Beetle-Pollination—Cantharophily—in *Amorphophallus hohenackeri* (Araceae)

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ABSTRACT

The beetle, *Haptoncurina motschulskii* (Reitter) Jelinek (Coleoptera: Nitidulidae) is found to be an effective agent of cantharophily in *Amorphophallus hohenackeri* (Schott) Engl. et Gehrm., an endemic of Southwest India. Detailed observations on the floral characters and the pollination mechanism are given.

KEY WORDS

Araceae, *Amorphophallus hohenackeri*, Beetle pollination, Cantharophily.

INTRODUCTION

The pollination biology of the family Araceae is little studied except for the significant works of Hubbard (1895), Cleghorn (1913), Knoll (1926), van der Pijl (1937), Meeuse (1959), Meeuse & Hatch (1960), Dormer (1960), Monteith (1973), Williams & Dressler (1976), Golubev & Volokitin (1983), Valerio (1984), Gottsberger & Amaral (1984) and Young (1986). Their works revealed that the aroids are mostly entomophilous, (insect pollinated) and in most cases the pollinators are beetles (Coleoptera) and flies (Diptera). Very rarely, bees (Hymenoptera) also act as pollinators, as in the case of *Spathiphyllum* (Williams & Dressler 1976). There might be other important reports on studies on pollination biology of aroids which the authors have not come across. Apart from Araceae, cantharophily (beetle pollination) is prominent in families like Palmae (Henderson 1986), Nymphaeaceae (Prance 1980) and in many families of the Annonales (Ashton 1969, Faegri & van der Pijl 1979, Thein 1979, 1980, Armstrong & Drummond 1986).

The general syndrome of beetle pollination is rather uncharacteristic. Beetle flowers are frequently overlooked owing to their lack of specialization. The visits of beetles in blossoms are considered to be accidental, which they sometimes, but far from always, are. The role of beetles in pollination was long overlooked even after Diels' (1916) demonstration of cantharophily and its importance (Grinfeld & Issi 1958, Meeuse 1959). One reason is that typical beetle pollination is especially rare in the European extra-tropical flora, and prevailing concepts in pollination ecology still depend largely on European tradition. Beetle pollination is as characteristic of the tropical zone as bee pollination is of temperate (semi-arid) regions (Faegri & van der Pijl 1979).

Beetles (Coleoptera) are one of the oldest groups of insects. They were already numerous at the time we assume that higher plants first came into existence, during the Upper Jurassic or Lower Cretaceous, whereas the higher hymenoptera and lepidoptera, so important in pollination today, had not developed. So, if insects had any function in pollination at that time, we may safely assume that beetles stood at the cradle of the flower (Faegri & van der Pijl 1979).

A review of pollination in palms by Henderson (1986) has shown that cantharophily is widespread. Barfod, Henderson & Balslev (1987) pointed out that cantharophily is generally associated with phenomena like protogyny (pistils maturing before stamens) elevation of temperature, musty odor, crowded pistil-

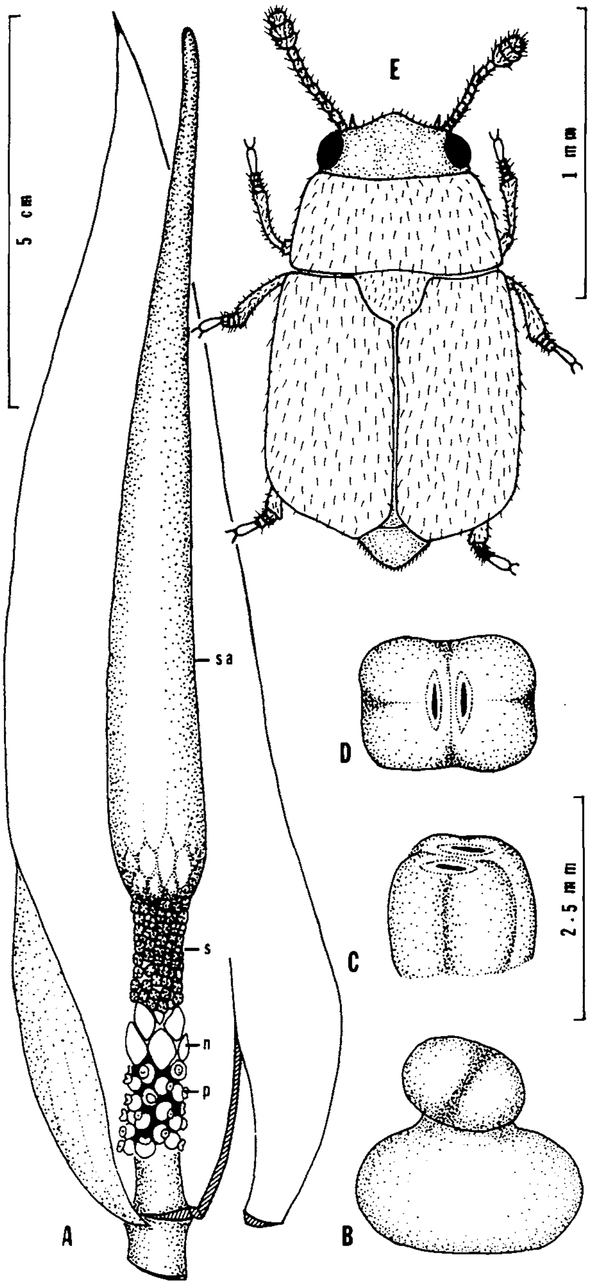

Fig. 1. Sketches of inflorescence and flowers of *Amorphophallus hohenackeri*, and the pollinator beetle *Haptoncurina motschulskii*.

(A) Inflorescence of *Amorphophallus hohenackeri*.
(B) Single pistillate flower.
(C) Single staminate flower, view from side.
(D) staminate flower, view from top.
(E) Pollinator beetle, *Haptoncurina motschulskii*.
[n—neuter flowers; p—pistillate flowers; s—staminate flowers; sa—sterile appendix]

late flowers enclosed by bracts during a brief nocturnal anthesis, and by crowded staminate flowers with many stamens enclosed by bracts during a brief nocturnal anthesis.

STRUCTURE OF SPADIX IN *AMORPHOPHALLUS HOHENACKERI*

Amorphophallus hohenackeri (Schott) Engl. et Gehrm., an endemic species of Southwest India, grows abundantly in the Calicut University Campus (Malappuram Dist., Kerala State). Flowering begins soon after the first rains (April-May). During the monsoon season (June-September) only leafy and fruiting specimens are seen.

As is characteristic of the genus, *A. hohenackeri* is a monoecious, tuberous herb. The inflorescence is produced on a long peduncle of about 45-60 cm long and 6-10 mm in diameter. An erect, ovate-acuminate, shortly apiculate spathe subtends the stipitate spadix (Figs. 1A, 2A.). The lower quarter portion of the spadix constitutes the fertile region with a basal pistillate zone of 25-40 spirally arranged pistillate flowers (Fig. 1A-p), a staminate zone of 50-75 staminate flowers above (Fig. 1A-s), seperated by a central zone of 8-15, round to elongate-rhomboid, gibbous, cream colored, neuter flowers arranged in 1-3 rows (Fig 1A-n). The rest of the spadix is produced into a sessile, barren appendix (Fig. 1A-sa). Sometimes inconspicuous, rhombic projections are found at the base of the appendix. The presence of neuter flowers between pistillate and staminate zones is characteristic of the *Amorphophallus* section *Rhaphiophallus* Schott to which this species belongs.

The flowers are protogynous. Initially the basal portion of the spathe is convolute, encircling the basal portion of the spadix to the staminate portion and exposing the upper portion. At a very later stage, the margins separate, partially exposing the basal portion of the spadix.

MECHANISM OF BEETLE POLLINATION

While studying a population of *A. hohenackeri* in the Calicut University Campus, we came across an interesting small, 2-3 mm long beetle, *Haptoncurina motschulskii* (Reitter) Jelinek (Coleoptera : Nitidulidae) which acts as an effective pollinator in this species. (Fig 1E).

The beetles were noticed to occur in a good number of plants of this species with 5-15 beetles seen at a time on a single spadix. The spathe normally opened in the evening and emitted a foul, fetid smell. The odor remained for a day and the intensity of smell gradually decreased. Beetles carrying pollen grains from other inflorescences were presumably attracted by that odor and alighted on the sterile appendix. In freshly opened inflorescences, the appendix surface was very smooth and slippery. The beetles alighting on them fell to the bottom of the spathe immediately or after taking a few paces. The flowers being protogynous, the stigma was receptive during that period. The beetles below the spadix were seen attracted by the swollen neuters situated above the pistillate zone, and those neuters acted as an attractant 'food-bait'. The beetles, carrying the pollen, crawled up across the pistillate zone to the neuter zone, simultaneously effecting pollination.

Some beetles alighting on the base of the appendix crawled over the staminate portion to reach the neuteriflorous zone and remained there for 3-4 days eating the neuter flowers. In the meantime, some beetles wandered around and crawled over pistillate flowers effecting pollination. Some beetles made their way out through the gap at the base between the margins of the spathe. The beetles which remained for 3-4 days on the spadix eating neuter flowers crawled up over the staminate flowers on their way out. By that time the staminate flowers were mature and released pollen which adhered to the body of those beetles which passed over the staminate flowers. The inflorescence eventually withered and the beetles flew off, covered with pollen. They could visit other inflorescences and effect cross pollination.

DISCUSSION

Van der Pijl (1937) described a similar type of beetle pollination in *Amorphophallus variabilis* Bl. In that species the presence of a slippery zone on the spadix appendix was not reported, but the insects were assumed to have crawled down from the appendix over the stigma of pistillate flowers and reached the base of the spathe where there was a zone of food tissue containing starch grains and oil drops. During the passage of the insects over stigmas, pollination was effected. Here the initial source of attraction of insects to the inflorescence was reported to be a fetid smell emitted by the spadix. The attraction of insects towards the base of the spathe was neither nectar nor pollen, but a coherent food tissue. The view that the insects crawled down attracted by the visual effect of food tissue as observed by van der Pijl is corroborated by the observations made in *A. hohenackeri*.

In *A. hohenackeri* no food tissue is present at the botttom of the spathe, but the neuter flowers between the pistillate and staminate zones act as a food-source and also function as a 'food-bait'. The position of food source above the pistillate zone is seemingly a draw back of the plant which hinders the chances of attracting beetles to the pistillate zone which crawl down from above through the appendix. But the presence of a slippery surface on the appendix overcomes this by making the insects fall to the bottom and by forcing them to crawl up over stigmas of the pistillate flowers by the visual attraction of the food-source, the neuter flowers.

One might expect that a winged insect which lost its foothold would fly away. In reality, only the larger ones can do so. Smaller insects take too long to get their wings in operation, and therefore fall into the bottom of the spathe. The plant thus catches only the smaller insects attracted by the smell. Larger ones often make an inspection and fly away. If they alight and fall, they generally become airborne very promptly (Dormer 1960).

In *A. hohenackeri* three phases of 'insect trapping' are in operation which facilitate pollination. The initial phase of attracting beetles from a distance is obtained by the 'odor-trap' which emits a foul smell. Here odor acts as a bait. In the second phase, a majority of insects fall to the bottom via the 'slippery-trap' provided by the appendix. The last phase of effecting pollination is obtained by making the insects crawl over the stigma of pistillate flowers by a 'food-trap'. Here the visual attraction of neuters acts as a bait of food-source and functions as a 'food trap'.

Adaptation for effective pollination and subsequent trapping of beetles inside the spathe until the pollen shedding occurred was reported earlier in *Typhonium brownii* (Monteith 1973, Armstrong 1979). In this species also, the beetle-attractant was a fecal odor similar to that of *A. hohenackeri*, and it lured the dung beetles of the genus *Onthophagus* (Scarabaeidae). The beetles dropped onto the inflorescence and were funnelled by the spathe into the chamber containing the receptive pistillate flowers, where they were trapped overnight, but a food-trap to keep the beetles inside was totally absent. The insects were mechanically prevented from going out by barricading the neck region of the spathe with the downwardly pointed, rigid, bristle-like neuter flowers present just above the pistillate-flowered zone on the spadix.

The insects, in an attempt to escape, could only crawl through the pistillate flowers up to the neuter-flower zone on the first day. This in fact helped in an effective deposition of pollen, which had remained adhered to the beetles from an earlier visit to a *Typhonium* flower, on the receptive stigma. The rigidity of the bristles was lost only on the second day allowing the insects to fly off. The pollen from the staminate flowers was shed before that time and adhered to the body of the insects which helped to pollinate other plants on their later visits. A similar method of pollination was reported earlier in *Arum nigrum* (Knoll 1926). The trapped insects were prevented from escaping, partly by the character of the epidermal cells and partly by the obstacles formed by the bristle-like sterile flowers. Here it was reported that a liquid exuded by the stigma hairs was devoured by the insects trapped in the blossom.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. R. Madge, Commonwealth Institute of Entomology, London, U.K., for indentifying the beetle and Dr. Dan H. Nicolson, Smithsonian Institution, Washington D.C., U.S.A. for reviewing the manuscript. The first author is grateful to the University Grants Commission for the award of Research Scientistship to work on the taxonomy of Araceae of India. □

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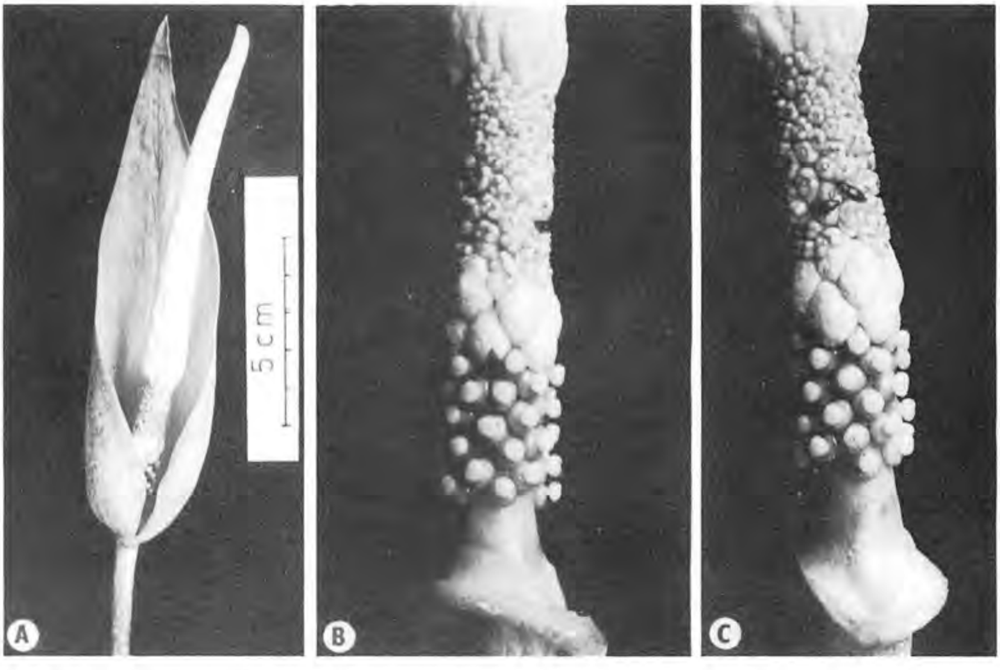

Fig. 2. Inflorescence and flowers of *Amorphophallus hohenackeri*, and the pollinator beetle.

(A) Inflorescence of *Amorphophallus hohenackeri*.

(B) and (C) Basal fertile portion of the spadix with pollinator beetles-*Haptoncurina motschulskii* among pistillate, neuter and staminate flowers.