

The Reproductive Biology of the Peach or "Pejibayé" Palm (*Bactris gasipaes*) and a Wild Congener (*B. porschiana*) in the Atlantic Lowlands of Costa Rica

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The reproductive biology of few of the 2,800 species of palms has been studied in detail so that we know very little about the modes of reproduction in this predominantly tropical family (Tomlinson 1979). Though palms were long thought to be largely wind-pollinated, their pollination is now known to involve several insect orders (Schmid and Schmid 1970, Moore and Uhl 1982).

Bactris is a monoecious, neotropical genus of 239 species, in the cocosoid palm group (Moore 1973). This paper presents observations made on two species: *B. gasipaes* H.B.K., the cultivated "pejibayé" palm, and *B. porschiana* Burret. Pejibayé, grown in plantations for its nutritionally valuable fruits (Figs. 1,2), has been recognized as an underexploited food plant, which has stimulated the development of germ plasm collections and breeding programs in Costa Rica and Brazil. Interest in developing new cultivated strains of pejibayé has now reached a high level, indicating the palm's future role as an increasingly important tropical food crop (Anonymous 1975, Clement and Mora Urpí 1982). Pejibayé's economic potential has led to research into its origin, genetics and reproduction by J. Mora Urpí (Univ. of Costa Rica), and C. R. Clement (INPA-Brazil) and co-workers. The results of this study complement and expand on some of their observations but also differ in some

aspects, e.g., with regard to the potential importance of scarab beetles as pollinators.

Habitat and Habit

Both *Bactris gasipaes* and *B. porschiana* were studied in 1978, 1979 and 1980 at the Organization for Tropical Studies' Finca La Selva field station located in northeastern Costa Rica at the confluence of the rios Sarapiquí and Puerto Viejo (140 m a.s.l.). The primary rain forest vegetation at La Selva is classified by Holdridge et al. (1971) as Tropical Wet Forest and Premontane Wet Forest.

Pejibayé, not known from the wild, formerly extended in cultivation from Honduras to Bolivia and Brazil in moist forests at low and middle elevations (Mora Urpí and Solís 1980). The study plants at La Selva are in an abandoned plantation contiguous with primary forest. Pejibayé clusters, producing sprouts from the base of the mature plant to form a tight clump of several reproductive stems, and grows to about 20 m in height (Fig. 1).

Bactris porschiana, a much smaller species, 5-10 m in height, is a primary forest understory tree native to La Selva. *B. porschiana* also sprouts at the base but produces multistemmed colonies of shoots rather than tight clumps like pejibayé (Fig. 11). Thirty inflorescences of

pejibayé and 14 of *B. porschiana* were observed during the study.

Inflorescence and Flower Morphology

The inflorescence of *Bactris* (Figs. 3,4,12) superficially resembles a "raceme of spikes," but is actually a morphologically complex structure of densely packed triads or cincinni of staminate and pistillate flowers (Moore 1973, Mora Urpí and Solís 1980). The inflorescence has many rachillae and is subtended by a large, heavily armed bract (spathe) which completely encloses it in bud. In both *Bactris gasipaes* and *B. porschiana*, staminate flowers greatly outnumber pistillate flowers (Table 1). Mora Urpí and Solís (1980) found small inflorescences of pejibayé that had staminate flowers only. The pistillate flower consists mainly of a large and hard ovary with inconspicuous rings of petals and sepals at its base (Figs. 3,13). Staminate flowers are smaller with sepals and a well-developed corolla of three valvate petals which enclose six stamens (Uhl and Moore 1977).

The inflorescences of the two *Bactris* species studied are morphologically simi-

lar and differ primarily in size. The pejibayé inflorescence (Fig. 3) has from 46 to 62 rachillae about 40 cm in length. The inflorescence of *B. porschiana* (Fig. 12) is smaller with 42 to 48 rachillae about 25 cm in length.

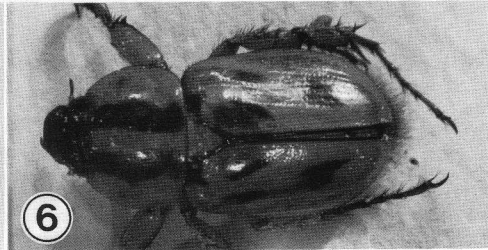
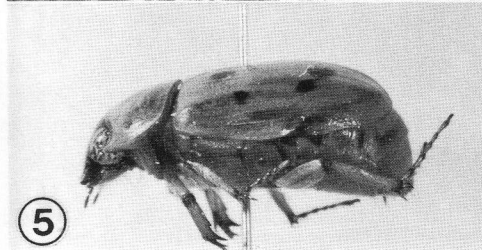
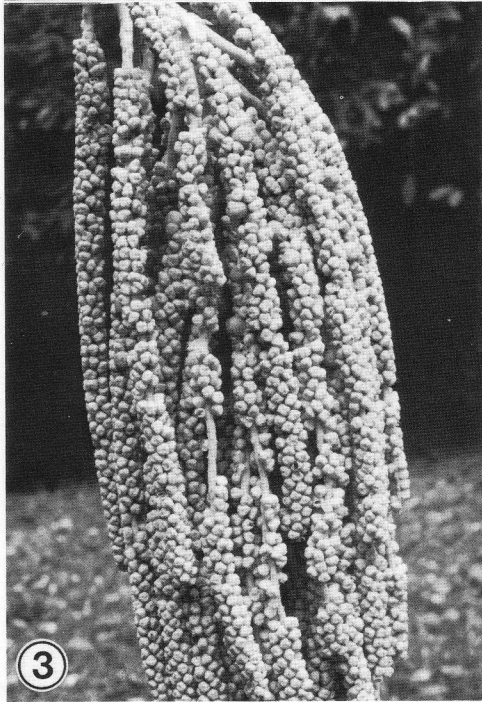
A potentially important difference in the floral morphology of the two species, and one which may differentiate pejibayé from non-cultivated species, is that the pistillate flowers of *B. porschiana* have exerted stigmatic lobes, whereas the stigmatic surface of pejibayé is recessed at the junction of the three connate carpels.

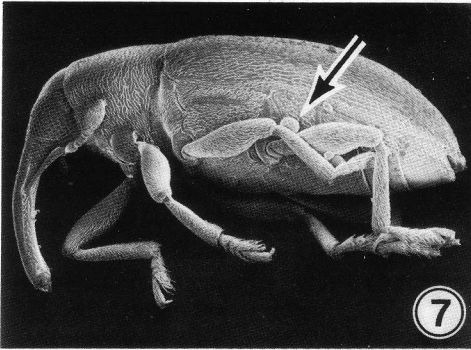
Both species of *Bactris* produce specialized, uniseriate, multicellular trichomes on the peduncle and rachillae of the inflorescence (Figs. 8,9). The distal segments of the trichomes are globose and range from 0.07 mm to 0.09 mm in diameter. The trichome cells have a very thick, lamellate wall and a small central lumen. They are easily detached from the epidermis of the inflorescence, and are eaten by visiting insects.

Phenology

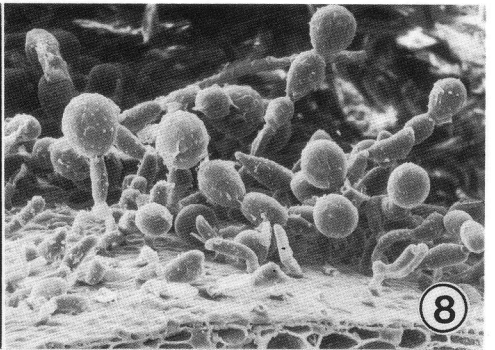
Pejibayé flowers twice a year at La Selva. A major flowering episode occurs

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1. Habit of *Bactris gasipaes* in a plantation at Finca La Selva. $\times 0.004$. 2. Infructescences of *B. gasipaes* with mature fruits. $\times 10$. 3. Inflorescence and flowers of *B. gasipaes* showing many rachillae. $\times 15$. 4. Pistillate phase inflorescence of *B. gasipaes* with two collared arçaris (*Pteroglossus torquatus*) feeding on *Cyclocephala* located inside the inflorescence branches. $\times 0.03$. 5. *Cyclocephala amazona*. The most important scarab beetle visitor to *B. gasipaes* and *B. porschiana* at La Selva. Side view. $\times 3.6$. 6. *C. amazona*. Dorsal view. $\times 4.0$.
 7. SEM side-view of *Phyllotrox megalops*, the most abundant weevil visitor to the inflorescences of both species of *Bactris*. Sphere at the base of hind leg (arrow) is a trichome segment (Fig. 8). $\times 39$. 8. SEM of the uniseriate, multicellular inflorescence trichomes from *B. gasipaes*. $\times 94$. 9. SEM of epidermal surface of *B. gasipaes* peduncle showing densely-packed trichomes. $\times 42$. 10. SEM of the head of *Cyclocephala amazona* showing many *Bactris* trichome segments in mouth cavity and on other parts of the body. $\times 36$.
 11. Habit of a young, mature individual of *Bactris porschiana* in the Arboretum at La Selva. $\times 0.03$. 12. Inflorescence of *B. porschiana* showing scarab beetles (*Mimeoma* and *Cyclocephala*). Photograph taken in the late afternoon of a Day 2 inflorescence after male flowers had opened but before they abscised. Scarabs are feeding on pollen from the open male flowers. $\times 37$. 13. Close-up view of a portion of a *B. porschiana* inflorescence during the pistillate phase, showing male and female (arrows) flowers. $\times 1.3$. 14. Top view of *Mimeoma acuta*, a common visitor to inflorescences of *B. porschiana*. $\times 2.8$. 15. Side view of *Mimeoma acuta*. $\times 2.8$.

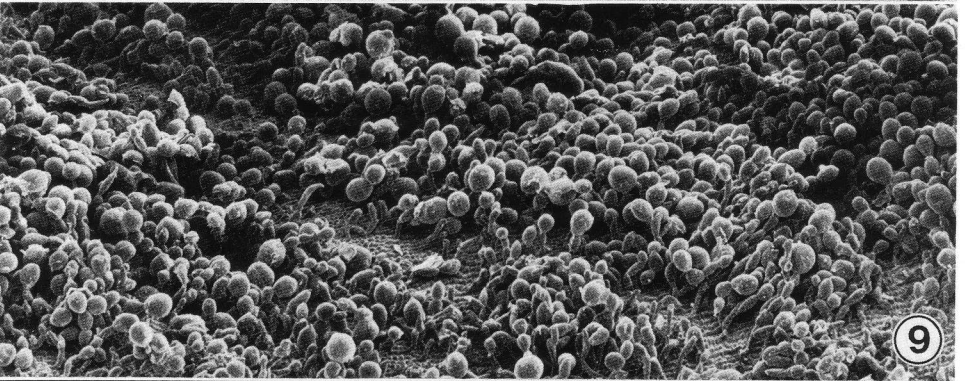




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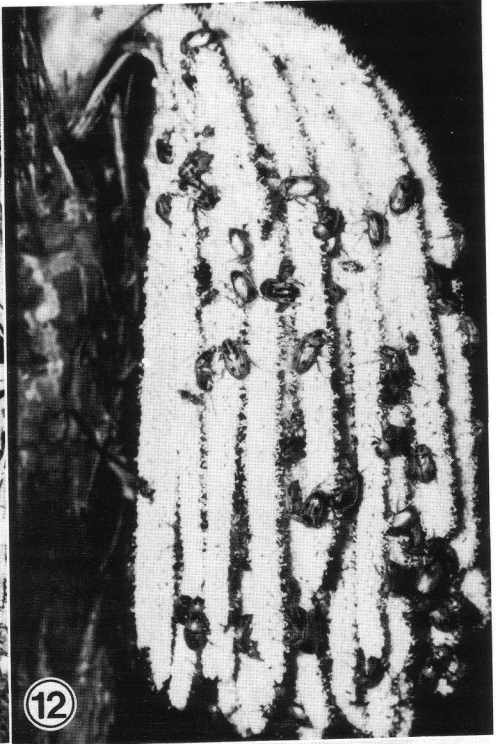
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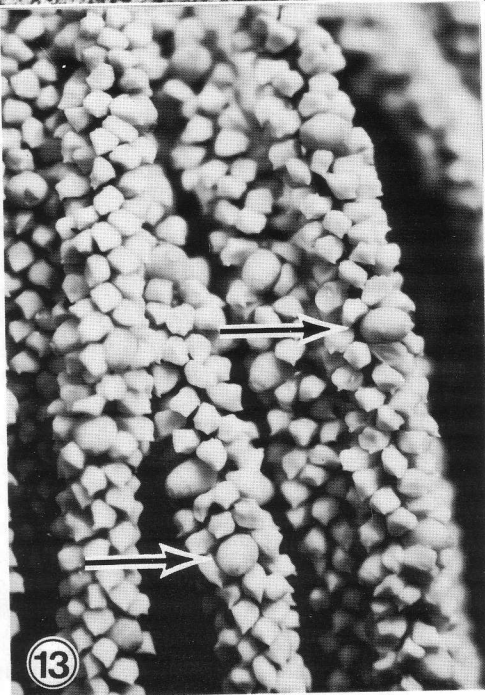
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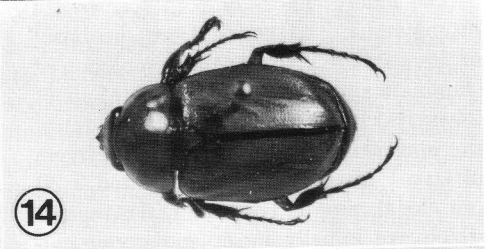
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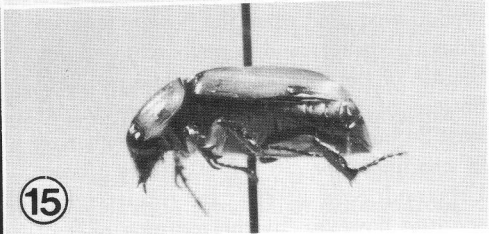
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Table 1. Flower number and sex ratio of flowers on inflorescences of *Bactris gasipaes* and *B. porschiana*.

Species	Sample Size (# Infl.)	Staminate Flowers (Range)	Pistillate Flowers (Range)	Staminate: Pistillate (Range)
<i>B. gasipaes</i>	6	8,622-31,248 \bar{x} = 20,119	52-573 \bar{x} = 253	40:1-217:1
<i>B. porschiana</i>	4	27,930-36,168 \bar{x} = 30,586	540-1,018 \bar{x} = 736	36:1-60:1

in May through early July with a minor flowering in January. Mora Urpí and Solís (1980) provide quantitative data on the flowering of the species in the Atlantic lowlands. Individual stems of pejibayé produce several temporally staggered inflorescences. Usually only one inflorescence per stem is active at a time, but because there were over 500 flowering stems in the La Selva plantation, several plants were in flower each day. *Bactris porschiana* has only one flowering episode per year from mid-August until mid-September.

The inflorescences of both species are protogynous. The period from the onset of the pistillate phase to the completion of staminate anthesis has a duration of about 24 hours. The inflorescence breaks out of the enclosing bract in the late afternoon of Day 1 usually between 4:00 and 5:20 pm (local time). The stigmatic regions which are initially moist and cream-colored are exposed when the flowers emerge from the bract, and remain exposed for the life of the inflorescence. The pistillate flowers of pejibayé are receptive for at least 24 hours and do not show any change in condition for 36 to 60 hours (Mora Urpí and Solís 1980). In *Bactris porschiana* however, by the morning of Day 2 they become increasingly brown, though the period of actual receptivity was not determined.

No nectar is produced by either palm. In both species, the petals of the staminate flowers remain completely closed for the first 24 hours until 4:30 to 5:00 pm of

the second day of the inflorescence, at which time they begin to open. In pejibayé the margins of the petals separate only slightly to form cracks through which the open anthers partially exert. Within a few minutes after opening, the staminate flowers begin to abscise from the rachillae and fall to the ground. In *B. porschiana*, the petals open much more widely and the stamens are fully exposed. The open staminate flowers remain on the inflorescence for about an hour before abscising. Staminate flowers fall until 6:30 pm, when all the flowers have dropped from the plant and the flowering activity is completed.

Insect Visitation to *Bactris gasipaes*

Day 1. When the bract opens in the late afternoon, the inflorescence produces a musky odor. In addition, heat is produced which makes the spadix several degrees warmer than the ambient air temperature (Schroeder 1978). Within a few minutes after opening, weevils 2 mm in length, of the genus *Phyllostox* (Fig. 7), fly into the inflorescence. Once on the inflorescence, the weevils walk down the sides of the staminate flowers and begin feeding on the succulent lower portions of the perianth. Within ten minutes most of the ten to twenty thousand staminate flowers on an inflorescence have weevils feeding at their bases. Weevils continue to arrive in large numbers during the early evening, eventually becoming packed in very densely around the bases of the sta-

Table 2. Flight times of *Cyclocephala amazona* ($n = 4$ nights).

Time (pm)	Average Immigration Rate into an Ultra-Violet Light Source (# Immigrating Scarabs per H)
5-6 (dusk)	0
6-7	74
7-8	88
8-9	35
9-10	6

minate flowers. An estimated 40,000 to 100,000 individuals of *Phyllotrox* come into each inflorescence.

A short time later, about thirty minutes before darkness, 2 cm long scarab beetles of the species *Cyclocephala amazona* (L.) (Figs. 5,6) begin to arrive at the inflorescence at the rate of 10 to 20 per minute. Many scarabs do not land directly on the flowers, but fly into other parts of the palm, especially dead, hanging leaves and the stem, before successfully locating the inflorescence. The beetles' response to missing the inflorescence is to drop immediately from the plant and fly once again back onto it. Once the scarabs land on the inflorescence, they make their way to its interior. At nightfall (6:00 pm), and for the next two to three hours, the scarabs continue to fly into the plant at a high rate. The flight activity of *Cyclocephala* after dusk was also monitored by noting their rate of immigration into an ultra-violet light source located in the pejibayé plantation. The number of flying beetles drops markedly after 9:00 pm (Table 2). Several hundred to several thousand scarab beetles accumulate on the inflorescence by the morning of the second day (Front Cover, Table 3).

Once on the inflorescence some scarabs attempt to copulate while others feed on the closed staminate flowers. Many beetles

Table 3. The number and sex ratios of *Cyclocephala amazona* collected from inflorescences of *B. gasipa*es.

Infl. #	Total Beetles Collected	Male : Female (n) ^a
1	5,652	1:2.2 (1,432)
2	657	1:1.7 (137)
3	1,239	1:2.6 (199)
4	975	1:2.7 (232)
5	587	1:2.7 (177)
6	1,057	1:1.2 (173)

^a Sex ratio determined from a random sample (n) of all beetles caught on the inflorescence.

go to the upper parts of the inflorescence and within one to two hours consume the densely-packed trichomes found on the surface of the peduncle (Figs. 8,9). Scarabs examined under magnification had their mouth cavities filled with the globose segments of the trichomes (Fig. 10). Intact trichome segments and pollen grains were also abundant in the frass of the scarabs. Weevils were never seen eating the globose trichome cells. Sample spikes taken from inflorescences during this time period and examined under a dissecting scope showed many weevils mating and a small number feeding on the succulent stigmatic tissues of the pistillate flowers. Most weevils feed on the petals of the staminate flowers throughout the evening and as a result bore small pits into the corolla bases. The damage does not seem to harm the plant as the insects do not penetrate into the central cavities of the still-unopened flowers.

During the morning of the second day, the stigmas show some minor damage from weevil feeding, and most stigmas have a small number of pollen grains and trichome parts adhering to them. As many as 25 individuals of *Derbe westwoodi* Fowler (Homoptera: Derbidae) and several *Ischnomela pulchripennis* Rehn (Tettigoniidae) were regularly seen feeding on the fleshy inner surfaces of the bract.

Ischnomela also feed on a small number of unopened staminate flowers during the first night.

Day 2. During daylight hours, the minute weevils remain on the bases of the male flowers. Before dawn, the scarabs usually retreat to the inside of the inflorescence, so that none is readily visible. Scarabs exposed during the day are often quickly eaten by birds or lizards. Even when scarabs are hidden deep within the *Bactris* inflorescence, birds, such as colored aracaris (*Pteroglossus torquatus*, Fig. 4) and oropendulas (*Zarhynchus wagleri*; Perry, 1980: p. 47), may land on the inflorescence, poke their bills in between the spikes and feed on the beetles.

There is little insect activity during the daylight hours of Day 2 until about 4:00 to 4:30 pm, when the weevils begin to leave the inflorescence before any apparent change in the staminate or pistillate flowers. At this time, a few hundred individuals of *Drosophila* (Diptera) land on the flowers. An increasing number of *Trigona* bees also come into the vicinity of the inflorescence. Twenty to 30 minutes after the weevils have begun to leave, the corollas of the staminate flowers begin to open, exposing the pollen. The scarabs inside the inflorescence become increasingly active and start to walk around on the inflorescence and feed on the pollen in the partially opened staminate flowers. Weevils continue to leave in large numbers with some pollen and trichome cells stuck to their bodies. Within a few minutes after the onset of anthesis, staminate flowers begin to abscise from the inflorescence and, by 4:30 to 5:00 pm, drop steadily, causing a "rain" of flowers. The activity of the drosophilid flies greatly increases and they lay eggs in the floral cavities of the staminate flowers a few minutes before the flowers drop from the inflorescence.

While the flies are ovipositing, 80 to 150 *Trigona* bees forage quickly on the

most exposed flowers on the outside rachillae of the inflorescence. The flies, several times smaller than the bees, attack the rear legs of the bees whenever they land on an inflorescence thus irritating the bees so that they can remain on the spike for less than a second. When the flies were experimentally removed from one inflorescence, the bees alighted and collected pollen without interruption for a much longer period.

Thirty minutes after the onset of staminate anthesis, most of the staminate flowers have fallen to the ground (5:30 to 5:50 pm). The majority of the scarabs, covered with pollen, have left the inflorescence by this time. In the pejibayé plantation, scarabs could be seen flying from staminate-phase, second-day inflorescences to pistillate-phase inflorescences on neighboring plants. At nightfall, the bees and flies also leave the inflorescence.

Insect Visitation to *B. porschiana*

Day 1. With few differences, the phenology of *Bactris porschiana* and the behavior of its insect visitors are similar to that of pejibayé. Unlike pejibayé, the inflorescences of *B. porschiana* do not produce heat or any detectable odor when they first open but do so later in the evening. Very small weevils, predominantly *Phyllotrox megalops* Champion, along with *Grasidius longimanus* Champion and an unidentified species (Baridinae/Centrini) begin to migrate into the inflorescences during the late afternoon of the first day of the inflorescence. However, a majority of the weevils come into the flowers after nightfall when a slight odor can be detected. They approach the inflorescence from downwind. There are fewer weevils per inflorescence than on pejibayé, but their behavior is the same.

Cyclocephala amazona and another dynastine scarab, *Mimeoma acuta* Arrow (Figs. 14,15), begin to arrive at the inflorescence from 6:10 to 6:30 pm, the same

Table 4. Scarab beetle visitors to *Bactris porschiana*.

Infl. #	Total	Species on Infl. (Number)
1	108	<i>Cyclocephala amazona</i> (80) <i>Mimeoma acuta</i> (28)
2	207	<i>C. amazona</i> (205) <i>M. acuta</i> (2)
3	130 ^a	<i>C. amazona</i> <i>M. acuta</i>
4	60 ^a	<i>C. amazona</i> <i>M. acuta</i>

^a Total estimated based on the number of beetles captured and the number of beetles seen escaping. Both beetles were seen on the inflorescence but were not distinguished in total counts.

time that the weevil immigration reaches its peak. Scarabs were seen to come into the plants until 8:30 pm, but some may have arrived later. An inventory of scarabs found on four inflorescences is shown in Table 4.

The beetles are fairly active during the first night. Copulating pairs are seen and many others walk over the spikes contacting the exerted stigmatic lobes of the pistillate flowers. Other insects are also associated with the inflorescences during the night of Day 1, including up to about 40 small black weevils (*Baridinae*/*Centrinini*) which feed on the staminate flower tissues. As with pejibayé, several individuals of *Derbe westwoodi* Fowler and *Ischnomela pulchripennis* Rehn are usually present feeding on the smooth inner surface of the inflorescence bract. Large numbers of a minute unidentified species of Staphylinidae (Coleoptera) are also attracted to the inflorescence.

Day 2. There is little visible insect activity during the morning daylight hours of Day 2. Most of the scarab beetles are torpid, resting on the inner spikes of the inflorescence. At 4:40 to 5:10 pm, the staminate flowers open and insect activity increases. The weevils start to leave the inflorescence at this time. The scarabs

Table 5. Summary of reproductive events in *Bactris*.

Day 1	Day 2
am	6:00 am-4:00 pm
1. Inflorescence closed	1. Inflorescence remains in female phase
2. No insect activity	2. Little insect activity
4:00-5:30 pm	4:00-6:00 pm
1. Inflorescence emerges from bract, female flowers receptive	1. Male flowers open and abscise from inflorescence
2. Scarabs and weevils begin to fly into the inflorescence	2. Weevils leave inflorescence in dense swarms
5:30 pm-6:00 am	3. Scarabs feed on open male flowers, mate
3. Scarabs mate and feed on trichomes and male flowers	4. <i>Drosophila</i> oviposit into open male flowers
4. Weevils feed on male flower bases	5. <i>Trigona</i> collect pollen
	6. Remaining male flowers fall from plant
	7. Scarabs and weevils depart for another plant (scarabs leave in the pm of Day 3 in <i>B. porschiana</i>)

become more active, feeding on pollen from the partially opened staminate flowers and continuing to mate. While doing this, they become covered with pollen. By 6:10 to 6:30 pm, all the staminate flowers are open, and begin to fall from the plant. *Trigona* spp. collect pollen before the flowers fall to the ground. *Drosophilid* flies are also present and behave as described above for pejibayé.

Unlike in pejibayé though, most of the scarabs do not leave the pendulous inflorescence at the end of the staminate phase, but walk up the rachillae to the base of the peduncle (where it attaches to the stem) and remain partially hidden there throughout the daylight hours of the next day. It is not until after nightfall, in the

early evening of Day 3 that the scarabs leave the plant. Table 5 contains a summary of the reproductive events in *Bactris*.

Discussion-Insect Behavior

The exceptional level of insect activity at the inflorescence of pejibayé and the diverse behavior of each of the visitors to the inflorescence makes the pollination biology of *Bactris* a composite of ecological interactions. Because of the abundance of pollen-carrying weevils (*Phyllostrox*) and scarabs (*Cyclocephala*), the relative importance of these two groups of beetles in the pollination of the palms is difficult to assess. The genus shows several features generally found in beetle-pollinated species, e.g., the protogynous reproductive cycle, and use of the inflorescence as an aggregation site for mating and for protection (Beach 1982, Gottsberger 1977, Meeuse and Schneider 1980, Prance and Arias 1975, Schneider and Buchanan 1980, Sohmer and Sefton 1978, Thien 1974, Valla and Cirino 1972).

The beetles are presumably attracted to the flowers by the musky odor produced by the inflorescence. Although the odor from inflorescences of *B. porchiana* was very weak, observations on isolated plants of that species revealed that both weevils and scarabs approach the inflorescence exclusively from downwind. According to Mora Urpí and Solís (1980), the attracting odor in pejibayé is produced by glands located on the petals of the staminate flowers. Heat produced by the inflorescence may function in volatilizing the attracting odor. Such an increase in temperature has been associated with odor production in other species (Smith and Meeuse 1966).

After alighting on the inflorescence, the scarabs eat the trichomes found on the peduncle and rachillae. The minute weevils never showed any gustatory interest

in them although Mora Urpí and Solís (1980) report that weevils ate trichomes on their study plants. Detached trichome segments frequently adhere to various regions of the bodies of the weevils (Fig. 7) and scarabs (Fig. 10).

How the scarabs benefit from eating the trichomes is unknown. Chemical analyses are incomplete but their relatively small size, thick, lamellate cell wall and small lumen, make them atypical morphologically as glandular trichomes. Examination of the frass of two *Cyclocephala* under a compound microscope showed that the globose trichome segments pass through the gut of the scarabs intact. This observation further obscures their putative nutritional significance.

The feeding activity of the weevils is largely confined to basal tissues of the unopened staminate flowers. Because of the extremely large number of feeding weevils, all of the male flowers have many small pits bored into their base. This does not appear to affect the function of the yet unopened staminate flowers. Uhl and Moore (1977) have correlated the feeding behavior of the weevils with the anatomy of the staminate flowers in *Bactris major*. They found thick, fibrous bundle sheaths along with cells containing protective raphides in the petals near the inner surface. Tannins, which are common in other parts of the flower and known to be distasteful to herbivores, were lacking in the outer petal tissue. The authors provide a transection of a staminate flower showing these small pits penetrating through the outer tissues of the petal but stopping at the fibrous bundle sheath layer. Thus, as Uhl and Moore point out, the histology of the staminate flower suggests that the outer tissue of the petals has evolved as a food source, while the positioning of the fibrous bundle and raphides serves to protect the pollen from the insects. Weevils are also known to use flowers for oviposition, but it was not established if this had occurred with *Bactris*. The weevils also infre-

quently feed on the succulent stigmatic tissues.

As Mora Urpí and Solís (1980) have previously reported, several additional insects visit the inflorescence during the brief period of pollen liberation, but probably play no role in the pollination of the palms. At La Selva, at least three species of flies descend onto the flowers during staminate anthesis. As mentioned above, *Drosophila* oviposit into the opened male flowers before they drop from the plant. Adult *Drosophila* were raised from male flowers that were caught while falling from staminate phase inflorescences. An additional unidentified dipteran was raised to the maggot stage in these flower cultures. Trigonid bees which are ubiquitous scavengers at La Selva visit the inflorescence to collect pollen. The drosophilid flies attack the bees which are several times their size. Mora Urpí and Solís (1980) reported that the flies were collecting pollen from the corbiculae on the legs of the bees. My observations indicate that they irritate the bees that land on the open male flowers, and chase them off the inflorescence. This aggressive behavior is presumably an attempt by the flies to keep the pollen-collecting bees away from their eggs which have been deposited in the male flowers. The bees and the flies rarely contact the stigma surface.

Discussion-Pollination

The reproductive biology of other wild species of *Bactris* in Costa Rica has received limited attention. Essig (1971) made observations over a four day period on the pollination of *B. major* and *B. guineensis* on the Pacific slope and described morphology and flowering phenology patterns similar to those of the present study. Although Essig admits that his observations on the insect visitors to the palms were very limited, he concluded that 2 mm long weevils and equally small nitidulid beetles are the most likely polli-

nators of the two species. Bullock (1981) studied the flowering phenology and insect visitors to *Bactris longiseta* and *B. wendlandiana* at La Selva. He also found the typical protogynous flowering pattern and documented both weevil and scarab beetle visitors to the inflorescences. Bullock does not provide quantitative data on the beetle visitors but lists *Cyclocephala stictica* Burmeister, *C. amazona* (L.), *C. brittoni* Endrodi, and *Mimeoma acuta* Arrow as visitors to *B. wendlandiana*, and *Mimeoma acuta* as a visitor to *B. longiseta*. These studies corroborate my observations on the flower morphology and phenology syndrome of the genus, but because of their limited scope, no firm conclusions can be made as to the importance of the various insect species in the pollination of the palms.

Mora Urpí and Solís (1980) examined pejibayé in two plantation localities in Costa Rica: in Guapiles near La Selva and in San Isidro del General, a much drier locality on the Pacific slope of the country. Their observations on the insects visiting at pejibayé in Guapiles largely agree with those of the present study, though they state that the importance of *Cyclocephala* "as a pollinating agent is secondary" because the scarab was not usually found in abundance in Guapiles and because it was absent altogether in San Isidro. They conclude that the weevils, which were found in large numbers in both localities, are the co-adapted pollinator of the palm. The authors also demonstrate that some pejibayé pollen is carried by the wind and that in plantations wind may be a pollinating agent.

Mora Urpí (1982) found very large numbers of weevils visiting the inflorescences of pejibayé and an unidentified *Bactris* species in Amazonian Brazil and Bolivia. He and C. R. Clement (pers. comm.) conclude that the curculionids are the most important pollinators of the palms.

The possibility that *Cyclocephala* or

allied scarab genera can be important pollinators of *Bactris* should not be underestimated. More information is needed from studies of *Bactris* in native habitats to ascertain the importance of the two types of beetles. Several questions need to be addressed. Do scarabs visit the inflorescences of *Bactris* in other parts of its range? Are the 2 mm long weevils capable of flying between conspecific plants in natural populations where palms are separated by distances of tens or hundreds of meters? How effective are the two types of beetles in contacting the stigmas of the pistillate flowers? Are the epidermal trichomes specialized food bodies of nutritional importance to the scarabs? Does the histology of the staminate flowers indicate that they have, in fact, evolved to serve as food source for weevils? Or are the weevils simply opportunistic herbivores? Is the pollination of pejibayé under conditions of cultivation qualitatively different from the pollination of *Bactris* in natural populations? If, as Mora Urpí and Solís found, *Cyclocephala* is uncommon in plantations which are far from the natural haunts of the scarabs and where inter-plant distances are but a few meters, then weevils or wind may become the most important pollinating agents. Additional studies of the reproductive biology of this interesting genus with the goal of answering these questions should allow us to determine with more certainty, the most effective agent of cross-pollination in *Bactris*, and its co-evolved pollinator type.

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LETTERS

To my knowledge, I have the largest growing viable-seed-producing betel nut palm (*Areca catechu*) in California. It all started back in 1966 when I collected seed from the University of Mayaguez Experimental Station in Puerto Rico. Of the many seedlings that sprouted, I selected the largest and fastest growing one and planted it in the ground of my 18' high heated greenhouse. It grew in the summer at a phenomenal rate, at least 2" every evening. It's at night that most palms seem to grow.

Within several years, the fronds began to push against the fiberglass ceiling and I was confronted with the prospect of either digging the palm up and repotting it, cutting it down and killing it, or cutting a hole in the ceiling to let it grow through. I opted for the latter. It was necessary to cut the fronds drastically and also insulate around the new palm spike with foam strips to keep the heat from escaping. It took another several years for the entire crownshaft to emerge completely through the roof. About the same time, I did the

very same thing with a single-trunked *Chrysalidocarpus lutescens* growing in the same greenhouse. Eventually I had two palms each with a full crown of leaves growing through the 18' high roof.

About four years ago, we in Southern California experienced about the coldest winter since I've moved here in 1961. I live in Westminster, Orange County, about seven miles from the coast on level ground and we had a 32 degree temperature in early winter, another one in late winter (both with heavy hail), and cold, cold weather in between. Shortly after, it became apparent that the *C. lutescens* had succumbed to the cold, while just 8' away, the *Areca catechu* remained unaffected. Today it is still thriving, with about five feet of bare trunk above the roof of the greenhouse. It sets viable seed and one of the seedlings from the tree was planted outdoors and is now growing beautifully through its third winter. It would appear I have accidentally made my own "Hardy Betel Nut Palm." I will every winter continue to hope so.

RALPH VELEZ