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Significance of Hermaphrodite flowers in Coconut Breeding

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In coconut hybridization involving the dwarf and tall varieties, which has recently assumed great importance, a percentage of the resultant seeds (seedlings) turns out to be pure dwarfs similar to the seed parent. Various factors contribute to the reduced recovery of genuine hybrids in such crosses, the major one being the lack of promptness on the part of the technicians who effect emasculation and other control measures. In the dwarf variety of coconut, a very small number of flowers are found to possess both pistils and stamens. Such hermaphrodite or bisexual flowers are intermediaries in size between normal female and male flowers. The Nias yellow dwarf which is most commonly used in Indonesia for producing dwarf × tall hybrid seeds is also seen to produce hermaphrodite flowers. A critical study made at the seed garden at Manado (North Sulawesi) has shown that 27% of the palms sampled bore at least one hermaphrodite flower in three months. At the time of emasculation, most of the hermaphrodite flowers escape notice and pass for female flowers, and eventually cause fertilization within the flower, between flowers of the same palm or between palms, thereby producing dwarf seedlings similar to the seed parent. Timely removal of hermaphrodite flowers, therefore, would reduce the undesirable true-to-mother type progeny and enhance the success of inter-varietal hybridization.

Key Words: Coconut, Hermaphrodite flowers affect breeding efficiency

Why Dwarfs appear in Dwarf × Tall Cross-breeding ?

Of the factors that lead to the reduced recovery of genuine hybrids in coconut hybridization between dwarf and tall varieties (or between forms of the tall variety), the presence of hermaphrodite flowers that usually escape emasculation can be an important one. Some of the resultant progeny turn out to be genetically similar to the seed parent, and the percentage of such seedlings, termed 'illegitimates' (de Nuce & Rognon 1972), may range from 2.00% to 20.54% (table 2). Detection of these undesirable seedlings at a very early stage is not always easy, except where the parents possess

known but differing genetic markers. For example, when Malayan yellow dwarf or red dwarf, Nias yellow dwarf or Chowghat orange dwarf are crossed with any green pollen parent, culling the inbreds (self-pollinated progeny) is very easy even at the rudimentary leaf stage because yellow and orange colours are recessive. But in other cases where the colour of leaf petioles cannot be relied upon, the difference in the speed of germination between the hybrids and their parents is used as a criterion (Rognon 1972, Balingasa & Santos 1978). However, this cannot be an efficient method, and so, based on the performance of the transplanted seedlings, culling the suspected inbreds up to two years seems desirable. With time, the hybrids would grow larger and faster compared to the dwarf seedlings by producing larger leaves, more roots, and developing a thicker collar/stem. Taulu et al. (1980) suggested that the trichome index of the lamina could be another way of recognising the hybrids from the rest.

The chief factors which contribute to the production of dwarf seeds similar to the mother in dwarf × tall crosses are the following: Delays in commencing emasculation is the most serious factor that causes 'self pollination'. This is caused by the irregular attendance of the technicians who effect emasculation. The information received from the Research Department of the Coconut Industry Board, Jamaica would emphasize this point. In their mass production of hybrids, in general, a 92% recovery of true hybrids was attained. However, due to lack of promptness on the part of one of the pollinators (a contractor), the percentage of hybrids obtained from the small number of palms assigned to him went as low as 50%. Other causes are, careless disposal of male flowers, reuse of male flower-disposal bags without fully eliminating the pollen grains adhering to them, nearness to unemasculated palms of the seed parent type, use of pollen parents which carry some of the genetic characters of the seed parents etc. Where pollination bags are used, the possible defects are: use of damaged bags or those having large mesh that could permit pollen grains to pass through, not securely tying the mouth of the bag with the peduncle, keeping the bags opened for longer durations during active female phase, and defective emasculation. The presence of hermaphrodite flowers can be yet another factor.

Steps taken to Minimize Production of Dwarf Seeds

In order to minimize the percentage of 'inbred' dwarfs in hybridization, various precautions are adopted by coconut breeders in different countries. Judging from results, the most rigorous precautions seem to be taken in Sri Lanka and the Ivory Coast in their hybrid production programme. In Ivory Coast, effecting a cross between Malayan yellow dwarf and West African tall has yielded the familiar PB 121. The procedure as reported by de Nuce and Rognon (1972) consists of systematic removal of all male flowers produced by mother palms to avoid any emission of pollen. The operation is carried out as soon as the spathe opens. When a slit appears through which a few spikes begin to emerge, the tip of the spathe is cut off and the remaining portion torn lengthwise which is also cut away at the base. The spikes, trimmed 5 or 6 cm above the topmost female flower, are collected in a bag and burnt. The remaining male flowers are detached by hand. The emasculation work is methodically organised and strictly checked. The emasculator examines the state of the inflorescences of the seed parents 5 or 6 times a day. One person is responsible for 250–300 trees resulting in 300–400 emasculations each month. Each operation is recorded and the quality of the work of the

emasculator is checked by a supervisor. It is further reported that the supervisor keeps his team up to mark at all time. Because of these precautions, 95% to 97% legitimacy is reported from Ivory Coast. Since most of these are expensive operations, strict vigilance may not be possible when very large quantities of seeds have to be produced for distribution within relatively short periods. The emasculator examining the condition of the spadices of the seed parents five or six times a day seems unnecessary even if one can afford to carry out such costly operations. Further, according to these authors, 'the operation is carried out as soon as the spathe opens'. As per conditions prevailing in India and Indonesia, even this is a dangerously late stage since some pollen grains get dispersed as soon as an opening appears on the spathe. In many parts of Kerala (India), thousands of mites get collected within the grooves of the spathe during two or three days prior to opening of spathe and they reach the spikes as soon as a slit is formed on the spathe within which some male flowers have already bloomed. The vigorously moving mites getting loaded with pollen grains can be easily blown away by breeze or be dispersed through insects, thus increasing the chance of fertilization between dwarfs. Even 3 or 4 days prior to normal opening of spathe, some male flowers start blooming and shedding their pollen grains. The special advantage of such 'cleistogamous flowers' is not known. Investigations have shown that pollen grains of these flowers are smaller, and the percentage of non-viable or under-developed pollens among them is much higher than the pollen from flowers located on lower regions of spikes and which bloom only after the normal opening of the spathe. Moreover, many spadices bear abnormal flowers at the tip of some spikes which always bloom before the spathe opens. Such abnormal flowers are more common in the dwarf variety, some of which have been reported by Ninan and Ratnam (1961).

Cocount breeders elsewhere take further precautionary steps. In Malaysia, according to Hoak (1980), all inflorescences are emasculated before the spathe has a chance to open by itself. A 2.0% formalin is sprayed on a limited scale to kill the pollen from flowers that accidentally slip pass the 'flower catcher'. Abnormal inflorescences that fail to elongate are chiselled off. A reserve gang of emasculators is maintained for emergency and for service during peak crop season.

Inspite of all these, unexpected contingencies may arise that would affect the efficient arrangements and reduce the hybrid recovery. According to de Nuce (1980), due to a drastic reduction in the quantity of pollen used at the seed garden at Lampung (Indonesia), the percentage of dwarfs could go up to 10.0% even though under normal conditions, dwarfs appeared only less than 2.0%. This is a sound prediction since the results we observed from over 20,000 seedlings reached 9.56% (table 2). But what is difficult to understand is how a reduction in the supply of pollen from tall parent could increase the 'contamination' by dwarf pollen when emasculation is done properly and the garden is adequately isolated, or protected by a barrier. Another instance of unexpected results was reported by de Nuce. In Ivory Coast, where normally only less than 5.0% dwarfs appear in dwarf × tall crosses, such a percentage increased to 15% because part of their garden was slightly contaminated by pollen from hybrid palms in spite of a 300 m-wide barrier.

Hermaphroditism in Coconut

While the flowers of a great majority of palm species are unisexual, those of a few others are hermaphrodites, as for example, the various species of *Thrinax, Corypha, Licuala, Livistona, Prichardia, Washingtonia,*

Copernicia and *Korthalsia*. In addition to the above categories, a palm may produce hermaphrodite as well as unisexual flowers. Such polygamous palms may be either polygamo-dioecious (*Calamus radiatus* and *C. delicatulus*) or polygamo-monoecious (*Trachycarpus fortuneii*). The flowers of coconut palm are unisexual and monoecious. However, exceptional cases of hermaphrodite flowers were recorded (Gopal Rao 1948). More strikingly, Davis et al. (1954) published quantitative data on four palms of the tall variety from Kerala which produce appreciable numbers of hermaphrodite flowers in all the spadices examined. The percentages of hermaphrodite flowers to normal female flowers ranged from 10.0% to 55.0% between palms. There was no association between the numbers of hermaphrodite flowers to female flowers of any spadix. The hermaphrodite flowers reported by Davis and others occupied a position in the spikes in between the female and male flowers. In size too, the hermaphrodites are intermediates between the other two kinds (figures 4 & 5). The bisexual flowers can be distinguished into three groups, one which closely resembles the females, many of which develop into fruits. Another group resembles closely the males, and practically none of them develops into fruit, and the third group bears characters intermediate between groups one and two. Also it was reported that the anthers of bisexual flowers matured with the male phase of the spike while the stigma became receptive during the female phase of the spadix.

Hermaphrodite Flowers in Nias Yellow Dwarf

The Industrial Crops Research Institute maintains four coconut seed gardens one each in North Sulawesi, South Sulawesi, West Java and Aceh provinces comprising 510 ha. In all these gardens, only one dwarf form (a yellow dwarf from the Nias Is. of Sumatra) has been employed for the production of hybrids with three tall forms/cultivars (Tenga, Palu and Bali). One dwarf palm at the Manado seed garden (North Sulawesi) was observed to produce a few hermaphrodite flowers in a spadix. Further observations on this palm showed that production of hermaphrodite flowers is a common feature for this palm. Data on the female, hermaphrodite and male flowers from a selected spadix from this palm are given in table 1. This particular spadix produced the maximum number of hermaphrodite flowers recorded from Indonesia.

To see how common is the production of bisexual flowers in the Nias yellow dwarf, a random survey was made on 200 palms where flowers of three consecutive spadices could be examined. The number of hermaphrodite flowers per palm ranged from zero to four. Out of the 200 palms, 54 had at least one flower. In other words, 27% of the Nias dwarfs are polygamo-monoecious. If more bunches per palm are examined, perhaps the percentage would increase. The hermaphrodite flowers can be potential sources of pollen that would interfere with breeding.

Figures 1 and 2 show portions of three spikes belonging to the spadix detailed in table 1. The spike in figure 1A has a large female flower at the base and three hermaphrodites which are smaller than the female flower. In addition, there are a few male flowers remaining on the spike. Spike B has two females and five bisexuals. Figure 2 which is a portion of the terminal spike has at least 8 hermaphrodite flowers visible at this view. Usually the terminal spike (continuation of the peduncle) bears more bisexual flowers. We wish to emphasize that all small-sized flowers that resemble female flowers superficially are not necessarily hermaphrodites. Even the group of bisexual flowers which resemble closely the female flowers have many of the filaments developed and some

Table 1 *Analysis of a spadix of Nias yellow dwarf bearing hermaphrodite flowers*

Spike number	Length of spike (cm) Total	Below♀ flr.	No. female flrs. Twins	Singles	Total	No. male flrs. Twins	Singles	Total	Hermaphrodites
1	36.5	6.0	—	3	3	128	78	206	—
2	45.0	8.0	—	6	6	158	67	225	—
3	39.5	7.0	—	3	3	140	62	202	2
4	35.0	8.0	—	1	1	108	76	184	—
5	45.5	6.0	—	2	2	142	63	205	—
6	45.0	7.5	—	8	8	172	53	225	2
7	37.0	6.5	—	3	3	132	64	196	—
8	33.0	7.0	—	1	1	106	76	182	—
9	37.5	5.5	—	2	2	128	63	191	1
10	39.5	6.0	1	6	8	168	61	229	—
11	38.5	6.0	—	5	5	134	61	195	—
12	33.5	6.0	—	1	1	112	65	177	1
13	33.5	7.0	—	1	1	120	56	176	—
14	36.0	5.0	1	4	6	148	53	201	—
15	35.5	5.0	1	5	7	152	52	204	2
16	33.0	6.0	—	3	3	118	61	179	—
17	32.5	6.0	—	1	1	100	54	154	—
18	32.5	6.0	1	2	4	134	61	195	—
19	34.5	5.0	—	8	8	126	50	176	1
20	32.5	5.0	—	2	2	118	49	167	—
21	30.0	7.5	—	2	2	102	54	156	—
22	31.5	4.4	—	2	2	112	51	163	—
23	32.4	4.5	1	6	8	146	41	187	—
24	29.8	4.4	—	2	2	124	48	172	—
25	30.3	5.3	—	6	6	110	43	153	1
26	27.0	4.5	—	2	2	94	49	143	—
27	29.4	3.5	1	6	8	116	44	160	—
28	28.0	5.0	—	8	8	138	44	182	—
29	24.5	3.5	—	3	3	92	49	141	—
30	24.0	3.0	—	3	3	98	46	144	—
31	22.9	2.4	—	4	4	108	42	150	—
32	20.9	1.9	—	4	4	104	41	145	—
Terminus	24.5		—	4	4	60	40	100	10
Total	969.7	174.4	6	119	131	4048	1817	5865	20

Table 2 *Percentages of inbred dwarf seedlings resulting from dwarf† × tall crossings in different countries (based on number of nuts sown)*

Location/Source		Seed parent (dwarf)	Hybrids (Nos. or %)	Inbreds (dwarfs)	Percentages of dwarfs/inbreds
Indonesia					
LPTI	(a)	Nias yellow	558	74	11.71
	(b)	Nias yellow	1183	145	10.92
PNP X	(a)	Nias yellow	20303	2147	9.56
	(b)	Malayan red	2949	276	8.56
Ternate		Malayan yellow	938	91	8.84
Malaysia					
Highlands Estate		Malayan yellow	85.0%		15.0
United Plantations Berhad		Malayan red	95.0–97.0%		3.0–5.0
Jamaica		Malayan yellow	92.0%		8.00
India		Chowghat orange	15.49%		15.49
Ivory Coast		Malayan yellow	95.0–97.0%		3.0–5.0
Sri Lanka		Not known	95.0–98.0%		2.0–5.0

Note: So far as the Philippines are concerned, eventhough data from the mass pollination hybrid seed gardens are yet to become available, prof. Juan Carlos of the University of the Philippines at Los Bānos was able to obtain 97% or 98% hybrids with yellow and red dwarfs as seed parents, each occupying only 0.5 ha garden (Personal communication)

of them bear fully or partially developed anthers. The anthers possess small numbers of pollen, most of which are not developed fully. However, the anthers of the other two categories of bisexual flowers are well-developed.

In figure 3, an unusual flower cluster is shown. A large female flower (a) has a twin flower (b); which is hermaphrodite. Of the two partially opened flowers (c and d); c is hermaphrodite even though it resembles a male. Here all the six stamens are fully developed, flower (d) as well as the unopened one (e) are normal males.

Influence of Hermaphrodite Flowers on Breeding

Hybridization in the coconut is effected between tall strains, between dwarf and tall varieties (or tall × dwarf), and to a very small extent between dwarf strains. In the different techniques employed, in spite of adopting good control measures, some of the resultant seedlings turn out to be similar to the seed parent. The percentage of such seedlings depends on the extent of precaution taken to prevent self-pollination, the genetic make-up of the seed and pollen parents as well as on whether the seed parents produce hermaphrodite flowers or not. Information kindly supplied by colleagues from different countries on the percentages of inbred dwarf seedlings appearing in dwarf × tall crossings involving different parents are given in table 2. Of these, some are the results of controlled

pollination by the use of pollination bags and the rest are from mass pollination techniques.

From data in table 2, one may presume that on an average, not less than eight per cent of the millions of 'hybrid seeds' produced become dwarfs which is a matter for concern since the share of the amount spent on supervision, labour, attention, storage and transport, etc., for these seeds is quite large. It is hoped that in their attempts to reduce the production of dwarf seeds (where dwarf seedlings are not in demand) coconut breeders will give the required attention to eliminate the hermaphrodite flowers. Palms known to produce regularly large numbers

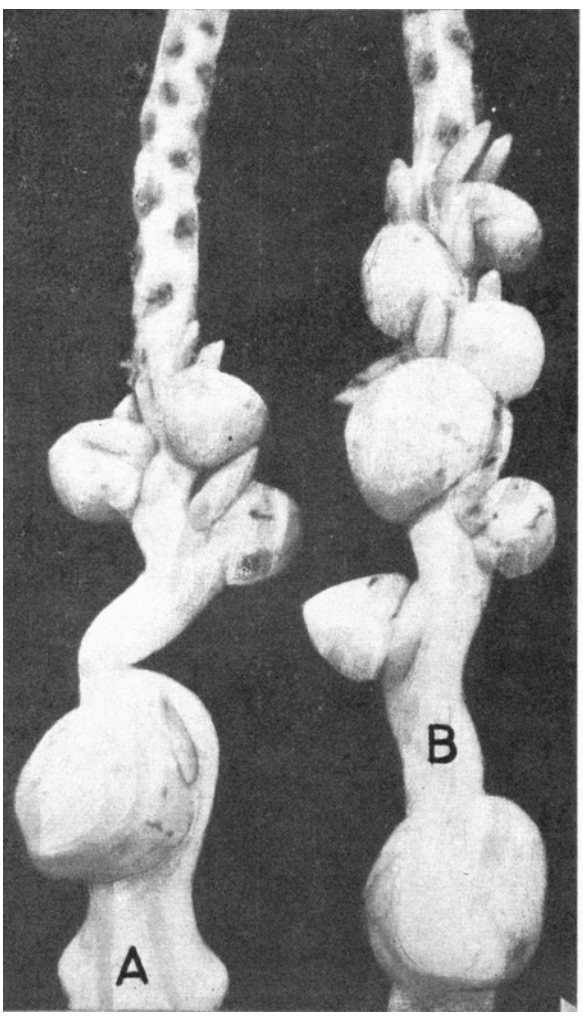

Figure 1 Portions of two coconut spikes. Spike A has one female and three hermaphrodite flowers apart from a few males

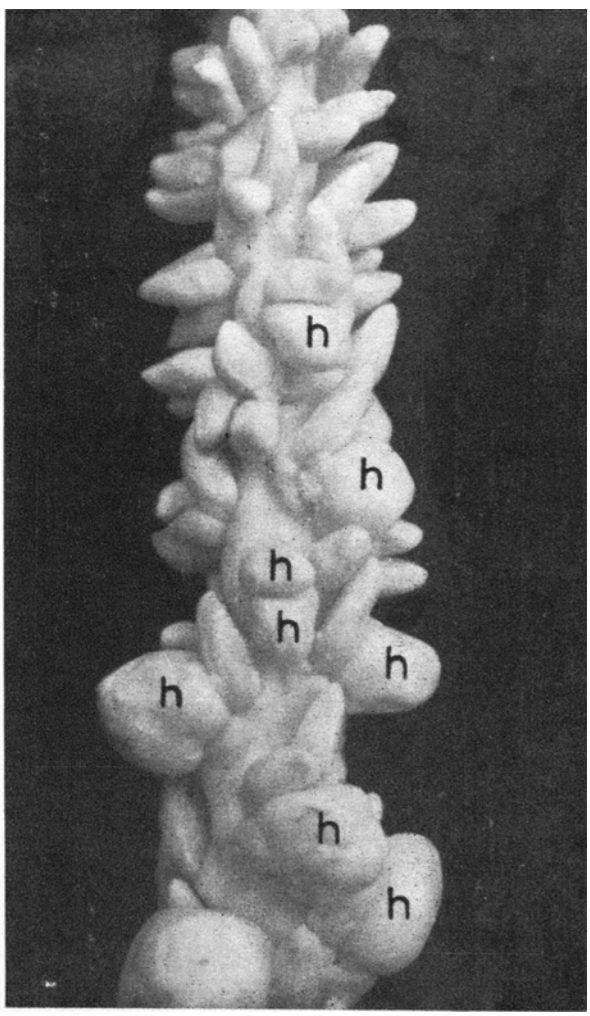

Figure 2 Portion of the terminal spike bearing many hermaphrodite flowers. At least eight hermaphrodite flowers are visible in the picture. Their size varies considerably

of bisexual flowers may be removed from seed gardens.

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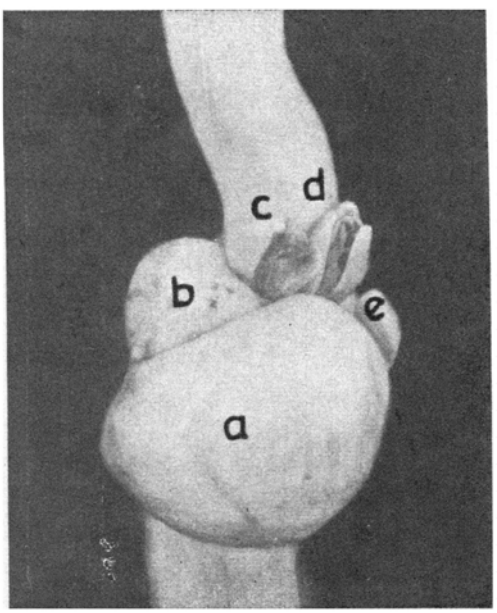

Figure 3 An unusual flower cluster having a normal female flower (a), one hermaphrodite flower (b) resembling a female, and another hermaphrodite flower (c) resembling a male flower. Also there are two males (d, e)

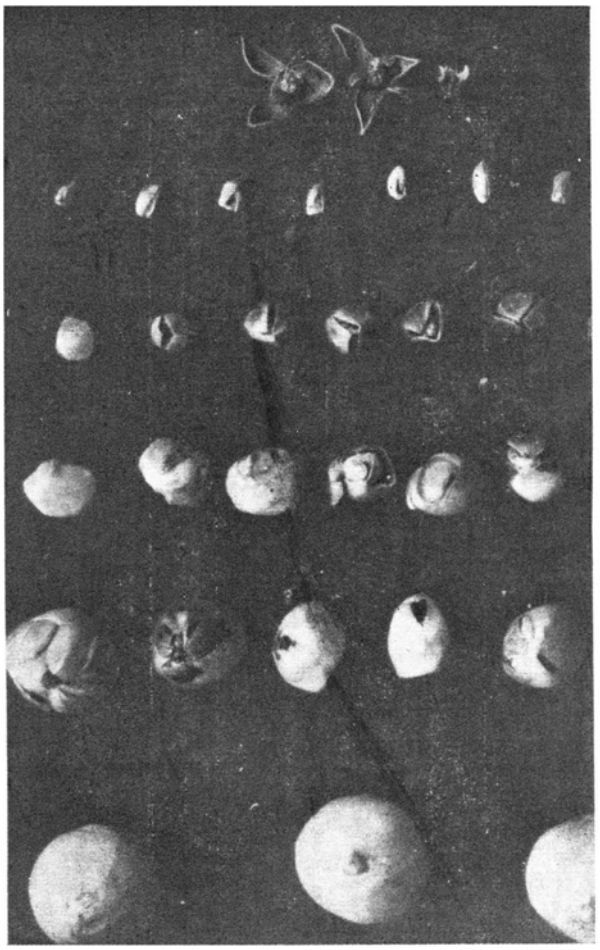

Figure 4

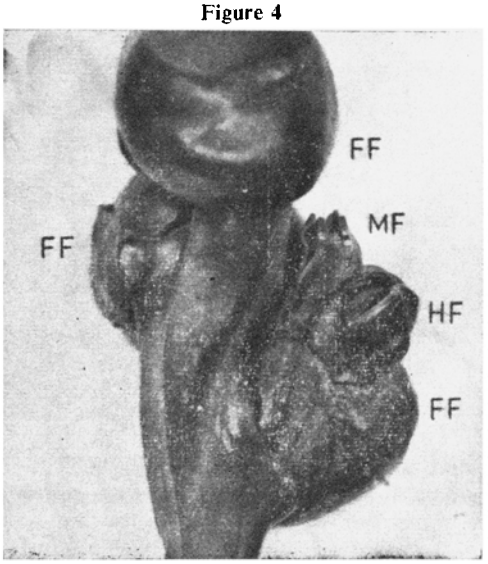

Figure 5

Figure 4 Coconut flowers: Topmost row of 3 flowers are hermaphrodites. Next row shows normal male flowers. Lower most row has normal female flowers. The three intermediary rows are hermaphrodite flowers, some of which containing stamens

Figure 5 Portion of spike of coconut showing 3 normal female flowers (FF). Attached just over the lowest female flower are one hermaphrodite flower (HF) and a male flower (MF). Stamens are visible in the hermaphrodite flower

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