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Pollen carriers of *Cocos nucifera* L. (Palmae) in Costa Rica and Ecuador (Neotropical region)

Ingemar Hedström
Department of Zoology, Section of Entomology, Uppsala University, Box 561, S-751 22 Uppsala, Sweden. Present address: Escuela de Biología, Universidad de Costa Rica, Costa Rica.

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Abstract: Potential pollinating insects of the coconut palm, *Cocos nucifera* L. (Palmae), were identified in Cahuita National Park, Barbilla Biological Reserve, Pacuarito de Siquirres, Guácimo and Bribrí, Province of Limón, and in Turrúcares and La Garita, Province of Alajuela, Costa Rica. Observations were also conducted in Guayaquil and Cerecita, Province of Guayas, Ecuador. The most common pollen carrier in Costa Rica was *Trigona silvestriana* Vachal, followed by *T. testacea* Klug, *T. fulviventris* Guérin, *T. frontalis* Friese, *T. tataira* Smith, *T. corvina* Cockerell, *Melipona fasciata* Latreille, all stingless meliponid bees, and the honeybee *Apis mellifera* L. In Ecuador, *A. mellifera* was observed visiting both staminate and pistillate flowers of *C. nucifera*. Observations on interference competition between some of the species of *Trigona* from Costa Rica are also presented.

The coconut palm, *Cocos nucifera* L. (Palmae) has a pantropical distribution, and it is currently believed to have originated in the Pacific islands (Purseglove, 1972). Gruezo and Harries (1984) pointed out that coconuts that germinated during voyages of the Spanish explorers, or remained unconsumed, were usually planted on any shore they visited. The data of introduction of *C. nucifera* into America is unknown, and it may well have been long prior to the arrival of the Europeans (Standley and Steyermark, 1958). In Costa Rica, the coconut palm is found in all lowland habitats (Vandermeer, 1983) and occasionally at higher altitudes as well. Although *C. nucifera* is believed to be an introduced palm in the Neotropics, it has been very well adapted and normally yields abundant crops. It has a nonseasonal life cycle and sets fruits year round. The flowering of *C. nucifera* begins normally at 6-10 years of age and proceeds at the rate of about one inflorescence a month (Vendermeer, 1983). One individual, which was planted by the author in Guayaquil, Ecuador, in December 1977, produced its first inflorescence in February 1986, e.g. 8 years later. On the other hand, in Barbilla National Park, Costa Rica, the only observed individual of *C. nucifera*, which is a so called "small Malaysian coconut tree", was planted in January 1983 and set its first inflorescense in July 1986, e.g. 3 1/2 years later (Hedström, unpubl.).

The dimorphic flowers of *C. nucifera* (Fig. 1), which is a monoecious plant, are adapted to both wind and insect pollination (Heywood, 1978), although the latter seems to be the general rule. Sholdt and Mitchell (1967), who studied coconut pollination in Hawaii, concluded that *Apis mellifera* L. was the main pollinator, but also wind pollination occured to a certain extent. Sauer (1983) reported that *Apis indica* Fabr. has been observed visiting the flowers of *C. nucifera* in tropical Asia.

To my knowledge no data has been published on insects visiting *C. nucifera* in the Neotropical region. This was confirmed by the specialist Andrew Henderson (personal communication, 1985) at the New York Botanical Garden. Hence the objetive of this study was to present a check-list on some pollen carriers of *C. nucifera* in the Neotropics.

Study sites and methods

In Costa Rica, the observations were carried out on November 11, 1984 (between 8:00-11:00 hours), on January 9-10, 1985 (8:00-9:30 and 13:00-16:00 hours), respectively, and

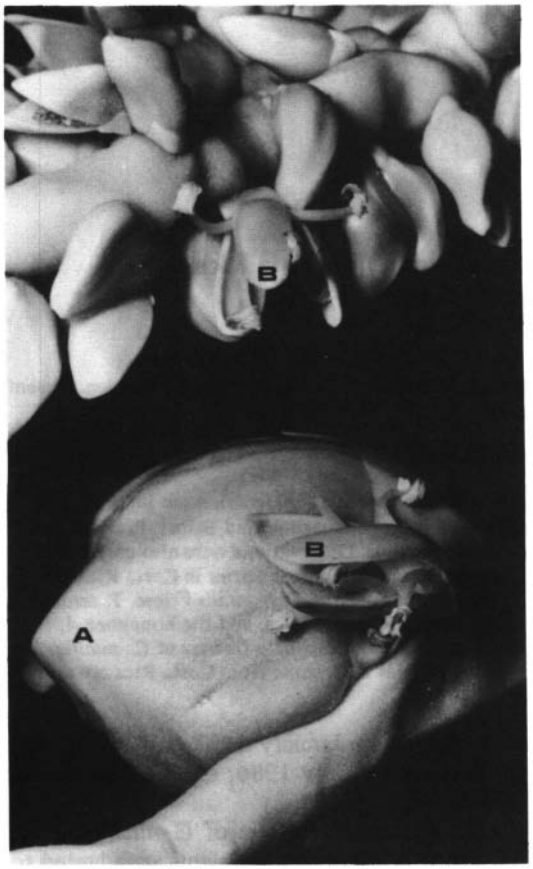

Fig. 1. The dimorphic flowers of *Cocus nucifera*. –A: Inmature pistillate flower. –B: Newly opened staminate flowers. Cahuita National Park, Costa Rica, June 1985.

on June 15, 1985 (15:00-16:00 hours), along the Caribbean beach at Cahuita National Park (Fig. 2), by sitting perched at the hight of the inflorescences of *C. nucifera*. The same method was utilized in Guayaquil and Cerecita, Province of Guayas, on the Pacific lowlands, on respectively November 11, 1986 (15:00-16:00) and November 12, 1986 (10:30-11:00 hours).

Field observations and collection of foraging insects on *C. nucifera* were also conducted in Pacuarito (30 m), Guácimo (100 m), Bribrí (30 m) and River Dantas (200 m), at the upper, northern border of Barbilla Biological Reserve, Province of Limón, and in La Garita (700 m) and in Turrúcares (680 m), Province of Alajuela, Costa Rica, one June 15, 1985 (8:30-9:30 hours), on January 12, 1985 (5:30 and 18:00 hours), on July 24, 1986 (15:00-16:00 hours), on July 20, 1986 (7:00-18:30 hours), on January 19, 1985 (16:00-17:00 hours), and on July 27, 1986 (10:15-12:30 hours), respectively. These seven sites have been ascribed by Holdridge (Tosi, 1969) to the ecological zones of tropical moist forest (Cahuita, Bribrí, Guácimo), tropical wet forest (Barbilla), premontane wet forest (Pacuarito), and premontane moist forest (La Garita, Turrúcares.

Fig. 2. The study site in Cahuita National Park of Costa Rica.

Close observations of the behaviour of visiting insects on the flowers of *C. nucifera* at all study sites were carried out in order to determine their efficiency in transferring pollen between individuals of the palm species.

Visiting insects on the flowers of *C. nucifera* were collected with a net or by the quick use of a killing bottle with one hand kept behind the flowers to prevent escape. Flower visitors were killed and the presence of pollen grains attached to their body was investigated. On August 20-25, 1985, in Turrúcares, Costa Rica, individual female flowers (n = 20) of *C. nucifera* were bagged between 17:00-07:00 hours during the receptive period, in order to hinder insects active at night to pollinate the flowers.

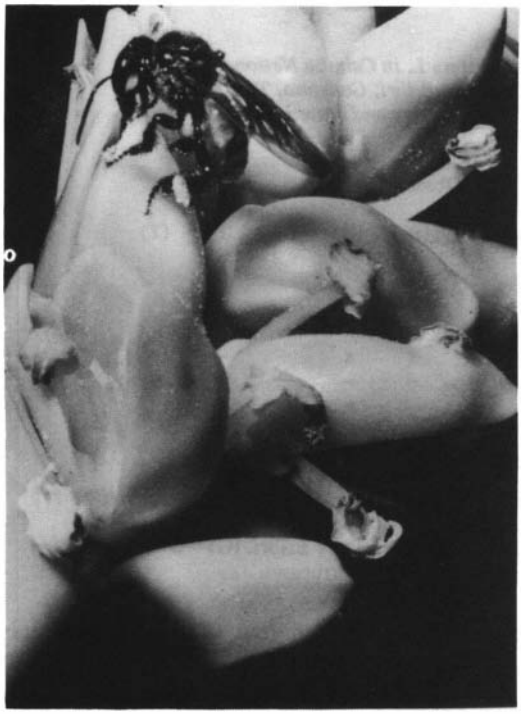

Fig. 3. *Trigona fulviventris* (Apidae) feeding on pollen from anthers of the male flower of *Cocus nucifera*. Pacuarito de Siquirres, Costa Rica, June 1985.

RESULTS

At the study sites in *Cahuita* National Park the most common pollen vector on both staminate (male) and pistillate (female) flowers of *C. nucifera* was the comparatively large and dark coloured species of *Trigona silvestriana* Vachal, followed by the smaller and somewhat lighter coloured species *T. fulviventris* Guérin (Fig. 3), *T. testacea* Klug, *T. frontalis* Friese and *T. tataira* Smith, all stingless meliponid bees (Hymenoptera; Apidae). Specimens of *Melipona fasciata* Latreille and *Apis mellifera* Linneus, both members of the same insect family (Apidae), were also observed on the flowers of *C. nucifera* in the same study site, but in low numbers.

In Ecuador, large numbers of *A. mellifera*, together with unidentified species of Vespidae (Hymenoptera) and Diptera, were observed visiting both staminate and pistillate flowers in both study areas.

A most interesting observation was made at the study site in Guácimo, Costa Rica. One of the inflorescences in that area had both staminate and pistillate flowers. All observed potential pollen vectors of *T. corvina* (n = 18)

Fig. 4. Interference competition between two individuals of *Trigona fulviventris* facing off in the air. Pacuarito de Siquirres, Costa Rica, June 1985.

that approached that particular inflorescence of *C. nucifera* landed directly on the newly opened pistillate flowers in order to extract nectar. 83% (n = 18) of these bees carried light-yellow coloured pollen grains of *C. nucifera* in their corbicula, obviously from previously visited staminate flowers of the same species. After visiting the pistillate flowers of the inflorescence, 33% of the bees were observed visiting the staminate flowers on the same inflorescence. By now the bees had become rather "sticky" from the nectar attached to all parts of their bodies.

In Guácimo, both staminate and pistillate flowers of *C. nucifera* were visited by *T. testacea* and *T. corvina* (Table 1). In Pacuarito and La Garita, *T. fulviventris* and *T. corvina*, respectively, were the only observed visiting species on *C. nucifera*. Observed *T. silvestriana* on pistillate flowers in Turrúcares carried heavy loads of pollen of *C. mucifera* packed in the corbiculae. Pollen carriers on flowers of *C. mucifera* in Cahuita National Park, Barbilla Biological Reserve and Guácimo, Costa Rica were active all day from early sunrise till sunset.

Unidentified species of Vespidae (Hymenoptera), Lepidoptera, Coleoptera (Cetoniinae) and Diptera were occasionally observed visiting both staminate and pistillate flowers of *C. nucifera*, but few or no pollen grains at all, were found attached to the body of these non-apis species.

Of the pistillate flowers of *C. nucifera*, bagged at night, 20 % (n = 20) developed fruits.

What I interpreted as intraspecific interference competition between individuals of *T. fulviventris*, was observed in Pacuarito de Siquirres and Cahuita National Park. The aggressive bees faced off in the air and rose together up to

TABLE 1

Visiting bees on unisexual flowers of Cocos nucifera *L. in Cahuita National Park, Barbilla Biological Reserve, Pacuarito de Siquirres, Bribrí, Guácimo, Turrúcares and La Garita, Costa Rica, November 1984, January and June 1985, and July 1986*

	Observation sites						
	(C)	(B)	(Br)	(G)	(LA)	(P)	(T)
Apidae							
Trigona (Trigona) silvestriana Vachal	x	x	x	–	–	–	x
T. (Partamona) testacea Klug	x	x	x	x	–	–	–
T. (Plebeia) frontalis Friese	x	–	–	–	–	–	–
T. (Trigona) fulviventris Guérin	x	–	–	–	–	x	–
T. (Oxytrigona) tataira Smith	x	–	–	–	–	–	–
T. (Trigona) corvina Cockerell	–	–	–	x	x	–	–
Melipona fasciata Latreille	x	–	–	–	–	–	–
Apis mellifera Linneus	x	–	–	–	–	–	–

(C) = Cahuita National Park, (B) = Barbilla Biological Reserve, (Br) = Bribrí, (G) = Guácimo, (LG) = La Garita, (P) = Pacuarito de Siquirres, and (T) = Turrúcares.

a height of approximately 20 cm or more (Fig. 4). This behaviour was described by Johnson (1983), who studied the behaviour of *T. fulviventris* in lowland habitats of Guanacaste Province, Costa Rica.

When observed in Cahuita National Park and Pacuarito de Siquirres, respectively, *T. silvestriana* and *T. fulviventris* were the only foraging *Trigona* bees on the same inflorescence of *C. nucifera*; presumably these species, which never were seen together, had displaced other *Trigona* species from the same energy source. However, comparatively large bees of *Melipona fasciata* and *Apis mellifera* were occasionally observed on flowers of *C. nucifera* in the presence of *T. silvestriana* and *T. fulviventris* in Cahuita National Park.

There was no clear sign of interference competition between the medium sized *T. testacea* and *T. corvina*, foraging on the same inflorescense of *C. nucifera* in Guácimo.

DISCUSSION

Some palms are pollinated by night-active insects (Hendersson, 1985, unpubl.). In Costa Rica, pejibaye *Bactris gasipaes* H.B.K. is pollinated by nocturnal coleopterans (Mora-Urpí & Solis, 1980, Beach, 1984). At least two species of nectarivarous, pollen-dusted, bats in West Malaysia visited *C. nucifera* (Burley & Styles, 1976). Although it is possible that night-active insects and/or nocturnal bats may pollinate the flowers of *C. nucifera*, they are not the only pollinators since some of the during the night isolated pistillate flowers of *C. nucifera* (20 %, n = 20) set fruit.

Vandermeer (1983) stated that staminate flowers of *C. nucifera* normally open before pistillate flowers (protandry) and thus female flowers usually do not open until the male flowering period (on the very same inflorescense) is over. However, one observed inflorescence of *C. nucifera* in Cahuita National Park had receptive pistillate flowers when only 80% (n = 185) of the male flowers of that same inflorescence had withered. Hence cross-pollination, between two genetically different individuals of the same species, is not necessarily the usual rule for *C. nucifera*.

On the Caribbean coast of Costa Rica, Wille and Michener (1973) found that *T. silvestriana* usually build their nests resting on large branches or between "coconut bases" of the flower (rachillae), 3-12 meters above ground. This close relationship between the insect and the palm tree might explain the high number of *T. silvestriana* on the flowers of *C. nucifera* along the beaches of Cahuita National Park, where *C. nucifera* is very abundant.

Johnson and Hubbel (1974) reported several cases of interspecific interference competiton between species of *Trigona* from Turrialba, Costa Rica. In one contest between large (10 mm) *T. silvestriana* and medium-sized (7 mm) *T. testacea*, the latter species spent an

average of 5 sec. hovering and 11 sec. feeding in the absence of *T. silvestriana*. Once large *T. silvestriana* started to utilize the same food source, smaller-sized *T. testacea* spent around 11 sec. hovering and only 3 sec. feeding. Heinrich (1978) commented that smaller, less aggressive bee species may specialize on widely-spaced plants which provide relatively slight amounts of pollen and nectar. In this case small *T. testacea* could make an energy profit at less rewarding food that is inadequate for large bees like *T. silvestriana*. The aggressive strategy of large *Trigona* bees is therefore presumably only profitable at high quality food sources, in this case on the inflorescence of *C. nucifera*.

RESUMEN

Se hicieron observaciones sobre las especies de insectos que visitan las flores del cocotero, *Cocos nucifera* L. (Palmae), en Guayaquil y Cerecita, provincia de Guayas, Ecuador, y en el Parque Nacional de Cahuita, la Reserva Biológica de Barbilla, Bribrí y en Guácimo, provincia de Limón, en Turrúcares y en La Garita, provincia de Alajuela, Costa Rica, en noviembre de 1984, en enero y junio de 1985, y en julio y noviembre de 1986. Entre los vectores potenciales de polen más abundantes en Costa Rica fueron observadas las siguientes especies de abejas (Hymenoptera; Apidae): *Trigona silvestriana* Vachal, *T. testacea* Klug, *T. fulviventris* Guérin, *T. frontalis* Friese, *T. tataira* Smith, *T. corvina* Cockerell, *Melipona fasciata* Latreille, y *Apis mellifera* Linneus. El vector de polen en *C. nucifera* más observado en el Ecuador era *A. mellifera*. Además se demuestra la existencia de interferencia por competencia entre algunas de las especies de *Trigona*.

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REFERENCES

Beach, J.H. 1984. The reproductive biology of the Peach or "Pejibaye" Palm (*Bactris gasipaes*) and a Wild Congener (*B. porschiana*) in the Atlantic lowlands of Costa Rica. Principes 28:107-119.

Burley, J. & B.T. Styles. 1976. Tropical trees: variation, breeding and conservation. Linnean Society Symposium Series. No. 2. London. 243 p.

Johnson, L.K. 1983. *Trigona fulviventris*, p. 770-772. *In* D.H. Janzen (ed.). Costa Rican Natural History. University of Chicago Press. 816 p.

Johnson, L.K. & S.P. Hubbel. 1974. Aggression and competition among sting-less bees: field studies. Ecology 55:120-127.

Gruezo, W.S. & H.C. Harries. 1984. Self-sown, wild-type coconuts in the Philippines. Biotropica 16:40-147.

Heinrich, B. 1978. The economics of insect sociality, p. 97-128. *In* J.R. Krebs & N.B. Davies (eds.). Bahavioural Ecology: an evolutionary approach. Blackwell, Oxford.

Heywood, V.H. (ed.). 1978. Flowering plants of the World. Oxford University Press, 336 p.

Mora-Urpí, J. & E.M. Solís. 1980. Polinización en *Bactris gasipaes* H.B.K. (Palmae). Rev. Biol. Trop. 28:153-174.

Sauer, J. 1983. *Cocos nucifera* (Coco, Cocotero, Coconut), p. 216-219. *In* D.H. Janzen (ed.) Costa Rican Natural History. University of Chicago Press. 816 p.

Sholdt, L.L. & W.A. Mitchell. 1976. The pollination of *Cocos nucifera* L. in Hawaii. Trop. Agriculture, Trin. 44:133-142.

Standley, P.C. & J.A. Steyermark. 1958. Flora of Guatemala. Chicago Natural History Museum. 478 p.

Purseglove, J.W. 1972. Tropical Crops: Monocotyledons. Vol. 2. John Wiley, New York.

Tosi, J.A. Jr. 1969. Mapa Ecológico de Costa Rica. Centro Científico Tropical, San José, Costa Rica.

Vandermeer, J. 1983. Coconut (Coco), p. 85-86. *In* D.H. Janzen (ed.). Costa Rican Natural History. University of Chicago Press. 816 p.

Wille, A. & C.D. Michener. 1973. The Nest Architecture of Stingless Bees with Special Reference of those of Costa Rica (Hymenoptera; Apidae). Rev. Biol. Trop. 21 (Supl. 1):1-278.

Trigona silvestriana + testacea + fulviventris