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Pollination in Salacca edulis

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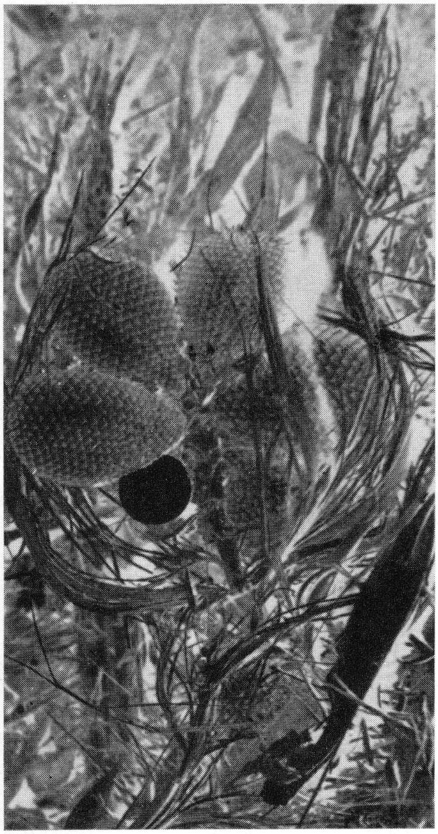
In the Old World, especially in Indonesia, *salak* (*Salacca edulis* Reinw. and *Salacca sumatrana* Becc.) is well known because of the edible fruit. This plant belongs to the lepidocaryoid palms (Beccari, 1918), as do sago palms, raphia palms, and all rattans. Amongst them, *salak* has the biggest fruits, which usually are pear-shaped, 5–7 cm long by 3–5 cm in diameter and scaly (Fig. 3). The edible part, formed from the outer integument of the seed, is fleshy and usually cream-colored, but in the one from Sumatra is sometimes reddish. Actually this plant has been cultivated for a long time, for in 1605 Clusius described the *salak* fruit when it reached Europe from Bali and called it *Baly insulae fructus aspero cortice* (Clusius, 1605). Nowadays *salak* gardens maintained in the traditional manner are still present in some localities in Indonesia, namely in North Sumatra (Padangsidempuan, Fig. 1), Java (Condet, Depok, Batujajar, Manonjaya, Sleman, Pasuruan, and Bangkalan-Madura), North Celebes (Pangu and Tagulandang), and in Bali (Karang Asem).

Staminate and pistillate inflorescences occur on separate trees. The staminate rachilla consists of many

1. *Salacca sumatrana* garden near Padangsidempuan, North Sumatra.

2. A pistillate inflorescence of *Salacca edulis.*



3. An infructescence of *Salacca edulis*; the black spot is a coin 2.5 cm long used as a scale.

pairs of staminate flowers while the pistillate ones (Fig. 2) have a pistillate and a neuter flower (a sterile staminate flower) in each pair (see Fig. 5a–c). In Condet and several *salak* gardens in Java, inflorescences are always covered with many insects.

Materials and Methods

This study was made in Condet, a *salak* garden in the south of Jakarta. The area consists of about 93% *salak* garden, covering an area of just over 150 hectares. The mean temperature of the area is 27°C, the relative humidity 80%, and the mean rainfall 2173 mm/year. The size of the garden used in this study is 90 × 30 m square, consisting of 120 trees, four of them being staminate. Only one of the staminate trees was in flower. A few of the pistillate trees were also in flower, but only the one nearest to the flowering staminate tree was used in this study.

The life cycle of the insects was observed by collecting some samples of inflorescences and by examining them in the laboratory. The activities of the insects during one day on staminate and pistillate inflorescences with flowers at anthesis were observed on two

Table 1. Number of the curculionid beetles on the staminate inflorescence of Salacca edulis *at different times*

June 12, 1973		June 13, 1973		June 13, 1973	
1600	74	0000	62	0800	56
15	72	15	66	15	50
30	52	30	62	30	48
45	50	45	62	45	32
1700	50	0100	40	0900	24
15	54	15	40	15	20
30	54	30	66	30	48
45	56	45	65	45	48
1800	54	0200	58	1000	46
15	60	15	56	15	54
30	68	30	56	30	72
45	68	45	56	45	50
1900	72	0300	56	1100	48
15	70	15	56	15	52
30	70	30	56	30	52
45	70	45	56	45	52
2000	70	0400	56	1200	52
15	85	15	56	15	54
30	74	30	56	30	70
45	80	45	56	45	52
2100	72	0500	56	1300	60
15	74	15	56	15	60
30	64	30	56	30	56
45	80	45	56	45	72
2200	76	0600	56	1400	84
15	74	15	56	15	84
30	76	30	67	30	84
45	84	45	67	45	76
2300	84	0700	67	1500	75
15	84	15	60	15	76
30	80	30	60	30	77
45	74	45	60	45	82

Table 2. Number of the curculionid beetles on the pistillate inflorescence of Salacca edulis *at different times*

June 12, 1973		June 13, 1973		June 13, 1973	
1600	65	0000	81	0800	18
15	65	15	52	15	16
30	78	30	52	30	13
45	78	45	52	45	20
1700	81	0100	52	0900	23
15	88	15	51	15	39
30	74	30	51	30	30
45	112	45	52	45	31
1800	112	0200	53	1000	25
15	81	15	53	15	11
30	81	30	54	30	8
45	81	45	52	45	11
1900	84	0300	52	1100	11
15	84	15	52	15	10
30	84	30	52	30	24
45	108	45	52	45	19
2000	108	0400	49	1200	19
15	101	15	49	15	20
30	83	30	49	30	26
45	94	45	49	45	27
2100	74	0500	49	1300	20
15	74	15	49	15	14
30	74	30	49	30	14
45	78	45	49	45	12
2200	78	0600	49	1400	12
15	78	15	30	15	12
30	81	30	31	30	21
45	81	45	44	45	6
2300	81	0700	44	1500	6
15	81	15	35	15	8
30	81	30	28	30	8
45	81	45	20	45	7

trees that grew ca. 20 m apart from each other. The number of the insects on the inflorescences was counted every 15 minutes (Table 1 and 2). To facilitate the counting of insects, each inflorescence was divided into eight regions with a white thread. For night observation a small flashlight with two batteries was used.

Five pistillate inflorescences were covered with 300-gauge cellophane to determine whether the flowers need cross pollination to produce fruits. These cellophane covers remained on the pistillate inflorescences for five weeks, namely from their young stage until after anthesis. The cellophane is transparent, stiff, penetrable by air, waterproof, and resistant to dry climate. It is usually used as candy paper, for cigarette boxes and for bread packages (Paist, 1958).

Results

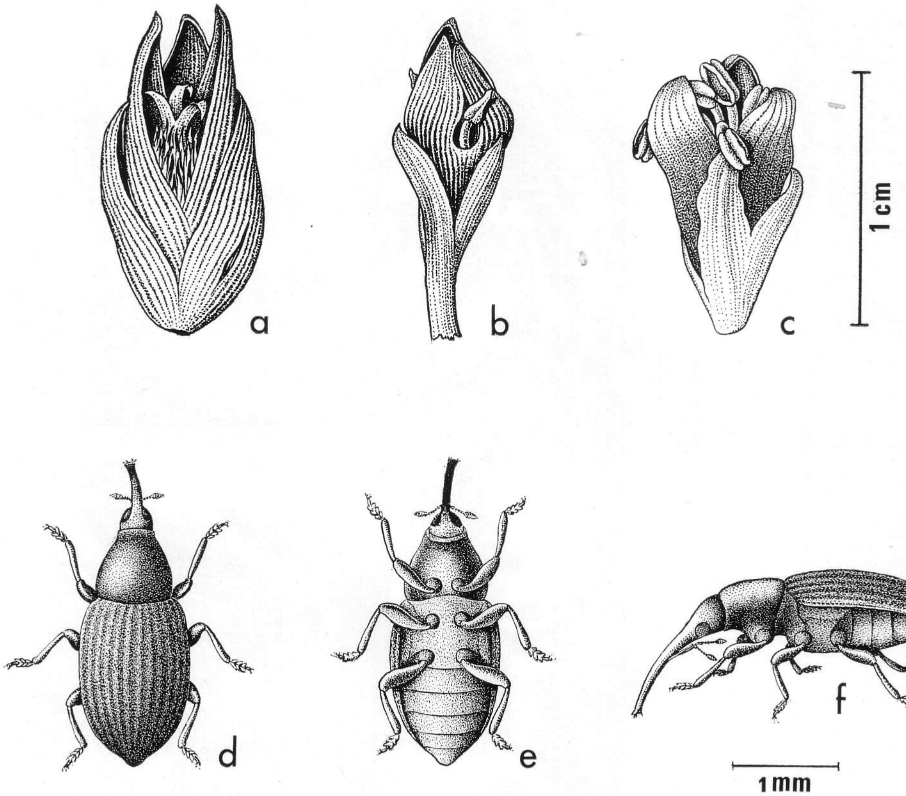
The insects found on the inflorescences were *Trigona* sp. (Hymenoptera), *Rhynchophora palmarum* L. (Coleoptera), a small dipteron 1 mm long, and a curculionid beetle (Curculionidae). The diptera were found during the day only on the staminate inflores-

4. A pistillate inflorescence of *salak Bali*; the arrow indicates a reduced rachilla. Photo by J. Dransfield.

cence, but they were not found on the pistillate inflorescence when flowers were at anthesis. *Trigona* and *Rhynchophora* have also been found on other genera and species of palms (Lepesme, 1947). However the curculionid is found on the inflorescences in large numbers, especially when flowers are at anthesis.

The curculionid beetle (Fig. 5d–f), the identity of which is not yet known, is 2–3 mm long, blackish-brown, and its proboscis is cone-shaped as in *Calandra oryzae* L., which usually can be found in rice. A secondary sexual character of this beetle is the length of snout. The female has a longer snout. The egg is oblong, 0.3 mm long, white, and is usually hidden in the petal of a young pistillate flower, but sometimes can also be found in the petal of a pistillate flower at anthesis. Two to three weeks later, the petal has dried up and died, and the larva developed from the egg has reached its last stage and shortly after formed a pupa. After two to three days in this stage, it emerges a beetle like those seen on flowers at anthesis.

The amount of insect activity on the inflorescences is shown in Figure 6. Between about 2100 hours (9:00 P.M.) and 0700 (A.M.), the insects were not active but there was a relatively con-

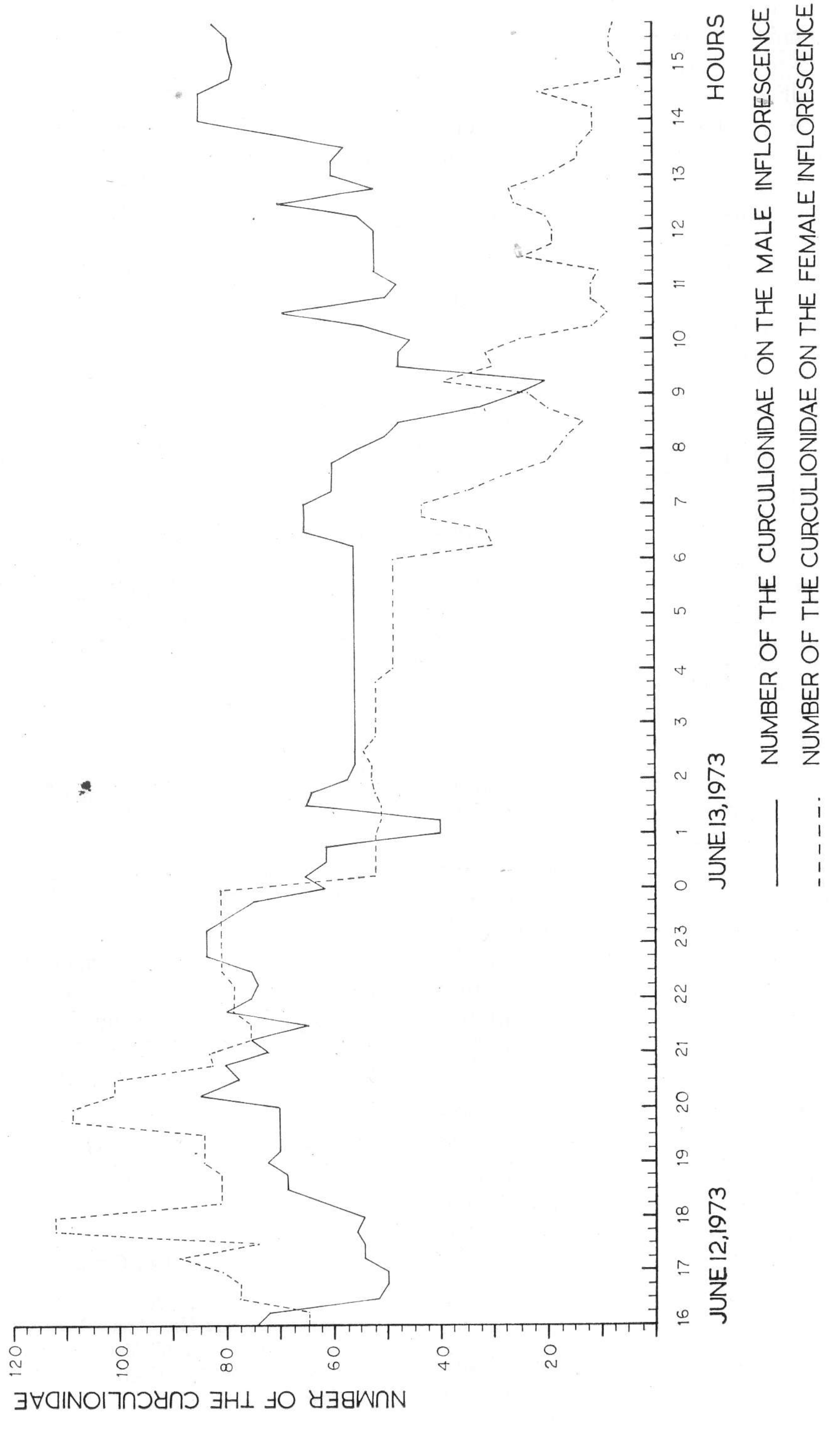


5. Flowers of *Salacca edulis* (a–c) and their visitor (d–f). a, pistillate flower; b, neuter flower; c, staminate flower; d, e, f, curculionid beetle in dorsal, ventral, and lateral views.

stant number of insects during this period. Between 0700 and 2100 the number of insects fluctuated from time to time, which suggests that the insects fly from one inflorescence to another. The time when there was the largest number of insects on the inflorescence was between 1900 and 2100 hours. The pistillate flowers are at anthesis during the night from sundown at about 1800 until early in the morning. During the night the insects fed upon a nectarlike secretion in the basal parts of petals. By morning the petals were broken by the curculionid beetle and the number of insects decreased after the petals were broken.

The staminate inflorescence remained with flowers in anthesis for three days. The basal parts of the petals are also broken, which suggests that a nectar-like substance might have been fed upon by the beetles. But it is not clear whether the beetles are also feeding on the pollen grains. Up to 1600 hours, the number of the insects in the staminate inflorescence was greater than the number of the insects on the pistillate one. But the number of the insects on the staminate inflorescence decreased after 1600 while on the pistillate one the number of the insects increased, especially between 1900 and 2100 hours.

The five pistillate inflorescences covered by cellophane developed normally for three to seven days until the stage of anthesis. One month later the flowers were dried, dead, and had not pro-



6. Numbers of curculionid beetles on staminate and pistillate inflorescences.

duced fruit. This evidence suggests that the staminate flowers in those pistillate inflorescences are truly sterile, so that no pollination could occur. On the other hand, under a monocular microscope it was found that the insects collected from uncovered pistillate inflorescences had some pollen grains of *Salacca* on their breast and hairs of their feet. This is an indication that those trees are insect-pollinated. In this connection it should be noted that some of the characteristics of this species are petals with a strong ginger (*Zingiber officinale* Roxb.) fragrance (Ochse and Bakhuizen van den Brink, 1931) that attracts the insects, and stigmas often covered with litter because of the position of short erect axillary inflorescences. The trees themselves are of a gregarious nature, living together in a compact and enclosed area, thereby preventing the entrance of wind (Faegri and Pijl, 1966).

Discussion

Schmid (1970), in his observation of the pollination of *Asterogyne martiana* (H. Wendl.) H. Wendl. ex Hemsley, wrote that the number of insects on the inflorescences increased when the flowers produced nectar. Based on this phenomenon one may suggest that the production of a comparable substance in the staminate and pistillate inflorescences of *Salacca edulis* occurred at different times. The highest concentration of insects on the staminate inflorescence was between 1200 and 1600 hours, and on the pistillate inflorescence between 1900 and 2100 hours. As shown in the graph, during this latter period the number of insects decreased on the staminate inflorescence and increased on the pistillate one, indicating a migration from the staminate to the pistillate inflorescence. It is suspected that during this period the insects pollinate the pistillate flowers.

In Bangkalan-Madura the curculionid beetles on the inflorescences are few in number. Here pollination is carried out by man by cutting and moving parts of the staminate inflorescence with flowers at anthesis to the pistillate inflorescences.

Tan (1953) reported that according to Mahjoedi the *salak* in Bali is monoecious, which implies that the staminate flowers on the pistillate inflorescences are fertile. During a field study on *salak* gardens in Karang Asem in May 1973 together with Dr. John Dransfield, no male tree was found. What the local people had thought was a *salak laki-laki* (a male tree) was, in fact, a female plant that had never produced fruit. *Salak Bali* actually is different from the common ones, because it has erect leaves and the pistillate inflorescences often have some reduced rachillae near their bases (Fig. 4). The Balinese *salak* is generally regarded as the best *salak* of all and its seeds are fertile, but the mechanism of its fertilization is still unknown.

Acknowledgments

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NOTES ON CULTURE

Parajubaea cocoides seeds have a reputation with at least a few growers of being rather slow and difficult to germinate. I recently had a very fast and successful germination of a number of these seeds. Freshly collected fruits from Quito, Ecuador, arrived still reeking of fumigant from the U.S.D.A. station. They were intact, with the fibrous fruit coat around the bony endocarps, and were quite dry and hard. I soaked them for about two days in a weak fungicide solution, after which the fibrous fruit coats softened and came away easily. I moistened some very loose, porous, commercial planting mix in a large plastic container and placed the endocarps with enclosed seeds on top of the soil, covering them with only a layer of loose moist sphagnum. When the sphagnum became completely dry, I watered lightly. The container was kept loosely covered in my garage, which maintains a temperature of about 60° F at night and 80° by day rather consistently. Within four weeks the seeds began germinating, and after six more weeks approximately 80% had sprouted.

I believe the good results came from having the endocarps exposed to fresh air while at the same time surrounded loosely by a slightly moist medium. They never became overly wet, and the day-night temperature variation may also be important. Their native habitat is one of large day-night temperature differences.

That these conditions were conducive to good germination was proved by the fact that a number of *Parajubaea* fruits that I collected myself in Quito had never germinated under similar condition except that they were completely buried in soil for over eighteen months. I removed them to the above container with more air and they began germinating also. It is possible that, as with *Jubaeopsis caffra*, there is a growth inhibitor that is overcome in the presence of oxygen. This would certainly be of survival advantage to the seed. So long as the fruit coat remains intact, a condition approximated by the fruit being completely buried, the embryo remains dormant. With the arrival of a wet season, the fruit wall quickly decomposes, exposing the endocarp with its seed to air, and the seed can germinate.

Parajubaea cocoides is a beautiful tree and should be adaptable to most of coastal California as well as mild areas inland. But it has been extremely difficult to obtain plants. I hope the above information may help change that situation.

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