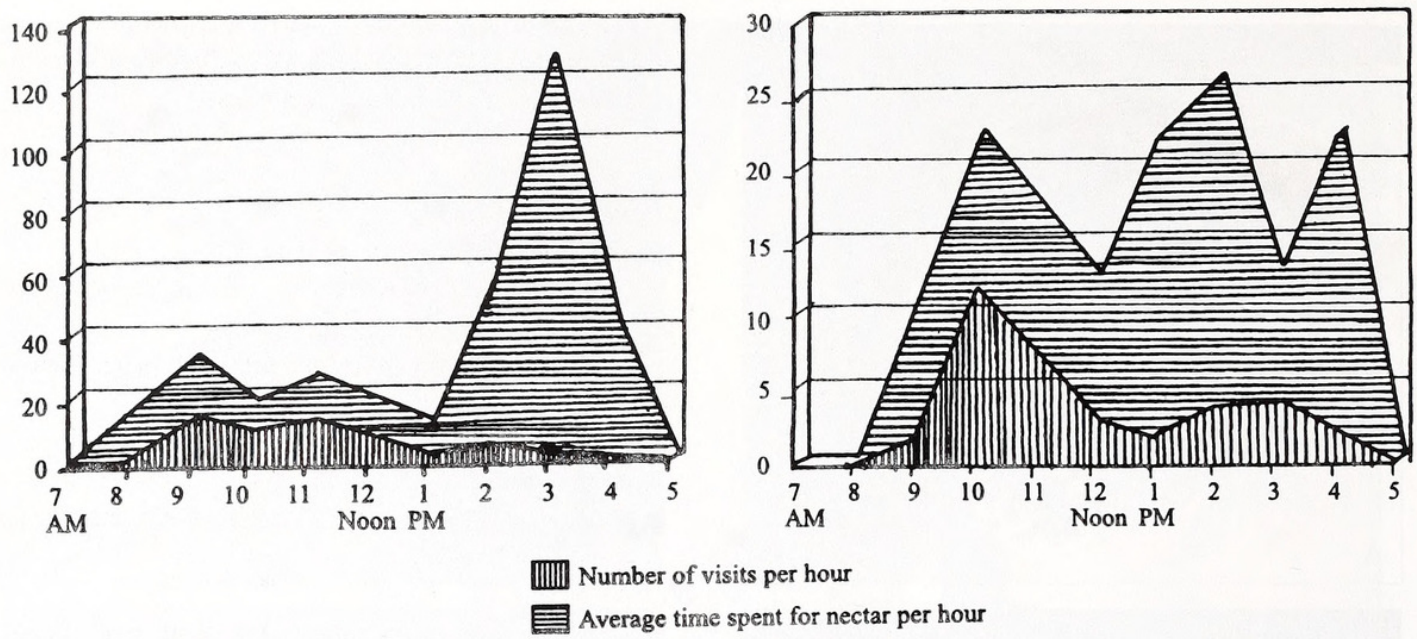


Fig. 5: Flower visiting behaviour of *Anthophorous zonata*

3-5 cm strip of bark was carefully removed (circular cut) without damaging the other parts. The phloem and cambium was completely removed by scraping with a blade to prevent the healing process. The scraped part was washed with Indole-3-butyric acid (IBA 4,000 ppm) for 5 minutes, the area covered with moist sphagnum moss and tied with a polythene sheet to keep the moss in place. Initiation of rooting was visible after two weeks. Rooting takes place within 21 days. The layers were ready for transplant within 45-50 days.

Cultural practices: The plant prefers slightly acidic soil and responds well to organic manure. Good growth is obtained in the following mentioned substratum.

Soil media: Red lateritic soil – 2.5 parts; Vermi compost – 1 part; Sterameal [7(N)-10(P)-5 (K)] – 0.5 part

For better growth, an additional 100 gm vermi compost + 100 gm sterameal per plant is required every three months.

Table 3: Leaf analysis (Macro & Micro nutrients) results of *Abutilon ranadei*

Parameter		Test value
Nitrogen (N)	-	3.25%
Phosphorus (P)	-	0.60%
Potassium (K)	-	2.06%
Calcium (Ca)	-	5%
Magnesium (Mg)	-	0.93%
Sulphur (S)	-	0.26%
Iron (Fe)	-	590 ppm
Manganese (Mn)	-	40 ppm
Zinc (Zn)	-	116 ppm
Copper (Cu)	-	22 ppm
Molybdenum (Mo)	-	<1 ppm
Boron (B)	-	51 ppm
Sodium (Na)	-	1984 ppm

Leaf analysis for various elements was carried out to understand the problem of flower fall after withering. The test values of the tissue samples showed high concentrations of Nitrogen and Potash, and deficiency of Phosphorus. Among the micronutrients, Sodium and Iron were present in significant amounts. The details of the leaf analysis are given in Table 3.

Spacing: 1 m x 1 m.

Watering: The plant requires good, regular watering. However, it cannot withstand water logging.

Light: *A. ranadei* is a light loving plant. It performs better under partially shaded conditions (The seedlings prefer 90% shade, while mature plants do well under 40% shade).

Pests & Diseases:

1. ***Tetranychus cinnabarinus* (Tropical Red Spider Mite)**

Family: Tetranychidae

Description: An oval shaped mite. Tiny, red or greenish with four pairs of legs (Fig. 6a). Polyphagous, common, serious pest of greenhouse plants and other cultivated crops.

Feeding habits: External feeder. All stages of insects feed on the lower side of the leaf surface.

Damage: Scarification, leaf silvering and appearance of yellow patches.

Control: Biological: *Phytoseilus riegeli* (predaceous mite).

Chemical: 1) Foliar spray of Dimethoate (0.5 ml/litre), 2) Carbaryl (2 ml/litre) + Neemarin (3 ml/litre), 3) Sulphur (3 gm/litre), 4) Kelthane (2 ml/litre).

2. ***Ferrisia virgata* (Ckll.) (Striped Mealy bug)**

Family: Pseudococcidae

Description: An elliptic shaped mealy bug with a pair

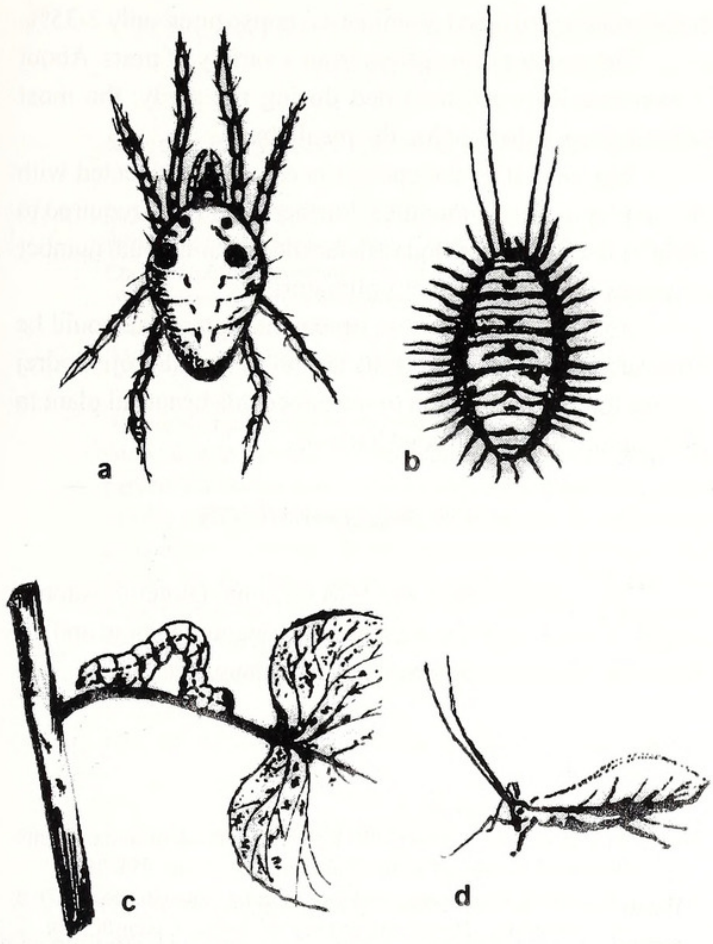


Fig. 6: Pests of *Abutilon ranadei* Woodr. *et* Stapf,

a. Tropical Red Spider Mite (*Tetranychus cinnabarinus*),
b. Striped Mealy Bug (*Ferrisia virgata*),
c. Cabbage Semi-looper (*Trichoplusia ni*),
d. Aphids (Family Homoptera)

of conspicuous longitudinal submedian dark stripes, pronounced long tail and long glassy wax threads (Fig. 6b).

Feeding habits: The most serious polyphagous pest. Sucking type, feeds on tender parts and leaves.

Damage: Wilting, infestation by sooty moulds, growth retardation.

Control: Biological: *Cryptoleumus monterouzuni* (6 per 100 sq. m)

Chemical: 1) Malathion (1 ml/litre) + Fish oil resin soap, Azinphos-methyl (2 ml/litre).

3. ***Trichoplusia ni*** **(Hb.) (Cabbage Semi-looper)**
Family: Noctuidae

Description: Green with a thin, white lateral line, and two white lines along the middle of the back. There are two pairs of prolegs (Fig. 6c).

Feeding habits: Larva feeds on young leaves. Active at low temperatures, makes irregular holes in the leaf.

Damage: Irregular holes in the leaf lamina.

Control: Biological: 1) *Bacillus thuringiensis*, 2) *Trichogramma* (parasitoid eggs 2000-3000 per 100 sq. m)

Mechanical: Ultraviolet light traps.

Chemical: Carbaryl (2 ml/litre)

4. **Unidentified (Aphids)**
Order: Homoptera, Family: Aphididae

Description: A small soft-bodied, sluggish insect, with piercing and sucking mouth parts (Fig. 6d).

Feeding habits: Usually attacks tender parts. Feeds on the lower surface of the leaves.

Damage: Leaf curling, infection with sooty mould, presence of ants.

Control: Biological: 1) Ladybird (Coccinellidae), 2) *Crysoperta carnae* (adults 400 per 100 sq. m), 3) Hymenopterous parasites.

Chemical: 1) Soap water, 2) A number of systemic insecticides (Permethrin, Pirimicarb).

5. ***Chrysomphalus aonidum*** **(L.)**
(Florida Red scale or Purple scale)
Family: Diaspididae

Description: Adult female is purplish and circular, with a reddish-brown boss or nipple in the centre.

Feeding habits: Feeds on leaves, young shoots and twigs.

Damage: Saliva is toxic, causing necrosis.

Control: Biological control: *Chilochorus nigritus*

Chemical: 1) Carbaryl (3%), 2) Parathion (0.5%), 3) Malathion with white oil

6. **Unidentified Leafminer**
(Microlepidoptera)

Description: Minor pest. Tunnel leaf mine with no central line of faecal pellets.

Feeding habits: Attacks during rainy season.

Damage: Leaf tunnels. Destroys the photosynthetic structure.

Control: Chemical: 1) Triozophos (Hostathion 3 ml/litre), 2) Phosphamidon (1 ml/litre) + Fish resin oil soap (1 ml/litre)

7. **Unidentified Snail**
Phylum Mollusca

Description: Nil.

Feeding habits: Nocturnal feeders. Feed on young leaves, flower buds.

Damage: Minor damage. Young leaves are affected.

Control: Mechanical: Hand pick, Cabbage and Papaya – yellow leaves for trapping.

Chemical: 1) 2-4% salt water, 2) Lime treatment

DISCUSSION

All over the world, endemic plants are in double jeopardy. On the one hand, they are restricted to small pockets, being habitat specific. On the other, their habitat is being lost at an alarming rate, pushing them towards extinction. *A. ranadei* is a critically endangered plant. Urgent measures are required to conserve this plant in its natural habitat, mainly comprising the edges of moist deciduous forests of Western Ghats. It is often found growing among *Carvia callosa* (Karvi) thickets, which are prone to a variety of disturbances: being periodically cleared by the local communities for fuel wood, and to stake tomato plants.

High level of flower fall (60-90%) without fruit formation is a common problem in all the studied locations. Leaf analysis of the macro and micronutrients indicated the deficiency of phosphorus. However, extra support of phosphorus in cultivated conditions did not improve the condition of flower fall. Percentage of seed germination is also poor, only 2-35%.

The species also suffers from a variety of pests. About 7 pest species were recorded during the study, the most serious among them being the mealy bug.

The habitat of the species needs to be protected with the help of local communities. Further studies are required to identify the pollinators and to determine the minimum number of plants needed to attract pollinators

Abutilon ranadei is an ornamental plant and could be cultivated. Experimental trials are on at the Naoroji Godrej Centre for Plant Research to introduce this beautiful plant to horticulture and in artificial habitats.

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