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IDENTITY AND GERMINATION OF SEEDS FROM FECES OF THE PHILIPPINE PALM CIVET (*PARADOXURUS PHILIPPINENSIS* JOURDAN)

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ABSTRACT

The seeds found in feces of the Philippine palm civet (*Paradoxurus philippinensis* Jourdan) are homogeneous and belong to one of four species, namely: *Pinanga insignis* Bl., (Palmae). *Caryota rumphiana* Mart. var. *philippinensis* Becc., (Palmae), *Coffea arabica* L., (Rubiaceae) and *Ficus minahassae* (Teijsm. & de Vr.) Miq., (Moraceae). *Pinanga insignis* and *Caryota rumphiana* var. *philippinensis* are the principal food items while *Coffea arabica* and *Ficus minahassae* are the alternate food preference of the Philippine palm civet in the Mount Makiling forest, Philippines.

Average days to emergence and percent germination for each plant taxon were as follows: 81 days after sowing (d.a.s.) and 50% for *P. insignis*, 101 d.a.s. and 43% for *C. rumphiana* var. *philippinensis*, 67 d.a.s. and 20% for *C. arabica*. The conditions and actions of the digestive system of Philippine palm civet on the seeds of *P. insignis* and *C. rumphiana* var. *philippinensis* substantially enhanced germination compared with seeds that had simply fallen on the ground surface or forest floor.

INTRODUCTION

Taxonomic determination of seeds that have passed through the alimentary canals of forest animals, particularly birds and mammals, is often difficult. This problem becomes more complicated when one studies food preferences and foraging patterns of nocturnal animals such as the members of the civet family Viverridae to which the Philippine palm civet (*Paradoxurus philippinensis* Jourdan) belongs.

In these specific studies, the logical approach to follow is to conduct a thorough survey of the natural habitat and foraging range of the animals. In this way, one will be familiar with its foraging behaviour and distinctive marks of daily routine activity, e.g. the appearance and composition of their fecal matter. A survey of the flora and fauna within the foraging territory should be undertaken, as the taxonomic identity of the food items that are regularly or seasonally consumed by the animals can be verified through direct comparison with *in situ* plants or collected specimens.

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The role of animals as dispersal agents of plant propagules in various ecosystems is well documented (see for example, BARTELS, 1964; DAVIDSE & MORTON, 1973; HOWE & PRIMACK, 1975; MCDIARMID et al., 1977; HOWE, 1977; HAMBALI, 1979; CANT, 1979; and RABOR, 1981). PIJL (1969) summarizes the characteristics of mammal-dispersed fruits while SNOW (1981) provides a world survey of the food plants of tropical frugivorous birds.

Whether the plant propagules have been dispersed by birds, mammals or abiotic agents like wind, water, etc., is to us only of secondary significance when viewed in the overall context of successful forest regeneration. Of prime significance is whether the dispersed propagules successfully germinate and thrive to maturity in the habitat where the dispersal agents left them. It is therefore necessary to evaluate germinability of seeds that have passed through the digestive system of animals. In addition, germination experiments will determine whether the conditions and actions of the digestive tract significantly enhance or inhibit germination or influence the viability of seeds.

This paper presents data on the identity and germination of seeds found in droppings of the Philippine palm civet (*Paradoxurus philippinensis* Jourdan*), locally known as "musang" or "alamid" (Tagalog) and "milo" (Bisaya). To our knowledge, there are no published local data on this quite interesting topic.

MATERIALS AND METHODS

In March 1984 during a botanical trek to Mount Makiling (Los Baños, Laguna Province, Philippines; see PANCHO (1983) for more details on the environment), several droppings of the Philippine palm civet were seen along the foot trail to peak 2 (altitude 1,140 m). The feces were present starting from an altitude of ca. 300 m up to as high as 800 m and at an apparently regular interval. A systematic collection and observation of the feces were conducted. A total of 12 fecal mounds was obtained (Table 1), together with one set of fruits and seedlings of *Pinanga insignis* collected from the base of a nearby representative plant. Photographs of fecal mounds and representative plants from where the fruits might have been obtained by the palm civet were taken. Fecal morphology was described *in situ* and the contents of the feces were examined more closely in the laboratory using a binocular dissecting microscope (10–20x). Selected seeds from the droppings and fallen fruits and seedlings from representative *P. insignis* plants were drawn while fresh. A minimum of 10 seeds or more (see Table 2) was taken from each collection and used in the germination experiments. The remaining seeds and seedlings were prepared as voucher specimens.

The identity of seeds in the fecal matter was verified through comparison with seeds obtained from nearby plants, and by examining the diagnostic seedling morphology

*Nomenclature follows RABOR (1977). Alternatively, a number of authors (e.g. DAVIS, 1962; BURTON & BURTON, 1969) treat all Philippine members of this genus as *Paradoxurus hermaphroditus* (Pallas). Still others, e.g. HEANEY (1984) consider the local populations as *P. hermaphroditus* (Pallas) subsp. *philippinensis* (Jourdan).

of each forest species. Developmental stages and seedling morphology of the different species were illustrated and corresponding voucher specimens were likewise prepared. All voucher specimens for this study are now deposited at the Botanical Herbarium (CAHP), Museum of Natural History, University of the Philippines at Los Baños, College, Laguna.

Germination Experiments

Ten seeds were picked out at random from each fecal collection except for *Ficus minahassae*, washed in running water and sown in clay pots containing ordinary clay-loam soil. The very tiny seeds of *Ficus minahassae* were first placed in a basin of tap water. Experimental seeds were then taken at random from those seeds that settled at the bottom. The seeds obtained were directly sown in clay pots: 10 seeds per pot, replicated 10 times. All pots were labelled and numbered consecutively. The entire experimental set-up was placed in a partially shaded area behind the Biological Sciences building, University of the Philippines at Los Banos, and maintained under ambient temperature (27-31°C) and light intensity (ca. 30 foot-candles). Sufficient moisture was maintained throughout the course of study. Average days to emergence and percent germination for each species were determined as well as seedling vigor.

RESULTS AND DISCUSSION

Fecal Morphology and Composition

The fecal mounds were situated on clear spots along the trail and were spaced at an interval of approximately 50 to 100 m. The feces when composed of palm seeds were more or less linear, 15-20 cm long, pitch-black, and mucilaginous (Fig. 1). On the other hand, when composed of *Ficus minahassae* and *Coffea arabica,* the droppings were more or less round 5-10 cm in diameter, pale brown to brownish black, mucilaginous in the former, and non-mucilaginous in the latter taxon.

Identity of Seeds in Feces

The identity of seeds of four species, *Caryota rumphiana* Mart. var. *philippinensis* Becc., (Palmae/Arecaceae), *Pinanga insignis* Bl., *Coffea arabica* L. (Rubiaceae), and *Ficus minahassae* (Teijsm. & de Vr.) Miq. (Moraceae), found in droppings of the Philippine palm civet is shown in Table 1. Generally, the seeds of all four species were intact. Only the fleshy exocarp and/or mesocarp were sloughed off, loosened or completely macerated (Fig. 3A, B; Fig 4A; Fig. 5A, B). Quite obviously the principal food items of the Philippine palm civet in the Mount Makiling forest are the fruits of *Pinanga insignis* and *Caryota rumphiana* var. *philippinensis. Coffea arabica* and *Ficus minahassae* are alternative food materials available throughout or during certain periods of the year, and abundant at slightly lower elevations.

Table 1. Identity and total number of seeds from fecal matter of Philippine palm civet (*Paradoxurus philippinensis* Jourdan) collected from Mount Makiling forest, Philippines, 24 March 1984.

Collection No.	Species	Total number of seeds
WM10908*	*Pinanga insignis* Bl.	22
WM10909	*P. insignis* Bl.	23
WM10910	*P. insignis* Bl.	19
WM10911	*P. insignis* Bl.	20
WM10912	*P. insignis* Bl.	13
WM10913	*Ficus minahassae* (Teijsm. & de Vr.) Miq.	numerous
WM10914	*F. minahassae* (Teijsm. & de Vr.) Miq.	numerous
WM10915	*Caryota rumphiana* Mart. var. *philippinensis* Becc.	13
WM10916	*C. rumphiana* Mart. var. *philippinensis* Becc.	13
WM10917	*Coffea arabica* L.	51
WM10918	*Caryota rumphiana* Mart. var. *philippinensis* Becc.	30
WM10919	*C. rumphiana* Mart. var. *philippinensis* Becc.	21

*Collection numbers preceded by WM were gathered by William Sm. Gruèzo.

Germination

The number of days to emergence (n.d.e.) and percent germination of each collection, and the averages for each species, are shown in Table 2. *Pinanga insignis* geminated after 61 days after sowing (d.a.s.) and kept germinating up to 102 d.a.s. Its average n.d.e. was 81. Seeds of *P. insignis* collected from the base of representative plants germinated after 84 d.a.s. and kept germinating up to 105 d.a.s. Its average n.d.e. was 88. *Caryota rumphiana* var. *philippinensis*, however, had a more uniform start of germination, i.e. 91 d.a.s. It kept on germinating until 128 d.a.s. and had an average n.d.e. of 101.

Of the two alternative food items, only *Coffea arabica* germinated, after 67 days. *Ficus minahassae* had not germinated by 160 days and no germination was observed thereafter. This could be attributed to the total death of the very minute seeds due to elevated temperature as these passed through the alimentary canal.

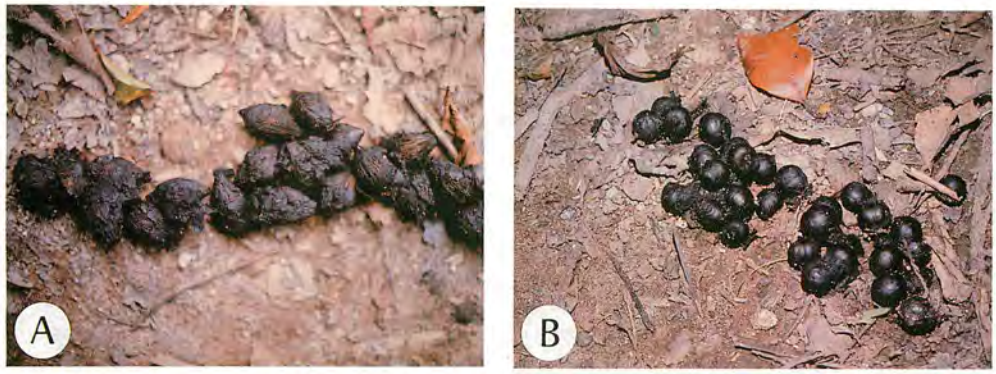

Figure 1. Fecal mounds of Philippine palm civet *(Paradoxurus philippinensis* Jourdan) collected from Mount Makiling, Philippines. A. Seeds of *Pinanga insignis* Bl., (WM10909). (Photo by Wm. Sm. Gruèzo, 24 March 1984). B. Seeds of *Caryota rumphiana* Mart. var. *philippinensis* Becc. (WM10918). (Photo by B.C. Tan, 24 March 1984).

Figure 2. Representative plant of: A. *Pinanga insgnis* Bl. growing on steep slope at c. 700 m altitude along trail to peak 2 of Mount Makiling, Philippines; the source of seed and seedling sample - WM10920. B. *Ficus minahassae* (Teijsm. & de Vr.) Miq. growing on level ground at c. 350 m altitude along trail to peak 2 of Mount Makiling, Philippines. Note: tubercles hanging from the trunk and branches. (Photo by Wm. Sm. Gruèzo, 24 March 1984.)

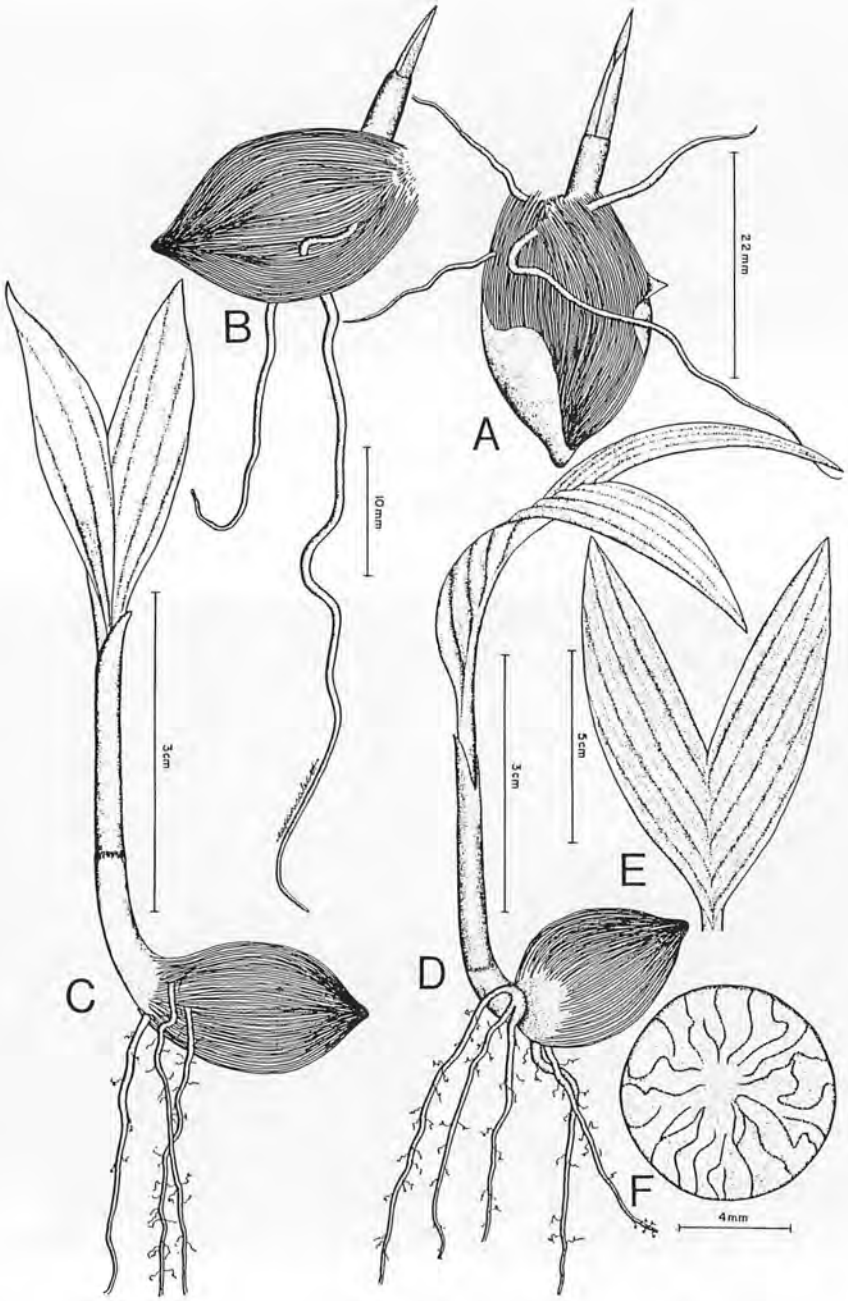

Figure 3. Developmental stages and seedling morphology of *Pinanga insignis* Bl. A. Nine days after sowing (d.a.s.). B. 19 d.a.s. C. 32 d.a.s. D. 72 d.a.s. E. leaf details of D, front view. F. Seed (cross-section) showing non-ruminate endosperm. (All drawn from WM10908).

The average percent of germination was 50, 43 and 20 for *P. insignis*, *C. rumphiana* var. *philippinensis* and *C. arabica*, respectively (see Table 2). With due consideration to other physical and biological parameters, it can be stated that the conditions and digestive action of the alimentary tract of the Philippine palm civet have comparatively enhanced the germination capacity of *P. insignis* and *C. rumphiana* var. *philippinensis*. The relatively low percent germination of *C. arabica* seeds is quite significant considering that in a study performed by TICSAY (1981), seeds of this species were found to be nonviable after passing through the digestive system of the Philippine palm civet. That study used a standard germination chamber and ran tests simulating the conditions in the gastro-intestinal tracts of animals that largely affect germination potential of ingested seeds. Percent germination and other related observations were obtained after 5 to 15 days (TICSAY, 1981).

Table 2. Number of days to emergence (n.d.e.) and percent germination of seeds from excreta of Philippine palm civet *(Paradoxurus philippinensis* Jourdan); date sown - 26 March 1984.

Species/Coll. no.	No. of seeds sown	n.d.e. (d.a.s.)*	Germination Percent
Pinanga insignis Bl.			
WM10908	10	61	70
WM10909	10	84/98**	10/30**
WM10910	10	84/91/102	10/20/10
WM10911	10	86	60
WM10912	10	84	20
		$\bar{x}$ = 81	$\bar{x}$ = 50
WM10920 (control)	10	84/105	40/10
Caryota rumphiana Mart. var. *philippinensis* Becc.			
WM10915	10	91/105/128	20/10/10
WM10916	10	91/112	30/10
WM10918	10	91/98/119	10/30/20
WM10919	10	91/98/105	10/10/10
		$\bar{x}$ = 101	$\bar{x}$ = 43
Coffea arabica L.			
WM10917	10	67	20
Ficus minahassae (Teijsm. & de Vr.) Miq.			
WM10913	100	-	0
WM10914	100	-	0

*d.a.s. = days after sowing.

**lowest to highest number of days to emergence and percent germination, respectively.

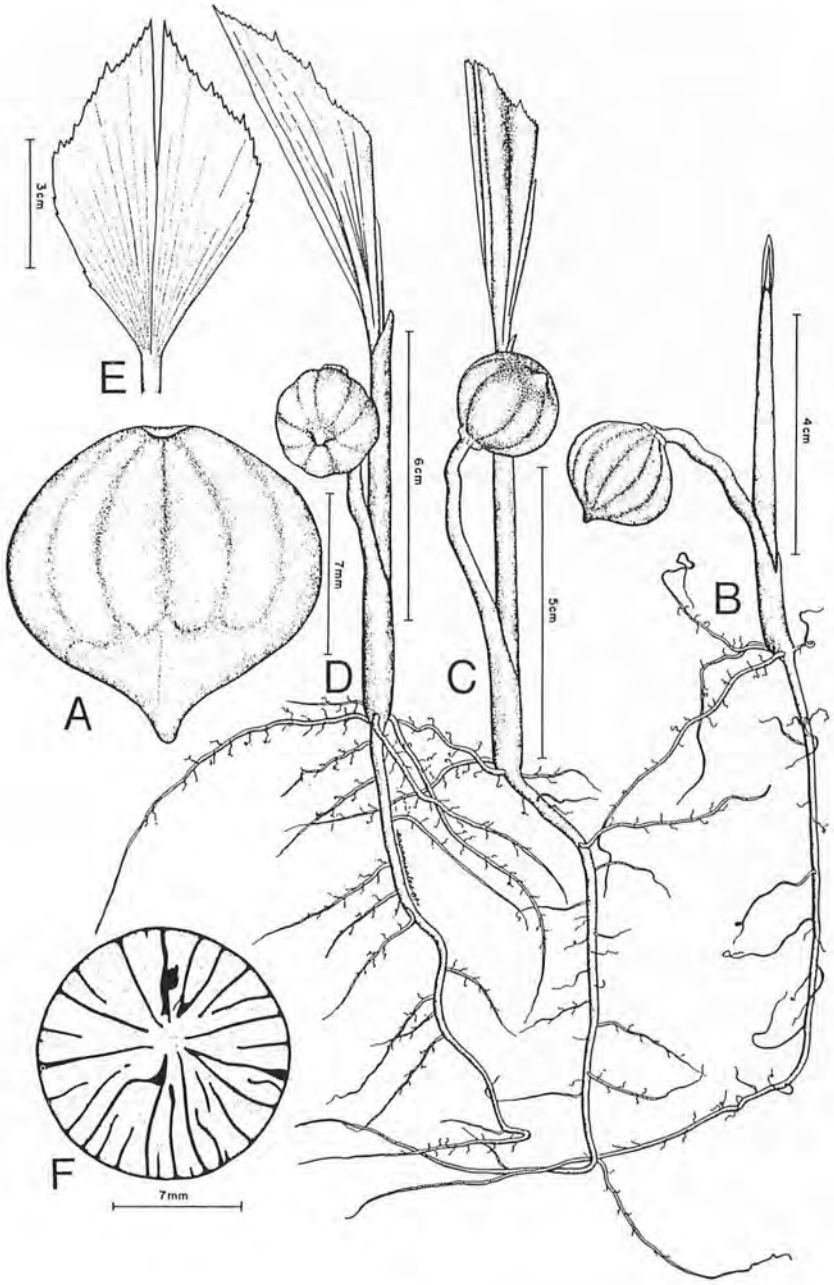

Figure 4. The seed, developmental stages and seedling morphology of *Caryota rumphiana* Mart. var. *philippinensis* Becc. A. Seed, lateral view. B. Seven days after sowing (d.a.s.). C. 32 d.a.s. D. 42 d.a.s. E. Leaf details of D, front view. F. Seed (cross-section) showing ruminate endosperm. (All drawn from WM10916.)

Seednuts of *P. insignis* obtained from the base of representative plants had undergone substantial decomposition of pericarp, a condition that resulted in an identical percent germination compared with the average for defecated seeds (see Table 2). However, on a per collection basis, two collections of defecated seeds showed much higher percent germination while the other three samples were slightly lower than the uningested seeds. Normally, freshly harvested seednuts show slower germination and a lower percentage. For example, THOHARI & SANTOSA (1984), at Gunung Gedeh-Pangrango National Park, Java, Indonesia, found a higher percent germination of *Pinanga kuhlii** and *P. javana** seeds found in feces of palm civet, *Paradoxurus hermaphroditus* (Pallas), compared with seednuts collected from the palm plants (67% versus 31%). This outcome was attributed to the enzymatic action of the civet's digestive system on the seednuts resulting in faster removal of the exocarp and loosening of the mesocarp (husk), allowing increased moisture penetration and retention.

Seedling Developmental Stages and Morphology

The stages of germination and seedling morphology of *P. insignis*, *C. rumphiana* var. *philippinensis*, and *C. arabica* are shown in Figures 3 to 5, respectively. The morphological characters of *P. insignis* seednut and seedlings collected from the base of representative plants are shown in Figure 6. Additional details on the species, their ecology as well as their fruit and seedling characters are given below.

Pinanga insignis Bl. ("Sarawag")

Pinanga insignis is an endemic arecoid pleonanthic palm species which bears fruits continuously throughout the year. It thrives well on moderate to steep slopes under the shade of the forest canopy as well as along margins of clearings and trails to the peaks of Mount Makiling (Fig. 1 A). Its fruit is bright red when ripe, oblong to nearly ellipsoid, ca. 10–14 x 18–25 mm, with a thick fibrous husk (mesocarp) and relatively thin fibrous shell (endocarp) (Fig. 3A, B; Fig. 6A, B).

Seedlings of *P. insignis* are semi-hypogeal and cryptocotylar. A positively geotropic stalk originating from the cotyledonary body emerges from the seed and grows downward into the soil. Temporary roots emerge from the stalk and grow downward. Subsequently, a leaf sheath is developed from the apex of the cotyledonary stalk and grows up to the soil surface. The first leaf emerges from within the sheath and rises above the ground. The leaves are V-shaped (due to deeply forked apex), with entire margin and the main parallel nerves are prominent (Fig. 3).

*Misspelled as "khuhlii" and "zavana" in THOHARI & SANTOSA (1984). According to BACKER & BAKHUIZEN VAN DEN BRINK JR. (1968), *Pinanga kuhlii* Bl. is a synonym of *P. coronata* (Bl. *ex* Mart.) Bl. while *P. javana* Bl., an insufficiently known taxon, may also be conspecific with *P. coronata*.

Caryota rumphiana Mart. var. *philippinensis* Becc. ("Takipan")

Caryota rumphiana var. *philippinensis* is an endemic, caryotoid, monoecious, hapaxanthic palm species that thrives well on open level or sloping grounds. It bears lateral inflorescences that open from the top of the trunk downwards. For the genus *Caryota* in general, the flowering and fruiting processes continue from over 5 months to 2 years; thereafter, the whole plant dies (CORNER, 1966). The fruit of *C. rumphiana* var. *philippinensis* is globose, 14-18 mm diameter, light yellow when ripe and with thin soft pericarp and stony seed. The seed is prominently pointed at the basal end (Fig. 4A) and has ruminate endosperm (Fig. 4F).

The seedlings of *C. rumphiana* var. *philippinensis* are hypogeal to semi-hypogeal and cryptocotylar. Developmental stages of the seedlings are fairly similar to those of *P. insignis*. A cotyledonary stalk grows out from the globular nut down into the soil. Temporary roots arise from this stalk. As the stalk grows downwards, its apex turns upwards. At this point, the first permanent roots arise and grow downwards.

A leaf sheath from which the first foliage leaf emerges pushes through the apex of the cotyledonary stalk. The first foliage leaf is nearly simple, deep green, about 7–7.5 cm long and 5 cm wide, fan-like and sometimes splitting along the middle. One side of this first leaf is nearly triangular to wedge-shaped, with jagged tip (Fig. 4E).

Coffea arabica L. ("Kape" or Coffee)

Coffee is commonly planted by swidden cultivators in large clearings at the lower slopes (ca. 100–500 m altitude) of Mount Makiling. Its fruit is nearly ovoid to ellipsoid, 9–12 x 15–20 mm, fleshy, yellow-orange to dark red when ripe, moderately sweet. The fruit has 2 planoconvex, coriaceous, 1–seeded pyrenes. The seeds are concave or grooved ventrally (Fig. 5A, B).

The seedlings of *C. arabica* are epigeal and phanerocotylar. The radicle and hypocotyl emerge from one end of the seed. The hypocotyl gradually becomes erect, raising the entire seed above the ground. After a short resting period, the testa is shed off exposing the cotyledons which remain in this stage for about 7 weeks. The hypocotyl is slender, terete, ca. 3 cm long, green and glabrous. The two cotyledons are opposite, stipulate, shortly petiolate, foliaceous, glabrous and are persistent up to the first leaf stage. The lamina is orbicular with truncate base and broadly rounded apex and entire margin. The first two leaves are simple, opposite, shortly petiolate, herbaceous, glabrous, slightly reddish while young and becoming green with age. The lamina is obovate, with acute base, acuminate apex and entire margin. The taproot is slender, flexuous and moderately branched (Fig. 5).

Ficus minahassae (Teijsm. & de Vr.) Miq. ("Hagimit")

Ficus minahassae is a low-spreading to moderately tall tree (8–15 m) with characteristically long pendulous tubercles arising from its trunk and large branches (Fig. 1B). The figs that are borne on these tubercles are sessile, in round heads and turn red when fully ripe. The seeds are very minute. The plants bear flowers and fruits nearly throughout the year.

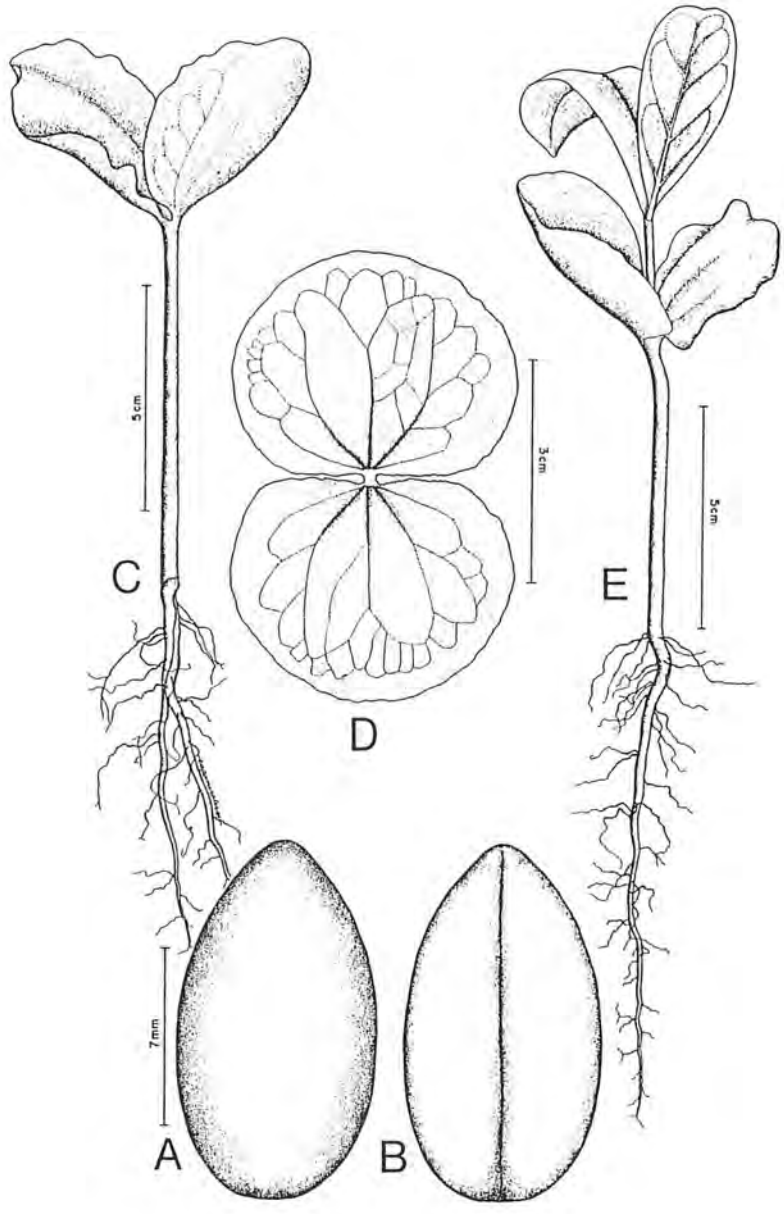

Figure 5. The seed, developmental stages and seedling morphology of *Coffea arabica* L. A.B. Seeds, lateral view; A, dorsal convex side; B, ventral grooved side. C. 70 days after sowing (d.a.s.). D. Leaf details of C, top view. E. 120 d.a.s. (All drawn from WM10917.)

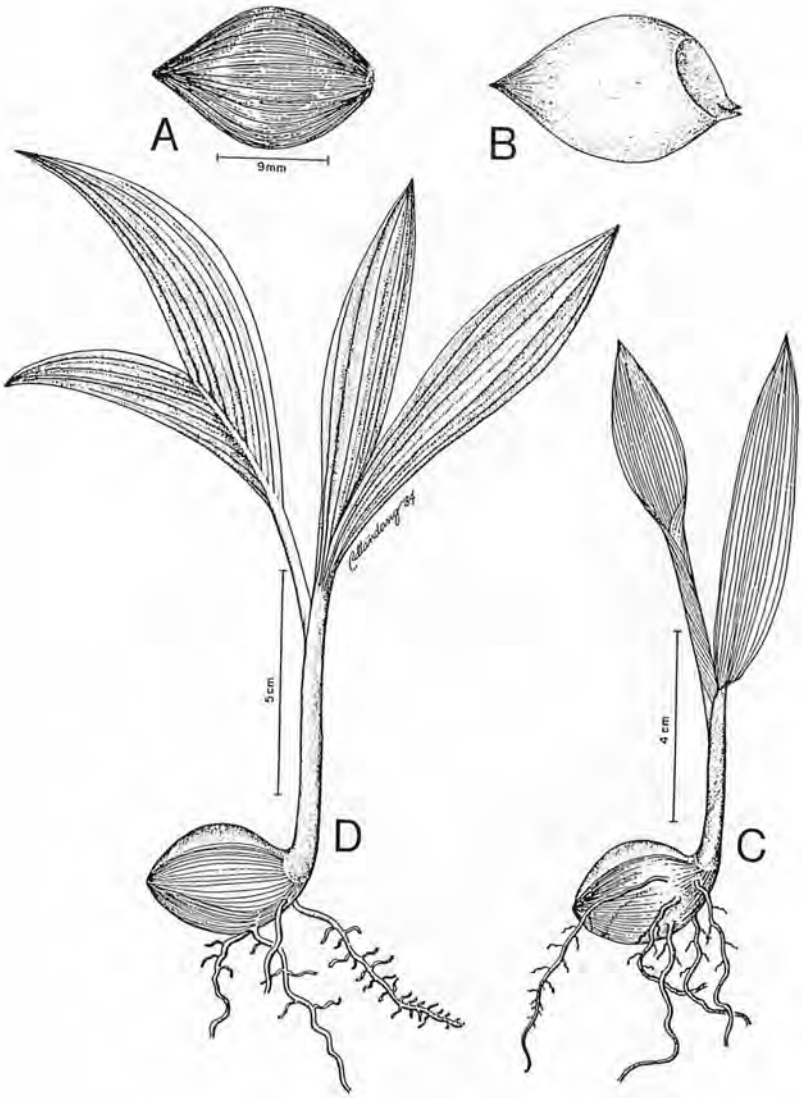

Figure 6. Seeds and seedlings of *Pinanga insignis* Bl. collected from the base of representative plant (see Fig. 2A) growing on Mount Makiling, Philippines. A. Seed with loose husk (mesocarp). B. Dehusked seed. C, D. Seedlings in two distinct developmental stages. (All drawn from WM10920.)

CONCLUSIONS

Uniform seed composition found in droppings of the Philippine palm civet (*Paradoxurus philippinensis* Jourdan) indicates that this nocturnal mammal has a habit of consuming in bulk amount fruits of a single species at one particular feeding time. The digestive action and attendant conditions of the alimentary canal of this palm civet on seeds of *Pinanga insignis* and *Caryota rumphiana* var. *philippinensis* significantly enhanced germination potential compared with untreated seeds. This, coupled with the inherently long and staggered break of dormancy of defecated large seeds, e.g. palm seednuts, insures a continuous supply of dispersed propagules for natural forest regeneration.

The Philippine palm civet, being a very skillful tree climber and highly mobile mammal, is a potentially very effective seed dispersal agent. It has also the habit of defecating in open sites such as natural gaps and man-made clearings in forests, lowland-cultivated areas and newly established human settlements. Seeds eaten by this vector mammal therefore may have a higher probability of germinating and surviving to maturity in such open areas. Seedlings from palm civet droppings thus probably contribute significantly to natural forest regeneration.

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