Details of the structures of the radula of both the species are shown in Figures 1 and 2 respectively. The teeth of *C. monile* (Figure 1 *a*) averaged 1–1.2 mm in length compared to the teeth of *C. amadis* which has a length of 1.5 mm (Figure 2 *a*). The teeth of both the species consist of chitinous material rolled into a tube, which is sharpened to a point at the apex and has adapical barbs (b) (Figures 1 *a* and 2 *a*). Both the species observed show 2 barbs and 2 cutting edges with the base (ba) of the tooth of both the species starting at the basal opening (bo). The basal opening with an elevated base (eb) and external fold (ef) is broader in *C. amadis* when compared to *C. monile*. A construction (c) just before the expansion of the tooth base is seen (Figure 2 *b*), and shows the basal opening open into the lumen and attachment ligament (l) which was also observed for *C. monile*. The teeth of *C. amadis* has a basal spur (s) at its base which is lacking in the teeth of *C. monile*.

The middle portion of the teeth of both the species shows considerable variations (Figures 1 *c* and 2 *c*). The shafts (st) of *C. monile* teeth are tubular (Figure 1 *c*) whereas those of *C. amadis* are constricted and uneven, with a thick swelling before joining with the tip of the radula (Figure 2 *c*). Moreover, the *C. amadis* radula clearly lack denticles (dt) which are seen on the *C. monile* teeth. The tips (t) of the teeth of both the species are elaborated (Figures 1 *d* and 2 *d*). Simple modifications of the apex and the prominent denticles are adequate for *C. monile* tooth to penetrate and hold on to the body of the worm. Conduction of the venom from the venom gland to the victim is via the basal opening, the lumen and through to the adapical opening.

The structure of the radula by SEM confirms *C. amadis* to be molluscivorous and *C. monile* as vermivorous and is in agreement with previous reports[9] based on feeding behaviour. The radular teeth are highly modified, consistisng of a sheet of chitin rolled into a tube[2,9] and not arranged in rows, but attached to a common basal membrane. They are secreted individually in two files with each individual tooth having its own ligament. They are stored in the short arm of the radular apparatus and are always kept in readiness for use. The ligaments which are remnants of the basal membrane function to move the teeth into the short arm.

Members of the worm feeding cones feed on polychaete worms that have a soft body wall and dwell in tubes or burrows. These cones possess an additional requirement, the denticles and basal spur in their teeth to pull the worm out of its habitat. Also the spur and the denticles serve to retain the tooth in the proboscis and also probably serves to provide a better grip for the proboscis when it attempts to pull out the worm[9].

Radular morphology of *Conus* shows considerable interspecific variation with respect to the number of barbs, cutting edges and length of the teeth. Mollusc-hunting cones (to which *C. amadis* belongs) have 2 barbs and 2 cutting edges with the presence of denticles along the shaft. *C. textile* a mollusc-hunting cone, is unique in this group in that it does not possess any denticles on the shaft and, now, *C. amadis* is another which has a non-denticular shaft. The spur at the middle of the shaft in *C. amadis* ensures that the tooth is not pushed back into the proboscis when it attacks the prey. The presence of spur and decrease in barb number show that the prey of *C. amadis* are slow responding organisms like their own kind and also the absence of a basal spur suggests that it does not retain the teeth after attacking, unlike *C. monile* which retains it. The radula teeth of worm-hunting cones like *C. imperialis* and *C. pulicarius* are typified by the presence of a long cutting edge.

From the above studies it can be concluded that *C. amadis* is molluscivorous and *C. monile* vermivorous. Based on this and the previous studies the teeth of *Conus* can be classified into three main predatory groups based on their structure[2]. Although the three feeding groups can be distinctly differentiated, there are differences within each feeding group.

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Visitation patterns of birds and butterflies at a *Helicteres isora* Linn. (Sterculiaceae) clump

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There have been very few studies on pollination by birds in India. In this study, animal species visiting a flowering clump of *Helicteres isora*, their feeding behaviour and visitation patterns are recorded. A total of 20 species (11 birds, 8 butterflies, and a mammal) were recorded during the observation period of 36 hours. Birds accounted for the majority of visits, followed by butterflies. Only four species (birds) were pollinators and these visited 45.5% of the total flowers visited by all species, 12 were 'thieves' and four were 'robbers'. Among the birds, Jungle Babblers (*Turdoides striatus*) visited the highest number of flowers and were the main pollinators. There was

a clear temporal pattern in the visits with two visitation peaks: one in the morning and the other in the afternoon.

POLLINATION by birds and bird-pollinated flowers have received attention from all over the tropics. Hermit hummingbirds (Phaethorninae) and *Heliconia* flowers provide a striking example of specialized pollination mutualism[1]. In India, however, very few studies have been conducted on pollination by birds[2] but for a detailed study on the pollination aspects of mistletoes of southern India[3].

Apart from pollinators, flowers are also frequented by other kind of visitors which are mainly 'thieves' that use the pollen and nectar opportunistically[4]. This is detrimental to the reproductive success of plants. Inouye[5] classified various types of visitors to plants on the basis of their behaviour related to methods of pollen/nectar harvest.

In this note I document the various visitors to the flowering shrub *Helicteres isora* Linn. (Sterculiaceae) and classify them into three categories[5] to identify those that are beneficial (pollinators) to the plant and those that are not (thieves and robbers). A thief is one that derives benefits (nectar or pollen) without harming the morphological integrity of the flower but at the same time precludes pollination due to mismatch of morphologies. In contrast, robbers obtain nectar by damaging the flower, but do not effect pollination. I also analysed the temporal patterns of these visits.

H. isora is a large shrub, commonly found in the undergrowth of deciduous forests and teak plantation in southern India. Its tubular flowers measure about 4 cm in length and are red, fading to 'lead' (blue) towards the end of the day[6]. The red colour and tubular shape of the *H. isora* flower with a robust corolla and lack of any odour suggests it to be a typical bird flower[7]. Colour changes in flowers may help flower visitors in discriminating the nectar-producing flowers from the older flowers with no nectar, thereby increasing their foraging efficiency[8]. Subramanya and Radhamani[2] have included it in their list of plants regularly frequented by birds, though only three species of birds are listed as known to visit its flowers.

The flowering season of this plant varies and appears to follow the rainy season. In Mahabaleshwar (Western Ghats, Maharashtra), flowers were seen between July and September, the period of southwest monsoon[9] while at Venkatagiri (Eastern Ghats, Andhra Pradesh), it was seen in bloom in November during the north-east monsoon[10]. Being a common plant, flowering synchronously, it offers nectar in abundance during the flowering season.

The study was conducted at the Mundanturai Tiger reserve, 8°40′N and 77°28′E in the southern Western Ghats in Tamil Nadu state. The site was located about a kilometre from the Forest Rest House on the Mundanturai Plateau (elevation about 180 m). The vegetation at the site had been disturbed by human activities in the past and consist of scattered trees and scrub besides plantations of Teak (*Tectona grandis*) and *Eucalyptus* sp. In the past, the area supported moist deciduous forests and even at present, remnants of this vegetation can be seen.

Table 1. List of animal visitors and details of their visits at the *H. isora* clump

Species	1	2	3	4	5	6
Turdoides striatus Jungle Babbler	P	56	748	13.4	43.18	13
Nectarinia zeylonica Purplerumped Sunbird	T	135	415	3.1	23.96	–3
Pycnonotus luteolus Whitebrowed Bulbul	R	39	179	4.6	10.33	–9
Pycnonotus cafer Redvented Bulbul	R	21	96	4.6	5.54	–9
Pycnonotus jocosus Redwhiskered Bulbul	R	11	50	4.5	2.88	–9
Psittacula cyanocephala Blossomheaded Parakeet	R	1	21	21.0	1.21	–42
Chloropsis aurifrons Goldfronted Chloropsis	P	9	18	2.0	1.04	2
Acrocephalus dumetorum Blyth's Reed Warbler	T	25	14	0.6	0.80	–1
Dicrurus leucophaeus Grey Drongo	P	4	12	3.0	0.69	3
Dicrurus caerulescens Whitebellied Drongo	P	3	11	3.7	0.63	4
Nectarinia asiatica Purple Sunbird	T	1	1	1.0	0.05	–1
Butterflies						
Pachilopta hector Crimson Rose	T	39	65	1.7	3.75	–2
Principes polytes Common Mormon	T	31	65	2.1	3.75	–2
Neptis hylas Common Sailer	T	9	13	1.4	0.75	–1
Delias eucharis Common Jezebel	T	1	4	4.0	0.23	–4
Euploea core Common Crow	T	1	2	2.0	0.11	–2
Moduza procris The Commander	T	1	1	1.0	0.05	–1
Unidentified sp. 1	T	1	1	1.0	0.05	–1
Unidentified sp. 2	T	1	1	1.0	0.05	–1
Mammal						
Funnambulus palmarum Five-striped Palm Squirrel	T	2	15	7.5	0.86	–8
Total		391	1732	4.4	100.00	

1, Category (P = Pollinator, T = Thief and R = Robber. See text for definitions); 2, Total visits; 3, Total flowers visited; 4, Mean no. of flowers/visit; 5, % of total flowers visited; 6, Index of relative usefulness of the visitors to *H. isora*.

A large clump of *H. isora* bushes was monitored for five days from 18 to 23 January 1988 between 0700 and 1700 hrs, though the duration varied from day to day. The number of flowers at this clump varied from about 600 to 900. Observations totalling 39 hours were made of which only hour-wise observations amounting to 36 h were considered for analysis.

Observations were made from a spot, about 15 m from the clump using a pair of 8 × 40 binoculars. The following details were noted: (i) The time of the day; (ii) Species visiting the clump (a visit lasts from the time the bird lands on the clump till it leaves it; an individual that leaves the clump and returns after a lapse of time is treated as having visited a second time); (iii) Number of flowers visited (assuming that the animal fed every time it inserted its beak or proboscis into the corolla tube or punctured it at the base). Observations on the foraging manoeuvre employed by different species and the interactions among various species were also recorded. In case of flocks, the number of visits was recorded as one per individual. The total number of flowers visited by the flock was calculated using observations on any one individuals selected at random, and multiplying this with the total number of birds present in the flock.

A total of 20 species were recorded at the *H. isora* clump. This included eleven species of birds, eight species of butterflies and the Palm Squirrel (Table 1). Visitors were classified into three categories namely pollinators, thieves, and robbers (Table 2). The relative usefulness of the visitors to the plant was determined using a simple index where the mean number of flowers visited per visit was multiplied with the following values: 1 in the case of pollinators; –1 in the case of thieves and –2 in the case of robbers. The species most useful to the plant will have the highest positive value, while the one least useful to it will record the maximum negative value. Beak-length ranges of the bird species in the three above-mentioned categories (Table 3) were extracted from Ali and Ripley[11].

From the overall visitation pattern at the clump (Figure 1) it is clear that birds were the main visitors, accounting for 78% of the visits and 90.31% of the flowers visited. This was followed by butterflies who made 21.5% of the visits and visited 8.7% of the total flowers visited. Among the avian visits, Jungle Babblers accounted for the maximum flowers visited (748 flowers, 43.2%; Table 1). The next in importance were the Purplerumped Sunbird and Whitebrowed Bulbul. Of this, sunbird was the most frequent visitor in terms of total visits made: 135 visits (34.5%).

Table 2. Summary of the nature of visitors at the *H. isora* clump

	Birds	Butterflies	Squirrel	Total
Pollinators	4	–	–	4
Thieves	3	8	1	12
Robbers	3	–	–	4
Total	11	8	1	20

Table 3. Beak-length range of the three categories of birds visiting the *H. isora* (data from Ali and Ripley[11])

Species	Beak length (mm)
Pollinators	
Turdiodes striatus	22–25
Chloropsis aurifrons	22–25
Dicrurus leucophaeus	25–28
Dicrurus caerulescens	22–25 (27)
Robbers	
Pycnonotus luteolus	18–20
Pycnonotus cafer	19–21
Pycnonotus jocosus	17–20
Psittacula cyanocephala	16–19
Thieves	
Nectarinia zeylonica	16–19
Nectarinia asiatica	20–22
Acrocephalus dumetorum	15–18

Four bird species were classified as pollinators based on the presence of pollen on their foreheads (Table 1): Jungle Babbler, Goldfronted Chloropsis, Grey Drongo and Whitebellied Drongo. Together, these species accounted for 789 flowers (45.5%) of the total flowers visited by all visitors to the clump. Jungle Babblers were the main pollinators of the *Helicteres* at Mundanturai. Though omnivorous in their dietary habits, Jungle Babblers are known to be fond of nectar and Ali and Ripley[11] have recognized them as pollinators of other flowering plants. The Jungle Babbler with the highest positive index value of 13 emerged as the species most useful to the plant followed by the Whitebellied Drongo (Table 1).

Of the remaining 16 species, 12 were thieves and four were robbers. Thieves visited 34.4% of the flowers while robbers accounted for 20% of the flowers visited. All butterflies and the palm squirrel were thieves. Blossomheaded parakeets were the most destructive among the robbers and were seen plucking flowers and dropping them after squeezing them of their nectar. Bulbuls were also noticed plucking petals and staminal tubes to access the nectar. The species most harmful to the *Helicteres* was Blossomheaded Parakeet with an index value of –42 and was followed by all three species of bulbuls (–9).

Interestingly, among birds, all the pollinators had longer beaks (> 22 mm) while the thieves and robbers had shorter beaks (< 22 mm) (Table 3). Longer beaks may enable birds to access the nectar without damaging the flower.

The specialized nectar feeders belonging to the families Irenidae, Dicaeidae, Nectariniidae and Zosteropi-

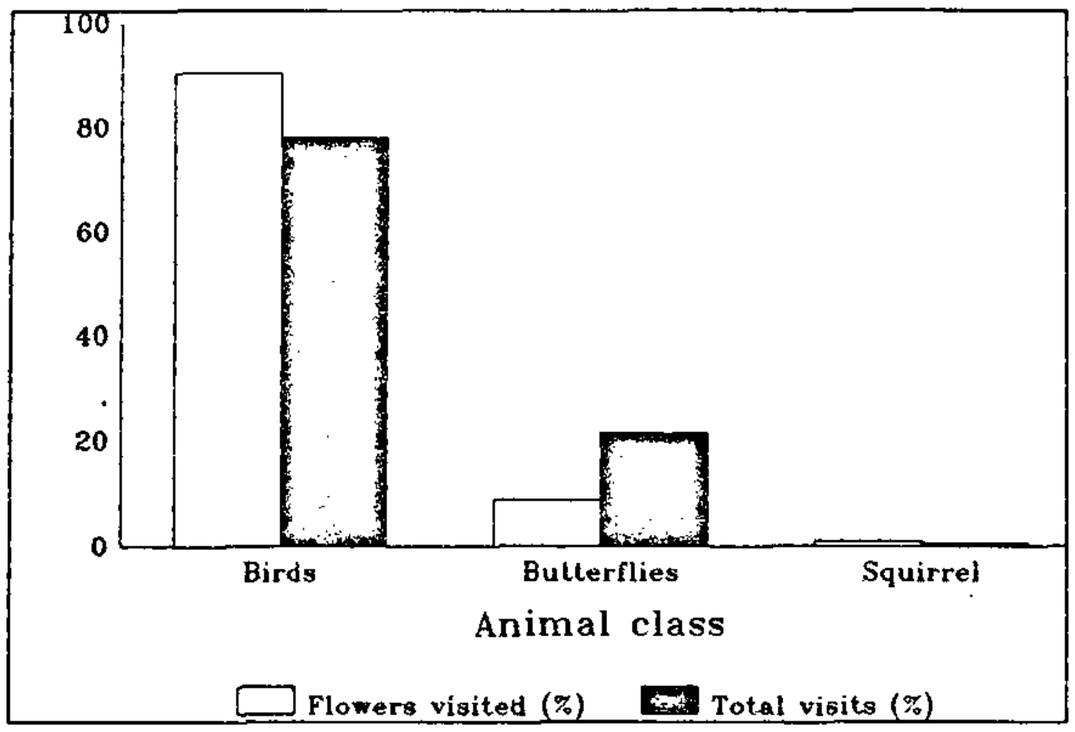

Figure 1. A summary of the number of visits to the *Helicteres* clump and total number of flowers visited by three classes of animals. Sample sizes [visits (flowers visited)] are: Birds, 305 (1565); butterflies, 34 (152) and squirrel, 2 (15).

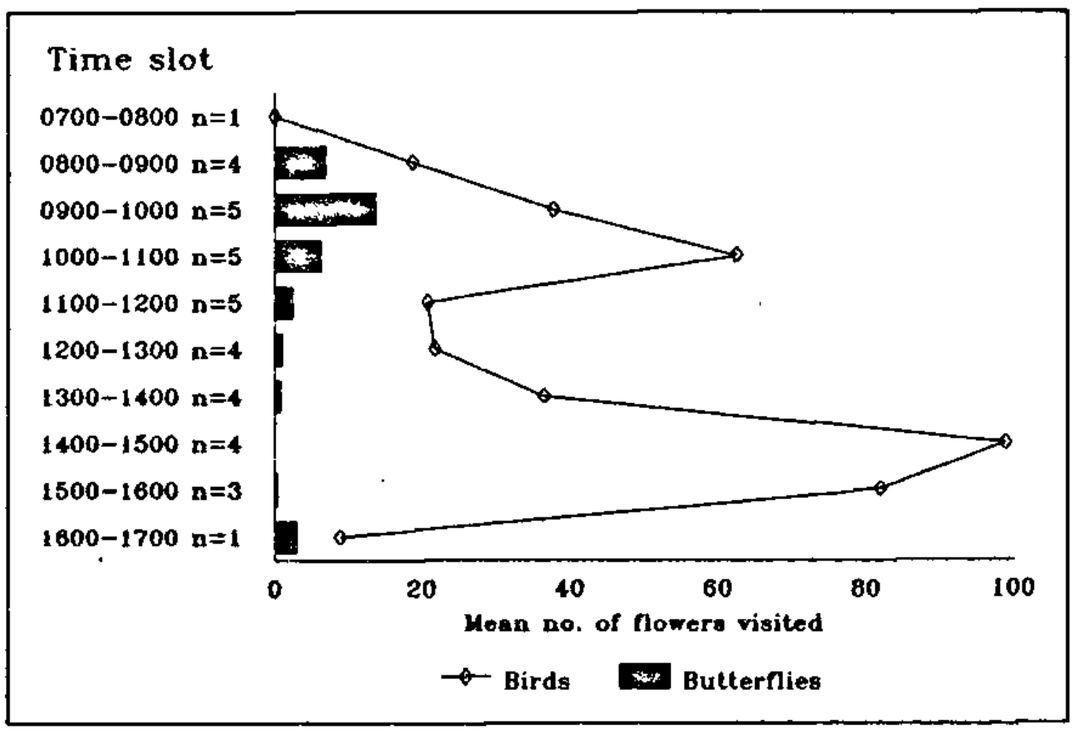

Figure 2. Temporal pattern in visitation by birds and butterflies at the *Helicteres* clump. (Values given are the mean of the five days' data per hour slot.) *N* values refer to the total number of hours of observation per hour slot.

dae[12,13] were represented by eight species in the study site (pers. obs.). However, only three of these visited the *Helicteres* flowers, accounting for visiting 434 flowers (25%). Of these, the two Sunbirds that accounted for bulk of the visits (24%), did not aid in pollination as they made no contact with the anthers. Some of the visitors to the clump such as the Blyth's Reed Warbler foraged mainly for insects and occasionally supplemented their diet with nectar and this accounts for the lower rates of flowers visited by them (Table 1).

The break-up of visitation data, hour-wise at the *Helicteres* clump showed a clear temporal pattern in the visits (Figure 2). The butterfly visits peaked in the morning between 0900 and 1000 h with the rates falling in the afternoon. There was some revival of visits between 1600 and 1700 h. In the case of birds, the peak was between 1000 and 1100 h in the forenoon and between 1400 and 1500 h in the afternoon. The main visitor in the afternoon was the Jungle Babbler that came in flocks and visited maximum number of flowers and this accounted for the higher activity in the afternoon. The biomodal peak of visitation at the clump may be a result of the tracking of resources by the visitors, as nectar secretion of typical bird flowers is known to follow a bimodal peak in the day[7]. However, further studies on nectar secretion pattern are needed to confirm this in *Helicteres*.

Territorial behaviour at flowering plants by birds has been reported by earlier studies, especially for Sunbirds[11–14]. However, during the present study, no such behaviour was evident. This was perhaps due to the abundance of flowering *Helicteres* clumps all over the study area during the study period.

The absence of Mynas (Sturnidae) at the *Helicteres* was most striking. Mynas are regular consumers of nectar[15] and being more aggressive and possessing longer beaks[11], they could play an important role in the pollination of this shrub. Elsewhere, two species of Mynas have been feeding on the nectar of *Helicteres* (pers. obs.). Their absence at the flowering clump at the present study area was related to the general paucity of Mynas at the plateau during the study period (pers. obs.).

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