

A revision of *Canarium* L. (Burseraceae) in Madagascar

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ABSTRACT

Trees in the genus *Canarium* L. are known to comprise an important component of the structure of Madagascar's moist forests, but recent work on *Canarium* in Madagascar reveals that the genus also comprises an important part of their diversity as well. To date, published Floras for Madagascar have recognized only three taxa of *Canarium*, but here we recognize 33 species, 27 of them new to science; this increases the number of accepted species in the genus by 33% worldwide and establishes Madagascar as a primary center of diversity for the genus. Despite its name, *C. madagascariense* Engl. proves to be one of the rarest and geographically most restricted species. Most Malagasy *Canarium* species are narrow endemic, and this is consistent with recent floristic and taxonomic research in other taxonomic groups on the island. The species of *Canarium* in Madagascar can be distinguished using mostly vegetative characters, and this will prove useful to foresters, ecologists, and conservationists. Most moist forests in Madagascar include multiple species of *Canarium*, and one important avenue of future research will be to further investigate the interdependence of the species of *Canarium* and the frugivorous lemurs that eat the pericarp of their fruits and possibly disperse their seeds.

KEY WORDS

biodiversity,
conservation,
endemism,
lemurs,
new species.

RÉSUMÉ

Révision du genre *Canarium* L. (Burseraceae) de Madagascar.

On savait que les arbres du genre *Canarium* L. constituaient un élément important de la structure des forêts malgaches, mais des recherches récentes sur *Canarium* à Madagascar révèlent que le genre représente aussi une partie appréciable de sa diversité. Les traitements actuellement publiés sur la flore de Madagascar reconnaissent trois taxa de *Canarium*, mais nous caractérisons ici 33 espèces, dont 27 sont nouvelles pour la science. Cela augmente le nombre d'espèces acceptées pour ce genre de 33% et positionne Madagascar comme un centre primaire de la diversité du genre. Nous avons découvert que *C. madagascariense* Engl. est une des espèces les plus rares et géographiquement les plus restreintes. Sur la base de notre connaissance de la flore actuelle, la plupart des espèces de *Canarium* à Madagascar sont reconnues comme endémiques, à distribution restreinte, ce qui correspond aux recherches floristiques et taxonomiques récentes. Les espèces de *Canarium* en Madagascar peuvent être identifiées en utilisant leurs caractères végétatifs, utiles pour les forestiers, les écologistes et pour les personnes travaillant dans la conservation. La plupart des forêts humides de Madagascar contiennent plusieurs espèces de *Canarium*; l'étude approfondie de l'interdépendance des espèces de *Canarium* et des huit (ou plus) espèces de lémuriens qui mangent le péricarpe des fruits et les disséminent vraisemblablement, constitue une voie de recherche prometteuse.

MOTS CLÉS

biodiversité,
conservation,
endémisme,
lémuriens,
espèces nouvelles.

INTRODUCTION

Canarium L. is a genus of usually large dioecious trees distributed in the wet to less often semi-deciduous tropical forests of Africa and especially of Asia, which is likely home to c. 80% of the species (Leenhouts 1959; Daly pers. obs.). Recent field and herbarium work in Malaysia has led the first author to estimate that the genus comprises c. 150 species. It is an important component of Malesian forests; for example, on a 50-ha plot in Lambir Hills National Park in Sarawak, the genus is represented by at least ten species (Center for Tropical Forest Studies 1991; Daly, pers. obs. [in the SAR herbarium]). *Canarium* also occurs in S China, the Pacific, continental Africa, India, Australia, and New Guinea. It is the source of the Pili Nut (*Canarium ovatum* Engl.) of the Philippines, the Java Almond (*C. commune* L.), the commercial resin Manila Elemi (*C. luzonicum* (Bl.) A. Gray) and other elemis, the Chinese Olive (*C. album* Reanch.), and several moderately valuable timber species (Uphof 1968).

Madagascar's flora is long known to be highly diverse and astonishingly endemic, with some 84% of its vascular flora and 96% of its tree and shrub species unique to the island (Callmender *et al.* 2011; Schatz 2000, respectively); moreover, within the country, many groups of organisms show patterns of microendemism (Wilmé *et al.* 2006). Recent revisions of several taxonomic groups there, including palms and *Impatiens* (Gautier & Goodman 2003), have yielded quite a number of new species.

TAXONOMIC HISTORY OF *CANARIUM* IN THE CONTEXT OF MADAGASCAR

Engler (1883) recognized two sections and five series in *Canarium*. Engler's sections were based on the number of floral parts and adnation of the stamens, and the series were based

on the degree of filament connation, the relative position of the disk, and the consistency of the endocarp. He recognized three species in Madagascar, placing *C. boivinii* Engl. and *C. madagascariense* Engl. in Sect. *Eucanarium* Ser. *Crassipyrrena*, characterized by the stamens confluent on a short disk or inserted on the outside of a disk, the pyrene thickly woody or bony. He placed *C. multiflorum* Engl. in Ser. *Choriandra*, characterized by the filaments free and inserted around a disk, the drupe sometimes small and the pyrene very thick.

Lam (1932) rejected Engler's sections and series because he noted too many intermediate conditions in the reduction to haplostemony and in connation of the filaments. To him, stipules and pseudostipules (highly reduced basal pair of leaflets) presented the only satisfactory characters for subdividing the genus. He recognized 109 species worldwide, including two for Madagascar, *C. boivinii* and *C. multiflorum*.

Perrier de la Bâthie reviewed the Burseraceae for Madagascar and the Comoros in 1944 and essentially reproduced his handling in the *Flore de Madagascar et des Comores* treatment in 1946, recognizing three species: *C. madagascariense* Engl. (incl. *C. multiflorum*, *C. harami* Bojer ex Engl., and *C. greveanum* Engl., *nom. nud.*); *C. boivinii* Engl. (incl. *C. obtusifolium* Scott-Elliot); and *C. pulchrebracteatum* Guillaumin.

The last relatively comprehensive treatments of *Canarium* were those of Leenhouts, who published a revision of the genus for the Pacific region (Leenhouts 1955), and subsequently treated the family for *Flora Malesiana* (Leenhouts 1956); finally, he revised *Canarium* once more for that flora (Leenhouts 1959). In his 1959 treatment, Leenhouts provided a geographical overview of the genus and engaged in rather drastic lumping, recognizing only 75 species (plus some infraspecific taxa). In Madagascar he recognized only one species, *C. madagascariense*, with three subspecies: the type subspecies (incl. *C. multiflorum* and *C. liebertianum* Engl.), subsp. *bullatum* Leenh., and subsp. *obtusifolium* (Scott-Elliot) Leenh. (incl. *C. boivinii*). Leenhouts (1959) stated that subsp.

madagascariense occurs in Tanganyika and Mozambique and while we cannot rule out this possibility, we have encountered no herbarium specimens confirming his assertion, nor have we encountered any other Malagasy *Canarium* species represented on the African continent.

Ongoing revisionary work on *Canarium* elsewhere is likely to restore a number of species synonymized by Leenhouts. Similarly, based on recent herbarium visits and field work by the first author in SE Asia, we believe that botanical exploration in both the field and herbarium will add at least another 30 new species. *Canarium* amply exemplifies the crucial observation that much of the plant diversity that remains to be documented already resides in the world's herbaria (Bebber *et al.* 2010).

SPECIES DESCRIPTION AND DELIMITATION

Leenhouts (1956) lamented the fact that the herbarium material existing at the time was insufficient to adequately describe species morphology and variation, noting the particular challenge of working with dioecious species and the consequent need for fruiting material plus flowering material of both sexes. Unfortunately, the same frustration continues today, despite tremendous advances since the 1950s in documenting the tropical flora, including Madagascar.

In the current revision of *Canarium* for Madagascar, we had complete material available to us – fruiting, staminate-flowering, and pistillate-flowering specimens – for only five species. Of the remaining species, we had fruits plus flowering material of only one sex for ten species, only fruits for eleven species, and only flowering material of one sex for six species. Seven species are represented only by the type collection. In addition to the obvious challenge this situation presents for developing a satisfactory key to the species, it also means that additional collections are needed and that the species descriptions will have to be greatly revised once more material is available.

CANARIUM IN MADAGASCAR'S VEGETATION

Canarium is a significant component of the structure and (we now realize) diversity in Madagascar's estimated 5.5 million ha (Dufils 2003) of lowland humid forests. For example, *Canarium* has the highest frequency of collection compared to any other genus by the forest service in the national parks of Ranomafana and d'Andringitra (Ranarivelo & Kotozafy 2001). In one-hectare plots established in the Réserve Spéciale de Manongarivo, Burseraceae was identified as the family with the 6th highest density, while it was the 5th in diversity, without correcting the number of species (D'Amico & Gautier 2000). *Canarium* is one of the dominant genera in the Manongarivo Special Reserve, and in plots in the Réserve Naturelle Intégrale Lokobe the genus often comprises roughly 30% of the standing biomass (Birkinshaw, pers. comm.).

At the Réserve Naturelle Intégrale de Betampona, the authors observed that *Canarium* was more dominant in terms of relative density on slopes exposed to cyclones than on more protected slopes. At approx. 800 m elevation in Marojejy

National Park, Messmer *et al.* (2000) found higher densities on crests than on slopes.

In Madagascar, *Canarium* trees are most often known by the folk generic name *ramy* or variants thereof (*aramy*, *haramy*, etc.), often alone or with a limited number of folk specifics that vary according to locality and ethnic group but do not reflect taxonomic species diversity. *Canarium* species have a number of uses. The fruit pulp and seed can be edible (Styger *et al.* 1999). The resin has been used for caulking canoes and boats (Daly pers. obs.) and in the treatment of several medical ailments including urinary infections (Perrier de la Bâthie 1946), dental caries, rheumatism, and wounds; after heating, its vapor is inhaled to treat headaches and other pains (Brink 2008). The resin of *Canarium* is also smeared on sticks that are positioned in locations where birds are likely to alight; when resting on the stick, the birds' feet become stuck and the trapped animal can be captured (Tsiza 1989).

The trees also have important cultural value, as the resin is often volatilized during a spirit possession ceremony, a *tromba*, where it acts as an olfactory guide for the spirit so that it can find the host. Due to its cultural importance, *Canarium* can often be the last tree left standing at some logged sites (Ferdman pers. obs.).

According to the literature, the wood of Malagasy *Canarium* species is not durable, being susceptible to attacks by fungi and insects (including termites and borers), although it is resistant to salt water and the sapwood can be treated with preservatives. Though not heavily exported, it is used for numerous purposes in Madagascar, including *pirogues* (dugout canoes), boxes, crates, general construction, tool handles, matches, everyday furniture and internal parts of fine furniture, veneer, plywood, hardboard and particleboard. It is also considered suitable for joinery, interior trim, turnery, and sometimes for flooring and poles. The dry heartwood is used to make torches, and the softer wood is used for making charcoal (Brink 2008).

In light of these myriad uses and the often large size of the trees, the wood of *Canarium* is considered desirable and, despite its cultural importance, it is often among the first trees to be selectively logged at some other sites. In the Ifanadiana region, which includes Ranomafana National Park, *Canarium* is one of 8 genera for which logging concessions were granted, along with *Symphonia* L.f., *Weinmannia* L., *Sloanea* L., *Cryptocarya* R.Br., *Ocotea* Aubl., *Dalbergia* L.f. and *Chrysophyllum* L. (Arrigo-Nelson 2006).

CANARIUM, LEMURS, AND CONSERVATION IN MADAGASCAR

We believe that the increase from three to 33 recognized taxa of *Canarium* in Madagascar will have important implications for conservation and management planning. This new understanding of *Canarium* taxonomy adds a compelling diversity component to its great structural importance in the country's moist forests. It also reveals the necessity of re-examining the ranges and distributions of individual taxa, as available data suggest that many Malagasy *Canarium* are highly restricted local endemics, and many of these species are likely threatened.

What compounds the significance of the discovery of so many new species of *Canarium* in Madagascar is the fact that their fruits comprise an important food source for lemurs. A new understanding of *Canarium* diversity has broad-ranging impacts for our understanding of the feeding ecology of those frugivorous lemurs that consume *Canarium* fruits. In virtually all of the studies citing interactions between frugivorous lemurs and *Canarium* species, not only are virtually all of the *Canarium* species names wrong, the number of *Canarium* species involved is likely to be incorrect as well, so these studies would benefit from a reassessment of the number and names of the *Canarium* species involved.

Multiple species of lemurs are documented as eating *Canarium* fruits and acting as dispersal agents. Observed lemur seed dispersers include *Eulemur fulvus* (É. Geoffroy, 1817) subsp. *collaris* (Bollen *et al.* 2004) and *Varecia variegata* (Kerr, 1792) (Wright *et al.* 2011), but we have also heard anecdotal evidence for the consumption of *Canarium* fruits by additional lemur species. Moreover, *Canarium* has been used to signal the presence of the aye-aye (*Daubentonia madagascariensis* (Gmelin, 1788), a specialized *Canarium* seed predator (Sterling, pers. comm.). The frugivorous lemur species eat the mesocarp, which is highly nutritious. In a study of fruit dispersal in SE Madagascar, Bollen *et al.* (2004) found a species of *Canarium* to have the second largest and third heaviest fruit and the heaviest seed, and to be the second highest in protein and third highest in fat consumed by *E. fulvus collaris*.

Abundant data on feeding ecology have been accumulating at several sites for the critically endangered black-and-white ruffed lemur (*Varecia variegata*). This, the largest extant frugivorous lemur, is dependent on large fruiting trees, *Canarium* principal among them. At the Réserve Naturelle Intégrale de Betampona, *Canarium* fruits constituted an important component of the diet of *V. variegata* (Britt 2000). *Canarium* fruits also constituted a “top five” food resource for *V. variegata* at Mangevo in Ranomafana National Park six months of the year, with two distinct fruiting peaks, and elsewhere in Ranomafana, *Canarium* frequently scores as the single most fed-on resource seven months per year, with three peaks (Baden, unpubl. data).

Varecia variegata is absent from areas exhibiting even mild levels of habitat disturbance (White *et al.* 1995; Balko 1998; Balko & Underwood 2005), as evidenced at sites within Ranomafana National Park that have experienced logging operations. The area of Talatakely was intensively logged until the late-1980s, and *V. variegata* is only recently returning, more than 20 years later (Baden pers. obs.). Similarly, Vatoharanana was selectively logged, and it also has very low *V. variegata* population densities; only Valohoaka and Mangevo have remained unlogged, and they also have the highest *V. variegata* population densities of the four sites (White *et al.* 1995; Wright *et al.* 2012).

Conversely, *Canarium* species depend heavily on the lemurs that disperse their seeds. Studies of tropical forests have found that larger, bigger-seeded fruits are consumed by progressively fewer species of dispersers with gapes large enough to effectively swallow the large seeds; the species with the largest fruits depend on a few species of large-bodied mammals and birds that are highly vulnerable to hunting, fragmentation and

habitat loss (Corlett 1998). In Madagascar, large-seeded trees are more reliant on primate dispersal than in most tropical regions (Bollen *et al.* 2004). *Canarium* trees are highly dependent on large lemurs not only for effective dispersal away from the mother tree – Drew & Wright (1998) found that of 300 *Canarium* stones not dispersed away from below the mother tree, 90% were predated by insects – but also for germination (Ganzhorn *et al.* 1999; Birkinshaw & Colquhoun 2003). A recent study found that, of the four sympatric large-bodied, diurnal lemur species occurring at Mangevo in Ranomafana National Park, *V. variegata* alone was responsible for dispersing *Canarium* seeds, leading the authors to predict local changes in forest composition and structure should this taxon be eliminated by hunting, disease, and/or habitat disturbance (Wright *et al.* 2011).

Our empirical observations of *Canarium* strongly indicate the possibility of niche partitioning among congeners at any given locality. We have observed sympatry of *Canarium* at every collecting site (e.g., minimum nine species around Masoala, six around Analamazaotra, four each in Maroantsetra and around Fort Dauphin). The niche partitioning may involve elevation (e.g., distinct altitudinal zonation in Marojejy), phenology (displacement of flowering and fruiting seasons), aspect (e.g., exposure to cyclones), forest type, and fruit size, shape, and texture. Published results also suggest it would be worthwhile to investigate niche partitioning and co-dependence involving fruit-dispersing lemurs and multiple species of *Canarium*. Vasey (2000) observed seasonal shifts among forest sites in regards to lemur feeding ecology. Ganzhorn *et al.* (2003) noted that within a frugivorous lemur's home range, a minimum level of tree species diversity is required in order to sustain it year-round. Our new understanding of the diversity of *Canarium* in Madagascar, plus its known status as an important lemur food source, indicate that in some locations *Canarium* may account for a significant part of the needed tree diversity.

The heretofore undocumented diversity of *Canarium* means that frugivorous lemur feeding ecology is more complex than the literature implies. Many publications on lemur feeding ecology refer to the nearly year-round fruiting of a single species, usually identified as either *C. madagascariense* or *C. boivinii*, both of which, incidentally, are among the rarest and most geographically restricted species in Madagascar (e.g., Birkinshaw & Colquhoun 2003).

Understanding the interactions between *Canarium* species and frugivorous lemur species will hinge on a deeper understanding of Malagasy *Canarium* taxonomy, geography, and ecology. It will be important to determine for example whether the distinct peaks in feeding by *V. variegata* on *Canarium* fruits correspond to peaks in fruiting by distinct species of *Canarium*, and whether seasonal shifts by lemurs among forest sites correspond to fruiting peaks by distinct *Canarium* species in different altitudinal zones or other changes in habitat. Regardless of the nature of interactions between frugivorous lemurs and *Canarium* trees, clearly whatever compromises one of these groups of organisms will threaten both. Creating an environment for the preservation of their interactions is integral to the success of conservation endeavors.

Evidence of niche-partitioning by multiple species of *Canarium* via altitude, phenology, or fruit morphology, coupled with behavioral observation data of spatial or temporal shifts by *Varecia variegata* among *Canarium* trees, would provide strong evidence of dependence on a cohort of *Canarium* species. Demonstration of lemur-*Canarium* co-dependence involving multiple species of either or both would mean that efforts to protect *Varecia* and other frugivorous lemur species will have to consider not only forest cover, and not only the presence of *Canarium* and other fruit trees, but also the presence of multiple *Canarium* species implicated in the niche-partitioning at each site. Crucial applications of this strategy will be in conservation corridors, including those requiring reforestation, like the Andringitra-Ranomafana Corridor.

PHYLOGENY AND LINEAGES

A well-supported infrafamilial classification of the Burseraceae is only now approaching resolution, and not only the position but also the composition of the major clades, including *Canarium*, are yet to be resolved (e.g., Garugeae of Thulin *et al.* 2008, *Canarium* Alliance of Daly *et al.* 2011). An initial infrageneric molecular phylogeny of *Canarium* based on a sample of 16 species (Weeks 2009) highlighted the paucity of available DNA samples. Recent botanical exploration has been securing *Canarium* Alliance samples from Vietnam, Papua New Guinea, Peninsular Malaysia and Borneo for which the vouchers are being identified and the DNA samples are being prepared for inclusion in a larger molecular phylogeny.

A number of investigators have noted the strong affinities of the Malagasy biota with the Indo-austral-malesian floras far to the east despite Madagascar's close proximity to Africa and its increasing separation from the Indian subcontinent 165 MYA. A recent analysis of angiosperm genera endemic to Madagascar for which phylogenetic information was available showed that 26% of the genera have a sister lineage also from Madagascar, while 22% have sister lineages from Africa, 9.1% from Southeast Asia, and 6.2% from India (Buerki *et al.* 2013).

Asian connections are especially prevalent among eastern Madagascar humid forest taxa. Some researchers (see Schatz 1996) have proposed that these humid forest connections represent an ancient vicariance resulting in relictual (Cretaceous) Gondwanan disjunctions, as well as continual dispersal events across the Indian Ocean. Alternative scenarios, however, de-emphasize the importance of the Gondwanan break-up, citing evidence that many lineages arose too recently to have been impacted (Buerki *et al.* 2013). It is interesting to note that in his revision of *Canarium*, Leenhouts (1959) placed *C. madagascariense* in a group of species (the “*denticulatum* Group”) most of which are found in Indonesia, Borneo, Sri Lanka, or Mauritius, the only exceptions being *C. madagascariense* and *C. schweinfurthii* Engl., the latter being the only species of *Canarium* known from continental Africa. Federman *et al.* (2015) included 23 species of *Canarium* in a phylogenetic investigation of the Canarieae. They inferred Malagasy *Canarium* to be a clade of relatively recent origin (*c.* 8 million years) arriving from Southeast Asia, which is consistent with Leenhouts' (1959) taxonomic placement of the group.

SYSTEMATICS

Our examination of herbarium collections at the MO, NY, P, TAN, and TEF herbaria, coupled with field work by all three authors, revealed the presence of at least 33 species of *Canarium* on Madagascar. Of those 33 species valid names were available for six, while the remaining 27 are new to science. This increases the size of the genus, as currently treated, by 33% worldwide and establishes Madagascar as a primary center of *Canarium* diversity.

Family BURSERACEAE

Genus *Canarium* L.

Herbarium Amboinense: 10 (1754) (quoad *Cenarium*). — *Nanari* Adans., *Familles des Plantes* 2: 342 (1763). — *Pimela* Lour., *Flora Cochinchinensis*: 407 (1790). — *Canariopsis* Bl. ex Miq., *Flora Indiae Batavae* 1 (2): 651 (1859). — *Sonzaya* Marchand, 8: 64 (1867). — Type species: *Canarium indicum* L.

DESCRIPTION

Small to large, usually dioecious trees, rarely shrubby or scandent, buttresses often present; bark smooth, rough, scaly, or scalloped, often fissured, sometimes densely lenticellate; resin translucent, watery or sticky, drying white or dark brown or blackish. Leaves imparipinnate, evergreen, usually with a pair of linear to foliose stipules on petiole toward or at base, or less often on branch near petiole base; pseudostipules sometimes present; distal pulvinuli usually present on terminal and lateral petiolules; leaflets entire to serrate or dentate; costal secondary venation brochidodromous or eucamptodromous, tertiary veins usually mixed opposite-alternate percurrent. Inflorescences axillary or (pseudo-)terminal, structurally a panicle of cymes but sometimes pseudospicate, pseudo-racemose, or fasciculate. Flowers 3-parted, unisexual, rarely the plants monoecious; calyx and receptacle cupular to funnel-shaped; calyx synsepalous but variously divided, valvate, in fruit usually persistent and enlarged; petals distinct, valvate at apex but imbricate in middle, the apex inflexed-apiculate; stamens in two subequal or less often unequal series, rarely the antepetalous series obsolete (*C. pallidum*, sp. nov.), the filaments sometimes partly or mostly connate to form a staminal tube inserted at base of disk, sometimes on the disk near the base, or rarely on the rim; disk usually annular but variously shaped, sometimes pubescent, rarely adnate to a shallow hypanthium in male flowers; pistillode usually reduced, sometimes fused with disk to form an ovariodisk (the structure comprising the fused disk and pistillode, Lam 1931), rarely the disk, stamens and ovary on a short androgynophore; staminodes usually only slightly reduced but not producing pollen; ovary 3-locular; style short; stigma subcapitate or 3-lobed, or 3 separate sessile stigmas. *Fruit* an indehiscent compound drupe, (ob)ovoid to ellipsoid, oblong, (sub-)globose, or fusiform, often slightly trigonous, rarely slightly oblique;

exocarp thin; mesocarp fleshy, oily-resinous, usually thick; pyrene bony, smooth to rugose, rarely slightly 3-winged. Seeds 1-2 (3) per fruit, other locule(s) abortive; cotyledons 3± palmatifid. Germination via opercula (these as many as developed locules), hypogeal and phanerocotylar; first eophylls opposite or alternate and simple, margin usually toothed.

NOTES ON MORPHOLOGICAL CHARACTERS

We emphasized leaf characters for several reasons. First, as noted above, they are the only organs for which we had material for every species. Second, leaf characters can be used in the field regardless of a tree's phenological status, and not just by botanists but also by foresters, conservation workers, ecologists, and others.

As Lam (1932) and Leenhouts (1956) realized, the stipules are taxonomically useful and usually present on specimens; we used distance from the petiole insertion, size and shape and pubescence of the stipules, and length of the stipular scar. Pseudostipules do not occur in the Malagasy species. Each species has a limited range in the number of leaflet pairs; the usefulness of this character is somewhat compromised by the paucity of specimens (additional specimens may change the range slightly) and by the fact that there is overlap in that number among species; still, it was essential to the construction of the key even though several species appear more than once in the key as a result.

Indumentum is often very useful taxonomically in the Burseraceae (e.g., Daly & Fine 2011), and often one is obliged to depend heavily on it to distinguish sterile individuals or specimens. In addition to trichome type (including glandular hairs), length, thickness, and color, one very important character is orientation (erect, ascending, descending, appressed and, very common in Canarieae, retrorse), as is shape (straight vs flexuous).

Petiole length, leaflet size and shape, and vein prominence speak for themselves, but we also emphasized leaf venation patterns because the character states are diverse in Malagasy *Canarium* and because a recently published manual of leaf architecture has helped to codify them for broader use (Ellis *et al.* 2009). It is our intention that once we have a firmer understanding of species distributions, we will construct site-specific keys and field guides based on sterile characters that distinguish the 4-8 congeners at each site. Such keys will be a great aid to both foresters and research scientists who may be conducting surveys at times when trees are neither flowering nor fruiting.

The strong sexual dimorphism of *Canarium* extends to inflorescence length, branching, stoutness, and bracts, so the gender of a tree or specimen must be considered before using a key or making comparisons. Inflorescence bracts and bracteoles can be very useful taxonomically, but they can differ greatly in size and shape on a given inflorescence, so one must be certain of what is being examined. Pedicels can be useful but often vary considerably even on a single inflorescence, so the range in length must be considered.

Sexual dimorphism on the flowers is more pronounced in *Canarium* than in any other genus of Burseraceae. Flower size is the most obvious difference, but usually the two genders also differ dramatically in calyx shape, perianth thickness, and often the proportion of the flower represented by the exposed part of the corolla, in addition to gender differences in the androecium and gynoecium that are found elsewhere in the family.

In Malagasy *Canarium*, the petals may be cream-colored, yellow, pink or red. In staminate flowers, the stamens can be inserted at the base of an (always intrastaminal) annular disk, or more often they are inserted on the outside or at the base of an ovariodisk that is often irregular in shape and whose apex is usually jagged in Malagasy species. The anthers can be pubescent. In pistillate flowers, the receptacle may be flat or more often concave; when flat the staminodes may be inserted on the rim or at the outside base of an annular disk, and when concave they can be inserted on the rim of the hypanthium, with the disk not visible, or less often outside an annular disk on the hypanthium rim.

The fruits of *Canarium* in Madagascar vary considerably in their size, shape, pubescence, and surface texture, the latter including the size, shape, and density of lenticels when present. Cross-sections of the fruits may reveal differences among species, as Lam (1931, 1932) found among the Asian species. However, this is impractical for field identification as a saw is required to cut through the woody endocarp. The opercula in the endocarp, part of a specialized mechanism for germination (Hill 1933), can vary in shape and size across species, but as yet we do not have enough material with mature fruits to use them as a taxonomic character.

Seedlings contain a wealth of characters that have been useful in other Burseraceae genera (e.g., Espinosa *et al.* 2006). The *Canarium* seedlings observed or collected in Madagascar to date all have the first eophylls opposite, but they may have the margin entire or serrate and glabrous or ciliate, and the venation patterns differ as on mature leaflets.

Bark and trunk characters are in many instances extremely useful for distinguishing *Canarium* species, but better sampling and more thorough descriptions (and images) are needed before we can use them in a comprehensive system. As examples, the outer bark of *C. galokense*, sp. nov. (Daly *et al.* 13100) is gray, thin, finely fissured, close (not shed in plates), and sparsely lenticellate with sepia inner bark; that of *C. multiflorum* (Daly *et al.* 13093) is gray, thick, rough, lenticellate, and shed in large, elongate, irregularly shaped plates with whitish inner bark; and that of *C. longistipulatum*, sp. nov. (Daly *et al.* 12958, 13010) is gray or brown, thick, sparsely but deeply fissured, scalloped, with some hoop marks and sparse raised lenticels, shed in large irregular plates to 60 cm long, and the inner bark reddish tan to deep blood-red. *Canarium longistipulatum*, sp. nov. (Daly *et al.* 12958) is one of several species that have tall, branched plank buttresses extending far from the trunk, while *C. multiflorum* can have an essentially cylindrical trunk.

KEY TO THE SPECIES OF *CANARIUM* L. IN MADAGASCAR

The following key employs primarily vegetative characters, and in fact reproductive characters are used only to supplement some of the couplets. Given the still sadly inadequate sampling of the Madagascar flora, the majority of the species of *Canarium* there are represented in herbaria by only flowers or only fruits, and virtually none are represented by flowers of both genders plus fruits, therefore emphasizing reproductive characters would quickly strand the user in most instances. Several species appear more than once in the key, in most instances because of overlap among species in the minimum and maximum number of leaflet pairs. The text of this key will form the basis for an illustrated interactive key once more of the species can be photo-documented.

1. Lateral leaflet base acute to truncate, sometimes some leaflets with cordate base 2
— Lateral leaflet base cordate, with rare exceptions on some leaflets 35
2. Leaflets in 5-8 pairs (some species rarely also with a few 3-4-jugate leaves) 3
— Leaflets in 1-4 pairs 14
3. Leaflets in 6-8 pairs 4
— Leaflets in 3-5 pairs (some species rarely also with a few 6-jugate leaves) 7
4. Stipules oblong-ovate to oblong-orbicular, 7-17 mm long, inserted at base of petiole or up to 2 mm from base; lateral leaflets ovate *C. madagascariense* Engl.
— Stipules (only the stipular scar known for *C. ampasindavae*, sp. nov.) cruciform to orbicular or obovate, 3-9 mm long, inserted 4-23 (35) mm from petiole base; lateral leaflets oblong to oblong-elliptic or oblong-(ob)ovate, less often elliptic or ovate 5
5. Leaflet apex gradually and narrowly long-acuminate; leaflet venation on adaxial side narrowly prominulous; fruit ovoid *C. ampasindavae* Daly, Raharim. & Federman, sp. nov.
— Leaflet apex abruptly and broadly short-acuminate or rounded to slightly emarginate; secondary veins on adaxial side broadly prominulous to flat or impressed; fruit oblong to oblong-ovoid or ellipsoid 6
6. Stipules somewhat coriaceous, provided with dense, ascending to appressed, fine, ferrugineous hairs to 0.2 mm; leaflets usually glossy (sometimes dull adaxially); secondary veins regularly spaced, essentially straight, the angle usually almost perpendicular and increasing toward the base *C. boivinii* Engl.
— Stipules fleshy (especially on fruiting specimens), provided with sparse to scattered (rarely dense), erect, thick, often whitish hairs 0.1-0.2 mm long; leaflets dull; secondary veins somewhat irregularly spaced, slightly curved, the angle acute and increasing toward apex and decreasing toward base *C. planifolium* Daly, Raharim. & Federman, sp. nov.
7. On lateral leaflets, secondary vein angle decreasing toward base 8
— On lateral leaflets, secondary vein angle increasing or uniform toward base 9
8. Petiole 4-9 cm long; stipules 18-20 mm from petiole base; leaflet apex tip eglandular; lateral leaflet base symmetric, cuneate to rounded; secondary veins in 5-9 pairs; staminate inflorescences c. 34 cm long *C. laxiflorum* Daly, Raharim. & Federman, sp. nov.
— Petiole 3-5 cm long; stipules 2-6 (8) mm from petiole base; leaflet apex tip glandular; lateral leaflet base often asymmetric, the acroscopic side truncate to obtuse, basicopic side obtuse, rarely acute or slightly cordate; secondary veins in (8) 9-14 pairs; staminate inflorescences 15-18 cm long *C. planifolium* Daly, Raharim. & Federman, sp. nov.
9. Lateral petiolules not canaliculate; leaflet tertiary venation alternate-percurrent or irregular-reticulate; fruit ovoid, obovoid, broadly oblong, or oblong-ellipsoid, green turning brown or gray, the surface lenticellate and usually pubescent 10
— Lateral petiolules canaliculate; leaflet tertiary venation consistently irregular-reticulate (sometimes alternate-percurrent in *C. betamponae*, sp. nov.); fruit globose to (ob)ovoid, green to glaucous or turquoise, the surface smooth and glabrous 13
10. Terminal leaflet elliptic; leaflet apex gradually acuminate, the apex tip glandular; leaflet abaxial surface glabrous or with only a few scattered hairs on the midvein 11
— Terminal leaflet obovate or less often broadly elliptic or ovate; leaflet apex rounded or abruptly acuminate, the apex tip eglandular; leaflet abaxial surface usually pubescent 12
11. Petiole 2.5-4.5 cm long; basal petiolules 3-6 mm long; petiole and rachis with dense to scattered hairs to 0.5 mm long, fruit ovoid and coarsely lenticellate *C. subsidarium* Daly, Raharim. & Federman, sp. nov.

- Petiole 3.5-7.5 cm long; basal petiolules 10-15 mm long; petiole and rachis with scattered to sparse hairs to 0.25 mm long; fruit broadly oblong or broadly ovoid and finely lenticellate *C. galokense* Daly, Raharim. & Federman, sp. nov.
- 12. Stipules 5-6 mm long, the scar 3-5 mm long, petiole and rachis with sparse to scattered erect ferrugineous hairs to 0.05 mm long, lateral leaflets most often ovate, leaflet base cordate or less often truncate, very rarely acute, the apex rounded to abruptly and broadly short-acuminate, the acumen 2-6 mm long, on abaxial surface the midvein with sparse to scattered erect ferrugineous hairs to 0.05 mm long, also flexuous ferrugineous hairs to 0.2 mm, leaflets coriaceous *C. scholasticum* Daly, Raharim. & Federman, sp. nov.
- Stipules 3-4(8) mm long, the scar 1-3 mm long, petiole and rachis usually with dense ascending golden hairs to 0.5 mm (and other hair types), lateral leaflets most often lanceolate, leaflet base acute to rounded to truncate, the apex usually abruptly and narrowly sharp-acuminate, the acumen (2) 5-12 mm long, on abaxial surface the midvein with dense erect golden hairs to 0.45 mm, leaflets chartaceous *C. ferrugineum* Daly, Raharim. & Federman, sp. nov.
- 13. Leaflet secondary veins nearly straight and sub-perpendicular to midvein, spacing usually uniform, concolorous on adaxial side; inflorescence axes pubescent; calyx lobes not distinct in fruit *C. globosum* Daly, Raharim. & Federman, sp. nov.
- Leaflet secondary veins spreading, spacing increasing toward apex and base, discolorous on adaxial side; inflorescence axes subglabrous; calyx lobes distinct in fruit *C. betamponae* Daly, Raharim. & Federman, sp. nov.
- 14. All leaflets obovate or some laterals (oblong-)obovate (rarely oblong), the apex consistently rounded *C. obovatum* Daly, Raharim. & Federman, sp. nov.
- At least some leaflets shaped otherwise 15
- 15. Leaflets markedly revolute and convex (fresh or dry), when pressed and dried usually splitting (in *C. nitidifolium*, sp. nov. leaflets can be convex but abaxial surface usually with whitish cast and fruit smooth and glabrous) 16
- Leaflet not markedly revolute nor convex 17
- 16. Petiole, rachis and adaxial leaflet surface manifestly pubescent; fruit 2.8-3.5 × 1.5-2.3 cm *C. findens* Daly, Raharim. & Federman, sp. nov.
- Petiole, rachis and adaxial leaflet surface not visibly pubescent; fruit 3.5-5 × 2-3.5 cm *C. obtusifolium* Scott-Elliot
- 17. On abaxial leaflet surface, midvein and secondaries with dense to sparse hairs and either papillate or waxy-white; margin often with long flexuous hairs; fruit surface smooth and glabrous 18
- On abaxial leaflet surface, midvein and secondaries (when pubescent) with scattered to sparse hairs (dense on *C. ferrugineum*, sp. nov.), not papillate or waxy; margin glabrous; fruit lenticellate and pubescent or smooth and glabrous 19
- 18. Petiole and rachis with dense, fine, flexuous hairs to 0.15 mm long; lateral leaflet base rounded to acute; secondary veins usually spreading and the angle decreasing toward the base; older leaflets drying flat; on abaxial side the midvein and secondaries with sparse to dense stiff, relatively fine erect hairs to 0.25 mm long, the surface brown; margin with scattered long flexuous hairs or glabrous *C. pulchrebracteatum* Guillaumin
- Petiole and rachis with sparse to scattered flexuous ferrugineous hairs to 0.3 mm long, also fine erect to ascending hairs to 0.2 mm long; lateral leaflet base cordate to truncate; secondary veins usually spreading and the angle increasing toward the base; older leaflets often drying convex, the margin somewhat revolute; on abaxial side the veins with dense flexuous hairs to 0.3 mm long, the surface usually with whitish cast; margin near base with dense to scattered flexuous hairs to 0.35 mm long *C. nitidifolium* Daly, Raharim. & Federman, sp. nov.
- 19. Lateral leaflet base consistently acute 20
- Lateral leaflet base obtuse to truncate, less often acute or cordate on some leaflets (base can be predominantly acute in *C. arcuatum*, sp. nov. but secondary veins in 4-7 (vs 6-12) pairs and strongly arcuate (vs spreading or straight) 23
- 20. Lateral petiolules 1.8-2 mm long *C. pallidum* Daly, Raharim. & Federman, sp. nov.
- Lateral petiolules 2.5-17 mm long 21
- 21. Leaflets glossy at least on abaxial side; leaflet venation on abaxial side broad and flat; fruit 2-2.8 × 1.9-2.4 cm, globose to slightly (ob)ovoid, the surface smooth and glossy *C. subtilis* Daly, Raharim. & Federman, sp. nov.

- Leaflets dull; leaflet secondary venation on abaxial side prominulous (sunk in a groove in *C. elegans*, sp. nov.); fruit 2.8-3.8 × 1.8-2.6 cm, variously shaped but not globose, the surface dull, rough, lenticellate 22
- 22. Terminal leaflet elliptic; secondary vein angle acute and uniform; adaxial surface scattered black-punctate; fruit 2.8-2.9 × 1.8-2.1 cm *C. manongarivum* Daly, Raharim. & Federman, sp. nov.
- Terminal leaflet obovate or less often elliptic; secondary vein angle usually slightly increasing toward apex and decreasing toward base; adaxial surface not punctate; fruit 3.2-5.2 × 2.2-2.6 cm *C. elegans* Daly, Raharim. & Federman, sp. nov.
- 23. Stipules *c.* 2 mm long, stipular scar 1-1.5 mm long *C. indistinctum* Daly, Raharim. & Federman, sp. nov.
- Stipules 3-10 mm long, stipular scar usually longer (0.5-1.5 mm in *C. obtusifolium*) 24
- 24. Leaf 21-74 cm long; petiole and rachis usually with dense ascending golden hairs to 0.5 mm (and other hair types), leaflet secondary vein angle slightly increasing at base; on abaxial leaflet surface the midvein with dense erect golden hairs to 0.45 mm *C. ferrugineum* Daly, Raharim. & Federman, sp. nov.
- Leaf 7-41 cm long; petiole and rachis without long hairs; leaflet secondary vein angle uniform or irregular or decreasing toward apex; abaxial leaflet surface without long erect hairs 25
- 25. Leaflet secondary veins in 13-15 pairs *C. angulatum* Daly, Raharim. & Federman, sp. nov.
- Leaflet secondary veins in 4-12 pairs (*C. scholasticum*, sp. nov. with 8-13 pairs but stipules 5-13 mm from petiole base (vs 2-3 mm) and leaflets coriaceous (vs chartaceous) 26
- 26. Leaflet secondary veins strongly arcuate *C. arcuatum* Daly, Raharim. & Federman, sp. nov.
- Leaflet secondary veins straight to spreading (slightly arcuate to spreading in *C. lamianum*, sp. nov. and *C. scholasticum*, sp. nov., but the former with the angle acute to subperpendicular, increasing toward apex and decreasing toward base [vs acute and uniform], and *C. scholasticum*, sp. nov. with 8-13 pairs [vs 4-7]) 27
- 27. On lateral leaflets the secondary vein angle consistently decreasing toward base, on abaxial side the veins pale-discolorous when dry; staminate inflorescences *c.* 34 cm long, longer than the subtending leaves *C. laxiflorum* Daly, Raharim. & Federman, sp. nov.
- On lateral leaflets the secondary vein angle decreasing or increasing toward base or less often uniform, on abaxial side the veins not pale-discolorous when dry; staminate inflorescences 5-30 cm long, usually shorter than the subtending leaves 28
- 28. Most leaflets with cordate base; leaflets sometimes splitting along midvein when pressed and dried; on abaxial side the secondary veins obtusely prominent but usually sunk in a groove when dry *C. scholasticum* Daly, Raharim. & Federman, sp. nov.
- Most leaflets without cordate base; leaflets not usually splitting along midvein when pressed and dried; on abaxial side the secondary veins not sunk in a groove when dry 29
- 29. Stipules usually caducous; leaf rachis with dense to scattered erect hairs to 0.5 mm long; leaflets drying gray-green, on adaxial side the venation pale-discolorous *C. subsidarium* Daly, Raharim. & Federman, sp. nov.
- Stipules usually persistent; leaf rachis without long straight hairs; leaflet drying (dark) brown 30
- 30. Petiole (5) 7-11 cm long; secondary vein spacing irregular; dry forest *C. moramangae* Daly, Raharim. & Federman, sp. nov.
- Petiole 2.5-7.5 cm long (to 9 cm in *C. globosum*, sp. nov. but fruit glossy and smooth); secondary vein spacing uniform or decreasing toward apex (and sometimes base)(sometimes irregular in *C. lamianum*, sp. nov.); moist forest (*C. globosum*, sp. nov. sometimes in dry forest) 31
- 31. Leaflets dull; on adaxial side the higher-order venation and often secondary veins flat and indistinct; fruits dull, lenticellate; lowland or montane forests 5-1500 m elevation 32
- Leaflets glossy; on adaxial side the venation narrowly prominulous; fruits glossy, smooth; lowland forests 0-600 m elevation 34
- 32. Terminal leaflet elliptic; stipules 7-10 mm long, the scar 2-4 mm long; inflorescence bracts mostly caducous; fruit 2.5-3 cm diam, very broadly oblong *C. galokense* Daly, Raharim. & Federman, sp. nov.
- Terminal leaflet usually obovate; stipules 3-7 mm long, the scar 0.5-2 mm long; often some inflorescence bracts persistent; fruit 1.5-2.6 cm diam, (ob)ovoid to oblong-ellipsoid 33
- 33. Leaflet apex rounded to obtuse, rarely very broadly short-acuminate, the acumen 0 (2) mm long; leaflet margin often slightly revolute (at least when dry); leaflets usually drying light brown; secondary veins usually (sub)perpendicular to midvein but sometimes somewhat acute, the course usually straight but wavy; staminate flowers 5-5.5 (6.9) mm long overall, the calyx lobes 0.4-0.8 (1) mm long; fruit apex usually obtuse to truncate-obtuse, rarely slightly acute *C. obtusifolium*

- Leaflet apex abruptly and broadly short-acuminate, the acumen 2-7 (11) mm long, rarely some leaflets with rounded apex; leaflet margin flat; leaflets usually drying dark grayish brown; secondary vein angle irregular, usually acute, the course slightly arcuate and not wavy; staminate flowers (5.4) 6.8-8.6 (9.5) mm long overall, the calyx lobes 1.2-2 (3) mm long; fruit apex usually acute but sometimes rounded *C. lamianum* Daly, Raharim. & Federman, sp. nov.
- 34. Leaflet acumen 0-2(4) mm long; secondary veins nearly straight and sub-perpendicular to midvein, spacing usually uniform; inflorescence axes pubescent; calyx lobes not distinct in fruit *C. globosum* Daly, Raharim. & Federman, sp. nov.
- Leaflet acumen 2-7 mm long; secondary veins spreading, spacing increasing toward apex and base; inflorescence axes subglabrous; calyx lobes distinct in fruit *C. betamponae* Daly, Raharim. & Federman, sp. nov.
- 35. Leaves 7-10-jugate 36
- Leaves 3-6-jugate (rarely 7-jugate on *C. multiflorum*) 39
- 36. Stipular scar 6-14 mm from petiole base; leaflet acumen 12-27 mm long *C. compressum* Daly, Raharim. & Federman, sp. nov.
- Stipular scar 0-5 mm from petiole base; leaflet acumen 4-17 mm long 37
- 37. Petiole and rachis subglabrous or provided only with scattered erect golden hairs to 0.4 mm long; terminal leaflet (oblong)-elliptic to lanceolate *C. madagascariense*
- Petiole and rachis provided at least with dense flexuous hairs 0.2-0.9 mm long; terminal leaflet ovate to broadly elliptic 38
- 38. Petiole provided with dense flexuous ferrugineous hairs to 0.9 mm long; lateral leaflet base usually oblique; secondary vein angle (sub)perpendicular; few if any perpendicular epimedial tertiaries, intercostal tertiaries with some admedial branching toward axil of secondaries; abaxial leaflet surface with scattered thick appressed to ascending hairs to 0.15 mm long; on adaxial leaflet surface the midvein with scattered hairs *C. multinervis* Daly, Raharim. & Federman, sp. nov.
- Petiole provided with dense flexuous hairs to 0.2 mm long, sometimes also with dense straight hairs to 0.7 mm long; lateral leaflet base usually subsymmetric; secondary vein angle slightly acute but increasing toward base; perpendicular epimedial tertiaries present, no admedial branching apparent; abaxial leaflet surface glabrous (except sometimes midvein pubescent); adaxial leaflet surface glabrous *C. egregium* Daly, Raharim. & Federman, sp. nov.
- 39. Leaflet abaxial surface velvety, with dense fine, ascending, pale golden hairs (reddish on midvein) to 0.5 mm long; also dense, thick, ascending pale golden hairs to 0.1 mm long; fruit 5.5-5.9 cm long when dry..... *C. velutinifolium* Daly, Raharim. & Federman, sp. nov.
- Leaflet abaxial pubescence sparse to scattered or the surface glabrous; fruit 2.5-5.5 cm long when dry 40
- 40. On leaflet abaxial surface, axils of secondary veins with tufts of dense erect to ascending, ferrugineous hairs to 0.7 mm long *C. multiflorum* Engl.
- Leaflet abaxial surface without such tufts of hairs 41
- 41. Stipules 4-5 mm long; adaxial leaflet surface usually bullate (rarely not), on abaxial surface the veinlets and veins forming concavities *C. bullatum* (Leenh.) Daly, Raharim. & Federman, comb. et stat. nov.
- Stipules 4-13 mm long (if shorter, the stipules [ob]ovate to subulate [vs orbicular in *C. bullatum*, comb. et stat. nov.]); abaxial leaflet surface not bullate, on adaxial surface the veinlets and veins not forming concavities 42
- 42. Stipules inserted at base of petiole, leaflets drying dark brown *C. multinervis* Daly, Raharim. & Federman, sp. nov.
- Stipules inserted 2-22 mm from petiole base, leaflets drying various shades of brown 43
- 43. Leaflet acumen 10-30 mm long (rarely shorter in *C. longistipulatum*, sp. nov.), secondary veins consistently (sub)perpendicular to midvein, leaflets drying dark brown 44
- Leaflet acumen 2-6 (10) mm long (rarely longer in *C. egregium*, sp. nov.), secondary veins not consistently (sub)perpendicular to midvein, leaflets drying various shades of brown 45
- 44. Stipules orbicular; leaflet acumen somewhat broadly acuminate; secondary vein angle increasing toward the base only; inflorescence axes compressed and mostly glabrescent; fruit surface with dense descending to retrorse-appressed, white hairs, often dense among the lenticels *C. compressum* Daly, Raharim. & Federman, sp. nov.

- Stipules obovate to subulate; leaflet acumen more narrowly acuminate; secondary vein angle increasing toward apex and base; inflorescence axes not compressed, provided with dense, flexuous or ascending, ferrugineous hairs; fruit surface with only a few retrorse-appressed white hairs at base *C. longistipulatum* Daly, Raharim. & Federman, sp. nov.
- 45. Leaflets in 6-8 pairs; stipules 8-11 mm long; leaflet apex gradually acuminate to acute and the margin usually slightly revolute; inflorescence axes with dense dark brown hairs to 0.6 mm long *C. egregium* Daly, Raharim. & Federman, sp. nov.
- Leaflets in 4-6 pairs; stipules 5-8 mm long; leaflet apex abruptly acuminate and the margin usually flat; inflorescence axes with dense ferrugineous hairs to 0.3 mm long 46
- 46. Stipules broadly obovate to suborbicular; fruit ellipsoid or less often slightly obovoid, trigonous, lenticels on surface flat *C. pilicarpum* Daly, Raharim. & Federman, sp. nov.
- Stipules ovate; fruit ovoid to broadly oblong-ellipsoid to slightly obovoid, sometimes slightly angular, rarely broadly ovoid, lenticels on surface larger and raised *C. scholasticum* Daly, Raharim. & Federman, sp. nov.

Canarium ampasindavae

Daly, Raharim. & Federman, sp. nov.

(Figs 1; 2)

Small tree, leaves c. 7-jugate, fruits brown, lenticellate and pubescent; distinguished from C. boivinii Engl. by the leaflet apex gradually and narrowly long-acuminate (vs abruptly and broadly short-acuminate or rounded to slightly emarginate in C. boivinii) and the fruit narrowly ovoid (vs oblong to ellipsoid).

TYPUS. — **Madagascar.** Antsiranana (Diego-Suarez), Ampasindava Peninsula, Bongomirahavavy Forest, 210 m, 13°45'51"S, 48°4'19"E, 6.XII.2008, A. J. Tabinarivony, M. Y. Ammann & M. C. Madiomanana TAJ 179 (holo-, NY!; iso-, G, K, MO, P!, TEF, WAG).

DISTRIBUTION AND ECOLOGY. — To date, *Canarium ampasindavae*, sp. nov. is known only from the type collection from the Sambirano region, in the Bongomirahavavy Mountains, where there are areas of subhumid forest within the relatively dry northwestern part of the country. It is a relatively small tree found in evergreen forest on high hills. Fruiting in December.

DESCRIPTION

Trees, reproductive size 15 m × 40 cm diam. Buttresses present. Leaves c. 47.4 cm long, c. 7-jugate; petiole 10.4-13.5 cm long, petiole and rachis with sparse to scattered fine erect bristles to 0.05 mm long, glabrescent; stipules caducous, 8-15 mm from petiole insertion, scar 3.5-4 mm long; basal petiolules c. 16 mm long, the other laterals 10-16 mm long, terminal one c. 31 mm long, not canaliculate, lateral pulvinuli evident; basal leaflets 7.5-9.5 × 3.3-3.9 cm, (oblong-)ovate, other laterals 9.7-14.3 × 4.2-4.4 cm, oblong-lanceolate to ovate, terminal leaflet c. 12.4 × 4.9 cm, elliptic; leaflet apex narrowly long-acuminate, the acumen 9-17 mm long; lateral leaflet base asymmetrical, acroscopic side truncate to slightly cordate, the basiscopic side obtuse; margin revolute, especially at base; leaflets coriaceous, drying brownish green below, grayish green above; secondary venation framework weakly festooned-brochidodromous; secondaries in 10-13 pairs, insertion on midvein decurrent, secondary veins nearly straight, angle subperpendicular, increasing toward base, spacing irregular; usually 1 perpendicular epimedial tertiary per pair of secondaries, sometimes basiflexed; intercostal tertiaries mixed alternate-percurrent and irregular-reticulate, some admedial branching; on abaxial side all venation prominent, on adaxial side the midvein prominulous but sunk in a groove,

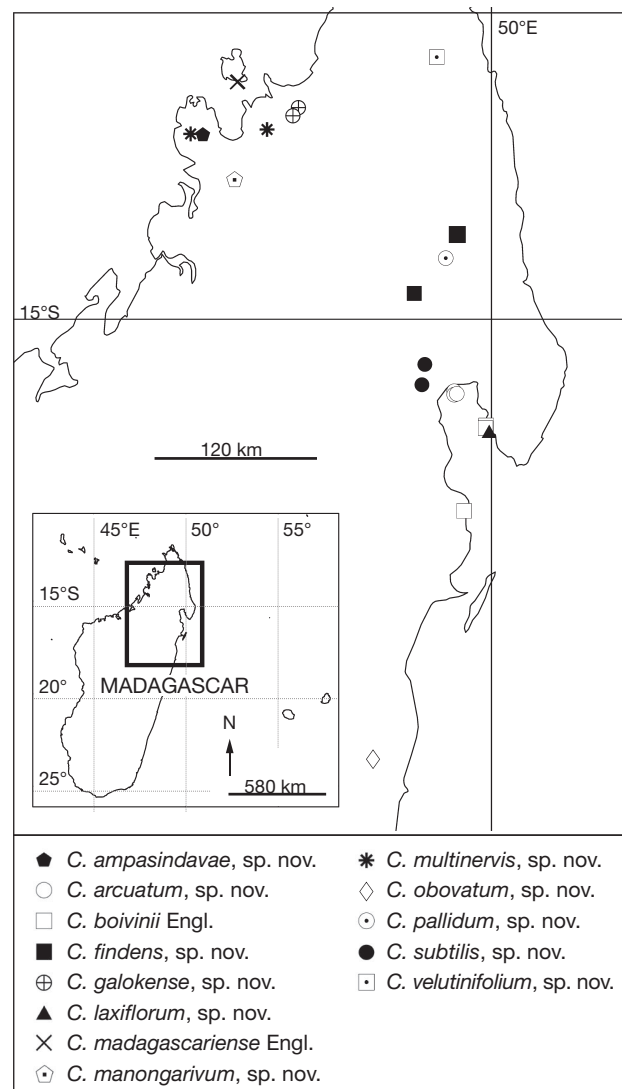


FIG. 1. — Distributions of *Canarium ampasindavae* Daly, Raharim. & Federman, sp. nov., *C. arcuatum* Daly, Raharim. & Federman, sp. nov., *C. boivinii* Engl., *C. findens* Daly, Raharim. & Federman, sp. nov., *C. galokense* Daly, Raharim. & Federman, sp. nov., *C. laxiflorum* Daly, Raharim. & Federman, sp. nov., *C. madagascariense* Engl., *C. manongarivum* Daly, Raharim. & Federman, sp. nov., *C. multinervis* Daly, Raharim. & Federman, sp. nov., *C. obovatum* Daly, Raharim. & Federman, sp. nov., *C. pallidum* Daly, Raharim. & Federman, sp. nov., *C. subtilis* Daly, Raharim. & Federman, sp. nov., and *C. velutinifolium* Daly, Raharim. & Federman, sp. nov.



FIG. 2. — *Canarium ampasindavae* Daly, Raharim. & Federman, sp. nov.: **A**, leaf, with detail of leaflet (**A'**) and of petiole with stipular scar (**A''**); **B**, infructescence, with detail of fruit surface (**B'**). From *Tahinarivony et al.* 179 (NY). Scale bars: A, B, 2 cm; A'', 1 cm; A', B', not to scale.

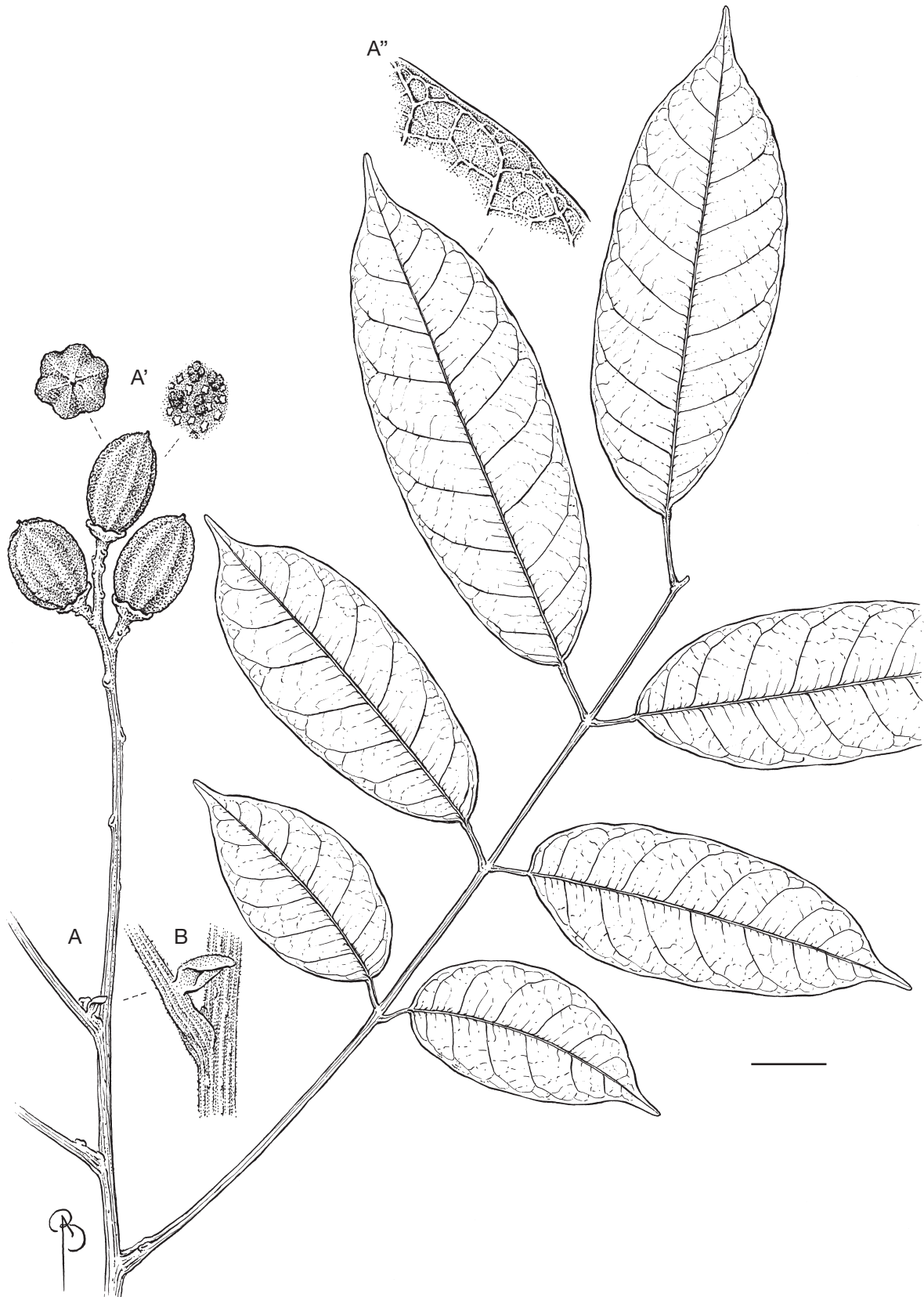


FIG. 3. — *Canarium angulatum* Daly, Raharim. & Federman, sp. nov. (*Cours* 4933, P): **A**, fruiting branchlet, with apical view of fruit and detail of fruit surface (**A'**) and detail of leaflet margin (**A''**); **B**, petiole base with stipule. Scale bar: A, 2 cm; A', A'', B, not to scale.

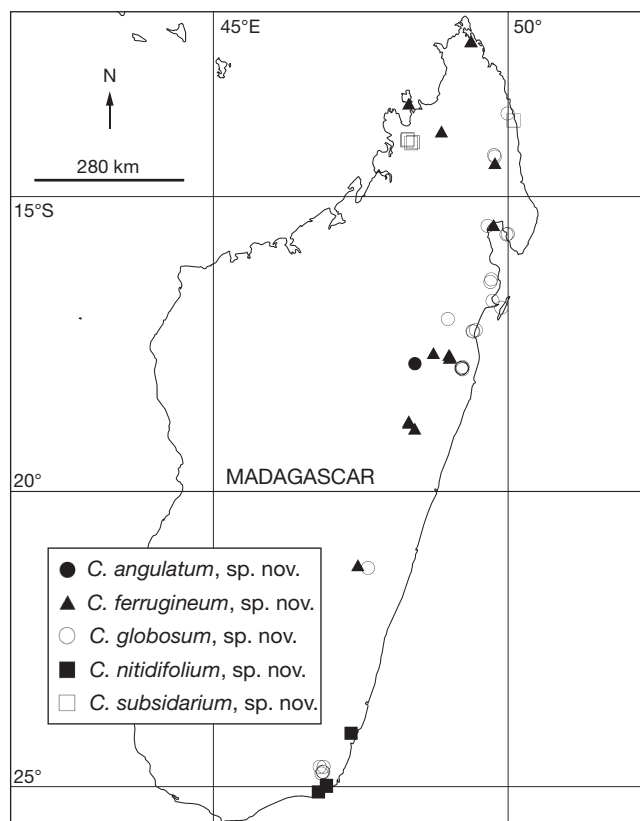


FIG. 4. — Distributions of *Canarium angulatum* Daly, Raharim. & Federman, sp. nov., *C. ferrugineum* Daly, Raharim. & Federman, sp. nov., *C. globosum* Daly, Raharim. & Federman, sp. nov., *C. nitidifolium* Daly, Raharim. & Federman, sp. nov., and *C. subsidarium* Daly, Raharim. & Federman, sp. nov.

rest of venation prominulous, both surfaces glabrous. Flowers unknown. Infructescence (incomplete) at least 7.5 cm long \times 5 mm diam, secondary axes at least 2.1 cm long, axes with dense flexuous golden to whitish hairs to 0.2 mm long; fruiting pedicel 3.5–4 \times 4–5 mm, cylindrical, calyx 8–9 mm long, the lobes not distinct. Fruits 4.5–4.9 \times 2.1–2.4 cm, narrowly ovoid, apex acute, base obtuse, surface finely and densely lenticellate, subglabrous, mesocarp relatively thin.

NOTES

Like *C. boivinii*, *C. ampasindavae*, sp. nov. has approx. 7-jugate leaves and fruits that are brown, lenticellate, and pubescent, but the latter can be distinguished by the leaflet apex gradually and narrowly long-acuminate (vs abruptly and broadly short-acuminate or rounded to slightly emarginate in *C. boivinii*), the leaflet venation on the adaxial side narrowly prominulous (vs broadly prominulous and almost flat), and the fruit narrowly ovoid (vs oblong to ellipsoid).

Canarium angulatum Daly, Raharim. & Federman, sp. nov.
(Figs 3; 4)

Leaves c. 3-jugate, rachis with only sparse to scattered hairs, stipules 4–5 mm long, secondary vein spacing decreasing toward apex; distinguished from *C. arcuatum*, sp. nov. by the stipules 2–3 mm from petiole insertion

(vs usually farther, 3–10+ mm in *C. arcuatum*, sp. nov.), leaflets chartaceous (vs coriaceous), secondary veins in 13–15 (vs 4–7) pairs and spreading (vs arcuate), the fruit smaller (2.5–3.4 \times 1.8–2 cm vs 3.6–4.5 \times 2.2–2.8 cm), and lenticels on the fruit surface sparse, large and raised (vs dense, relatively small, not raised).

TYPUS. — Madagascar. Sine loc., s.d., M. G. Cours 4933 (holo-, P[P05311852, P05311856]!).

DISTRIBUTION AND ECOLOGY. — The label for the only known collection of *Canarium angulatum*, sp. nov. lacks locality or date of collection, but Cours collected primarily in the subhumid forests of the central high plateau.

ETYMOLOGY. — The specific epithet refers to the angular fruit.

DESCRIPTION

Trees, reproductive size unknown. Leaves 23–38 cm long, 3–4-jugate; petiole 5–8 cm long, petiole and rachis with sparse, short, erect, thick white hairs to 0.05 mm long and scattered capitate glands, occasionally with some flexuous hairs to 0.15 mm long; stipules 2–3 mm from petiole insertion, 4–5 mm long, obovate-ligulate, surface with dense to sparse, short, ascending to appressed white hairs to 0.15 mm long; basal petiolules 3–10 mm long, other laterals 7–18 mm long, terminal one 25–44 mm long; basal leaflets 4.6–7 \times 2.1–3.7 cm, ovate, other lateral leaflets 8–15 \times 3–4.4 cm, oblong-elliptic, the terminal one 9–13.4 \times 3.6–5 cm, elliptic; leaflet apex abruptly and narrowly long-acuminate, the acumen 6–12 mm long; base of basal leaflets truncate, that of other laterals obtuse to truncate, sometimes medially asymmetrical; leaflets chartaceous, margin flat; secondary vein framework brochidodromous but looping near margin, secondary veins in 9–13 pairs, spreading, spacing and sometimes angle irregular, 1–2 perpendicular epimedial tertiaries present per pair of secondaries, tertiary venation irregular-reticulate or less often alternate-percurrent, quaternary venation irregular-reticulate with some admedial branching; on abaxial side all veins narrowly prominent, abaxial surface glabrous except for scattered golden appressed hairs to 0.05 mm long on midvein and secondaries, on adaxial side the midvein almost flat and sunk in a groove, rest of veins narrowly prominulous, the surface glabrous. Infructescence 9–15 cm long \times c. 2.5 mm diam, secondary axes to 1.4 cm long, axes with dense, thick, erect to flexuous hairs to 0.15 (0.2) mm, also with sparse capitate glands; fruiting pedicel 3.5–7 \times 3–3.2 mm, slightly clavate, fruiting calyx 3–4 mm long, very shallowly cupular, patent, the lobes distinct, c. 4 mm long, pubescence as on inflorescence axes, with large, raised lenticels. Fruit 2.5–3.4 \times 1.8–2 cm, slightly obovoid to broadly ellipsoid, trigonous, apex and base obtuse, surface with sparse, large, raised, ferruginous lenticels, also with dense to sparse straight whitish hairs to 0.15 mm long, ascending toward apex and descending near base.

NOTES

Like *C. arcuatum*, sp. nov., *C. angulatum*, sp. nov. has 1–4-jugate leaves, stipules 3–10 mm long, the petiole and rachis with only sparse to scattered hairs, a long terminal petiolule, secondary

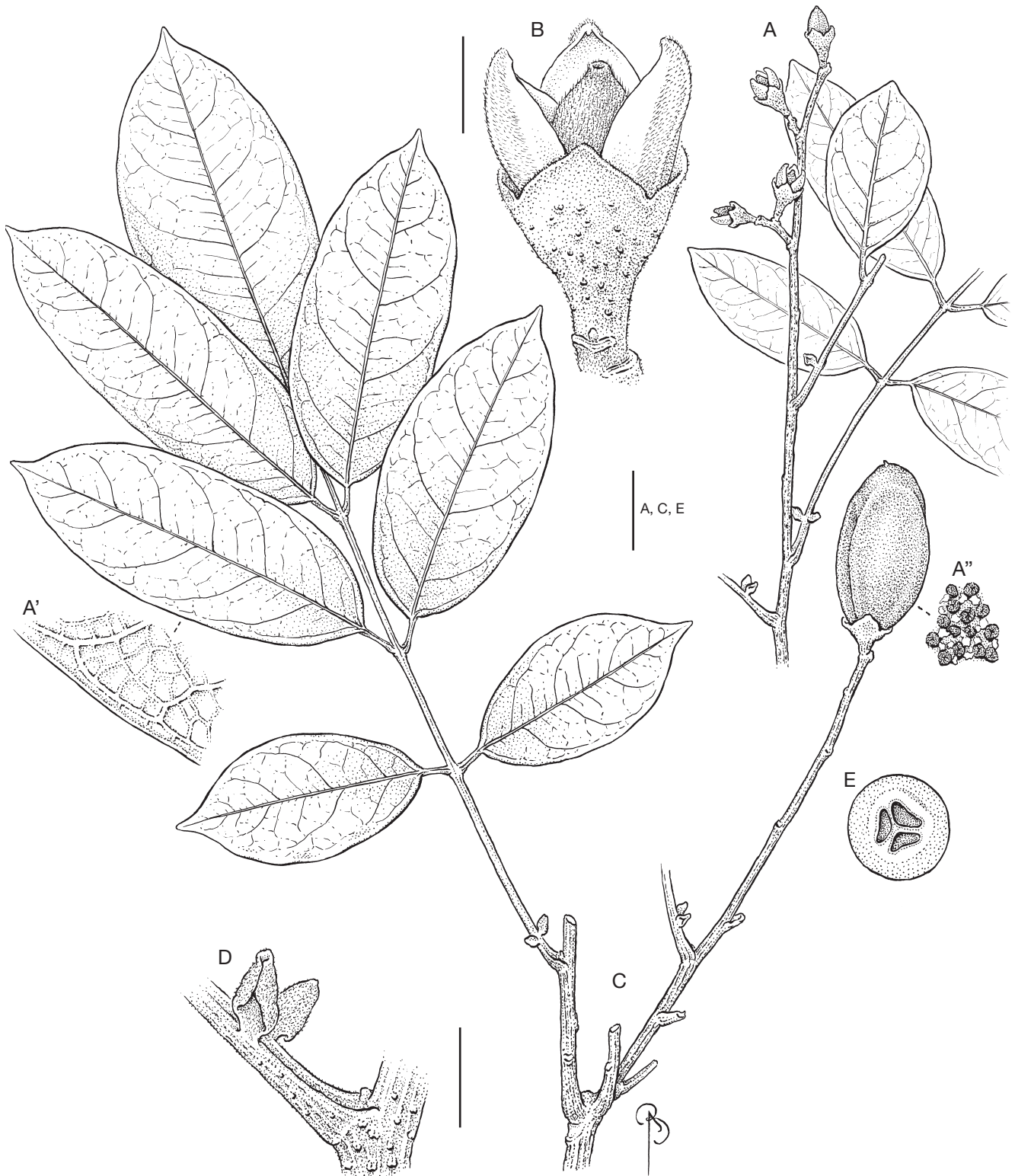


FIG. 5. — *Canarium arcuatum* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet; **B**, pistillate flower; **C**, fruiting branchlet, with detail of leaflet (**A'**) and of fruit surface (**A''**); **D**, petiole and stipules; **E**, cross-section of fruit; **A**, **B**, Carlson 46 (NY); **C**, **D**, Schatz & Miller 2520 (NY); **E**, after field photo by D. Daly. Scale bars: **A**, **C**, **E**, 2 cm; **B**, 3 mm; **D**, 1 cm; **A'**, **A''**, not to scale.

vein spacing decreasing toward apex and (abruptly) toward base, the leaflets at least sometimes glossy abaxially, the inflorescences 7-16 cm long, and the fruiting pedicel 3.5-7 mm

long, but *C. angulatum*, sp. nov. can be distinguished by the stipules 2-3 mm from petiole insertion (vs usually farther, 3-10+ mm in *C. arcuatum*, sp. nov.), the lateral leaflet base

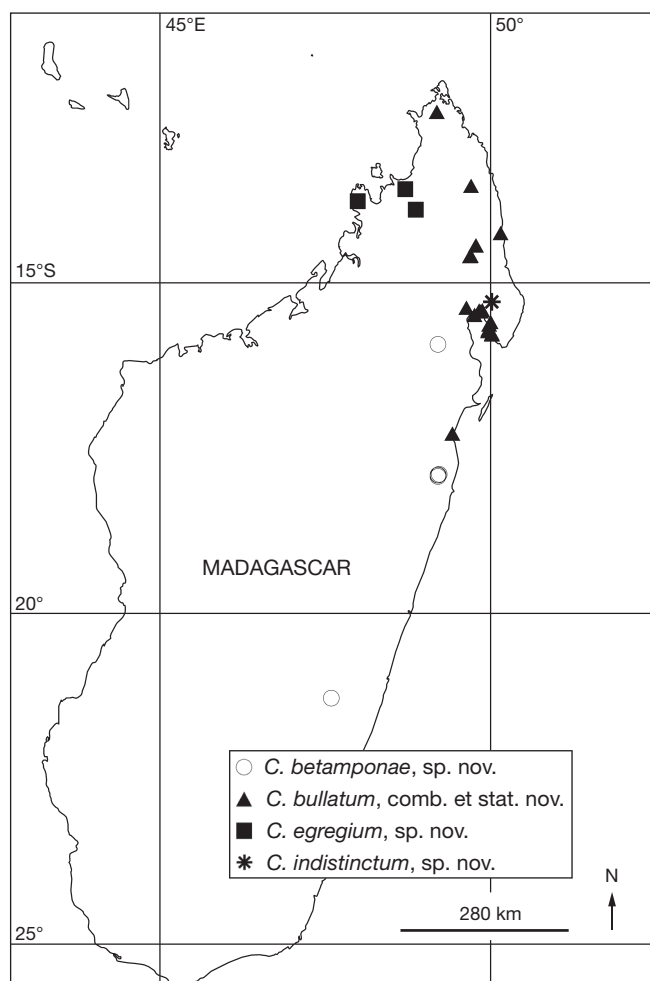


FIG. 6. — Distributions of *Canarium betamponae* Daly, Raharim. & Federman, sp. nov., *C. bullatum* (Leenh.) Daly, Raharim. & Federman, comb. et stat. nov., *C. egregium* Daly, Raharim. & Federman, sp. nov., and *C. indistinctum* Daly, Raharim. & Federman, sp. nov.

obtuse to truncate and sometimes medially asymmetrical (vs acute to rounded-obtuse and symmetrical), leaflets chartaceous (vs coriaceous), secondary veins in 13–15 (vs 4–7) pairs and spreading (vs arcuate), the fruiting calyx lobes longer (c. 3–4 vs 2–2.5 mm long), the fruit smaller (2.5–3.4 × 1.8–2 cm vs 3.6–4.5 × 2.2–2.8 cm), and lenticels on the fruit surface sparse, large and raised (vs dense, relatively small, not raised).

Canarium arcuatum Daly, Raharim. & Federman, sp. nov.
(Figs 2; 5)

Small trees, leaves 2–3-jugate, rachis with only sparse to scattered hairs, stipules c. 4.2 mm long, fruits c. 4.2 × 2.5 cm, oblong, the apex rounded, the base truncate, surface with lenticels dense, relatively small, not raised, ferrugineous; distinguished from *C. lamianum* Daly, Raharim. & Federman, sp. nov. by the lateral leaflet base usually rounded (vs obtuse to truncate, rarely some leaflet bases acute or cordate in *C. lamianum*, sp. nov.), the margin often slightly revolute (vs flat), leaflet secondary veins strongly arcuate (vs spreading to nearly straight, rarely slightly arcuate), and the fruit oblong and red-beige (vs broadly (oblong-)ovoid to slightly obovoid, sometimes trigonous, and (grayish-)green to (light) brown).

TYPUS. — **Madagascar.** Toamasina, Island of Nosy Mangabe, 5 km S of Maroantsetra in Bay of Antongil, 15°29'S, 49°45'E, 22.II.1990 (passed f fl), *B. Carlson* 46 (holo-, NY!; iso-, MO, P[P00501663]!, TAN, US!).

PARATYPI. — **Madagascar.** Toamasina, Nosy Mangabe, 15°29'S, 49°45'E, 22.II.1990, *B. Carlson* CB 46 (MO, NY); Analanjirofo, 475 m, 15°24'42"S, 49°29'55"E, 10.VI.2004, *P. Antilahimena* AP 2483 (NY); Nosy Mangabe, 300 m, 15°30'22"S, 49°45'01"E, 18.I.2006, *D. C. Daly, J. Raharimampionona, J. Razanatoa, J. Aridy & Senario* 12973 (NY); Analanjirofo, 400 m, 15°17'S, 49°50'E, 10.II.1988, *G. E. Schatz, J. Dransfield & S. Dransfield* 1873 (MO); Nosy Mangabe, 0–330 m, 15°30'S, 49°46'E, 9.I.1989, *G. E. Schatz & J. S. Miller* 2520 (MO, NY); Analanjirofo, 17°37'30"S, 49°11'30"E, 24.X.1964, *Service Forestier* 21912 (NY, TEF [not seen]).

DISTRIBUTION AND ECOLOGY. — A relatively small tree, to date confirmed only from the small island of Nosy Mangabe in the Bay of Antongil. Known to flower in Feb. and fruit in Jan.

ETYMOLOGY. — The specific epithet refers to the strongly arcuate leaflet secondary veins.

DESCRIPTION

Trees, reproductive size c. 15–16 m, with small buttresses. Leaves 19–25 cm long, 2–3-jugate; petiole 2.9–6.2 cm long, petiole and rachis with erect golden hairs to 0.5 mm, dense to scattered snail-shaped glands; stipules 3–8 mm from petiole insertion, c. 4.2 mm long, broadly ovate (but revolute when dry), slightly constricted at base, the scar 1.5–2 mm long, surface with dense erect to appressed white hairs to 0.05 mm long; all lateral petiolules 3–9 mm long, terminal one 19–22 mm long, petiolules very slightly canaliculate, lateral pulvinuli usually inconspicuous; basal leaflets 4.4–6.7 × 2.9–4 cm, obovate or less often ovate, other laterals 5.1–10.6 × 2.1–3.8 cm, broadly ovate or less often elliptic, or slightly obovate; the terminal 5.6–10 × 2.3–4.9 cm, slightly obovate; leaflet apex usually abruptly and usually broadly short-acuminate, the acumen 2–6 mm long, leaflet base symmetrical, rounded or less often obtuse, margin usually slightly revolute; leaflets coriaceous, drying light brown, sometimes glossy abaxially when dry; secondary vein framework brochidodromous but looping at margin, secondaries in 4–7 pairs, strongly arcuate, the angle uniform, spacing sometimes decreasing toward apex and decreasing abruptly toward base; tertiaries alternate-percurrent and irregular-reticulate, perpendicular epimedial tertiaries present, quaternaries irregular-reticulate; on abaxial side the midvein broadly prominent, secondaries prominulous, rest of veins broadly prominulous, the surface with scattered snail-shaped glands; on adaxial side the midvein narrowly prominulous but sunk in a groove, rest of veins broadly prominulous to almost flat, the surface glabrous. Staminate flowers unknown. Pistillate inflorescences 7–16 cm long, with few flowers or fruits, secondary axes to 2.5 cm long, axes with dense flexuous to straight golden hairs to 0.2 mm; bracts caducous, semi-clasping (scars very broad); pedicel 4–5 × 2–3 mm, cylindrical. Pistillate flowers (only incomplete post-anthesis flowers known) c. 9–10 mm long; calyx 5.5–6 × 5.3–6 mm overall, campanulate, the lobes 2–2.5 mm long, (depressed) rounded-deltate, abaxial surface with dense de-

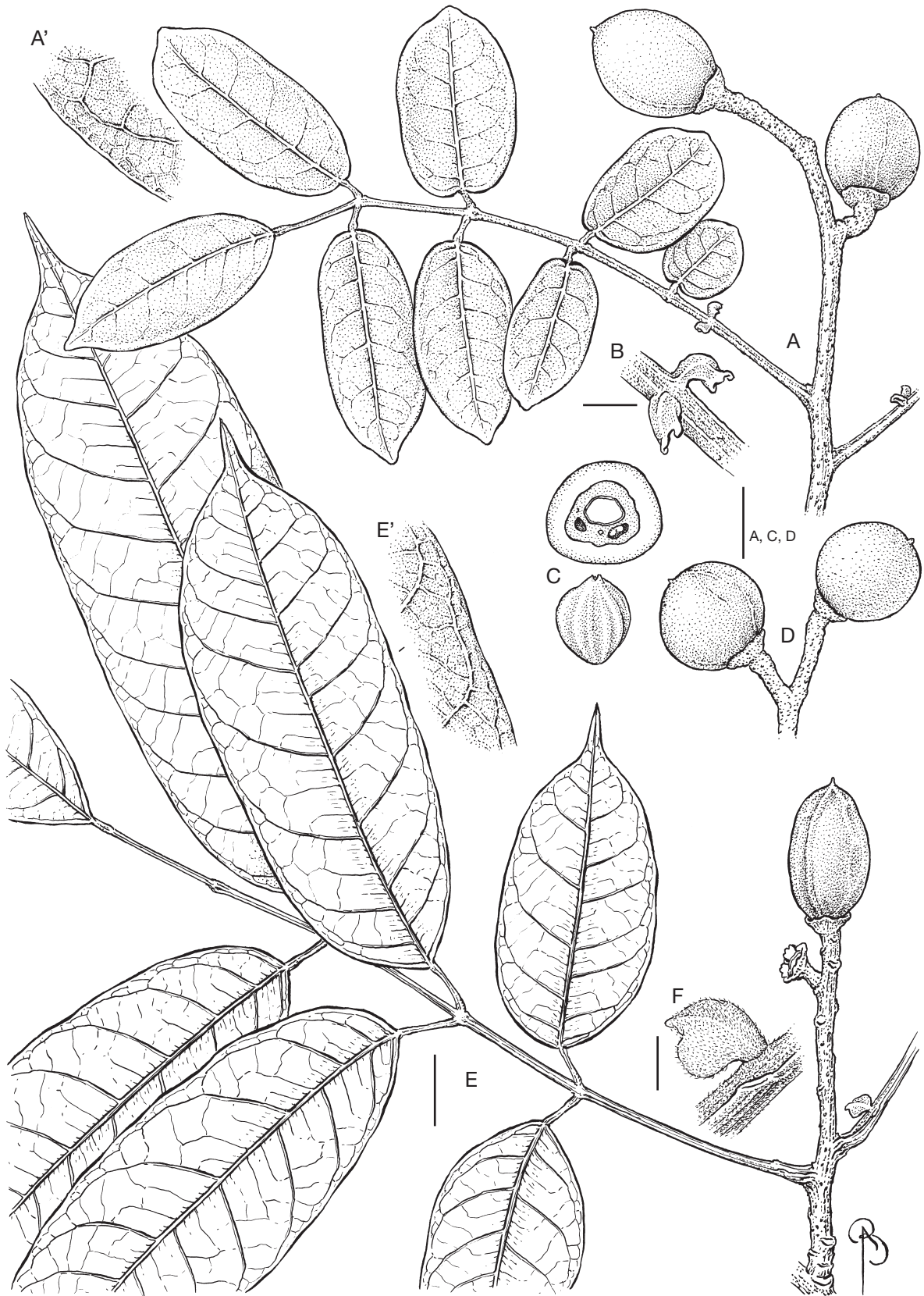


FIG. 7. — A-D, *Canarium betamponae* Daly, Raharim. & Federman, sp. nov.: A, fruiting branchlet, with detail of leaflet (A'); B, stipules; C, cross-section of fruit (above) and pyrene; D, detail of infructescence; E, F, *Canarium moramangae* Daly, Raharim. & Federman, sp. nov.: E, fruiting branchlet, with detail of leaflet (E'); F, stipule and scar; A, C, Daly et al. 13079 (NY sheet and field photos); B, Federman et al. 116 (NY); D, Daly et al. 13073 (field photo by D. Daly); E, F, Service Forestier-21894 no. 1748-R-100. Scale bars: A, C-E, 2 cm; B, F, 0.5 cm; A', E', not to scale.

scending thick ferrugineous hairs to 0.1 mm, adaxial surface with dense appressed whitish hairs to 0.25 mm long; petals c. 7–8 × 3.8–4 mm, ovate and slightly acuminate, with a strongly inflexed apiculum 0.25 mm long; abaxial surface with pale golden flexuous hairs to 0.5 mm long, ascending near apex and retrorse near base, adaxial surface subglabrous; androecium unknown; pistil with dense appressed whitish hairs to 0.25 mm long. Fruiting pedicel c. 6 × 3.5 mm, terete, fruiting calyx c. 3.5–4 mm long, patent, the lobes distinct. Fruit c. 4.2 × 2.5 cm, oblong, the apex rounded, the base truncate, surface with lenticels dense, small, not raised, ferrugineous, also with appressed golden hairs to 0.25 mm long, dense near apex but scattered elsewhere; mesocarp moderately thick.

NOTES

Like *C. lamianum*, sp. nov., *C. arcuatum*, sp. nov. has leaves with few juga, the petiole and rachis with only sparse to scattered hairs, stipules 3–7 mm long, and their fruits similar in size and shape, but *C. arcuatum*, sp. nov. can be distinguished by the stipule pubescence of fine (not thick) hairs, the petiole and rachis with long erect golden hairs to 0.5 mm long at least on the rachis (vs scattered thick, appressed golden hairs to 0.05 mm long in *C. lamianum*, sp. nov.), the pulvinuli usually inconspicuous (vs usually conspicuous), lateral leaflet base usually rounded (vs obtuse to truncate, rarely some leaflet bases acute or cordate), the margin often slightly revolute (vs flat), the secondary veins usually fewer (4–7 vs 6–10), abruptly crowded toward the base (vs often irregularly spaced), and strongly arcuate (vs spreading to nearly straight, rarely slightly arcuate), the infructescence more slender, and the fruit oblong and red-beige (vs broadly (oblong-) ovoid to slightly obovoid, sometimes trigonous, and (grayish-) green to (light) brown). *Canarium arcuatum*, sp. nov. is contrasted with *C. angulatum*, sp. nov. in the discussion under that species.

Canarium betamponae Daly, Raharim. & Federman, sp. nov.
(Figs 6; 7A–D).

Small to medium-sized trees, leaves 3–4(5)-jugate, fruits broadly obovoid (rarely slightly ovoid), glabrous and glossy, distinguished from C. galokense Daly, Raharim. & Federman, sp. nov., *C. globosum* Daly, Raharim. & Federman, sp. nov., *C. manongarivum* Daly, Raharim. & Federman, sp. nov. and *C. subsidarium* Daly, Raharim. & Federman, sp. nov. by membranaceous stipules and subglabrous inflorescence axes.

TYPUS. — **Madagascar.** Toamasina/Tamatave, District Toamasina II, Ambodirina, Réserve Naturelle Intégrale Betampona, 325–375 m elev., 17°55'53"S, 49°12'12"E, 3.II.2006 (fr), D. C. Daly, R. Ranaivojaona, R. B. Iambana, & C. Razafy 13073 (holo-, NY!; iso-, MO!, TEF!).

PARATYPI. — **Madagascar.** Toamasina, Atsinanana, Réserve Naturelle Intégrale Betampona, 325–375 m, 15°55'53"S, 49°12'12"E, 4.II.2006, D. C. Daly, R. Ranaivojaona, R. B. Iambana & C. Razafy 13079 (NY, TEF), 325–375 m, 15°55'53"S, 49°12'12"E, 4.II.2006, D. C. Daly, R. Ranaivojaona, R. B. Iambana & C. Razafy 13080 (NY, TEF), 400–600 m, 17°54'16"S, 49°12'13"E, 15.IV.2008, S. Federman, T. Treuer & J. Sylvain 9 (NY), 400–600 m, 17°54'33"S, 49°12'12"E, 7.III.2008, S. Federman, T. Treuer & J. Sylvain 28 (NY), 400–600 m, 17°54'29"S, 49°12'06"E, 9.III.2008, S. Federman, T.

Treuer & J. Sylvain 53 (NY), 400–600 m, 17°54'30"S, 49°12'14"E, 23.IV.2008, S. Federman, T. Treuer & J. Sylvain 116 (NY); Ambohimanga, Ambaro, Ifanadiana, 11.II.1956, *Service Forestier 20-R-332* [sic] (NY, TEF [not seen]); Atsinanana, Réserve Naturelle Intégrale Betampona, 400–600 m, 17°53'48"S, 49°13'11"E, 4.V.2008, T. Treuer, S. Federman & J. Sylvain 70 (NY), 400–600 m, 17°54'36"S, 49°12'10"E, 10.V.2008, T. Treuer, S. Federman & J. Sylvain 110 (NY).

DISTRIBUTION AND ECOLOGY. — To date, *Canarium betamponae*, sp. nov. appears to be restricted to the Réserve Naturelle Intégrale de Betampona in Toamasina, where it is usually a large tree occurring on sandy clay soils in primary humid forest with open canopy and many poles and lianas; it is found between 325–600 m on slopes usually not exposed to cyclones. Fruiting Feb.–Apr.

COMMON NAMES AND USES. — Ramy. Resin used for caulking canoes, also for illumination, and for religious (*tromba*) ceremonies.

DESCRIPTION

Trees, reproductive size 11–22 m × 20–65 cm diam, with thick low plank buttresses. Outer bark dark gray(-brown), thick, with deep short fissures, shed in elongate irregular plates; inner bark pale red or orange to tan, thick. Leaves 15–27 cm long, 3–4(5)-jugate; petiole 3.5–5.7 cm long, petiole and rachis with scattered capitate glands and a few scattered ascending to appressed pale golden hairs to 0.25 mm long, also with scattered elongate lenticels; stipules 11–38 mm from petiole insertion, 3–7 mm long, orbicular, membranaceous, with sparse appressed pale golden hairs to 0.15 mm long, the scar 1–2 mm long; all lateral petiolules 4–9 mm long, terminal one 7–10 mm long, petiolules canaliculate, lateral pulvinuli inconspicuous; basal leaflets 3.2–4.9 × 2.2–3 cm, broadly ovate to suborbicular or oblong, other laterals 3.7–6.5 × 2.2–3.2 cm, broadly elliptic to slightly ovate; terminal one 3.5–6.2 × 2.4–3.3 cm, broadly elliptic, rarely slightly obovate; leaflet apex usually abruptly and broadly short-acuminate, the acumen 2–7 mm long; lateral leaflet base symmetrical to slightly asymmetrical, obtuse or rounded to truncate or sometimes slightly cordate; leaflet margin flat to slightly revolute; leaflets coriaceous, drying brown; secondary vein framework festooned brochidodromous, usually looping far from the margin, secondaries in 6–9(11) pairs, spreading, spacing decreasing toward apex and base, the angle increasing toward the apex and sometimes toward the base, perpendicular epimedial tertiaries usually present, intercostal tertiaries irregular-reticulate, frequently some admedial tertiaries branching toward secondary vein axils from adjacent secondaries, quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, the surface glabrous; on adaxial side all veins narrowly prominulous except the midvein sunk in a groove, glabrous. Flowers unknown. Infructescences 9–20 cm long, the secondary axes 3–7 cm long, in fruit the axes (sub) glabrous, sometimes with some bristles to 0.1 mm long; bracts deciduous, not semi-clasping; fruiting pedicel 4–7 × 2–3 mm, slightly clavate; fruiting calyx 2–3 mm long, spreading to patent, the lobes distinct, with a few short thick ascending hairs to 0.15 mm long. Fruits 3–3.2 × 2.6–3.2 cm (to 3.4 cm long fresh), broadly obovoid, rarely slightly ovoid or depressed-globose, sometimes slightly 3-lobed (Daly et al. 13073), the apex round and base obtuse to truncate, surface glaucous to dull turquoise, smooth, glabrous, usually glossy; mesocarp to 5 mm thick; the pyrene 2–2.8 × 2.1–2.4 cm, operculum runs along the pyrene.

TABLE 1. — Comparison of the *Canarium betamponae*, sp. nov. complex (salient features in bold).

<i>Canarium</i> sp.	<i>C. betamponae</i> , sp. nov.	<i>C. galokense</i> , sp. nov.	<i>C. globosum</i> , sp. nov.	<i>C. manongarivum</i> , sp. nov.	<i>C. subsidarium</i> , sp. nov.
Provinces of distribution	Toamasina	Antsiranana	Antsiranana, Toamasina, Toliara	Antsiranana	Antsiranana
Elevation range (m)	325-600	300-700	10-700	c. 875	1000-1600
No. juga	3-4(5)	3-5	3-5	3	3-4
Stipule insertion from base (mm)	11-38	3-10	(4)8-23(35)	10-16	4-9
Stipular scar length (mm)	1-2	2-4	1-2	7-9	2-3 (raised)
Stipule length (mm) and shape	3-7, orbicular	4.5-10, orbicular, substipitate	3-8, orbicular	[Unknown]	[Unknown]
Stipule texture	Membranaceous	Coriaceous	Becoming fleshy	[Unknown]	[Unknown]
Leaf rachis pubescence (discounting capitate glands) (mm)	Few scattered ascending to appressed hairs to 0.25	Scattered thick short hairs to 0.1	Sparse to scattered, fine, appressed hairs to 0.2	Sparse thick erect hairs to 0.1 mm long	Dense to scattered fine erect hairs to 0.5; also bristles (fine erect hairs to 0.05)
Lateral leaflet shape	Broadly elliptic to slightly ovate	(Oblong-) lanceolate to ovate	Oblong or less often oblong-elliptic or ovate	Elliptic to slightly oblong-ob lanceolate	Oblong(-lanceolate) to elliptic
Leaflet apex, acumen (mm)	Usually abruptly and broadly short-acuminate, 2-7	Gradually and usually narrowly acuminate, (2) 5-10	Rounded to slightly emarginate, seldom abruptly and broadly short-acuminate, 0-2 (4)	Broadly short-acuminate or rarely obtuse, 0-4	Gradually and broadly short-acuminate, 2-6
Leaflet adaxial surface	Glabrous	Few scattered capitate glands or glabrous	Glabrous	Black-punctate	Glabrous
Inflorescence trichomes (discounting capitate glands) (mm)	(Sub)glabrous , sometimes with some bristles to 0.1	Dense to sparse flexuous hairs to 0.25	Sparse to dense flexuous hairs to 0.2	Sparse to scattered flexuous to erect thick hairs to 0.25	Dense to sparse flexuous hairs to 0.3, also sparse to dense bristles
Fruit size (cm)	3-3.2 × 2.6-3.2	3.5-4 × 2.5-3	2-3.8 × 2-2.5	c. 2.8-2.9 × 1.8-2.1 (immature?)	3.6-3.8 × 2.3-2.8
Fruit shape	Broadly obovoid, rarely slightly ovoid	Broadly oblong or broadly ovoid	Subglobose to (ob)ovoid	Slightly ovoid	Ovoid
Fruit surface	Glabrous, glossy	Lenticellate	Glabrous, glossy	Lenticellate and pubescent	Glabrous, dull; becoming finely lenticellate

NOTES

Canarium betamponae, sp. nov. is part of a complex of species including *C. galokense*, sp. nov., *C. globosum*, sp. nov., *C. manongarivum*, sp. nov. and *C. subsidarium*, sp. nov. that have 3-5-jugate leaves with short stipular scars (except *C. manongarivum*, sp. nov.), relatively small leaflets that are often oblong, and relatively small fruits. They are compared in Table 1.

Canarium boivinii Engl.

(Fig. 2)

In A.DC. & C.DC., *Monographiae Phanerogamarum Prodrumi* 4: 110, 111 (1883). — Typus: Madagascar. Prov. Toamasina, Sainte Marie, IV.1851, *L.-H. Boivin s.n.* (lecto-, annotated by Leenhouts July 1955, P[P00048609]!; isolecto-, P[P00048608]!).

MATERIAL EXAMINED. — Madagascar. Toamasina, Ambanizana, Parc National Masoala, Tampolo, 5 m, 15°42'43"S, 49°57'48"E, 16.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatoa, J. Aridy & Senario 12962 (NY, TEF), Forêt de Tampolo, 10 m, 15°43'45"S, 49°57'38"E, 16.X.2001, R. Randrianaivo 688 (MO); Analanjirofo, N of Ivontaka (S of Mananara), 0 m, 16°17'S, 49°49'E, 28.IX.1957, Service Forestier

18219 (MO, P[P05311778], TEF [not seen]). Antsiranana, Sava, Antalaha, Ambohitralanana, Ambinanimarambo to Sahanjana, 3 m, 15°13'44"S, 50°27'00"E, 9.VI.2001, Richard Razakamalala 122 (MO, NY, P, TAN).

DISTRIBUTION AND ECOLOGY. — *Canarium boivinii* is known only from NE Madagascar, on either side of the Bay of Antongil and slightly farther north to Ambohitralanana, where it is a small to relatively large tree of primary and disturbed moist forest on slopes and hills near and on the bay, elevation 5-10 m. Flowering Apr.-Jun., fruiting Sep.-Jan.

COMMON NAMES. — Haramtsitsihy, aramé.

DESCRIPTION

Trees, reproductive size 15-25 m, up to 75 cm diam, with thick plank buttresses. Outer bark gray, thin, slightly scalloped, with sparse small raised lenticels, shed only on buttresses in small rectangular plates; inner bark orange-tan, brittle. Leaves 17-42 cm long, 5-7-jugate; petiole 3.7-5 cm long, petiole and rachis with white bristles and sparse, thick, erect ferrugineous hairs to 0.15 mm long, sometimes becoming subglabrous in spots, also with scattered elongate raised lenticels; stipules 10-13 mm from insertion of petiole, 7-9 mm long, essentially

cruciform with two broad lateral lobes, constricted at base, somewhat fleshy, laterally involute, with sparse to dense appressed thick ferrugineous hairs to 0.2 mm long, the scar 2(-3) mm long; basal petiolules 4-7 (10) mm long, other laterals 4-8 (12) mm long, terminal one 13-22 mm long, petiolules not canaliculate, lateral pulvinuli inconspicuous; basal leaflets 3.5-4.3 × 2.1-2.8 cm, (broadly) ovate, other laterals 3.7-10 × 2.2-3.6 cm, oblong to oblong-ovate or less often elliptic, terminal leaflet 5.1-6.3 × 2.1-2.7 cm, elliptic to slightly oblanceolate; leaflet apex abruptly and broadly short-acuminate, the acumen 2-4 (10) mm long, the apex tip sometimes appearing glandular-apiculate; lateral leaflet base usually symmetrical, truncate to obtuse; margin flat, leaflets coriaceous, drying light brown, usually glossy (sometimes dull adaxially); secondary vein framework brochidodromous, looping near margin, secondaries in 6-16 pairs, insertion decurrent, spreading to almost perpendicular, the angle sometimes decreasing toward apex, spacing usually regular; tertiaries irregular-reticulate, quaternaries regular-polygonal; on abaxial side the veins all narrowly prominent, surface (or just midvein) with scattered thick appressed pale golden hairs to 0.1 mm long and scattered snail-shaped glands, or subglabrous; on adaxial side the midvein narrowly prominulous but sunk in a groove, higher order veins broadly prominulous or flat, the surface with pubescence as on abaxial surface (but fewer) or glabrous. Pistillate inflorescences 5.5-8+ cm long, secondary axes to 1.4-3.7 cm long, axes with dense to sparse, flexuous, ferrugineous hairs to 0.25 mm long, also with sparse round raised lenticels; bracts on inflorescence axes to 7.4 mm long, obovate, fleshy; pedicel *c.* 1.7 × 1.3 mm. Pistillate buds *c.* 9.2 mm long; calyx *c.* 8.5 × 4.8 mm overall, exceeding the ovary, fleshy, the lobes 0.8-1.2 mm long, semi-orbicular, abaxial surface with dense flexuous hairs as on inflorescence axes, adaxial surface with dense appressed whitish hairs to 0.15 mm long; in mature buds the petals *c.* 4.7 mm long, exposed much less than half their length, carinate, fleshy, abaxial surface with straight hairs to 0.25 mm long, retrorse-appressed except appressed on keels; antesealous staminodes *c.* 2.2 mm long with anthers *c.* 1.4 mm long, the antepetalous staminodes *c.* 2 mm long with anthers *c.* 1.3 mm long, the anthers lanceolate in dorsiventral view, obliquely lanceolate in lateral view; receptacle concave and somewhat perigynous; disk 0.3-0.4 tall, 0.25-0.35 mm thick; pistil 3.5 × 1.8 mm overall, the ovary essentially obovoid, with dense appressed whitish hairs to 0.2 mm long, the style 1 × 0.9 mm, slightly conical, with hairs as on ovary but in discrete vertical lines, the stigmatal area 0.9 mm long, the stigmas subglobose. Fruiting pedicel *c.* 11-15 × 5 mm, slightly clavate, fruiting calyx *c.* 4 mm long, usually patent, the lobes usually *c.* 2 mm long, the abaxial side with dense flexuous ferrugineous hairs to 0.15 mm long, the adaxial side with dense appressed whitish hairs to 0.25 mm long. Fruits 4.5-4.6 × 2.3-2.6 cm (to 5.2 × 2.2-2.7 cm when fresh), (oblong-) obovoid to broadly ellipsoid, sometimes slightly trigonous, the apex rounded to acute and apiculate, the base rounded, surface with rather dense raised ferrugineous lenticels, also with sparse or sometimes dense retrorse/descending, pale golden hairs to 0.6 mm long among the lenticels.

NOTES

Canarium boivinii is compared and contrasted with *C. planifolium*, sp. nov. in the discussion under that latter species.

Canarium bullatum

(Leenh.) Daly, Raharim. & Federman, comb. et stat. nov. (Fig. 6)

Canarium madagascariense Engl. subsp. *bullatum* Leenh., *Blumea* 9 (2): 381. 1959. — Typus: Madagascar. Forêt d'Ambatosoratra, 8.I.1949, Cours 3368 (holo-, P[P00048600]!).

MATERIAL EXAMINED. — Madagascar. Antsiranana, Sava, Sambava, Parc National Marojejy (Campement 1, Mantella), 100-350 m, 14°26'07.8"S, 49°46'19.2"E, 26.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa & D. Ravelonarivo 13001 (NY, TEF); Mandena, Maroambihy, Réserve Naturelle Intégrale no. 12 de Marojejy, 470-530 m, 14°26'13"S, 49°46'32"E, 11.X.1996, P. J. Rakotomalaza, N. Messmer & D. Ravelonarivo 733 (MO, P). Toamasina, Ambanizana, Parc National Masoala, Tampolo, 50-200 m, 15°37'58"S, 49°58'22"E, 15.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa, J. Aridy & Senario 12952 (NY, P[P04799031], TEF); Analanjirofo, 1-2 km E of Fampanambo, 20-25 m, 15°25'56"S, 49°50'41"E, 26.I.1999, G. E. Schatz *et al.* 3818 (MO); Station Forestière Farankaraina, 20 m, 15°22'35"S, 49°37'46"E, 28.I.1999, G. E. Schatz *et al.* 3859 (MO).

DISTRIBUTION AND ECOLOGY. — Although often abundant where it occurs, *Canarium bullatum*, comb. et stat. nov. is restricted to NE and far northern Madagascar, including Maroantsetra, Farankaraina, Tampolo, and Ambanizana, but also at lower elevations at Marojejy and Montagne d'Ambre. Found in (sub-)littoral forest in sandy soils, also moist forest on steep slopes and on ridges, usually between 10-350 m elevation, rarely 1000-1150 m. Flowering Jan.; fruiting Jan.-May.

COMMON NAMES. — Ramy be, ramy, haramy be, ramy fotsy.

DESCRIPTION

Trees, reproductive size 12-40 m tall, up to 200 cm diam, with plank buttresses to 2.5 m high and 3 m extension. Outer bark gray, slightly scalloped, sometimes fissured at base; hoop marks sometimes present, sparsely to densely lenticellate but relatively smooth; shed in short, thin, irregular plates 10-20 cm long; inner bark tan. Resin clear. Leaves 28-50 cm long, 5-6-jugate; petiole 3.5-9 cm long, petiole and rachis with dense to sparse erect fine golden hairs to 0.1 mm long, also scattered to dense erect to flexuous golden hairs to 0.5 mm long, and scattered to sparse capitate glands; stipules 0-5 mm from petiole insertion, 4-5 mm long, (semi-)orbicular, surface with dense appressed golden hairs to 0.4 mm long at base, submembranaceous, scar 3-8 mm long, raised; basal petiolules 4-6 mm long, other laterals 2-8 mm long, terminal one 15-30 mm long, petiolules not canaliculate, lateral pulvinuli inconspicuous; basal leaflets (2.6) 4-6.6 × (2.6) 4-6.3 cm, suborbicular or less often broadly ovate, other laterals 9.6-21.5 × 5.3-10 cm, broadly oblong-ovate or rarely suborbicular, the terminal 11-16 × 5.2-11.4 cm, ovate (usually broadly so), rarely oblong-ovate, leaflet apex abruptly to somewhat gradually and narrowly short-acuminate, the acumen 3-8 (10) mm, sometimes the apex tip apiculate; lateral leaflet

base symmetrical, cordate (truncate on terminal); margin usually slightly revolute; leaflets coriaceous and rigid, drying brown and often glossy on one or both sides, adaxial leaflet surface usually bullate (rarely not), on abaxial surface the veinlets and veins forming minute concavities,); secondary vein framework mixed eucamptodromous and brochidodromous (sometimes with some festooning), secondaries in 12-18 pairs, spreading, spacing decreasing toward base, angle slightly acute but decreasing toward apex and increasing toward base, intercostal tertiary fabric opposite-alternate percurrent; perpendicular epimedial tertiaries present; on abaxial side all veins acutely prominent, surface papillate, also with dense to sparse, erect, thick golden hairs to 0.1 mm long on the veins and veinlets, and scattered ascending to erect golden hairs to 0.7 mm long (usually only on midvein); on adaxial side the midvein and secondaries (also sometimes tertiaries) prominulous but sunk in a groove, remaining veins finely prominulous, midvein and secondaries with sparse to scattered erect to ascending golden hairs to 0.2 (0.3) mm long, rest of surface with sparse ascending hairs to 0.1 mm long, all of surface with scattered capitate glands. Inflorescences all 14-34.5 cm long overall but pistillate ones more robust and less branched, all axes with sparse to dense flexuous golden hairs to 0.3 (0.5) mm long, sparse to scattered thick erect hairs to 0.1 mm long, and sparse capitate glands, also with long narrow lenticels; on staminate inflorescences the secondary axes 4-14 cm long, bracts on primary axes to 7 mm long, obovate to broadly subulate, fleshy, bracts on other axes 1.8-4 mm long, lanceolate to (ob) ovate, bracteoles 0.8-2 mm long, almost linear; pedicel 0.7-2 (4) × 0.7-1.1 (1.4) mm. *Staminate flowers* 6.3-8 (8.5) mm long at anthesis; calyx 2.1-2.8 (4.8) × 4.2-4.5 mm overall, shallowly cupular to slightly campanulate, taller than the ovariodisk, the lobes 0.3-0.85 mm long, rounded depressed-deltate, abaxial surface densely provided with flexuous golden hairs to 0.35 mm long, thick appressed hairs to 0.15 mm long, and capitate glands; petals 5.3-6 (9) × 3.7-4.3 (5) mm, oblong-ovate, visible portion much longer than the calyx, (sulfur-)yellow to light orange-beige, fleshy, abaxial side densely provided with thick golden hairs to 0.35 mm long, appressed in the center but retrorse-appressed toward the margin; stamens inserted at base of ovariodisk, yellow, the antesealous ones 3.5-4.6 mm long with anthers 1.8-2.5 mm long, antepetalous ones 3.2-4.45 mm long with anthers 1.4-2 mm long, anthers ovate in dorsiventral view and obliquely oblong-ovate in lateral view, filaments fleshy; ovariodisk 1.5-2.4 × 0.85-2.1 mm, essentially cylindrical to (depressed-)obovate with craggy apex, glabrous or provided with ascending hairs to 0.15 mm long. On pistillate inflorescences the secondary axes 2-11 cm long; bracts on primary axes 5-8 mm long, broadly subulate, somewhat fleshy, other bracts 3-5.2 mm long, (narrowly) lanceolate to ligulate, acute, bracteoles 1.3-3.5 mm long, narrowly lanceolate, usually acuminate. Pistillate flowers 7-9.2 mm long at anthesis, the calyx 3.8-5.7 × 4.7-6 mm overall, somewhat urceolate, the lobes 0.4-1 mm long, depressed-deltate; petals 7.1-7.5 × 5.2-5.7 mm, broadly ovate, visible part of corolla

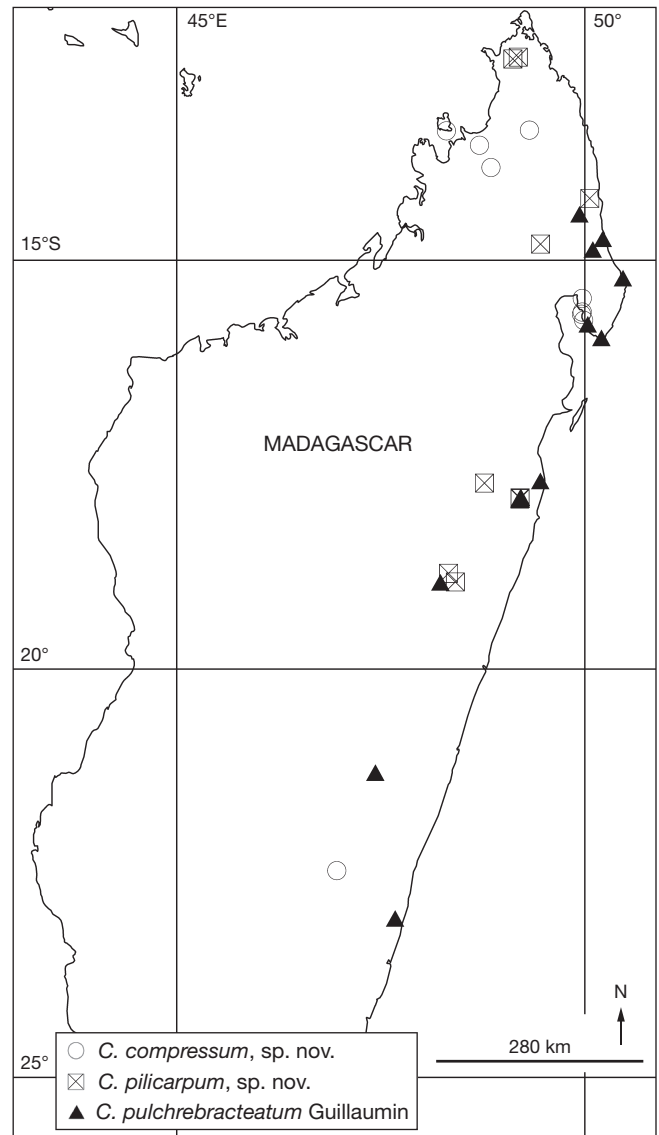


FIG. 8. — Distributions of *Canarium compressum* Daly, Raharim. & Federman, sp. nov., *C. pilicarpum* Daly, Raharim. & Federman, sp. nov., and *C. pulchrebracteatum* Guillaumin.

shorter than calyx; antesealous staminodes 2.6-3 mm long with lanceolate anthers 1.55-1.8 mm long, antepetalous staminodes 2.2-2.6 mm long with ovate anthers 1.4-1.75 mm long, the anthers with dense, ascending hairs to 0.25 mm long; disk 0.7-0.9 mm tall, 0.25-0.3 mm thick; pistil set in a shallow hypanthium, 6.7 × 3.8 mm overall, green, ovary ovoid and substipitate, with ascending dark-ferrugineous hairs to 0.3 mm long; the style 1.6 mm long, stigmata area 1.3 mm tall. Infructescences robust, to 16 mm diam at base, the pedicel 3.2-7 × 5.2-7 mm, cylindrical to clavate, with sparse white raised lenticels, fruiting calyx 3-5 mm long, patent to very shallowly cupular, the lobes sometimes distinct. Fruits erect, 3-4.5 × 2.3-3 cm, gray-brown, when immature obovoid, when mature slightly obovoid or less often slightly ovoid, apex and base rounded to obtuse; surface glabrous, with lenticels dense, small, circular, slightly raised, (pale) tan.

NOTES

Canarium bullatum, comb. et stat. nov. and *C. multinervis*, sp. nov. both belong to a group of 10 species that all have relatively large, broad leaflets with truncate to slightly cordate base; both also have the stipules inserted at the petiole base (or up to 5 mm from base in *C. bullatum*, comb. et stat. nov.), up to 18 secondary veins, leaflet abaxial surface with sparse to scattered pubescence or the surface glabrous, and adaxial surface often glossy. *Canarium bullatum*, comb. et stat. nov. can be distinguished in this group by the stipules 4–5 (vs 5–13) mm long, basal leaflets usually suborbicular (vs broadly ovate), lateral leaflets usually longer (9.6–21.5 vs 6.8–12 cm), terminal leaflet usually broadly (ob)ovate, less often ovate, rarely oblong-ovate (vs usually broadly elliptic), leaflets usually bullate and drying light brown (vs not bullate and drying dark brown), bracts on secondary axes of staminate inflorescences 3–5.2 mm long and (narrowly) lanceolate to ligulate, acute (vs 5.5–7 mm long, rounded, concave, and covering the subtended buds), and staminate flowers 6.3–8 (vs 4.4–5.5) mm long, and calyx 2.1–2.8 (vs 3.1–3.5) mm long overall, the lobes 0.3–0.85 (vs 1.5–1.7) mm long.

Canarium compressum Daly, Raharim. & Federman, sp. nov.
(Figs 8; 9)

Small to large trees, stipules 5–13 mm long, lateral leaflet base truncate to slightly cordate, abaxial surface with scattered thick, appressed white hairs to 0.2 mm long, the fruit broadly oblong-ellipsoid or broadly slightly ovoid, distinguished from *C. egregium* Daly, Raharim. & Federman, sp. nov. and *C. pilicarpum* Daly, Raharim. & Federman, sp. nov. by the petiole usually longer (6.3–8 vs 1.8–6.8 mm), leaflet acumen long (10–30 vs 2–6(10) mm in the two others), the secondary veins subperpendicular to the midvein and often straight (vs spreading to arcuate), and inflorescence axes markedly compressed.

TYPOS. — Madagascar. Prov. Toamasina, Masoala Peninsula, coastal trail 1–2 km S of Ambanizana, 0–5 m elev., 15°38'–39'S, 49°58'E, 2.I.1991, G. E. Schatz & G. Modeste 3117 (holo-, NY!; iso-, MO!; P[P00501658], TAN [not seen]).

PARATYPI. — Madagascar. Antsiranana, Diana, Réserve Naturelle Intégrale de Tsaratanana, 500 m, 13°51'50"S, 48°50'53"E, 28.III.2000, P. Antilahimena et al. 434 (MO); Diana, Nosy Be, Réserve Naturelle Intégrale Lokobe, 2 m, 13°24'26"S, 49°19'22"E, 08.II.2006, D. C. Daly, J. Raharimampionona & R. Ranaivojaona & J. Hervais 13093 (NY, TEF), 5–100 m, 13°24'51"S, 48°18'20"E, 07.II.2006, D. C. Daly, J. Raharimampionona, R. Ranaivojaona, & J. Hervais 13090 (NY, TEF); Diana, Ambilobe, Anaborano, Galoko Mountains, 300–400 m, 13°35'19"S, 48°42'33"E, 10.II.2006, D. C. Daly, J. Raharimampionona & R. Ranaivojaona 13097 (NY, TEF). Fianarantsoa, Ihorombe, Ivohibe, N limit of Réserve Spéciale d'Ivohibe, 900 m, 22°28'12"S, 46°57'36"E, 6.X.1997, C. Rakotovo, P. J. Rakotomalaza & N. Messmer 827 (G, MO, P; TAN). Toamasina, Analanjirofo, Masoala Peninsula, S of Ambanizana, 0–100 m, 15°28'S, 49°58'E, 25.XII.1989, G. E. Schatz SGE 2919 (MO, NY); near Baie d'Antogil, W of Anandrovola, 100–150 m, 11.IX.1957, Service Forestier 18238 (MO, TEF [not seen]); Masoala Peninsula, Ambanizana, along Androka River, 0 m, 15°39'30"S, 49°57'30"E, VI.1993, M. L. Zjhra & J. Hutcheon 433 (NY, P[P00501657]).

DISTRIBUTION AND ECOLOGY. — *Canarium compressum*, sp. nov. is known from Ambanja in the Sambirano region to Maroantsetra and Ambanizana, found in forested stream-beds, forest on steep slopes with rock outcrops, and sublittoral forest in rocky soils, between 0–500 (900) m elevation. Known to flower Jan. and to fruit much of the year.

ETYMOLOGY. — The specific epithet refers to the compressed inflorescence axes, particularly evident in fruit.

DESCRIPTION

Trees, reproductive size 8–28 m tall, to 60 cm diam, sometimes with low plank buttresses. Trunk angular. Outer bark pale gray (pinkish: Zjhra & Hutcheon 433), thick, with sparse lenticels, shed in thin, very large, very irregular plates pulling away acropetally from trunk. Resin clear. Leaves 19–40 (51) cm long, 4–6-jugate; petiole 6.3–8.3 cm (to 11 cm in Daly et al. 13090), petiole and rachis with sparse to scattered erect whitish hairs to 0.1 mm long and scattered snail-shaped glands, surface also with scattered elongate lenticels; stipules 6–14 mm from petiole insertion, 5–13 mm long, orbicular, usually with constricted base, surface with dense, flexuous, appressed, golden to ferruginous hairs to 0.15 mm long, the scar (2) 3–6 mm long; basal petiolules 6–8 mm long, other laterals 4–10 mm long, terminal one 20–42 mm long, petiolules not canaliculate, lateral pulvinuli inconspicuous; basal leaflets 4.2–9 × 3.4–4.5 cm, broadly ovate, rarely orbicular, other laterals 7.5–18.5 × 4–7.5 cm, (oblong-) ovate, the terminal one 7–17.5 × 3.8–8.2 cm, (oblong-) ovate, leaflet apex gradually and broadly long-acuminate, the acumen 12–27 mm long, the base usually subsymmetrical, cordate to truncate; margin usually flat, leaflets chartaceous, drying dark brown, abaxial surface sometimes slightly glossy, adaxial surface usually glossy; secondary vein framework weakly brochidodromous, often some festooning, secondaries in 12–18 pairs, straight to spreading, spacing decreasing toward base and slightly toward apex, angle almost perpendicular, increasing toward the base; intercostal tertiaries opposite-alternate percurrent, some opposite-percurrent; quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, the surface with scattered thick, appressed white hairs to 0.2 mm long; on adaxial side all veins narrowly prominent except midvein sunk in a groove, the surface glabrous or at base some short hairs as on abaxial side, also sometimes white pustules. Inflorescences 16.5–36 cm long, axes with flexuous to appressed ferruginous hairs to 0.2 mm long and snail-shaped glands but mostly glabrescent on inflorescence, also some elongate raised lenticels; on staminate inflorescences the secondary axes to 21 cm long, bracts c. 2 mm long, broadly ovate or broadly subulate; pedicel 1–1.5 mm long, cylindrical. Staminate flowers 3.4–4.4 mm long; calyx 1.3–2.2 × 2.7–3 mm overall, taller than the ovariodisk, greenish-beige, the lobes 0.5–0.9 mm long, depressed-ovate with apex abruptly sharp-acuminate, slightly spreading; petals 3.4–3.8 × 3–3.4 mm, exposed part longer than calyx, broadly obovate, light yellow-beige, membranaceous; stamens 2.4–2.7 mm long, the anthers 1.25–1.4 mm long, lanceolate in dorsiventral and lateral views; ovariodisk 0.9–1.1 × 0.7–1.15 mm, slightly obovate, apex jagged. On pistillate inflorescences the secondary axes to 10 cm long, bracteoles 2.5–4.2 mm long, ovate, pedicel 1–2.2 × 1.5–1.8 mm. Pistillate flowers 6–8 mm long; calyx 3.8–4 × 5 mm overall, deeply cupular to slightly urceolate, taller than staminodes, reaching base of stigmas, the lobes 0.3–0.8 mm long, perdepressed-deltate, fleshy, adaxial surface with dense white appressed hairs to 0.1 mm long; petals c. 5.9 mm long, exposed part shorter than calyx, ovate, fleshy, slightly spread-



FIG. 9. — *Canarium compressum* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet, with detail of leaflet (**A'**); **B**, shoot apex with stipule; **C**, petiole base with stipule; **D**, detail of inflorescence with bracts, bracteoles and bud; **E**, pistillate flower; **F**, pistillate flower with part of calyx and one petal removed; **G**, pistillate flower in longisection (**left**); pistil (**center**); longisection with pistil removed (**right**); **H**, portion of infructescence; **A**, **D**–**G**, Schatz 3117 (NY) and field photos by D. Daly of Daly *et al.* 13093. Scale bars: **A**, 2 cm; **B**, **C**, 5 mm; **D**–**G**, 3 mm; **A'**, not to scale.

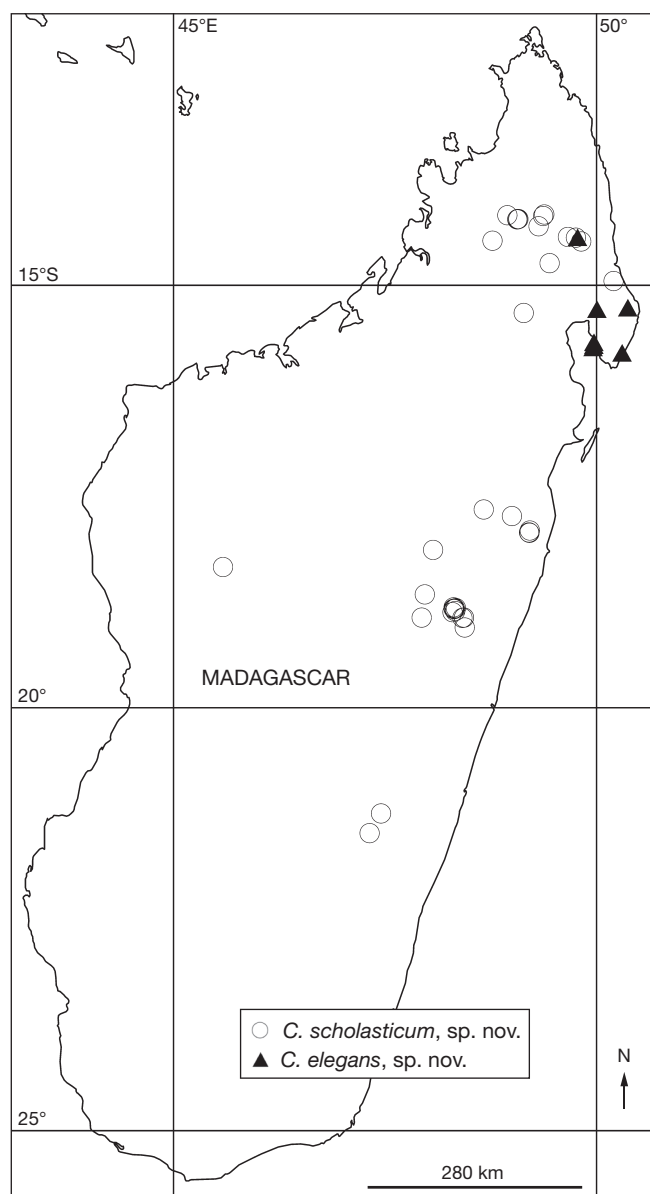


FIG. 10. — Distributions of *Canarium elegans* Daly, Raharim. & Federman, sp. nov. and *C. scholasticum* Daly, Raharim. & Federman, sp. nov.

ing; staminodes inserted on rim of a short hypanthium, the antesealous staminodes 2.5 mm long with anthers 1.25 mm long, the antepetalous ones 2.1 mm long with anthers 1.1 mm long, the anthers oblong-lanceolate in dorsiventral view and lanceolate in lateral view; pistil 4.5 × 1.7 mm overall, the style 1 mm long and thick, the stigma 1 mm high, 3-lobed, pistil surface with dense ascending ferrugineous hairs to 0.15 mm long. Fruiting pedicel 3-7 × 3-4 mm, cylindrical, with sparse raised lenticels, fruiting calyx 5-6 mm long overall, patent to spreading, the lobes usually distinct, <2 mm long. Fruits 3.4-3.8 × 2.5-2.6 cm, broadly oblong-ellipsoid or broadly slightly ovoid, the apex rounded to obtuse, the base rounded; surface with dense to sparse, relatively large round lenticels, usually raised, whitish, also with scattered descending to appressed-retorse white hairs to 0.25 mm long.

NOTES

Canarium compressum, sp. nov., *C. egregium*, sp. nov. and *C. pilicarpum*, sp. nov. all belong to a group of 10 species that all have relatively large, broad leaflets with truncate to slightly cordate base. On all three the leaflet abaxial pubescence is sparse to scattered or the surface glabrous, stipules not inserted at the petiole base and usually 5-13 mm long, and the secondary veins spreading to arcuate (vs subperpendicular). *Canarium compressum*, sp. nov. can be distinguished from the other two by the petiole usually longer (6.3-8 vs 1.8-6.8 mm), leaflet acumen long (10-30 vs 2-6(10) mm), secondary veins subperpendicular to the midvein (vs spreading to arcuate), and inflorescence axes markedly compressed.

Canarium egregium Daly, Raharim. & Federman, sp. nov.
(Figs 6; 11).

Small to medium-sized trees, leaves 6-8-jugate, leaflet apex gradually acuminate, and lateral leaflet base truncate to slightly cordate; distinguished from C. madagascariense Engl. by the stipules inserted 2-5 mm from petiole insertion (vs at petiole base in C. madagascariense), stipules symmetrical (vs oblique), inflorescence with darker ferrugineous pubescence, infructescences shorter (c. 11 vs 18 cm) and fruits slightly obovoid (vs narrowly ovoid).

TYPUS. — **Madagascar.** Prov. Antsiranana, Diana, Ambilobe, Région Anaborano, Galoko Mountains, 300-400 m elev., 13°35'19"S, 48°42'33"E, 10.II.2006, D. C. Daly, J. Raharimampionona & R. Ranaivojaona 13103 (holo-, NY!; iso-, G!, MO!, TEF!).

PARATYPI. — **Madagascar.** Antsiranana, Diana, Ambanja, Réserve Naturelle Intégrale de Tsaratanana, 561 m, 13°53'47"S, 048°51'57"E, 17.XI.2001, P. Antilahimena 834 (MO); Diana, Ambilobe, Anaborano, Galoko Mountains, 300-400 m, 13°35'19"S, 48°42'33"E, 10.II.2006, D. C. Daly, J. Raharimampionona & R. Ranaivojaona 13096, 130988 (NY, TEF).

DISTRIBUTION AND ECOLOGY. — *Canarium egregium*, sp. nov. is known only from the Sambirano region, in the upper Ramena and the Réserve Naturelle Intégrale de Tsaratanana, where it is a small to medium-sized tree in moist forests with a relatively closed canopy c. 25 m high, on steep slopes with rock outcrops, between 150-560 m elevation. Flowering Feb., fruiting Nov.

ETYMOLOGY. — The specific epithet *egregium* means "to stand apart," which is certainly true of this distinctive new species.

DESCRIPTION

Trees, reproductive size 13-20 m × 15-47 cm diam, with plank buttresses to 1 m high. Outer bark gray, thin, rough, some raised lenticels, shed in thin, irregular, variable-sized plates; inner bark reddish(-tan). Leaves 30-35 cm long, 6-8-jugate, petiole 4.5-6.8 cm long, usually dilated at base, petiole and rachis on young leaves with dense fine straight (but variously oriented) hairs to 0.7 mm long (these sometimes deciduous), also with dense capitate glands and dense flexuous hairs to 0.2 mm long; stipules inserted 2-5 mm from petiole insertion, 5-8 mm long, broadly ovate or possibly suborbicular, with dense appressed to ascending ferrugineous hairs, stipule scar c. 4 mm long; basal petiolules 4-5 mm long, other laterals 5-11 mm long, terminal 20-25 mm long, pulvinuli

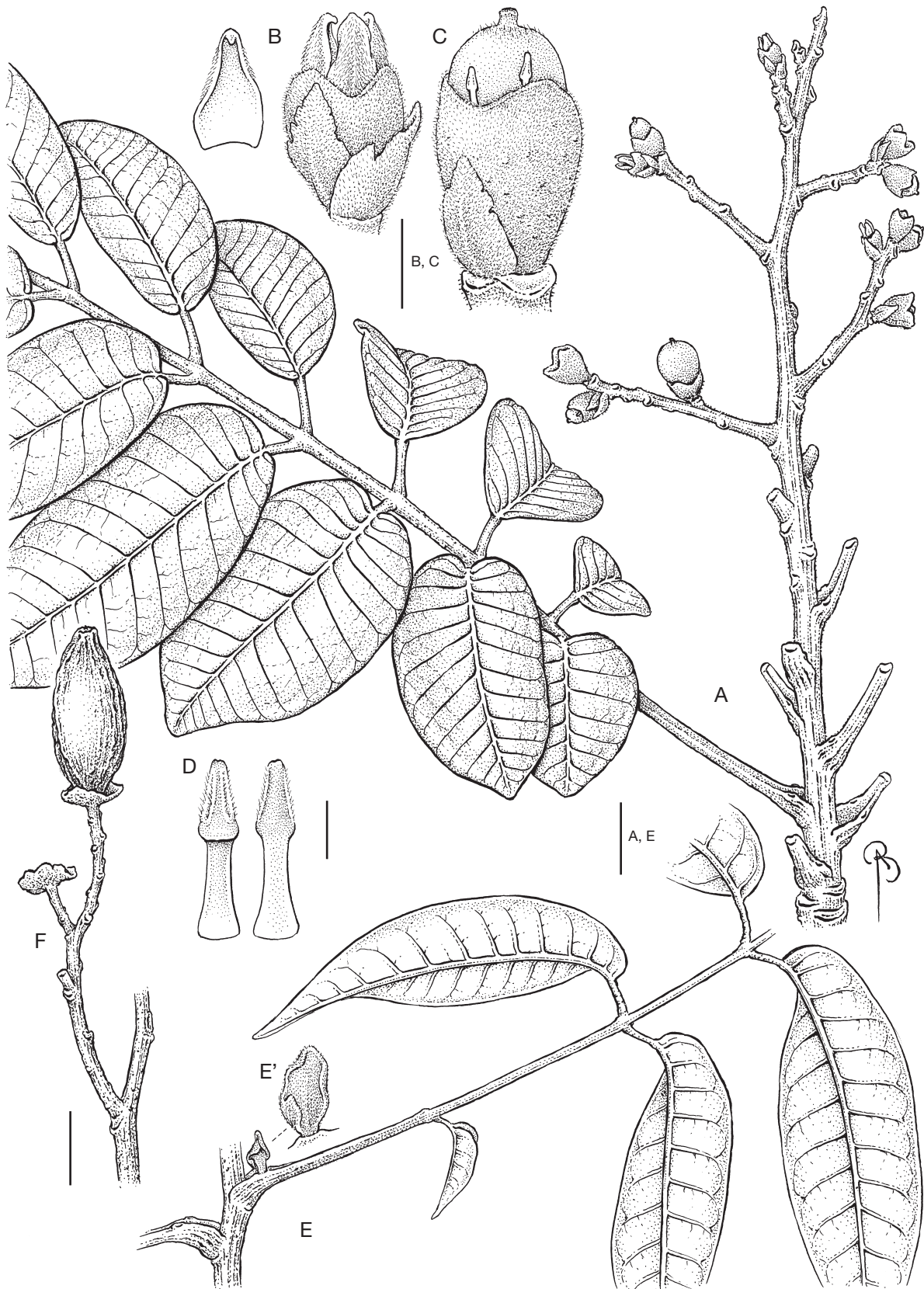


FIG. 11. — *Canarium egregium* Daly, Raharim. & Federman, sp. nov.: **A**, branchlet with pistillate flowers and immature fruits; **B**, pistillate flower with bracteoles and petal (left); **C**, young developing fruit with persistent bracteole, calyx and staminodes; **D**, adaxial and abaxial views of staminode; **E**, basal portion of leaf with detail of stipule; **F**, portion of infructescence; **A-D**, *Daly et al.* 13103 (NY sheet and field photos by D. Daly); **E, F**, *Antilahimena* 834 (MO). Scale bars: A, E, F, 2 cm; B, C, 5 mm; D, 1 mm; E', not to scale.

inconspicuous; basal leaflets 3.5–4.5 × 2.6–3 cm, broadly ovate, other laterals 6–19 × 2.8–6.6 cm, oblong(-lanceolate) to (broadly) ovate, terminal one 8–14 × 4.1–5.5 cm, ovate to broadly elliptic; leaflet apex gradually acuminate (rarely acute), the acumen to 10 (20) mm long, base of laterals cordate to truncate, subsymmetric, less often slightly oblique; margin often slightly revolute, leaflets coriaceous, drying grayish-brown, abaxial side somewhat glossy and adaxial side less so; secondary venation weakly brochidodromous with some festooning, secondary veins in 13–19 pairs, slightly spreading (almost straight), insertion excurrent, spacing decreasing toward apex and especially toward base, angle slightly acute but increasing toward the base, some perpendicular intersecondary veins and (often multiple) perpendicular epimedial tertiaries, the intercostal tertiaries alternate-percurrent, quaternaries regular-polygonal; on leaflet abaxial side the midvein and secondaries prominent, the rest narrowly prominulous, the surface papillate and glabrous or the midvein with hairs as on the rachis; on adaxial side all venation narrowly prominulous except the midvein sunk in a groove, glabrous. Pistillate inflorescences (staminate unknown) 15.5–23 cm long, robust, the secondary axes 2–6 (13.5) cm long, axes with dense fine darkly ferrugineous hairs to 0.6 mm; bracteoles 6–11 mm long, broadly ovate, slightly acuminate and with slightly constricted base, the scars broad and semi-clasping; pedicel 0–2 mm long, slightly clavate. Pistillate flowers *c.* 1 cm long; calyx deeply cupular and fleshy, *c.* 7 mm long, red, the lobes rounded perdepressed-deltate, 1–3 mm long, surface with dense thick retrorse-appressed to descending ferrugineous hairs to 0.2 mm; corolla (passed) red, exposed part negligible. Infructescences 11 cm long, secondary axes to 3 cm long; persistent bracts on primary axes *c.* 8 mm long, fleshy, ovate, semi-clasping, the margin long-ciliate. Fruiting pedicel *c.* 4 mm long, subcylindric, slender, sparsely raised-lenticellate; fruiting calyx large, *c.* 12 mm long, the lobes only slightly distinct, nearly patent, chartaceous, sparsely raised-lenticellate, with long, appressed, ferrugineous hairs. Fruits (immature) 4.3–5 × 1.9–2 cm, narrowly ovoid (slightly obovoid when very young), apex slightly acuminate but apex tip truncate, base acute, surface smooth or sparsely and finely lenticellate, glabrous or with a few scattered ascending fine white hairs to 1 mm long near apex.

NOTES

Canarium egregium, sp. nov. belongs to a group of 10 species that all have relatively large, broad leaflets with truncate to slightly cordate base. Like *C. madagascariense*, it has numerous leaflets (6–8 vs 7–10 pairs), stipules conspicuous, leaflet gradually acuminate, primary bracts on inflorescence large and often persistent, calyx in fruit large, and glabrous fruit. *Canarium egregium*, sp. nov. differs by the stipules 2–5 mm from petiole insertion (vs at petiole base), the stipules symmetrical (vs oblique), leaflet secondary vein angle more acute (except at base), inflorescence with darker ferrugineous pubescence, infructescences shorter (*c.* 11 vs 18 cm), fruiting pedicel shorter (*c.* 4 vs 8 mm), and distinct fruit shape (slightly obovoid vs narrowly ovoid).

Canarium elegans Daly, Raharim. & Federman, sp. nov.
(Figs 10; 12D–H).

Small to medium-sized trees, petiole and rachis with sparse to scattered hairs and capitate glands, leaves 1–3-jugate, lateral leaflet base consistently acute, fruits (ob)ovoid or oblong-ellipsoid, lenticellate; distinguished from C. manongarivum Daly, Raharim. & Federman, sp. nov. by the terminal leaflet obovate or less often elliptic (vs consistently elliptic in C. manongarivum, sp. nov.), secondary vein angle usually slightly increasing toward apex and decreasing toward base (vs angle acute and uniform), and the fruit 3.2–5.2 × 2.2–2.6 cm (vs 2.8–2.9 × 1.8–2.1 cm).

TYPUS. — **Madagascar.** Antsiranana, Masoala Peninsula, W of Ambohitralanana, forest near Sahafary, 75 m elev., 15°16'S, 50°22'E, 19.VII.1997, G. McPherson 17118 (holo-, NY!; iso-, G, MO, TAN).

PARATYPI. — **Madagascar.** Antsiranana, Sava, Parc National Masoala, km 21 Sahamalaza-Vakoanina, 0–113 m, 15°48'S, 50°18'E, 15–16.II.1996, J. Aridy & Moise 141 (MO, NY, P, TEF); Masoala Peninsula, S of Ambanizana, 110–260 m, 15°40'24"S, 49°57'51"E, 24.XI.1994, N. Vasey & N. Velo 122 (MO, NY). Toamasina, Analanjirofo, Ambanizana, Parc National Masoala, Tampolo, 25 m, 15°42'43"S, 49°57'48"E, 16.I. 2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa, J. Aridy & Senario 12963 (NY, TEF), 12965 (NY, TEF); Parc National Marojejy, 850 m, 14°26'07.8"S, 49°46'19.2"E, 27.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa & D. Ravelonarivo 13024 (NY, TEF); Analanjirofo, Ambanizana, Tampolo, 200–400 m, 15°44'12"S, 49°57'24"E, 12.X.2001, R. Randrianaivo 668 (NY).

DISTRIBUTION AND ECOLOGY. — *Canarium elegans*, sp. nov. is known from NE Madagascar, from Masoala National Park to Marojejy National Park. It is a relatively small tree found in dense lowland forest, sublittoral forest, or wet forest on steep slopes, between 0–400 (850) m elevation. Flowering Jan., fruiting (Feb.) July–Oct.

COMMON NAME. — Aramitsitsy.

ETYMOLOGY. — The specific epithet refers to the rather delicate, attractive foliage.

DESCRIPTION

Trees, reproductive size 12–18 (30) m, to 45 cm diam. Branched plank buttresses to 1.5 m high and extending to 4 m from base. Outer bark gray, thin, pitted, with sparse raised lenticels, shed in small thin irregular plates; inner bark orange with thin red striations. Resin clear or translucent. Leaves 14–31 cm long, 1–3-jugate; petiole 3.4–8 cm long, petiole and rachis with scattered capitate glands; stipules (3) 7–20 (24) mm from leaf insertion, 2–3 mm long, obovate with clawed base, chartaceous or more often coriaceous, with dense to sparse thick hairs to 0.05 mm long, stipule scar to 1 mm long; basal petiolules 4–12 mm long, other laterals 6–17 mm long, terminal one (16) 20–50 mm long, petiolules deeply canaliculate, lateral pulvinuli distal and conspicuous, terminal pulvinulus long and conspicuous; basal leaflets 2.5–8.5 × 1.5–4 cm, slightly (ob)ovate, rarely subrotund, other laterals 3.2–11 × 1.6–4.4 cm, elliptic or less often oblong-elliptic or oblanceolate, terminal one 5–9 × 2.5–3.8 cm, obovate or less often elliptic; leaflet apex usually abruptly and broadly short-acuminate, the acumen 2–5 mm long, the laterals with base symmetric, acute and attenuate, rarely obtuse; margin



FIG. 12. — **A-C**, *Canarium findens* Daly, Raharim. & Federman, sp. nov.: **A**, branchlet with detail of stipular scars (**A'**); **B**, apex with stipules; **C**, detail of leaflet margin; **D-H**, *Canarium elegans* Daly, Raharim. & Federman, sp. nov.: **D**, portion of infructescence; **E**, branchlet with detail of leaflet margin (**E''**) and of stipules (**E'**); **F**, bud with bracteole; **G**, leaf with detail of petiole base and stipules (**G'**); **H**, portion of infructescence; **I**, fruit and longisection (left); **A-C**, *Daly et al.* 13033 (NY); **D**, *Miller & Lowry* 3956 (NY); **E, F**, *Daly et al.* 13024 (NY); **G**, *Daly et al.* 12963 (NY); **H**, from *Vasey & Velo* 122 (MO); **I**, *McPherson* 17118 (NY). Scale bars: **A, D, E, G-I**, 2 cm; **B**, 5 mm; **C**, 1 cm; **A', E', G'**, not to scale.

flat; leaflets drying brown, coriaceous to chartaceous, dull; secondary vein framework brochidodromous but looping near the margin, secondaries in 7-11 pairs, spreading, insertion excurrent or slightly decurrent, spacing often slightly irregular but decreasing toward apex, angle usually slightly increasing toward apex and decreasing toward base, intercostal tertiaries alternate percurrent and irregular-reticulate, perpendicular epimedial tertiaries usually 1 per pair of secondaries, quaternaries irregular-reticulate; on abaxial surface the midvein broadly prominent, secondaries prominulous but usually sunk in a groove, rest prominulous, surface glabrous; on adaxial side the midvein narrowly prominulous but sunk in a groove, secondaries same or flat or impressed, rest of venation flat or broadly prominulous, surface glabrous. Staminate inflorescences terminal, *c.* 4.9 cm long \times 2.3 mm diam (with buds), the axes with scattered to sparse appressed thick golden hairs to 0.1 mm long, also dense to sparse capitate glands; bracts 3.3-4.6 mm long, subulate to lanceolate. On staminate buds the calyx 3.2 \times 2.25 mm overall, the lobes 1.25 mm long, ovate, calyx with dense to sparse or scattered flexuous golden hairs to 0.1 mm long, also capitate glands; corolla with dense retrorse-appressed to flexuous paler golden hairs to 0.25 mm long. Infructescences 2.5-9.5 cm long, unbranched or sparsely so, secondary axes 0-2 cm long, fruiting pedicel 4-10 \times 2.8-3.1 mm, cylindrical, fruiting calyx 3-5 mm long overall, the lobes distinct, 1-2 mm long, patent to spreading. Fruits (immature) 3.2-3.8 \times 2.2-2.6 cm (Masoala collections) or 4.5-5.2 \times 1.7-2.3 cm (Marojeje collections), (ob)ovoid (Masoala) or oblong-ellipsoid (Marojeje), green or whitish, maturing brown, apex rounded to subacute, base obtuse, surface with usually dense, somewhat raised, ferruginous lenticels.

NOTES

Like *C. indistinctum*, sp. nov., *C. elegans*, sp. nov. has 1-3-jugate leaves, the petiole and rachis with only sparse to scattered hairs, stipules 2-3 mm long, the stipular scar 1-1.5 mm long, lateral leaflet base usually symmetric, and similar leaflet venation and vein prominence. The latter can be distinguished by the stipules 8-24 (vs 4-8 in *C. indistinctum*, sp. nov.) mm from petiole insertion, the lateral leaflets elliptic or less often oblong-elliptic or oblanceolate (vs ovate to slightly oblong-ovate), the fruit pedicel 4-10 mm long (vs 3-4 mm), and the fruit 3.2-5.2 \times 1.7-2.6 cm (vs 2.8-3.5 \times 1.7-1.9 cm) and (ob)ovoid to oblong-ellipsoid (vs (oblong-)obovoid and trigonous).

Like *C. manongarivum*, sp. nov., *C. elegans*, sp. nov. has the petiole and rachis with only sparse to scattered hairs, the lateral leaflet base consistently acute, the lateral petiolules 2.5-17 mm long, the leaflets dull, and the fruit with the surface dull, rough, and lenticellate. The latter can be distinguished by the terminal leaflet obovate or less often elliptic (vs consistently elliptic in *C. manongarivum*, sp. nov.), secondary vein angle usually slightly increasing toward apex and decreasing toward base (vs angle acute and uniform), adaxial leaflet surface not punctate (vs black-punctate), and the fruit 3.2-5.2 \times 2.2-2.6 cm (vs 2.8-2.9 \times 1.8-2.1 cm).

Canarium ferrugineum Daly, Raharim. & Federman, sp. nov. (Figs 4; 13).

Small to medium-sized trees, leaves 2-4(5)-jugate, terminal leaflet usually (broadly) obovate, the fruits usually broadly ovoid to slightly oblong-obovoid and densely lenticellate; distinguished from C. scholasticum Daly, Raharim. & Federman, sp. nov. *by the stipules 1-3 (vs 5-6) mm long, leaflets chartaceous (vs coriaceous in C. scholasticum, sp. nov.), the apex usually abruptly and narrowly sharp-acuminate (vs rounded to abruptly and broadly short-acuminate), the base acute to rounded to truncate (vs cordate or less often truncate), and stamens inserted on side of ovariodisk (vs around base).*

TYPUS. — **Madagascar.** Prov. Toamasina, W of Vavatenina, Réserve Naturelle Intégrale Zahamena, forest of Amboditamenaka, 500-750 m elev., 17°44'S, 49°00'E, 15-20.IX.1993, S. Malcomber *et al.* 2574 (holo-, NY!; iso-, G, K, MO, P[P00501656]!, S, TAN, WAG).

PARATYPI. — **Madagascar.** Antsiranana, Nosy Komba, Andranobe, Nosy Be [Nossi Be], 225 m, 09.XII.1947, Bernard 1288 (NY). Fianarantsoa, Vatovavy-Fitovinany, Ranomafana, 21°15'S, 47°27'E, VII.1988, F. J. White 2 (MO). Toamasina, Analanjirofo, Vavatenina, Miarinarivo, Anamborano, Savaharina, Réserve Naturelle Intégrale Zahamena, 17°41'08"S, 48°59'43"E, 650 m, 12.VI.2001, S. Rakotonandrasana 486 (NY), N of Andraratanantsoitra, Réserve Naturelle Intégrale Zahamena, 590 m, 17°43'S, 49°01'E, 14.XII.1993, L. M. Randrianjanaka & B. M. J. Arnaud 19 (MO, NY, P[P00501655], TAN).

DISTRIBUTION AND ECOLOGY. — *Canarium ferrugineum*, sp. nov. is known from Ranomafana National Park in the south to Andasibe and Moramanga in central Madagascar, north to Zahamena Reserve and Marojeje, as well as within the Sambirano region. It occurs in wet forest on steep slopes with discontinuous canopy, also moist lowland forest, submontane forest, and rarely sublittoral forest, between (100) 550-950 m elevation. Known to flower Dec. and to fruit most of the year. Eaten by *Varecia* lemurs (White 2).

ETYMOLOGY. — The specific epithet refers to the distinctly rusty pubescence on the abaxial leaflet surface.

USES. — Wood used to make pirogues (canoes).

DESCRIPTION

Trees, reproductive height 7-25 m. Outer bark gray-white, shed in thick brittle plates; inner bark rose-colored. Resin clear. Leaves 21-74 mm long, 2-4(5)-jugate (-8 in Daly *et al.* 13094); petiole 4.1-11 cm, petiole and rachis usually with dense ascending golden hairs to 0.5 mm, also with dense snail-shaped glands, thick erect golden hairs to 0.1 mm, and (when longer hairs not present) flexuous golden hairs to 0.15 mm; stipules (3)5-12(16) mm from petiole insertion, 3-4(8) mm long, broadly ovate to (obliquely) orbicular, sometimes constricted at base, both sides with dense appressed hairs to 0.4 mm long or dense flexuous hairs to 0.3 mm long, scar 1-3 mm long; lateral petiolules 4-14 mm (to 20 mm on sterile leaves), terminal petiolule 15-40 mm long, petiolules not canaliculate, pulvinuli inconspicuous; basal leaflets 2.2-9 \times 1-7 cm, ovate (rarely elliptic-ovate) or broadly elliptic, other laterals 3.5-22.4 \times 1.7-6.5 cm, ovate to elliptic, terminal one 5.8-19.4 \times 2.1-7.1 cm, (broadly) obovate, less often (broadly) ovate, leaflet apex usually abruptly and narrowly and sharply acuminate, the acumen (2) 5-12 mm long (to 20 mm on sterile branchlets); lateral leaf base symmetric or

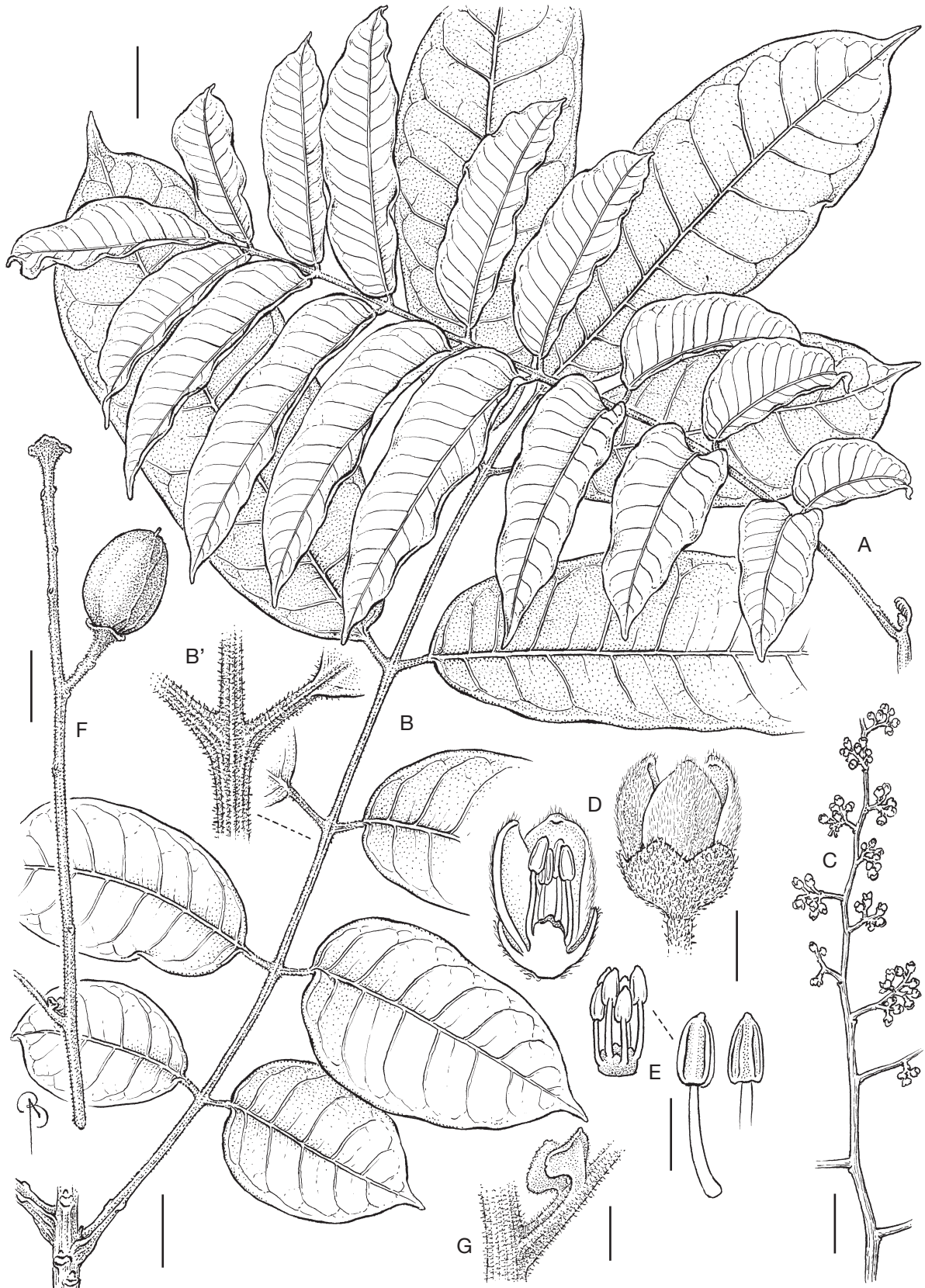


FIG. 13. — *Canarium ferrugineum* Daly, Raharim. & Federman, sp. nov.: **A**, leaf; **B**, leaf with detail of rachis and petiolules (**B'**); **C**, portion of staminate inflorescence; **D**, staminate flower (right) and longisection (left); **E**, stamens and ovariodisk (left) and stamen; **F**, portion of infructescence; **G**, base of petiole and stipules; **A**, Daly et al. 13094 (NY); **B**, Daly & Ranaivojaona 10351 (NY); **C-E**, Bernard 1288-RN (NY); **F-G**, Malcomber et al. 2574 (NY). Scale bars: **A**, 4 cm; **B**, **C**, **F**, 2 cm; **D**, 2 mm; **E** (individual stamen), 1 mm; **G**, 5 mm.

rarely slightly oblique, acute to rounded to truncate; leaflets drying dark brown, chartaceous, dull; secondary vein fabric weakly brochidodromous but looping submarginal, less often eucamptodromous, secondaries in 9-16 pairs, slightly arcuate, spacing uniform to somewhat irregular, the angle uniform or increasing distally, 1-2 perpendicular and basiflexed epimedial tertiaries per pair of secondaries, intercostal tertiaries mixed opposite-alternate percurrent and sometimes random-reticulate, also admedially branched toward secondary vein axils; on abaxial side the midvein and secondaries prominent, quaternaries flat to narrowly prominulous, midvein with dense erect golden hairs to 0.45 mm and sparse snail-shaped glands (sparser on secondary veins), rest of surface either with dense erect hairs or with sparse appressed thick golden hairs to 0.1 mm and scattered snail-shaped glands and long erect hairs; on adaxial side midvein and secondaries narrowly prominulous but sunk in a groove, rest of veins flat or narrowly prominulous, midvein sometimes pubescent as on abaxial side, otherwise all the surface with scattered thick erect golden hairs to 0.1 mm and snail-shaped glands. Inflorescences 8.5-25 cm, the axes as well as bracts and pedicel with dense flexuous golden hairs to 0.4 mm and snail-shaped glands; on staminate inflorescences the secondary axes to 5.8 cm long, often densely branched, bracts on secondary axes 1.6-2.5 mm long, subulate to lanceolate, bracteoles 0.6-1 mm long, bracts usually caducous. Staminate flowers 4-4.6 mm long at anthesis, the calyx 1.7-2.4 × 2.3-2.7 mm, exceeding the ovariodisk, green, the lobes 0.6-1 mm, rounded-deltate, abaxial surface with dense capitate glands, sparse ascending to appressed thick golden hairs to 0.2 (0.25) mm long, and scattered flexuous golden hairs to 0.2 mm, adaxial surface with dense appressed-retrorse golden hairs to 0.15 mm; petals 3.9-4 mm long, exposed part as long as the calyx, petals obovate with rounded and very slightly acuminate apex, milky white, abaxial surface with dense appressed to ascending pale golden hairs to 0.2 mm long, adaxial surface glabrous; stamens 2.5-2.6 mm long, anthers 1-1.05 mm long, yellow, lanceolate in dorsiventral view, ovate in lateral view; ovariodisk 0.9-0.8 mm, slightly obovoid, the apex craggy. Secondary axes on infructescences to 2.5 cm long; fruiting pedicel 3-11 × 2.7-3.5 mm, clavate, fruiting calyx 3-5 mm long, the lobes distinct, 2-4 mm long but sometimes broken off, broadly triangular, patent. Fruits 3-3.5 × 2-2.4 cm (4.4 × 3 cm on *White 2*), broadly ovoid to slightly oblong-obovoid, slightly trigonous, or broadly (oblong-)ellipsoid, apex rounded or obtuse or rarely acute, base obtuse, pale brown, green-brown, or brick red, the surface with dense fine raised ferrugineous lenticels and dense retrorse-appressed golden hairs to 0.5 mm long among the lenticels. Seedlings with cotyledons reddish green and fleshy; first eophylls opposite, simple, densely pubescent; first metaphylls alternate and unifoliolate.

NOTES

Like *C. scholasticum*, sp. nov., *C. ferrugineum*, sp. nov. has the petiole (1.4) 4.1-11 cm long, the basal petiolules (2) 4-14 mm long, the terminal leaflet obovate or less often broadly elliptic or ovate, the leaflet apex rounded or abruptly acuminate, the

apex tip eglandular, the leaflet secondary vein angle increasing or uniform toward base, the leaflet abaxial surface usually pubescent, and the fruit surface lenticellate and usually pubescent. The latter can be distinguished by its stipules 1-3 (vs 5-6 in *C. scholasticum*, sp. nov.) mm long, the scar 1-3 (vs 3-5) mm long, petiole and rachis usually with dense ascending golden hairs to 0.5 mm (and other hair types) (vs sparse to scattered erect ferrugineous hairs to 0.05 mm long), leaflet apex usually abruptly and narrowly sharp-acuminate, the acumen (2) 5-12 mm long (vs rounded to abruptly and broadly short-acuminate, the acumen 2-6 mm long), the base acute to rounded to truncate (vs cordate or less often truncate, very rarely acute), on abaxial surface the midvein with dense erect golden hairs to 0.45 mm (vs sparse to scattered erect ferrugineous hairs to 0.05 mm long, also flexuous ferrugineous hairs to 0.2 mm long), the leaflets chartaceous (vs coriaceous), and the stamens inserted on side of ovariodisk (vs around the base).

Canarium findens Daly, Raharim. & Federman, sp. nov.
(Figs 1; 12A-C)

Large trees, leaves 2-3-jugate, leaves rigidly coriaceous, fruit oblong-(ob)ovoid to oblong to ovoid, densely lenticellate; distinguished from C. obtusifolium Scott-Elliot by the petiole and rachis surface sparsely short-pubescent (not densely pubescent with hairs to 0.3 mm long).

TYPUS. — **Madagascar.** Antsiranana, Parc National Marojejy, along trail to summit of Marojejy Est, NW of Mandena, 850-1000 m elev., 14°26'S, 49°15'E, 11.II.1989, J. S. Miller & P. P. Lowry II 3956 (holo-, NY!; iso-, MO, P[P00501653], TAN).

PARATYPI. — **Madagascar.** Antsiranana, Sava, Parc National Marojejy, 900 m, 14°26'07.8"S, 49°46'19.2"E, 28.I.2006. D. C. Daly, J. Raharimampionona, J. Razanatsoa & D. Ravelonarivo 13033 (NY, TEF), Réserve Spéciale d'Anjanaharibe-Sud, 1161-1424 m, 14°46'15"S, 49°28'E, 21.III.1994, D. Ravelonarivo *et al.* 97 (MO, NY, P[P00501654], TAN).

DISTRIBUTION AND ECOLOGY. — *Canarium findens*, sp. nov. is known only from NE Madagascar, in Marojejy National Park and the Réserve Spéciale Anjanaharibe Sud, where it is a large tree usually of (lower) montane wet forest on very steep slopes between 550-1424 m elevation. Fruiting Feb.-Apr.

COMMON NAME. — Haramin-tsitsihy.

ETYMOLOGY. — The specific epithet refers to the tendency of the thick leaflets to split when pressed.

DESCRIPTION

Trees, reproductive size 25-40 m, to at least 50 cm diam. Low thick plank buttresses present. Outer bark gray, thin, rough, with raised lenticels, shed in thick irregular plates; inner bark reddish. Resin translucent white. Leaves 11-46.5 cm long, 2-3-jugate; petiole (2.5) 6.5-10.4 cm long, petiole and rachis with dense ascending golden hairs to 0.3 mm long, also with elongate lenticels; stipules 5-13 mm from petiole insertion, c. 4 mm long, semi-orbicular, caducous, the scar 1.5-4 mm long; basal petiolules 5-20 mm long, other laterals 6-33 mm long, terminal one 22-52 mm long, petiolules not canaliculate,

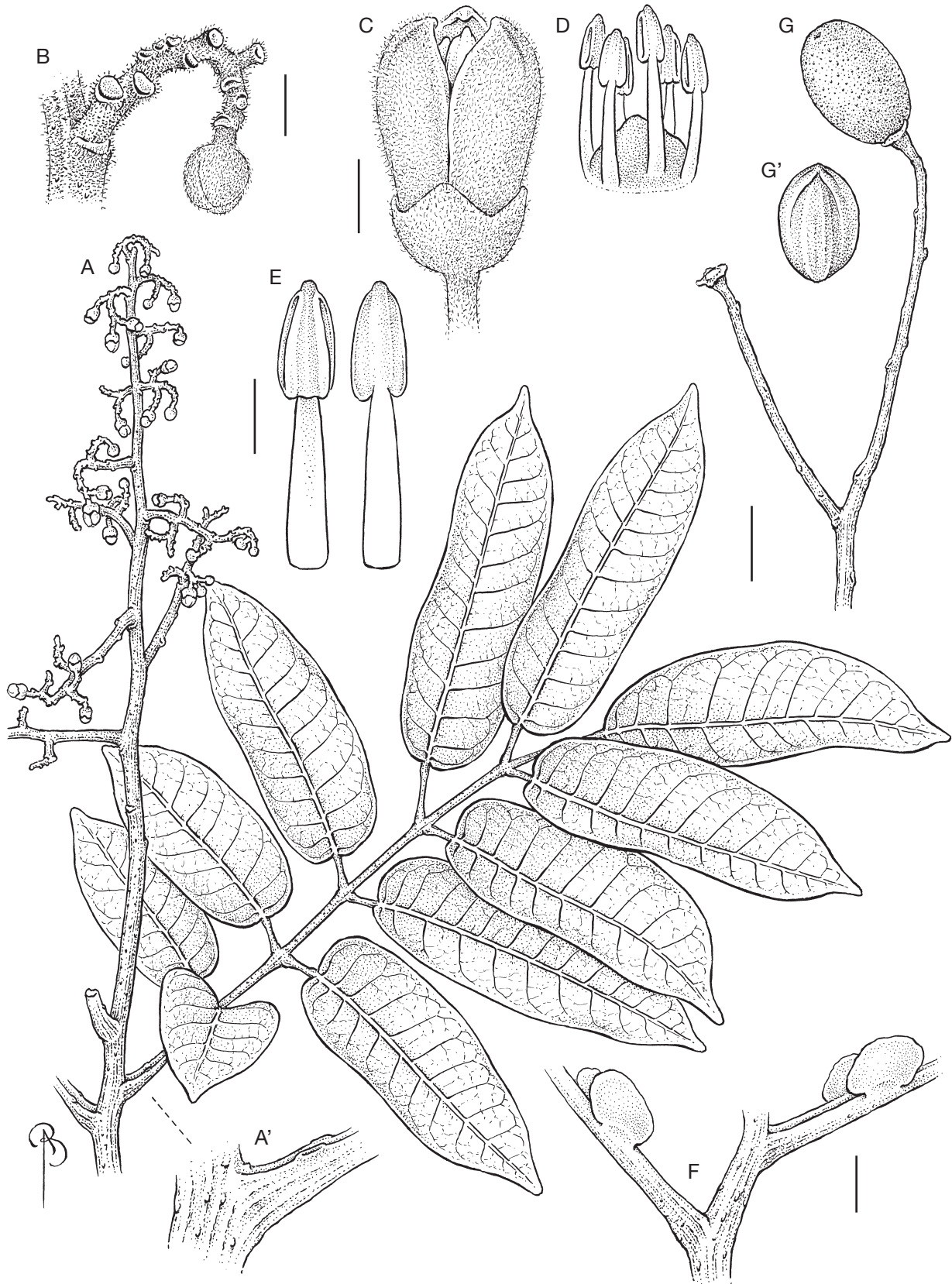


FIG. 14. — *Canarium galokense* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet with detail of petiole base and stipular scars (**A'**); **B**, portion of inflorescence with pendent bud; **C**, staminate flower; **D**, stamens and ovariodisk; **E**, ventral and dorsal views of stamen; **F**, two petiole bases with stipules; **G**, portion of infructescence with pyrene (**G'**); **A-E**, *Daly et al.* 13100 (NY); **F-G**, *Callmender et al.* 600 (NY). Scale bars: A, G, G', 2 cm; B, C, D, 2 mm; E, 1 mm; F, 5 mm; A', not to scale.

distal pulvinuli sometimes conspicuous; basal leaflets 3-12 × 2.5-8.5 cm, broadly (ob-)ovate to subrotund, other laterals 4-16.2 × 2.4-7.2 cm, (broadly) obovate, rarely broadly ovate, leaflet apex abruptly and broadly short-acuminate, sometimes rounded, the acumen 0-2 mm long, lateral leaflet base usually symmetric to slightly oblique, cuneate to acute or truncate, terminal leaflet 7.5-15 × 32.85 cm, obovate; leaflet margin usually revolute or sometimes flat; leaflets drying dark brown, markedly coriaceous, dull, often brittle and splitting when pressed; secondary vein fabric usually brochidodromous but looping at the margin and sometimes appearing eucamptodromous on adaxial side, secondaries in 8-12 pairs, essentially straight, insertion slightly decurrent, spacing sometimes irregular, angle decreasing toward apex and increasing toward base, sometimes 1-2 perpendicular epimedial tertiaries present per pair of secondaries, intercostal tertiaries and quaternaries opposite-alternate percurrent; on abaxial surface all veins prominent, all surface with sparse ascending golden hairs to 0.25 mm long (dense on midvein through tertiaries); on adaxial surface all veins flat or slightly impressed except midvein sometimes prominulous and sunk in a groove, the surface with descending ferrugineous hairs to 0.5 mm long. Infructescences 22-26 cm long, secondary axes to 12 cm, all axes with scattered to dense, fine, flexuous golden hairs to 0.3 mm long, also scattered straight golden hairs to 0.7 mm long; fruiting pedicel 4-10 mm long, cylindrical to slightly clavate, fruiting calyx 6-7 mm long, spreading to almost patent, the lobes often distinct, 2-3 mm long but sometimes broken off. Fruits 2.8-3.5 × 1.5-2.3 cm, oblong-(ob)ovoid to oblong to ovoid, rarely slightly trigonous, apex rounded to almost acute, the base obtuse to truncate, surface with dense, raised, large, ferrugineous lenticels, also with dense appressed golden hairs to 1 mm long among the lenticels.

NOTES

Canarium findens, sp. nov. is easily distinguished from its congeners in Madagascar by its rigidly coriaceous leaflets that are markedly revolute and convex (fresh or dry), usually splitting when pressed and dried. Occasional specimens of *C. obtusifolium* have similar properties, but the latter can be distinguished by the petiole and rachis surface with sparse hairs to 0.05 mm long (vs dense hairs to 0.3 mm long).

Canarium galokense Daly, Raharim. & Federman, sp. nov.
(Figs 1; 14).

Small to medium-sized trees, leaves 3-5-jugate; distinguished from C. betamponae Daly, Raharim. & Federman, sp. nov. and *C. globosum* Daly, Raharim. & Federman, sp. nov. by the stipules closer to the petiole base (7-10 vs 11-30 mm in the other two), the much longer stipular scar (2-6 vs 1-2 mm long), the fruit broadly oblong to broadly ovoid (vs globose to ovoid), and the fruit surface lenticellate (vs smooth and usually glossy).

TYPUS. — **Madagascar.** Antsiranana, Diana, Ambilobe, Anaborano, Galoko Mountains, 300-400 m, 10.II.2006 (m fl), D. C. Daly, J. Raharimampionona & R. Ranaivojaona 13100 (holo-, NY!; iso-, MO!, P!, TEF!).

PARATYPI. — **Madagascar.** Antsiranana, Diana, Ambilobe, Anaborano, Galoko Mountains, 300-400 m, 13°35'19"S, 48°42'33"E 10. II.2006, D. C. Daly, J. Raharimampionona & R. Ranaivojaona 13101 (NY, TEF), 700 m, 13°38'31"S, 48°40'25"E, 25.XI.2006, M. Callmander, J. Vasaha & Malaza 600 (G, MO, P, TAN).

DISTRIBUTION AND ECOLOGY. — To date, *Canarium galokense*, sp. nov. is known only from the Sambirano region in the Galoko mountains, in forest on steep slopes with rock outcrops and relatively closed canopy to 25 m, at 300-700 m elevation. Known to flower in Feb. and fruit in Nov.

DESCRIPTION

Trees, reproductive size 10-25 m × 10-26 cm diam. Outer bark (Daly *et al.* 13100) relatively smooth, with some raised lenticels, very finely & shallowly fissured, inner bark orangish. Leaves 21-41 cm long, 3-5-jugate; petiole 3.7-7.7 cm long, petiole and rachis with scattered to sparse thick erect golden hairs to 0.1 mm long and capitate glands; stipules inserted 3-10 mm from petiole insertion, 4.5-10 mm long, orbicular with constricted base, subcoriaceous, stipular scar 2-4 mm long; basal petiolules 9-15 mm long, other laterals 6-18 mm long, terminal one 16-31 mm long, pulvinuli inconspicuous; leaflet margin flat; leaflets thickly chartaceous, drying grayish brown, sometime slightly glossy; basal leaflets 5-10.3 × 2.3-5.1 cm, (broadly) ovate, other laterals 8.3-13.8 × 2.8-6 cm, (oblong-)lanceolate to ovate, terminal one 8-14 × 2.8-6 cm, elliptic; leaflet apex gradually and usually narrowly acuminate, the acumen (2) 5-10 mm long, base of laterals symmetrical to slightly oblique, rounded to truncate; secondary vein framework brochidodromous, secondaries in 8-13 pairs, spreading to almost straight, insertion on midvein excurrent, spacing slightly decreasing toward the extremes, initial angle often subperpendicular, decreasing distally, perpendicular epimedial tertiary veins present, intercostal tertiaries alternate-percurrent and random-reticulate with some admedial branching, quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, on adaxial side the midvein narrowly prominulous but sunk in a groove, the rest narrowly prominulous, both surfaces with a few scattered capitate glands along the midvein and rest of surface with scattered glands or glabrous. Staminate inflorescences to 20 cm long with secondary axes to 2.7 cm long, the axes with dense to sparse flexuous darkly ferrugineous hairs to 0.25 mm long and capitate glands; bracts on secondary axes 1.5-3 mm long, subulate. Staminate buds 5.7-6 mm long; calyx 2-2.1 × 4 mm overall, taller than ovariodisk, lobes 0.5-0.7 mm long, rounded depressed-deltate, abaxial surface with dense glands and dense flexuous hairs to 0.1 mm long; petals 5-5.1 × 2.1 mm, exposed part longer than calyx, obovate, abaxial surface with dense, flexuous hairs to 0.2 mm; stamens inserted at base of ovariodisk, 3.9-4 mm long with anthers 1.4-1.6 mm long, narrowly ovate in dorsiventral view, lanceolate in lateral view; ovariodisk 1.6-1.8 × 0.8-1 mm, ovoid, apex obtuse. Pistillate flowers unknown. Infructescences to 12 cm long with secondary axes to 7 cm long, fruiting pedicel 4-5 mm long, cylindrical; fruits 3.5-4 × 2.5-3 cm, broadly oblong or broadly ovoid, apex truncate, base obtuse, the surface with fine, slightly raised lenticels; pyrene trigonous but the apex obtuse.



FIG. 15. — *Canarium globosum* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet; **B**, adaxial and lateral views of stipules; **C**, pistillate flower with longi-section (right); **D**, pistil and longisection of pistillate flower with pistil removed; **E**, adaxial view of staminode and (below) ventral, dorsal and lateral views of stamen; **F**, staminate bud and bud with part of calyx and one petal removed; **G**, adaxial, abaxial, and lateral views of stamen; **H**, leaf with detail of leaflet (**H'**); **I**, portion of infructescence; **J**, lateral and apical views of pyrene; **K**, fruit and cross-section (left); **A-E**, *Malcomber* 625 (NY); **F-G**, *Service Forestier* 4221 (NY); **H**, *Schatz et al.* 1807 (NY); **I**, *Birkinshaw et al.* 504 (NY); **J**, *Treuer et al.* 8 (NY); **K**, *Rabenantoandro et al.* 532 (NY). Scale bars: **A**, **H**, **I-K**, 2 cm; **B**, 5 mm; **C**, **D**, **F**, **G**, 2 mm; **E**, 1 mm; **H'**, not to scale.

NOTES

Canarium galokense, sp. nov. belongs to a group of species including *C. betamponae*, sp. nov., *C. globosum*, sp. nov. and *C. subsidarium*, sp. nov. that all have 3-5-jugate leaves, usually small and oblong leaflets, and similarly sized fruits. They are compared in Table 1 under *C. betamponae*, sp. nov. Moreover, *C. galokense*, sp. nov. is distinguished from all three by its much longer stipular scar (2-6 vs 1-2 mm long), inflorescence hairs dark-ferrugineous, the fruit broadly oblong to broadly ovoid (vs globose to ovoid), and the fruit surface lenticellate (vs glabrous and usually glossy). It is further distinguished from *C. betamponae*, sp. nov. and *C. globosum*, sp. nov. by the stipules closer to petiole insertion (7-10 vs 11-30 mm in the latter two).

Canarium globosum Daly, Raharim. & Federman, sp. nov.
(Figs 4; 15)

Small to large trees, leaves 3-5-jugate, the fruit subglobose to (ob)ovoid, smooth and glossy; distinguished from C. galokense Daly, Raharim. & Federman, sp. nov., *C. betamponae* Daly, Raharim. & Federman, sp. nov., *C. manongarivum* Daly, Raharim. & Federman, sp. nov., and *C. subsidarium* Daly, Raharim. & Federman, sp. nov. principally by the leaflet apex rounded to slightly emarginate, seldom abruptly and broadly short-acuminate, the acumen 0-2 (4) mm long (vs usually with acumen 2-10 mm long in the others).

TYPUS. — **Madagascar.** Toamasina, 5-12 km SW of Maroantsetra along Route Nationale 5, 10 m elev., 15°30'S, 49°39'E, 28.XI.1987, G. E. Schatz, J. F. Villiers & J. Klackenberg 1807 (holo-, NY!; iso-, MO, P[P00501644]!, TAN).

PARATYPI. — **Madagascar.** Antsiranana, Vohémar/Iharana, Fanambana, Forêt d'Analalava, Antsoha, 13°35'37"S, 49°59'11"E, 12.XI.2001, R. Randrianaivo, J. Andriantiana, H. Razafindrabe, A. Ratodimanana, T. Ratafindrabeaza, J. R. Rakoto, T. Jaohindy & Achille 746 (MO). Toamasina, Analanjirofo, Ambanizana, Parc National Masoala, 250 m, 15°38'36"S, 49°58'11"E, 17.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa, J. Aridy & Senario 12967 (NY, TEF); Atsinanana, Réserve Naturelle Intégrale Betampona, 400-600 m, 17°54'58"S, 49°12'10"E, 15.II.2008, T. Treuer, S. Federman & J. Sylvain 8 (NY). Toliara, NW of Taolagnaro, Andohahela Réserve Intégrale, Parcelle I, N of Isaka Ivondro, 250-500 m, 24°45'S, 46°51'E, 17-21.XII.1993, S. Malcomber 2625 (K, MO, NY, P, TAN); Fénérive Est, Ampasimaningoro, Tampolo, 10 m, 17°17'22"S, 49°24'31"E, 30.VI.2001, J. Rabenantoandro, R. Razakamalala, H. Razafindraine, R. Ludovic & F. Joma 532 (NY, US); Taolagnaro, Ambahibe, Isaka-Ivondro, Parcelle I de la Réserve Naturelle Intégrale d'Andohahela, 0-500 m, 24°47'S, 46°50'E, 10-27.IX.1993, B. Randriamampionona 627 (MO, NY, P, TAN); Anosy, Taolagnaro, Isaka-Ivondro, Forêt d'Andohahela (Parcelle I), 500 m, 24°45'30"S, 46°51'47"E, 25.XI.2002, R. Randrianaivo & Justin 841 (MO).

DISTRIBUTION AND ECOLOGY. — *Canarium globosum*, sp. nov. is one of the more broadly distributed species of the genus in Madagascar, known from Fort-Dauphin in the south to Vohémar in the North, occurring in littoral forest, dry forest, and humid forest, 0-500 m elevation. Flowering Jan., fruiting throughout the year.

ETYMOLOGY. — The specific epithet refers to the globose fruit shape.

COMMON NAMES AND USES. — Tsiramiramy; ramy mena, ramy-tsitsihy, sandramy.

The resin is used to kill mites on the feathers and skin of chickens (*famonoana tsingongotran'akoho*), also used for caulking canoes, illumination, and religious (*tromba*) ceremonies.

DESCRIPTION

Trees, reproductive size (5) 10-30 m × 14-70 cm diam, trunk with thick low plank buttresses extending up to 4 m from base. Outer bark gray, thick, irregularly cracked, sparsely lenticellate, shed as irregular plates; inner bark light tan and reddish. Resin clear or white. Leaves 10.2-30 cm long, 3-5 (6)-jugate; petiole 2.6-9 cm long, petiole and rachis with sparse to scattered, fine, appressed pale golden hairs to 0.2 mm long; stipules (4)8-23(35) mm from petiole insertion, 3-8 mm long, orbicular, (thickly) chartaceous, sometimes constricted at base, often drying revolute and ligulate, outer surface with ascending pale golden hairs to 0.1 mm long, inner with dense, flexuous, ferrugineous hairs to 0.15 mm long, the scar 1-2 mm long; basal petiolules 3-7 mm long, other laterals 3-12 mm long, terminal one 12-32 mm long, petiolules usually narrowly and deeply canaliculate, lateral pulvinuli sometimes conspicuous; basal leaflets 2.2-6.1 × 1.1-3.3 cm, orbicular to broadly & slightly (ob)ovate, other laterals 3.4-9.6 × 1.3-4.2 cm, oblong or less often oblong-elliptic or ovate, terminal one 3.6-7.5 × 1.7-3.8 cm, (broadly) obovate to oblanceolate, leaflet apex rounded to slightly emarginate or less often abruptly and broadly short-acuminate, the acumen 0-2 (4) mm long; base symmetrical to slightly oblique, truncate to obtuse; margin flat; leaflets chartaceous, drying (dark) grayish brown or brown, glossy on both surfaces; secondary vein framework weakly festooned-brochidodromous, secondaries in 8-10 pairs, discolorous, spreading to almost straight, spacing essentially uniform, angle sub-perpendicular, increasing slightly toward apex; perpendicular intersecondaries present or less often perpendicular epimedial tertiaries, intercostal tertiaries irregular-reticulate, quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, surface glabrous or with thick appressed pale hairs to 0.1 mm long along midvein and across surface, on adaxial side all veins narrowly prominent or prominent but midvein sunk in a groove, surface glabrous. Staminate inflorescences 17-30 cm long, secondary axes to 12 cm long, axes with dense ferrugineous capitate glands, also sparse to dense flexuous ferrugineous hairs to 0.2 mm long; subglabrescent in fruit; bracts 1.5-1.6 mm long, apex acute, shorter than the buds, with thick ascending ferrugineous hairs to 0.05 mm long; bracteoles c. 1.2 mm long, lanceolate to subulate, shorter than mature buds; pedicel c. 2.5 × 0.5 mm, with dense ferrugineous capitate glands, also sparse flexuous ferrugineous hairs to 0.2 mm long. Staminate buds (mature) 3.3-3.4 mm long; calyx 1.4-1.5 × 2.6-2.7 mm overall, taller than ovariodisk, cupular, cream-colored, the lobes 0.4-0.5 mm long, rounded depressed-deltate, pubescence as on inflorescence but denser; petals 3.3-3.4 × 1.5-1.7 mm, exposed part longer than calyx, oblong, apex obtuse with an inflexed apiculum 0.3-0.4 mm long, fleshy, abaxial surface with dense retrorse whitish hairs to 0.1 mm long; stamens inserted at base of ovariodisk, the antesealous stamens 2.6 mm long with anthers 1.4 mm long, the antepetalous stamens 2.2 mm long with anthers 1.2 mm long, the anthers oblong-lanceolate in dorsiventral view, oblong in lateral view, with apiculate connective; ovariodisk 0.25-0.45 mm tall, 0.8-1.1 mm thick, discoid, apex



FIG. 16. — *Canarium indistinctum* Daly, Raharim. & Federman, sp. nov.: A, Fruiting branchlet with detail of fruit surface (A'), leaflet margin (A''), and leaflet apex (A'''); B, petiole base with stipular scars; A, B, *Birkinshaw et al.* 494 (NY). Scale bars: A, 2 cm; A'-A''', B, 5 mm.

craggy. Pistillate inflorescences to 11.5 cm long, secondary axes to 5 cm long; 3.6-5.7 cm × 0.9-1.3 mm diam. Pistillate flowers 5.6-6.2 mm long; calyx 2.8-4.5 × 3.2-4.4 mm overall, reaching the base of stigma, slightly urceolate, fleshy, lobes 0.6-1 mm long, depressed-deltate, abaxial surface with dense erect to ascending golden to ferrugineous hairs to 0.2 mm long; petals 4.6 × 1.4 mm, exposed part of corolla shorter than calyx, narrowly obovate, apex obtuse, slightly spread-

ing, abaxial surface with dense ascending pale golden hairs to 0.15 mm long; staminodes inserted on rim of a shallow hypanthium, 2-2.3 mm long, anthers 1-1.3 mm long, lanceolate; pistil 3-3.3 × 1 mm, the ovary narrowly ovoid and substipitate, style 0.7-1.1 mm long, stigmatal area 0.6-0.8 mm long, capitate. Fruiting pedicel 4-9 × 2.5-3.6 mm, cylindrical to slightly clavate, fruiting calyx 2-3 mm long, spreading to patent, lobes not distinct, abaxial surface with scattered round

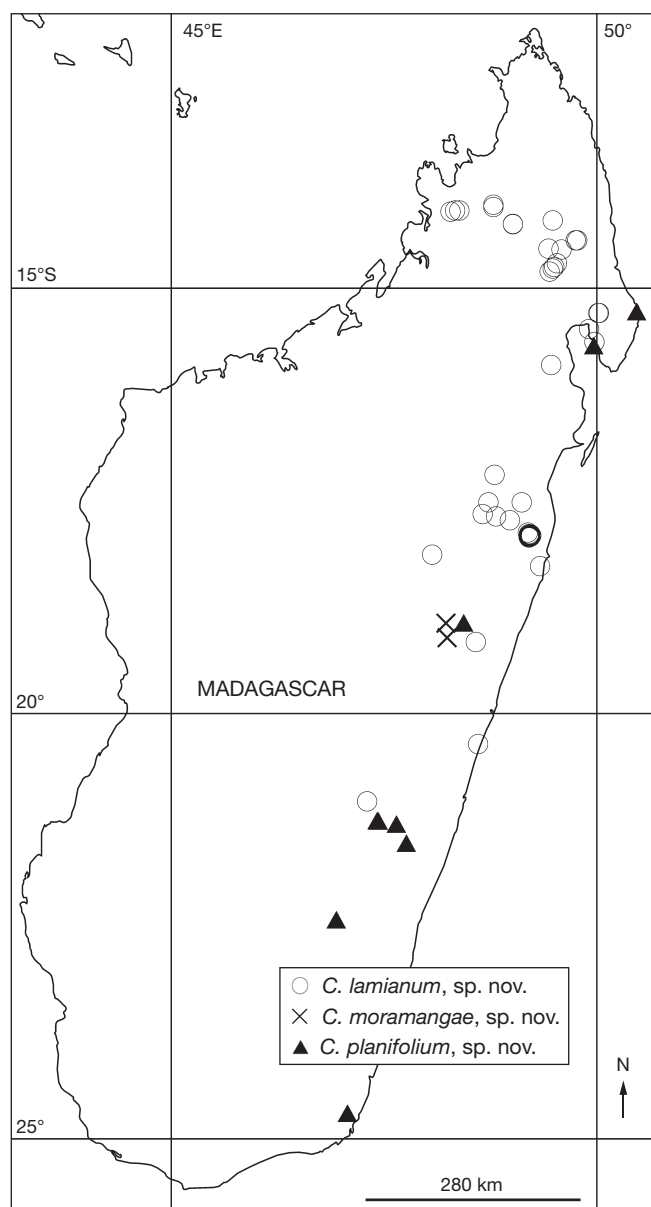


FIG. 17. — Distributions of *Canarium lamianum* Daly, Raharim. & Federman, sp. nov., *C. moramangae* Daly, Raharim. & Federman, sp. nov., and *C. planifolium* Daly, Raharim. & Federman, sp. nov.

raised lenticels, adaxial surface with dense appressed golden hairs to 0.1 mm long. Fruits 2-3.8 × 2-2.5 cm, subglobose to (ob)ovoid, sometime broadly so, surface smooth and usually glossy (appearing foveolate under 40× magnification), green to brown or dark brownish violet, glabrescent, mesocarp thin (dries only slightly wrinkled).

NOTES

Canarium globosum, sp. nov. is part of a complex of species including *C. galokense*, sp. nov., *C. betamponae*, sp. nov., *C. manongarivum*, sp. nov., and *C. subsidarium*, sp. nov. that have 3-5-jugate leaves, relatively small leaflets that are often oblong, and relatively small fruits. They are contrasted in Table 1 under *C. betamponae*, sp. nov.

Canarium indistinctum Daly, Raharim. & Federman, sp. nov. (Figs 6; 16).

Medium-sized trees, leaves 1-3-jugate, stipules 2-3 mm long, the stipular scar 1-1.5 mm long, lateral leaflet base usually symmetric, petiole and rachis with only sparse to scattered hairs; distinguished from *C. elegans* Daly, Raharim. & Federman, sp. nov. by the stipules 8-24 (vs 4-8 in *C. elegans*, sp. nov.) mm from petiole insertion, the lateral leaflets elliptic or less often oblong-elliptic or oblanceolate (vs ovate to slightly oblong-ovate), the fruit pedicel 4-10 (vs 3-4) mm long, and the fruit 3.2-5.2 × 1.7-2.6 cm (vs 2.8-3.5 × 1.7-1.9 cm) and (ob)ovoid to oblong-ellipsoid (vs (oblong-)obovoid and trigonous).

TYPUS. — **MADAGASCAR.** Toamasina, path from “Pépinère” of Ambatondradama, Masoala Peninsula, Mahalevona, Maroantsetra, 375-1011 m elev., 15°17'22"S, 50°00'58"E, 8.X.1997, *C. Birkinshaw*, *H. Ralimanana* & *R. Ranaivojaona* 494 (holo-, NY!; iso-, MO!, TAN).

DISTRIBUTION AND ECOLOGY. — Known only from the type collection. So far as it is known, this species is a relatively small rainforest tree found at c. 950 m elevation near Maroantsetra on the Masoala Peninsula. Fruiting Jul-Oct.

ETYMOLOGY. — The specific epithet refers to the inconspicuous venation that characterizes this species.

DESCRIPTION

Trees to at least 15 m tall. Resin white when dry. Leaves 11-21 cm long, 1-3-jugate; petiole 1.8-4.7 cm long, petiole and rachis with a few scattered flexuous to ascending white hairs to 0.3 mm long; stipules 4-8 mm from petiole insertion, c. 2 mm long, obovate and constricted at base, folded laterally, with dense appressed white hairs to 0.15 mm long, the scar 1-1.5 mm long and raised; basal petiolules 5-8 mm long, other laterals 4-12 mm long, the terminal one 12-30 mm long, petiolules deeply canaliculate, pulvinuli not conspicuous; basal leaflets 32-85 × 23-42 cm, broadly ovate to very broadly elliptic, other laterals 60-12.2 × 3.0-4.4 cm, ovate to slightly oblong-ovate, terminal leaflet 6-10.4 × 3.2-4.6 cm, (slightly) (ob)ovate; leaflet apex abruptly and very broadly short-acuminate, the acumen 1-5 mm long; lateral leaflet base usually symmetric, sometimes slightly oblique, obtuse and slightly attenuate; margin flat; leaflets drying brown, coriaceous, dull; secondary vein framework festooned-brochidodromous, secondaries in 7-13 pairs, spreading or almost straight, spacing decreasing toward apex and base, the angle slightly increasing toward base, perpendicular epimedial tertiaries present (these reticulating distally), intercostal tertiaries random-reticulate and admedially branched, quaternaries random-reticulate; on abaxial side the midvein broadly prominent, rest of veins narrowly prominulous, with scattered appressed, thick, white hairs to 0.5 mm long on midvein and secondaries, plus a few on rest of surface; on adaxial surface the midvein narrowly prominulous but sunk in a groove, secondaries narrowly prominulous or flat, rest usually flat, sometimes broadly prominulous, surface glabrous except a few scattered ascending white hairs at base. Infructescence 5.5-11 cm long × 2.5 mm diam above base, axes with dense, flexuous, fine pale hairs to 0.15 mm long and sparse capitate glands; fruiting pedicel 3.7-4.2 × 3.7-4.2 mm, clavate, fruiting calyx 4-6 mm long, continuous with the pedicel, calyx lobes distinct, 2-3 mm



FIG. 18. — *Canarium lamianum* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet; **B**, staminate flower with bracteole; **C**, adaxial view of petal; **D**, stamens and ovariodisk; **E**, portion of infructescence; **F**, fruiting branchlet; **G**, leaf with detail of stipules (**G'**) and leaflet margin (**G''**); **A-D**, *Daly et al.* 13065 (NY); **E**, *Treuer et al.* 44 (NY); **F**, *McPherson & van der Werff* 16378 (MO); **G**, *Antilahimena et al.* 663 (NY). Scale bars: **A**, **E-G**, 2 cm; **B**, 3 mm; **C**, **D**, 2 mm; **G'**, **G''**, 5 mm.

long, rounded-triangular, nearly patent. Fruit 2.8–3.5 × 1.7–1.9 cm [*c.* 4 × 2.5 cm when fresh], (oblong-)obovoid and trigonous, the apex rounded to slightly acuminate, the base acute to rounded; surface with dense, small, slightly raised, ferruginous lenticels, also provided with descending, flexuous, white hairs to 0.4 mm long among lenticels, glabrescent.

NOTES

Canarium indistinctum, sp. nov. is distinguished from *C. elegans*, sp. nov. in the discussion under the latter species.

Canarium lamianum Daly, Raharim. & Federman, sp. nov. (Figs 17; 18).

Small to large trees, leaves (2)3–4-jugate, leaflet secondary veins in 6–10 pairs and on adaxial side very broadly prominulous to flat, the spacing (slightly) decreasing toward the apex, and fruits 3.3–5 cm long, (oblong-) ovoid to (oblong-)obovoid, with small raised lenticels; distinguished from C. obtusifolium Scott-Elliot by the leaflets drying darker brown and often glossy, the apex usually broadly short-acuminate (vs usually rounded in C. obtusifolium), and the secondary veins not wavy and concolorous (vs wavy and discoloured), and branching close to the flat margin (vs not branching close to the flat margin).

TYPUS. — **Madagascar.** Toamasina, Commune Ambodirina, Réserve Intégrale Naturelle Betampona, 400–600 m elev., 10.IV.2008, T. Treuer, S. Federman & Sylvain 109 (holo-, NY!; iso-, G, MO, P, TAN!).

PARATYPI. — **Madagascar.** Antsiranana, DIANA, Réserve Spéciale Manongarivo, Antsatrotro, E of Ankaramy, 1500–1600 m, 14°05'S, 48°23'E, 13.IV.1992, S. Malcomber, J. Hutcheon, A. Razafimanantsoa & M. Zjhra 1469 (MO, NY, TAN). Fianarantsoa: Fivondronana, Mahanoro, Firaisana, Ambodibonara, Fokontany, Ambalavontaka, Forêt de Nankinana, 10 m, 20°21'33"S, 48°36'20"E, R. Razakamalala, R. Ranaivojaona & Z. Rogers 1152 (US). Toamasina, Analanjirofo, Mananara, Vanono, Anjian'i Madiarano forest, 816 m, 15°54'03"S, 49°27'44"E, 23.VII.2007, P. Antilahimena *et al.* 5631 (MO, NY, P, TAN, TEF); Masoala Peninsula, Mahalevona, Maroantsetra, 375–1011 m, 15°17'22"S, 50°00'58"E, 08.X.1997, C. Birkinshaw, H. Ralimanana & R. Ranaivojaona 493 (MO, NY, P, TAN); Atsinanana, Réserve Naturelle Intégrale Betampona, 400–600 m, 17°54'18"S, 49°12'22"E, 07.III.2008, S. Federman, T. Treuer & Sylvain 40 (NY); Atsinanana, Réserve Naturelle Intégrale Betampona, 400–600 m, 17°54'11"S, 49°13'06"E, 07.IV.2008, T. Treuer, S. Federman & Sylvain 84 (NY).

DISTRIBUTION AND ECOLOGY. — *Canarium lamianum*, sp. nov. is one of the most broadly distributed, variable, and ecologically versatile species of the genus in Madagascar. It has been recorded in many of the moister parts of the country except the southeast. It tends to occur in dense forest on slopes and dense lowland forest, but it ranges between 5–1500 m elevation. Flowering Jan.–Mar., fruiting all year.

COMMON NAME AND USES. — Ramy. Used for caulking canoes, illumination, and in religious (*tromba*) ceremonies.

ETYMOLOGY. — We name this species in honor of H. J. Lam, who contributed so much to our understanding of paleotropical Burseraceae.

DESCRIPTION

Trees, reproductive size 6–30 m tall × 15–57 cm diam, with simple or branched plank buttresses 32–200 cm tall and extending 2–4 m from trunk. Outer bark (brownish-)gray, thin or thick,

scalloped, sometimes with hoop marks, sometime finely fissured, with dense to sparse raised lenticels, shed as irregular plates; inner bark pale red, light orange, or reddish orange. Resin clear when fresh. Leaves 14.5–33 cm long, (2) 3–4-jugate; petiole 2.5–6.5 cm, petiole and rachis usually with scattered thick, appressed golden hairs to 0.05 mm long, also with scattered (rarely sparse) capitate glands; stipules 4–13 (19) mm from petiole insertion, 3–7 mm long, orbicular to ovate, base constricted, fleshy, usually persistent, with dense ascending to appressed thick golden hairs to 0.15 mm long (sometimes sparse, or on older leaflets subglabrous); the scar 1.3–1.6 mm long, raised; basal and other lateral petiolules 4–12 mm long, terminal one 13–30 mm long, petiolules slightly canaliculate, lateral pulvinuli conspicuous; basal leaflets 2.7–11.1 × 1.7–4.1 cm, (ob)ovate to broadly elliptic or rarely lanceolate, other laterals 4 × 13.5 × 1.8–4.0 cm, (ob)long elliptic to slightly oblong-obovate or oblong-oblancheolate, terminal one 4.5–11.5 × 2–35, obovate or sometimes elliptic; leaflet apex abruptly and broadly short-acuminate, the acumens 2–7 (11) mm long (very rarely some leaflets with rounded apex or the apex tip sometimes retuse); lateral leaflet base usually subsymmetrical, obtuse to truncate to acute, sometimes short-attenuate; margin flat; leaflets coriaceous, drying dark brown, dull; secondary vein framework brochidodromous but secondaries branching near margin, secondaries in 6–10 pairs, slightly arcuate, concolorous, spacing slightly decreasing toward apex and base, often irregular, angle acute to subperpendicular, increasing toward apex and decreasing toward base or uniform, perpendicular epimedial tertiaries sometimes present; intercostal tertiaries random-reticulate with some admedial branching; on abaxial side the midvein broadly prominent, rest nearly flat, the surface subglabrous but often with a few scattered capitate glands and sometimes a few appressed fine hairs to 0.1 mm long; on adaxial side midvein narrowly prominulous but sunk in a groove, secondaries narrowly prominulous, sometimes immersed, rest nearly flat, the surface glabrous. Inflorescences 7–19 cm long, 1.8–3.2 (4) mm diam near base (2.5–5 mm diam in fruit), secondary axes to 6.5 mm long, axes with dense flexuous golden hairs to 0.25 mm long and dense capitate glands, or with sparse flexuous hairs to 0.1 mm long and sparse capitate glands (both scattered in fruit); bracts on primary axes of staminate inflorescences 3.4 mm long, very broadly ovate, semi-clasping, fleshy; other bracts 3.5–4.5 mm long, (ob)ovate to lanceolate, often with constricted base, longer than buds; bracteoles 2.2–2.7 mm long, lanceolate; bracts mostly deciduous, unknown for pistillate inflorescences; in staminate inflorescences the pedicel 0.5–2 × 0.9–1.1 mm, cylindrical. Staminate flowers (5.4) 6–8.6 (9.5) mm long at anthesis; calyx 3.6–4.5 × 4–5.3 (6) mm overall, the lobes 1.2–2 (3) mm long, ovate to deltate, somewhat spreading, abaxial surface with dense flexuous hairs to 0.1 mm long and capitate glands; petals 5.6–8.1 (9) × 1.8–3.3 mm, exposed part longer than calyx, (oblong-) ovate to oblong-obovate, sometimes slightly acuminate (usually acute), with an inflexed apiculum (not always evident) 0.35–0.4 mm long, abaxial surface with dense thick appressed hairs to 0.1 mm long (0.15 mm at apex), these retrorse near base, adaxial surface with dense capitate glands; two series of stamens inserted at two levels near base of ovariodisk, (3.2) 3.8–5 mm long (6.6 mm in *Service Forestier* 5892), some-



FIG. 19. — *Canarium laxiflorum* Daly, Raharim. & Federman, sp. nov.: **A**, branchlet with staminate buds, with detail of leaflet margin (**A'**) and detail of petiole and stipular scars (**A''**); **B**, detail of inflorescence; **C**, lateral view of staminate bud with bracteole (left); **D**, adaxial view of petal; **E**, lateral view of staminate bud with one petal and part of calyx removed; **F**, androecium and ovariodisk (left), ovariodisk (right); **G**, ventral and dorsal views of stamen; **A-G**, *Rabevohitra et al.* 3985 [P00501630]. Scale bars: **A**, 2 cm; **A'**, 5 mm; **B**, 1 cm; **C-F**, 2 mm; **G**, 1 mm; **A'**, not to scale.

times the two series somewhat unequal, the anthers 1.1–1.7 (2.3) mm long, lanceolate in dorsiventral view, (oblong-)lanceolate in lateral view; ovariodisk 0.9–2 × (0.7) 0.9–2.2 mm, essentially columnar to slightly (depressed-)obovoid with craggy apex. Pedicel for pistillate flowers 3–3.7 × 2.3–2.4 mm, clavate; pistillate flowers (passed and incomplete) *c.* 11 mm long; calyx 6.8–8 × 7.4–7.7 mm overall, cupular, lobes 2–2.5 mm long, rounded depressed-deltate; pistil with dense appressed stiff pale hairs to 0.3 mm long. Fruiting pedicel 2–4.5 (7) × 3.4–5 mm, clavate, fruiting calyx 4–5 mm long, usually slightly cupular, the lobes distinct, 1–2 mm long, spreading. Fruits 3.3–4.6 × (1.5) 1.9–2.7 (3) cm (to 3.4 cm diam when fresh), (grayish-) green to (light) brown, usually slightly obovoid, sometimes oblong-elliptic or rarely slightly ovoid, sometimes trigonous, apex rounded, base obtuse to truncate, lenticels on surface dense, small, slightly raised, ferrugineous, surface also with dense ferrugineous capitate glands and dense erect to flexuous golden to whitish hairs to 0.25 mm long, rarely glabrescent on older fruits. Pyrene (oblong-)ovoid, operculum $\frac{3}{4}$ its length.

NOTES

Canarium lamianum, sp. nov. is contrasted with *C. arcuatum*, sp. nov., *C. laxiflorum*, sp. nov. and *C. obtusifolium* under the discussions for these latter species.

Canarium laxiflorum Daly, Raharim. & Federman, sp. nov.
(Figs 1, 19)

*Medium-sized tree, leaves 4–5-jugate, leaflets chartaceous, secondary veins in 5–9 pairs and arcuate; distinguished from C. pulchrebracteatum Guillaumin by the stipules 5–13(23) (vs 18–20) mm from petiole insertion, lateral leaflets usually laterals elliptic to obovate (vs narrowly oblong(-elliptic) to oblanceolate in C. pulchrebracteatum), the leaflet apex narrowly (vs broadly) acuminate, midvein on the the abaxial leaflet surface with stifferect hairs (vs ascending to appressed hairs), staminate inflorescences *c.* 34 (vs 7–19) cm long, bracteoles ovate to (narrowly) elliptic (vs almost linear), and flowers longer (10–13.5 vs 7.6–8 mm).*

TYPEUS. — Madagascar. Toamasina, S du Campement de Tampolo, 17°17'S, 49°25'E, 21.X.2001, R. Rabevohitra, F. Breteler & J. Aridy 3985 (holo-, P[P00501630]!; iso-, TEF).

DISTRIBUTION AND ECOLOGY. — *Canarium laxiflorum*, sp. nov. is known only from the type, a relatively large tree collected in wet (sub)littoral forest near Tampolo in Fénérive Est, Toamasina.

COMMON NAME. — Ramy.

ETYMOLOGY. — The specific epithet refers to the long, laxly branched inflorescences.

DESCRIPTION

Trees, reproductive size *c.* 20 m × 25 cm diam. Leaves 13.6–31 cm long, 4–5-jugate; petiole 4–9 cm long, petiole and rachis with sparse to scattered, erect to ascending, white hairs to 0.15 mm long, also scattered snail-shaped glands; stipules caducous, 18–20 mm from petiole insertion, the scar 2 mm long; all lateral petiolules 5–11 mm long, terminal one 22–25 mm long; basal leaflets 6–7 × 2.8–3.6 cm, ovate or broadly elliptic, other laterals 6.1–10.1 × 2.5–3.6 cm,

narrowly oblong-elliptic to oblanceolate, terminal one 8–9.4 × 3.1–3.3 cm, oblanceolate; leaflet apex abruptly and broadly short-acuminate, the acumen 3–9 mm long; lateral leaflet base symmetric, cuneate to rounded; margin slightly revolute; leaflets chartaceous, drying dark brown abaxially, dark grayish brown adaxially, dull or adaxial side slightly glossy; secondary vein framework weakly festooned-brochidodromous, secondaries in 5–9 pairs, arcuate, spacing and angle decreasing toward base, 1–2 perpendicular epimedial tertiaries per pair of secondaries, intercostal tertiary venation irregular-reticulate and alternate-percurrent, quaternaries mixed regular- and irregular-polygonous with some admedial branching; on abaxial side all veins prominent and discoloured, the surface papillate and with scattered white hairs to 0.15 mm long on the midvein, rest of surface glabrous; on adaxial side all veins prominent, with a few scattered white hairs to 0.15 mm long on midvein and at base and a few on secondary veins, or glabrous. Staminate inflorescences terminal, *c.* 34 cm long, *c.* 3.8 mm diam at base, secondary axes to 10 cm long, axes with dense to sparse, fine, flexuous, ferrugineous hairs to 0.2 mm long; bracts on primary axis to 4 mm long, ligulate; bracteoles *c.* 1–3.4 mm long, sublinear to subulate, shorter than the buds, with flexuous hairs to 0.2 mm long; pedicel 1–1.7 × 0.8–1 mm. Staminate flowers 7.6–8 mm long; calyx 2.8–3.1 × 4.5–4.8 mm overall, cupular, taller than ovariodisk, lobes 0–0.6 mm long, rounded depressed-deltate; petals 6.6–7.2 × 3.7 mm, exposed part longer than calyx, (oblong-) ovate, with an inflexed apiculum 0.4–0.5 mm long, abaxial surface with dense, mostly retrorse-appressed, golden hairs to 0.2 mm long; stamens inserted at base of ovariodisk, antesealous stamens 3.2–3.7 mm long, the antepetalous ones 2.8 mm long, anthers 2–2.3 mm long, (ovate-)oblong; ovariodisk 0.8–1.9 × 0.7–3.8 mm (variable in flowers on same inflorescence), essentially discoid to essentially obovoid, with craggy apex.

NOTES

Like *C. lamianum*, sp. nov., *C. laxiflorum*, sp. nov. has the stipules 3–10 mm long and the stipular scar longer than 1.5 mm, and the leaflet secondary veins in 5–10 pairs. The latter can be distinguished by the staminate inflorescences *c.* 34 (vs 7–19) cm long, the secondary axes densely branching distally, the bracts ligulate to subulate or linear and shorter than the buds (vs ovate and foliose and longer than the buds), and *Canarium laxiflorum*, sp. nov. is similar to *C. pulchrebracteatum* but contrasted with it in the discussion under the latter species.

Razakamalala 2416 (NY) may represent a pistillate-flowering specimen of *C. laxiflorum*, sp. nov., but there are enough differences that we reserve judgment at this point. This specimen has 1–3-jugate leaves; on the abaxial leaflet surface the midvein and secondaries have scattered thick appressed hairs to 0.05 mm long; the inflorescence has dense ascending to appressed golden hairs to 0.2 mm long plus capitate glands; and the calyx and petals have dense thick appressed golden hairs to 0.1 mm long plus capitate glands. Moreover, it is from Fort-Dauphin, i.e., the other extreme of the country.

Canarium longistipulatum
Daly, Raharim. & Federman, sp. nov.
(Figs 20; 21)

Large trees, leaves 4-6-jugate, stipules 5-22 mm from petiole insertion, fleshy and often persistent, lateral leaflet base truncate to slightly cordate, the apex gradually acuminate, secondary veins nearly perpendicular to the midvein, inflorescences 16-22 cm long and laxly branched, and fruits (oblong-)ovoid to oblong(-obovoid); distinguished from *C. compressum* Daly, Raharim. & Federman, sp. nov., *C. madagascariense* Engl., *C. multiflorum* Engl., and *C. multinervis* Daly, Raharim. & Federman, sp. nov. by the stipules broadly obovate to subulate (vs (sub)orbicular to ovate in the others), lateral leaflets (elliptic-)lanceolate to slightly ovate (versus (oblong-)ovate to oblong-lanceolate), and fruits very dark brown and with sparse, conspicuously raised lenticels (vs whitish to lighter brown, the lenticels not conspicuously raised).

TYPOS. — **Madagascar.** Antsiranana, Ambohitralanana (Cap-Est), Forêt Tanandavahely, 0-15 m elev., 15°18'S, 50°29'E, 9.XII.1994 (m fl), R. Bernard, G. Rahajasoa & J. Rabe 99 (holo-, NY!; iso-, MO, P[P00501634]!).

PARATYPI. — **Madagascar.** Antsiranana, SAVA, Parc National Marojejy, Campement 1 (Mantella), 250 m, 14°26'07.8"S, 49°46'19.2"E, 26.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa & D. Ravelonarivo 13010 (NY, TEF), Campement 1 (Mantella), 250 m, 14°26'07.8"S, 49°46'19.2"E, 26.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa & D. Ravelonarivo 13011 (NY, TEF), between Campement 1 (Mantella) & Campement 2, 500 m, 14°26'07.8"S, 49°46'19.2"E, 27.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa & D. Ravelonarivo 13017 (NY, TEF). Fianarantsoa, E of Ifanadiana, 2.3 km W of Ambodirafia, 21°19'S, 47°39'E, 08.III.1985, L. J. Dorr 3878 (MO, NY). Toamasina, Analanjirofo, 2 km E of Ambanizana, 190 m, 15°37'15"S, 49°50'55"E, 18.VI.2002, P. Antilahimena, J. Aridy & Valeste 1123 (NY), Ambanizana, Parc National Masoala, 50-200 m, 15°37'58"S, 49°58'22"E, 15.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa, J. Aridy & Senario 12950 (NY, TEF), Parc National Masoala, 50-200 m, 15°37'58"S, 49°58'22"E, 15.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa, J. Aridy & Senario 12958 (NY, TEF); Nosy Mangabe, Réserve Spéciale Nosy Mangabe, 300 m, 15°30'22"S, 49°45'01"E, 19.I.2006, D. C. Daly, J. Raharimampionona, J. Razanatsoa, J. Aridy & Senario 12984 (NY, TEF); Analanjirofo, Ambanizana, Maroantsetra, 100 m, 15°38'S, 49°58'E, 09.XI.1994, J. Rabe 190 (MO, NY, P, TAN), Station Forestière Farankaraina, 20-25 m, 15°25'56"S, 49°50'41"E, 26.I.1999, G. E. Schatz et al. 3822 (MO, NY).

DISTRIBUTION AND ECOLOGY. — *Canarium longistipulatum*, sp. nov. is known principally from around the Baie d'Antongil in Maroantsetra as well as from Marojejy National Park, in wet forest on steep slopes with canopy discontinuous and emergents to 40 m, or in lower forest with canopy 15 m, at 0-500 m elevation. Flowering Nov.-Jan., fruiting Jan.-Jun.

COMMON NAME. — Aramintsitsihy.

ETYMOLOGY. — The specific epithet refers to the conspicuous persistent stipules far from petiole insertion.

DESCRIPTION

Large trees 20-35 m and up to 210 cm diam (above buttresses), the crown to 50 m diam, trunk often angular, with often branched plank buttresses to 4 m high and extending 3 m or more from base. Outer bark gray, thick, scalloped, with some hoop marks and sparse raised lenticels, sparsely but deeply fissured, shed in large irregular plates to 60 cm long; inner bark reddish tan to deep red. Resin clear. Leaves

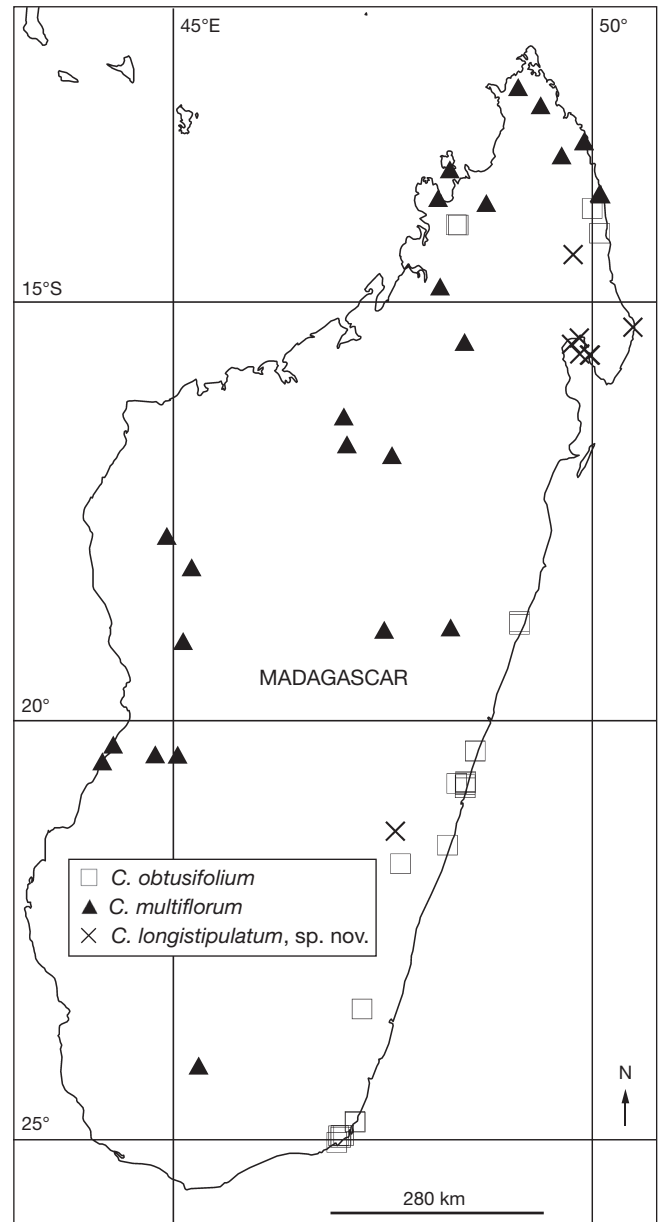


FIG. 20. — Distributions of *Canarium longistipulatum* Daly, Raharim. & Federman, sp. nov., *C. multiflorum* Engl., and *C. obtusifolium* Scott-Elliot.

16-32 cm long, 4-6-jugate; petiole 3.8-8 cm long, petiole and rachis with dense to sparse erect thick whitish hairs to 0.05 mm long, also dense to sparse snail-shaped glands; stipules 5-22 mm from petiole insertion, 3-7 mm long, usually obovate but sometimes broadly subulate or ovate, sometimes acuminate, the base constricted, markedly fleshy and often persistent, with short, erect white hairs, the scar 2-4 mm long, sometimes raised; basal petiolules 3-10 mm, other laterals 5-11 mm long, terminal 12-19 mm long; basal leaflets 3-8.5 × 1.5-4 cm, ovate, other laterals 3.5-12.6 × 2.3-4.4 cm, (elliptic-)lanceolate to slightly ovate, terminal one 6-11 × 1.9-4.4 cm, lanceolate to narrowly ovate; leaflet apex gradually and narrowly long-acuminate, the acumen (3) 10-30 mm long; base of laterals symmetric to slightly oblique, usually

cordate, sometimes truncate; margin sometimes slightly revolute; secondary vein framework brochidodromous but looping submarginal, some festooning, secondaries in 11-16 pairs, nearly straight, insertion excurrent, spacing uniform, angle (sub)perpendicular, tertiary veins alternate-percurrent or less often random-reticulate, quaternaries random-reticulate; on abaxial side the midvein prominent, secondaries prominent but often sunk in a groove, rest of venation prominulous to impressed, with sparse to scattered appressed fine white hairs on all of surface, or glabrous; on adaxial side all venation narrowly prominulous or sometimes the tertiaries flat, glabrous, the midvein and secondary veins yellowish green, rest of surface dark glossy green. Inflorescences laxly branched and flowers not congested; staminate inflorescences 16-28 cm long, secondary axes to 7-9 cm long, axes with dense to sparse (especially on fruit) snail-shaped glands and flexuous or less often straight ferrugineous hairs to 0.15 (0.2) mm long; bracts on primary and secondary axes 1.8-4.5 mm, ovate to elliptic to subulate, fleshy, bracteoles 0.8-2 mm long, (broadly) subulate, bracts and bracteoles larger than buds; pedicel 1.1-2 mm long. Staminate flowers 4.1-4.8 mm long; calyx 1-2.7 × 2.8-4 mm overall, usually shallowly cupular, much taller than ovariodisk, lobes (0.3) 0.5-1.5 mm long, (depressed-)ovate, pale green to greenish-ferrugineous, hairs ascending and shorter than on inflorescence axes; petals 3.7-4.3 × 3-3.2 mm, exposed part shorter than calyx, broadly ovate to broadly and slightly obovate, pale yellow, almost patent at anthesis; stamens 2.4-2.8 (3.3) mm long, anthers 1-1.5 mm long, oblong to narrowly ovate, yellow, filaments paler yellow; ovariodisk 0.6-0.9 × (0.5) 0.8-1.3 mm, variable in shape, broadly columnar to ovoid to broadly obovoid, apex craggy, yellow. Pistillate flowers unknown. Infructescences 5-13 cm long, secondary axes to 7 cm long, fruiting pedicel 4-5 mm, subcylindric, sparsely lenticellate, fruiting calyx 3-6 mm long, patent, lobes usually indistinct. Fruits 3-4.5 × 1.8-3 cm, oblong to oblong-(ob) ovoid, apex rounded and base truncate to rounded, gray to brown, lenticels sparse, whitish to brown, highly raised, surface between lenticels with sparse to dense, descending to erect golden hairs to 0.2 mm long, also sparse capitate glands.

NOTES

Canarium longistipulatum, sp. nov. belongs to a group of 10 species that all have relatively large leaflets (usually larger than this taxon's) with truncate to slightly cordate base; of these, the following also have the leaflet apex gradually acuminate and the secondary veins nearly perpendicular to the midvein and usually relatively straight: *C. compressum*, sp. nov., *C. madagascariense*, *C. multiflorum*, and *C. multinervis*, sp. nov. *Canarium longistipulatum*, sp. nov. differs from them by its stipules markedly persistent and broadly obovate or less often broadly subulate (vs (sub)orbicular to ovate in those other species); the lateral leaflets (elliptic-)lanceolate to slightly ovate (vs (oblong-)ovate to oblong-lanceolate), the acumen 10-30 mm long (vs 2-11 (15) mm long except 12-27 mm long in *C. compressum*, sp. nov.); and the fruits very dark brown with sparse, conspicuously raised lenticels (vs whitish to lighter brown, the lenticels not conspicuously raised).

Canarium madagascariense Engl.

(Fig. 1)

In A.D.C. & C.D.C., *Monographiae Phanerogamarum Prodrumi* 4: 111, 112 (1883). — Typus: Madagascar, Nossi-Bé [Nosy Be], 1840, J. M. C. Richard 340 (lecto-, P[P00048610]!), annotated by Leenhouts July 1955; isolecto-, P[P00048611, P00048612]!).

MATERIAL EXAMINED. — **Madagascar.** Antsiranana, Hell-ville, Réserve Naturelle Intégrale Lokobe & Nosy Be, 30 m, 13°25'S, 48°18'E, 15.I.1992, C. Birkinshaw 93 (MO); Nosy Be, Diana, Réserve Naturelle Intégrale Lokobe, 5-100 m, 13°24'51"S, 48°18'20"E, 07.II.2006, D. C. Daly, J. Raharimampionona & R. Ranaivojaona 13091 (NY, TEF).

DISTRIBUTION AND ECOLOGY. — Despite the voluminous literature on forest inventory and ecology and on frugivorous lemurs, in which *C. madagascariense* has been reported from various habitats in various parts of the country (e.g., Drew & Wright 1998 from SE Madagascar), it is in fact one of the rarest and most restricted species of the genus in Madagascar; to date we can confirm only two collections of this species, both from the island of Nosy Be in Antsiranana, where it is found in littoral forest and in moist forest on steep rocky terrain, at 5-100 m elevation. Fruiting Jan.

DESCRIPTION

Trees, reproductive height 25 m or more. Outer bark gray. Resin white. Leaves 27-54.5 cm long, 7-10-jugate; petiole 4-10 cm long, petiole and rachis subglabrous except on young leaves with scattered fine, erect golden hairs to 0.4 (0.8) mm long; stipules 0-2 mm from petiole insertion, 7-17 mm long, oblong-ovate to oblong-orbicular, base on distal side truncate, on proximal side broad and cordate, abaxial surface subglabrous, adaxial surface with scattered to dense (especially distally) appressed golden hairs to 0.6 mm long, sometimes also with sparse capitate glands, the margin densely ciliate with flexuous hairs to 0.4 mm long, the scar 3-6 mm long, usually raised; basal petiolules 4-12 mm long, other laterals 6-16 mm long, terminal one 11-22 mm long, petiolules not canaliculate, lateral pulvinuli somewhat conspicuous; basal leaflets 5.5-8.9 × 3-5 cm, (broadly) ovate, other laterals 6.5-18 × 2.5-5.4 cm (oblong)ovate, terminal one 7-16 × 2.4-5.8 cm, (oblong-)elliptic to lanceolate; leaflet apex gradually and narrowly long-acuminate, the acumen (3) 6-17 mm long; lateral leaflet base subsymmetrical to slightly oblique, slightly cordate or less often truncate (on basals sometimes obtuse); margin flat; leaflets chartaceous to somewhat coriaceous, drying dark brown, somewhat glossy; leaflet secondary vein framework brochidodromous but looping at margin, secondaries in 10-14 pairs, almost straight, spacing slightly decreasing toward apex and base, angle slightly increasing near base, sometimes slightly discoloured adaxially, 1-2 perpendicular epimedial tertiaries present per pair of secondaries, costal tertiaries alternate-percurrent, sometimes irregular-reticulate, quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, the surface glabrous but finely papillate; on adaxial side all veins narrowly prominent but midvein sunk in a groove, the surface glabrous. Staminate inflorescences c. 13 cm long, secondary axes to c. 4.5 cm long, axes with dense, flexuous, ferrugineous hairs to 0.3 mm long but mostly glabrescent, also with sparse to scattered capitate



FIG. 21. — *Canarium longistipulatum* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet with detail of lateral view of stipules (**A'**); **B**, detail of leaflet; **C**, portion of staminate inflorescence; **D**, lateral view of staminate flower and bracteole (left); **E**, apical view of staminate flower; **F**, lateral view of staminate flower with part of calyx and one petal removed; **G**, stamens and ovariodisk (left) and with three anterior stamens removed (center), longisection of ovariodisk (right); **H**, adaxial view of stamen; **I**, portion of infructescence; **J**, apical view of stipules; **A-H, J**, *Daly et al.* 13011 (NY and field photos by D. Daly); **I**, *Dorr* 3878. Scale bars: **A, I**, 3 cm; **B, C, J**, 5 mm; **D-F**, 2 mm; **G, H**, 1 mm; **A'**, not to scale.

glands; bracts on primary and secondary axes to 3.5 mm long or more, fleshy, ovate and acuminate; bracteoles subtending flowers to 3 mm long, lanceolate to linear. Flowers known only from mature staminate buds. Infructescences up to 18 cm long, fruiting pedicel 7–8 mm long, subcylindrical, sparsely raised-lenticellate, fruiting calyx *c.* 12 mm long, cupular, the lobes slightly distinct, sparsely raised-lenticellate, remainder of surface with appressed, ferrugineous hairs. Fruits *c.* 5 × 2.3–2.5 cm, ellipsoid-ovoid to narrowly ovoid, olive-green or dark brown or reddish brown, the apex slightly acuminate and base acute, the surface lenticels dense, small, linear, flat, whitish, forming long lines.

NOTES

Canarium madagascariense belongs to a group of 10 species that all have relatively large leaflets with truncate to slightly cordate base; of these, the following also have the apex gradually acuminate and the secondary veins nearly perpendicular to the midvein and usually relatively straight: *C. compressum*, sp. nov., *C. longistipulatum*, sp. nov., *C. multiflorum*, and *C. multinervis*, sp. nov. *Canarium madagascariense* differs from them by the greater number of leaflet pairs (7–10 vs maximum 6 in the others) and the stipules inserted on or almost at the petiole base (vs (2) 5–22 mm from insertion; in *C. bullatum*, comb. et stat. nov. also close to base but leaflets bullate).

Canarium manongarivum

Daly, Raharim. & Federman, sp. nov.
(Figs 1, 22).

Small trees, leaves usually 3-jugate, fruit 2.8–2.9 × 1.8–2.1 cm, slightly ovoid, the surface finely and sparsely lenticellate; distinguished from C. galokense Daly, Raharim. & Federman, sp. nov., *C. globosum* Daly, Raharim. & Federman, sp. nov., *C. betamponae* Daly, Raharim. & Federman, sp. nov. and *C. subsidarium* Daly, Raharim. & Federman, sp. nov. *by the long stipular scars (7–9 vs 1–3 mm long in the others) and adaxial leaflet surface scattered black-punctate (vs not punctate), distinguished from C. subtilis* Daly, Raharim. & Federman, sp. nov. *by the stipules 10–16 (vs 4–9) mm from petiole insertion, leaflets dull (vs glossy), and fruit smaller (2.8–2.9 vs 3.6–3.8 cm long).*

TYPOS. — **Madagascar.** Antsiranana, Réserve Spéciale de Manongarivo, Bekolosy, E of Ankaramy-Be, 875 m, 14°04'S, 48°17'E, IV.1993, P. J. Rakotomalaza 71 (holo-, NY!; iso-, MO, TAN).

DISTRIBUTION AND ECOLOGY. — As far as it is known to date, *Canarium manongarivum*, sp. nov. is a small tree of moist forests, found only in the Réserve Spéciale de Manongarivo, at *c.* 875 m elevation.

DESCRIPTION

Trees, reproductive size 8–10 m × 15 cm diam. Leaves 14–16.5 cm long, 3-jugate; petiole 3.2–4.7 cm long, petiole and rachis with scattered lenticels and with sparse thick erect hairs to 0.1 mm long; stipules caducous, the scar 10–16 mm from petiole insertion, 1.5–2 mm long, raised and cylindrical; basal petiolules 5–7 mm long, other laterals 7–11 mm long, terminal one *c.* 24–26 mm long, petiolules narrowly canaliculate, lateral pulvinuli conspicuous; basal leaflets 2.8–4.6 × 1.3–2.1 cm, ovate to elliptic, other laterals 5.7–8.4 × 1.8–2.7 cm, elliptic

to slightly oblong(-oblanceolate), terminal one *c.* 6.6–7.1 × 2.9–3 cm, elliptic; leaflet apex broadly short-acuminate or rarely obtuse, the acumen 0–4 mm long; leaflet base (sub) symmetrical, acute to slightly attenuate; margin slightly revolute; leaflets chartaceous, drying brown below and tan above; secondary vein framework simple-brochidodromous, secondaries in 8–12 pairs, almost straight, spacing somewhat irregular but decreasing toward apex and base, angle acute and uniform, some perpendicular epimedial tertiaries, intercostal tertiaries mixed alternate percurrent-irregular reticulate; on abaxial side the midvein narrowly prominent, rest of veins narrowly prominulous, surface glabrous; on adaxial side the midvein narrowly prominulous, rest of veins broadly prominulous, surface scattered black-punctate. Flowers unknown. Infructescences *c.* 12.3 cm long × 3.2 mm diam at base, secondary axes to at least 2.9 cm, axes with sparse to scattered, flexuous to erect, thick, golden to rusty hairs to 0.25 mm long, also with scattered lenticels; fruiting pedicel 3.1–4.5 × 3.2–3.3 mm, clavate, fruiting calyx lobes persistent, *c.* 4.1 mm long, depressed-deltate, fleshy, with appressed thick golden hairs to 0.25 mm long on both surfaces. Fruits 2.8–2.9 × 1.8–2.1 cm, ellipsoid, apex and base obtuse, surface finely and sparsely lenticellate, among the lenticels with dense to sparse malpighiaceous hairs to 0.3 mm long, the epidermis shedding to reveal a granular surface, mesocarp relatively thick.

NOTES

Canarium manongarivum, sp. nov. is part of a complex of species including *C. galokense*, sp. nov., *C. globosum*, sp. nov., *C. betamponae*, sp. nov. and *C. subsidarium*, sp. nov. that have 3–5-jugate leaves, relatively small leaflets that are often oblong, and relatively small fruits. They are compared in Table 1 under *C. betamponae*, sp. nov. *Canarium manongarivum*, sp. nov. can be distinguished from all the others in that group by its long stipular scars (7–9 vs 1–3 mm in the others) and the adaxial leaflet surface scattered black-punctate (vs not punctate). In addition, *C. manongarivum*, sp. nov. is vegetatively similar to *C. subtilis*, sp. nov. in leaflet size and shape, but the former is distinguished by the stipules more distant from petiole insertion (10–16 vs 6–10 mm in *C. subtilis*, sp. nov.), leaflets dull (vs glossy), the midvein abaxially narrowly prominulous (vs broad and flat), adaxial leaflet surface scattered black-punctate (vs not punctate), and the fruit smaller (2.8–2.9 vs 3.6–3.8 cm long).

Canarium manongarivum, sp. nov. is distinguished from *C. elegans*, sp. nov. in the discussion under the latter species.

Canarium moramangae

Daly, Raharim. & Federman, sp. nov.
(Figs 7E, F; 17)

Small trees, leaves 3–4-jugate, terminal petiolules 20–42 (60) mm long, leaflet secondary vein angle increasing or uniform toward base, and fruit broadly ellipsoid to slightly (ob)ovoid and ferrugineous-lenticellate; distinguished from C. subsidarium Daly, Raharim. & Federman, sp. nov. *by the petiole and rachis with thick hairs to 0.2 mm long (vs fine hairs to 0.5 mm long in C. subsidarium* Daly, Raharim. &



FIG. 22. — *Canarium manongarivum* Daly, Raharim. & Federman, sp. nov.: **A**, fruiting branchlet with detail of adaxial leaflet surface (**A'**) and of petiole base and stipular scars (**A''**); **B**, detail of leaf rachis, petiolules and leaflet base; **A**, **B**, *Rakotomalaza* 71 (NY). Scale bars: **A**, 2 cm; **A'**, **A''**, **B**, 5 mm.

Federman, sp. nov.), leaflet acumen 6-15(20) (vs 0-7) mm long, intercostal tertiary venation mixed alternate-percurrent and irregular-reticulate (vs irregular-reticulate only), the fruit broadly ellipsoid to slightly (ob)ovoid and surface with sparse, large, raised, ferrugineous lenticels (vs ovoid and becoming finely lenticellate), and its occurrence in dry forest (vs montane forest).

TYPUS. — **Madagascar.** Toamasina, Moramanga, Réserve Forestière Sandrangato, 27.X.1964, *Service Forestier* 21894 [1748-R-100] (holo-, NY!; iso-, P[P05311784], TEF).

PARATYPI. — **Madagascar.** Toamasina, Moramanga, Réserve Forestière Sandrangato, 900 m, 27.X.1964, *Service Forestier* 21894 (NY, TEF [not seen]), Toby PK 27, route d'Andasibe, 900 m, 29.X.1964, *Service Forestier* 21954 (NY, P[P05311801]), 900 m, 10.XI.1964, *Service Forestier* 21981 (NY, P[P05311799]), TEF [not seen], Sahantavolo, 900 m, 04.VIII.1965, *Service Forestier* 25372 (NY, P[P05311803], TEF [not seen]).

DISTRIBUTION AND ECOLOGY. — To date, *Canarium moramangae*, sp. nov. is known only from the region of Moramanga, where it is found in dry forest and in moist forest in steep valleys, at elevations up to 900 m. Fruiting Aug.-Nov.

COMMON NAME. — Ramy.

DESCRIPTION

Trees, reproductive height at least 12 m. Leaves 3-4-jugate, 21-40 cm long; petiole (3.1) 5-8.5 cm, petiole and rachis with sparse to dense, erect to ascending, thick white hairs to 0.2 mm long; stipules 2-10 mm from petiole insertion, 4-7 mm long, broadly orbicular, base sometime constricted, with sparse to dense, fine, erect to ascending hairs 0.05-0.1 mm long, the scar *c.* 3 mm long; basal petiolules 4-9 mm long, other laterals 6-20 mm long, terminal one 20-42 (60)

mm long, petiolules not canaliculate, pulvinuli inconspicuous; basal leaflets $2.4\text{--}9.5 \times 1.6\text{--}5.1$ cm, broadly ovate; other lateral leaflets $4.7\text{--}19.5 \times 1.8\text{--}6.2$ cm, oblong-(ob)ovate to ovate, rarely lanceolate or oblong-elliptic, terminal one $4.9\text{--}17.5 \times 1.9\text{--}5.9$ cm, (broadly) elliptic or usually obovate; leaflet apex abruptly (rarely gradually) and narrowly acuminate, the acumen 6–15 (20) mm; lateral leaflet base (sub)symmetric, obtuse to cordate, rarely cuneate; leaflets coriaceous, drying brown abaxially, dark grayish-brown adaxially, glossy adaxially and often abaxially; secondary vein framework weakly brochidodromous but looping at the margin, secondaries in 8–12 pairs, spreading to almost straight, spacing slightly decreasing toward apex and base, angle often irregular; often 1 perpendicular intersecondary per pair of secondaries, otherwise with perpendicular epimedial tertiaries, intercostal tertiaries alternate-percurrent and random-reticulate and with admedial branching toward axil of secondaries, quaternaries random-reticulate; on abaxial side the midvein prominent, rest of veins narrowly prominent or prominulous, surface glabrous except midvein with scattered thick appressed hairs to 0.1 mm long and sometimes scattered capitate glands, rest of surface with scattered glands; on adaxial side the midvein narrowly prominulous but sunk in a groove, secondaries narrowly prominulous, rest of veins broadly prominulous to almost flat, surface appearing at least sparsely black-punctate, glabrous except sometimes a few thick appressed hairs to 0.25 mm long near base of midvein abaxially. Flowers unknown. Infructescences (6) 11–17 cm long, secondary axes to 1.2 cm long, the axes with sparse to scattered appressed white hairs to 0.25 mm long, hairs to 0.4 mm long, and dense to scattered fine, flexuous, ferrugineous hairs to 0.5 mm long, also with small, long, slightly raised, ferrugineous lenticels; fruiting pedicel 2–4 mm long, clavate, sparsely lenticellate, fruiting calyx 7–10 mm long, cupular, the lobes distinct, hairs very dense, golden, flexuous to descending, 2–5 mm long. Fruits $3.8\text{--}5.5 \times 2\text{--}3.2$ cm, broadly ellipsoid to slightly (ob)ovoid, apex slightly tapering, base truncate, surface with sparse large, raised, ferrugineous lenticels, and among lenticels provided with, dense, fine, white hairs to 0.2 mm long, flexuous (near middle) to descending or retrorse-appressed (near base).

NOTES

Like *C. subsidarium*, sp. nov., *C. moramangae*, sp. nov. has the leaflet secondary vein angle increasing or uniform toward base (i.e., not decreasing) and the adaxial leaflet secondary veins narrowly prominulous or prominent; the latter can be distinguished by the petiole and rachis with sparse to dense, erect to ascending, thick white hairs to 0.2 mm long (vs dense to scattered fine erect hairs to 0.5 mm, also fine erect hairs to 0.05 mm long in *C. subsidarium*, sp. nov.), the leaflet acumen 6–15(20) (vs 0–7) mm long, the intercostal tertiary venation mixed alternate-percurrent and irregular-reticulate (vs irregular-reticulate only), the fruit broadly ellipsoid to slightly (ob)ovoid and surface with sparse, large, raised, ferrugineous lenticels (vs ovoid and becoming finely lenticellate), and its occurrence in dry forest (vs montane forest).

Canarium multiflorum Engl.

(Fig. 20)

In A.D.C. & C.D.C., *Monographiae Phanerogamarum Prodrumi* 4: 128, 129 (1883). — Typus. Madagascar, Mouroundavo, (without date), *Grévé s.n.* (holo-, P[P00048613]); iso-, P[P00048614]).

SELECTED MATERIAL EXAMINED. — **Madagascar.** Antananarivo, Analamanga, Parc du Tsimbazaza, 1300 m, $18^{\circ}55'S$, $47^{\circ}31'E$, 06.XI.1984, *L. Barnett & L. J. Dorr* 172 (MO, NY); Antsiranana, Sava, Vohémar/Iharana, Tsarabaria, Manakana, Ambondrobe, 13 m, $13^{\circ}43'05"S$, $50^{\circ}05'52"E$, 3.III.2003, *J. Rabenantoandro, R. Rabevohitra, R. Razakamalala & I. d'Analovana* 1413 (MO, NY); Fivondronana, Vohémar, Firaiana, Tsarabaria, Fokontany, Manakana, Ambondrobe, $13^{\circ}42'46"S$, $50^{\circ}05'25"E$, *R. Razakamalala & D. Rabehevitra* 1338 (US). Mahajanga, Melaky, 20 km W of Marerano on Manambolo river, 200 m, $19^{\circ}03'S$, $45^{\circ}07'E$, 21.III.1990, *B. Du Puy, D. Du Puy, J. Andriantiana & B. Carlson* 778 (MO, P); Sofia, Bora, Antsohihy, Ampombilava, 100 m, 14.XI.1956, *Service Forestier* 16444 (NY, P, TEF [not seen]); Betsiboka, Forêt d'Ambika, Tsaratanana, 0–400 m, $16^{\circ}49'40"S$, $47^{\circ}36'30"E$, 12.VI.1956, *Service Forestier* 16515 (NY, TEF [not seen]); Maintirano, Belitsaky, Antsakoabe, $18^{\circ}05'05"S$, $44^{\circ}32'55"E$, 352 m, 20.XI.2012, *C. Rakotovo, I. Luino & J. Razafimandimby* 6304 (NY). Toliara, Menabe, Berge de la Maharivo, Makojeby, Befasy-Morondava, 0–400 m, 23.XI.1956, *Service Forestier* 16549 (NY, P, TEF [not seen]); Ankilizato, Mahabo, Sakamaly River near Migodo, 04.XII.1957, *Service Forestier* 17870 (NY, TEF).

DISTRIBUTION AND ECOLOGY. — *Canarium multiflorum* is one of the most abundant and widely distributed species of the genus in Madagascar. It occurs in dry and subhumid forests and so is absent from the eastern moist forests. Still, it is somewhat versatile, ranging between 13–300 m elevation and from deciduous forests in Morondava to Mandritsara and near the Réserve Spéciale Manongarivo, to subhumid evergreen forest from the center to the north near Vohémar, and including Sambirano in the Nosy Be Reserve. It is also found in littoral forest and riparian forest. Flowering Nov.–Dec., fruiting Aug.–Nov.

COMMON NAMES AND USES. — Ramy. Resin used as insect repellent (*Service Forestier* 16444).

DESCRIPTION

Trees, reproductive size 10–16 m \times 35–150 cm diam. Outer bark gray, thin. Leaves 10–41 cm, 3–5(6)-jugate; petiole 3.2–5.6 mm long, often slightly dilated proximal to stipular scar, petiole and rachis with sparse to dense erect fine 0.15–0.5 (0.7) mm long, also scattered snail-shaped glands; stipules caducous, 6–15 (20) mm from petiole insertion, scar 1–2.5 mm long; basal petiolules 4–16 mm long, other laterals 4–22 (27) mm long, terminals one 12–30 (45) mm long, petiolules not canaliculate, lateral pulvinuli inconspicuous; basal leaflets $2.3\text{--}7.7 \times 1.2\text{--}5.5$ cm, (broadly) ovate, other laterals $3.4\text{--}21 \times 1.2\text{--}7.6$ cm, (oblong-)lanceolate to (oblong-)ovate, terminal one $4\text{--}13.5 \times 1.9\text{--}6.1$ cm, ovate or less often (broadly) elliptic; leaflet apex (usually) gradually acuminate, on basals 1–4 mm long, on others 4–11 (15) mm long; base (slightly) asymmetrical, broadly truncate to broadly cordate; margin flat; leaflets slightly coriaceous, drying brown to dark grayish-brown, glossy adaxially and often abaxially; secondary framework festooned-brochidodromous, secondaries in 6–14 pairs, almost straight, spacing slightly decreasing toward base and apex, angle subperpendicular,

slightly increasing toward base and decreasing toward apex, usually discolorous adaxially and sometimes abaxially, acute to perpendicular intersecondaries sometimes present, perpendicular epimedial tertiaries usually present, intercostal tertiaries alternate-percurrent and irregular-polygonal; on abaxial side the midvein and secondaries narrowly prominent, rest narrowly prominulous, axils of secondary veins with tufts of usually dense, erect to ascending, ferrugineous hairs to 0.7 mm long, also the midvein and secondaries (rarely all) with scattered or sparse fine erect to appressed hairs to 0.1 mm long; on adaxial side all veins narrowly prominulous but midvein also sunk in groove; surface usually glabrous except often along midvein near base with a few fine erect hairs to 0.1 mm long and snail-shaped glands. Staminate inflorescences 18–34 cm long, secondary axes to 11 cm long, axes with sparse thick hairs to 0.1 mm long, sparse snail-shaped glands, and (usually only on tertiary branches) flexuous hairs to 0.2 mm long; bracts on primary axes 1.5–2.2 mm long, lanceolate, fleshy, not semi-clasping; other bracts 1.3–2 mm long, linear to ovate; bracteoles 0.4–1.2 mm long, subulate to lanceolate, shorter than the buds; pedicel 1–1.6 × 0.5–0.7 mm long. Staminate flowers *c.* 7 mm long; calyx 3.3 × 3.4 mm overall, shallowly cupular, much taller than ovariodisk, lobes 1.4 mm long, rounded depressed-deltate, abaxial surface densely provided with all three types of hairs; petals 5.7 × 3.6 mm, exposed part shorter than calyx, slightly obovate, yellow-orange, abaxial surface with dense appressed pale hairs to 0.2 mm long (retorse-appressed along margin); stamens 4.1–4.5 mm long, anthers 1.6–1.7 mm long, narrowly ovate in dorsiventral view, lanceolate in lateral view; ovariodisk 1.5 × 1.3 mm, essentially broadly obovoid, apex craggy. Pistillate inflorescences to 11 cm long, the secondary axes to 2.5 cm; pedicel 0.2–0.6 × 0.8–0.9 mm; bracts on secondary axes *c.* 3 mm long, ovate with constricted base; bracteoles *c.* 1.7 mm long, ovate to lanceolate, partly covering the buds. Pistillate flowers *c.* 6.8 mm long; calyx 3.7–4 × 4–4.3 mm overall, deeply cupular, almost level with stigmas, lobes 0.8–1 mm long, rounded-deltate; petals 5 × 3.6 mm, exposed part much shorter than calyx, broadly ovate, apex obtuse, suberect at anthesis; staminodes *c.* 2 mm long, inserted on hypanthium or at base of thin annular disk, anthers 0.8–0.9 mm long, triangular in dorsiventral view, lanceolate in lateral view, filaments flat and almost triangular; pistil 3.4 × 2.3 mm, set in a shallow hypanthium but sometimes a short thin disk present *c.* 0.2 mm tall, style 0.6 × 1.1 mm, stigmal area 0.7 mm tall, stigma lobes globose. Fruiting pedicel 3–6 × 2.8–3.8 mm, subterete (somewhat clavate in N Madagascar), fruiting calyx 2–4 mm long, not cupular, patent, lobes not distinct. Fruits 1.7–3.8 (4) × 1.7–2.8 cm, brown, subglobose to broadly (ob) ovoid to oblong-ellipsoid, rarely somewhat angular, the apex slightly acuminate to obtuse, base slightly cordate to truncate, or obtuse; lenticels on surface dense, flat, small, white; among the lenticels provided with dense to sparse retrorse-appressed pale hairs to 0.25 mm long (forward-appressed toward apex).

NOTES

Canarium multiflorum belongs to a group of 10 species that all have relatively large leaflets with truncate to slightly cordate base; it can be distinguished from them by the secondary vein axils with tufts of usually dense, erect to ascending, ferrugineous hairs to 0.7 mm long.

This species displays two somewhat distinct fruit morphologies: in populations throughout the range of the species, they are (2) 3.5–4 × 1.8–2.5 cm, broadly (ob)ovoid to oblong-ellipsoid, rarely somewhat angular, apex round to slightly acuminate, base slightly cordate to truncate or obtuse, but in populations that follow the west coast of the country, they can be (1) 1.7–2.5 × 2–2.8 cm and (sub)globose.

Canarium multinervis Daly, Raharim. & Federman, sp. nov.
(Figs 1; 23A–E).

Medium-sized trees, leaves 5–8-jugate, stipules 0–3 mm from petiole insertion, leaflets sometimes glossy, lateral leaflets with truncate to slightly cordate base, secondary veins in 9–19 pairs; distinguished from C. bullatum, comb. et stat. nov. by the stipules 5–13 (vs 4–5) mm long; leaflets drying dark brown and not bullate; basal leaflets broadly ovate (vs usually suborbicular or less often broadly ovate in C. bullatum, comb. et stat. nov.), terminal leaflet usually broadly elliptic (vs usually broadly (ob-)ovate); bracts on secondary axes of staminate inflorescences 5.5–7 mm long, rounded and concave, covering the subtended buds (vs 1.8–4 mm long, lanceolate to (ob) ovate, not covering buds); staminate flowers 4.4–5.5 (vs 6.3–8) mm long when dry; and calyx 3.1–3.5 (vs 2.1–2.8) mm long overall, the lobes 1.5–1.7 (vs 0.3–0.85) mm long.

TYPUS. — **Madagascar.** Antsiranana, Diana, Ampasindava, forêt de Betsitsika, 150 m, 13°46'09"S, 47°59'27"E, 23.I.2009, *M. C. Madiomanana, M. Y. Ammann & A. J. Tahinarivony* 252 (holo-, NY!).

PARATYPI. — **Madagascar.** Antsiranana, Ambanja, Bemanevika, Bandrakorony, near Betsitsiky Stream on Ampasindava Peninsula, 123 m elev., 13°45'44"S, 47°59'20"E, 28.I.2009, *R. Bernard et al.* 1370 (MO, NY, P, TAN); Ambanja, 22.II.1956, *Service Forestier* 16941 (NY, TEF [not seen]).

DISTRIBUTION AND ECOLOGY. — *Canarium multinervis*, sp. nov. is known only from the Sambirano region near Ambanja, where it occurs in lowland primary subhumid forest at 10–150 m elevation. Flowering in Jan.–Feb.

COMMON NAMES. — Aramy, ramy.

ETYMOLOGY. — The specific epithet refers to the conspicuous, rather closely spaced leaflet secondary veins.

DESCRIPTION

Trees, reproductive size at least 14–16 m × 40 cm diam. Leaves 23–38.5 cm long, 5–8-jugate; petiole 3.8–6.2 cm long, petiole and sometimes rachis with dense flexuous ferrugineous hairs to 0.9 mm long (sometimes glabrescent), also fine ascending hairs to 0.1 mm long; stipules 0–3 mm from petiole insertion, *c.* 3.1 mm long, essentially reniform, stipular scar 2–4.5 mm long; basal petiolules 4–7.6 mm long, other laterals 6.8–11 mm, terminal one 15–31 mm long, petiolules not canaliculate, pulvinuli inconspicuous; basal leaflets 3–8.7 × 1.5–4.4 cm, broadly ovate, other laterals 6.8–

12 × 3.4–7.6 cm, (oblong-)ovate, terminal one 9.5–13.3 × 3–8.4 cm, (oblong-)ovate or broadly elliptic; leaflet apex gradually and narrowly acuminate, the acumen 4–9 mm long; lateral leaflet base asymmetric or slightly so, truncate to cordate (especially on acroscopic side); margin sometimes slightly revolute; leaflets slightly coriaceous, drying dark brown, often glossy abaxially and adaxially (but less so); secondary vein framework brochidodromous but looping at the margin, secondaries in 9–19 pairs, almost straight, insertion decurrent, spacing slightly decreasing toward base and apex, not discoloured, the angle subperpendicular, slightly increasing toward base and decreasing toward apex; intercostal tertiaries mostly alternate-percurrent and somewhat irregular-reticulate, some admedial branching toward axil near midvein, quaternaries irregular-reticulate; on abaxial side the veins all prominent (secondaries acutely so), the midvein with scattered flexuous hairs to 0.5 mm long, also sparse or less often dense fine ascending hairs to 0.2 mm long, rest of surface with scattered thick appressed to ascending whitish hairs to 0.15 mm long and a few scattered hairs to 0.4 mm long; on adaxial side all veins narrowly prominulous except midvein also sunk in a groove, the midvein with scattered ascending ferrugineous hairs to 0.25 mm long, on secondaries a few scattered shorter hairs, rest glabrous. Staminate inflorescences 17–25 cm long, 5.7–6.4 mm diam near base, secondary axes to 8.3 cm, axes with dense, flexuous, ferrugineous hairs to 0.9 mm long, also with small, long, narrow, slightly raised lenticels on older axes; bracts on primary axes at least 6 mm long, those on secondary axes 5.5–7 mm long, rounded and concave, covering the subtended buds, those on tertiary axes 4–6.2 mm long, (broadly) ovate and acute to acuminate, bracteoles (1.4) 2–4 mm long, (narrowly) lanceolate or less often subulate; on all bracts the abaxial side with dense, flexuous, ascending ferrugineous hairs to 0.3 mm, adaxial side with dense appressed golden hairs to 0.4 mm. Staminate buds (sub-) sessile, mature buds 4.4–5.5 mm long (dry); calyx 3.1–3.5 (4) × 3–3.2 mm overall, deeply and narrowly cupular, much taller than ovariodisk, the lobes 1.2–1.7 mm long, (broadly) ovate, abaxial surface provided with flexuous, erect to ascending hairs to 0.4 (0.6) mm long, adaxial surface with dense appressed pale golden hairs to 0.3 mm; petals only slightly exceeding the calyx in bud, abaxial surface with pale golden hairs 0.1–0.35 mm long, appressed on most of surface but retrorse-appressed near margin; stamens inserted near constricted base of ovariodisk, 3–3.5 mm long, filaments fleshy, anthers 1.5–1.7 mm long, lanceolate in dorsiventral view, obliquely lanceolate in lateral view, the connective apiculate (possibly glandular); ovariodisk 1.3–1.5 mm long, essentially cylindrical, minutely 3-lobular on rounded apex. Fruits unknown.

NOTES

Canarium multinervis, sp. nov. belongs to a group of 10 species that all have relatively large, broad leaflets with truncate to slightly cordate base. It is contrasted with *C. bullatum*, comb. et stat. nov. in the discussion under that species.

Canarium nitidifolium Daly, Raharim. & Federman, sp. nov.
(Figs 4; 24)

Small trees, leaves 2–3(4)-jugate, non-basal lateral leaflets broadly elliptic or less often slightly (ob)ovate, secondary veins in 5–10 pairs, leaflets markedly pubescent abaxially, and fruit ovoid with the surface smooth and glabrous; distinguished from C. pulchrebracteatum Guillaumin by the petiole and rachis with sparse to scattered flexuous ferrugineous hairs to 0.3 mm long (vs dense, fine, flexuous hairs to 0.15 mm long in C. pulchrebracteatum), stipule 2–3 (vs 5–7) mm long, leaflet acumen usually broad (vs usually narrow), lateral leaflet base truncate to cordate or less often acute (vs rounded to obtuse or acute), secondary veins usually arcuate (vs usually spreading) and the angle decreasing (vs increasing) toward base, and fruit base attenuate (vs obtuse to truncate).

TYPUS. — **Madagascar.** [Toliara,] Fort-Dauphin, Forêt de Manantantely, 50–300 m elev., 1.III.1947, *H. Humbert* 20369 (holo-, NY!; iso-, P[P05280062]).

PARATYPI. — **Madagascar.** Toliara, Anosy, Taolagnaro, Ambatotsirongorongo, Amboavola, Sarisambo, 289 m, 25°05'43"S, 46°46'41"E, 07.VI.1999, *J. Rabenantoandro, L. Randrihasipara & E. Ramisy* 88 (MO, P[P05280063], TAN), Taolagnaro, Sarisambo, Amboavola, Forêt d'Ambatotsirongorongo, 25°05'S, 46°47'E, (without date), *R. G. Ramison* 344 (MO, NY, P, TAN); Manantenina, Forêt de Marovony, 24°06'S, 47°20'E, 29.X.1990, *A. Randrianasolo D. Faber-Langendoen, N. Dumetz & R. Raveohitra* 188 (MO); vicinity of Fort Dauphin/Taolagnaro, 2 km W of Manantantely, 0–25 m, 25°00'S, 46°55'E, 09.III.1993, *A. Randrianasolo* 282 (MO); Anosy, Taolagnaro, Sarisambo, Amboahivola. Forêt d'Ambatotsirongorongo, 440 m, 25°04'35"S, 46°47'00"E, 22.II.2009, *R. Razaka et al.* 4304 (MO, NY, P, TAN).

DISTRIBUTION AND ECOLOGY. — *Canarium nitidifolium* is known only from the Tolagnaro region, in dense moist forest on lateritic or granitic substrates at 0–440 m. Fruiting Feb.–Jun. (Oct.).

COMMON NAME. — Ramy.

ETYMOLOGY. — The specific epithet refers to the glossy leaflet adaxial surface.

DESCRIPTION

Trees, reproductive size 10–15 m × 30–50 cm diam. Outer bark gray, rough due to raised lenticels, thin, shed in large, thin, irregular plates; inner bark brittle, drying reddish. Leaves 12.5–29 cm long, 2–3(4)-jugate (1-jugate on young branchlets); petiole 1.7–5.5 cm long, petiole and rachis with sparse to scattered flexuous ferrugineous hairs to 0.3 mm long, also fine erect to ascending hairs to 0.2 mm long; stipules 5–14 mm from petiole insertion on upper side of petiole, 2–4 (6) mm long, orbicular, sometimes involute and appearing ligulate, base slightly constricted, both surfaces with dense, appressed to ascending, pale golden hairs to 0.2 mm long, scar 1.5–2.5 mm long; basal petiolules 3–7 mm long, other laterals, 5–18 mm long, terminal one 15–26 mm long, petiolules not canaliculate, pulvinuli inconspicuous; basal leaflets (1.5) 2.7–6.5 × (1.2) 1.7–3.6 cm, broadly ovate or less often suborbicular, other laterals 4–9.2 × 1.8–5.0 cm, broadly elliptic or less often slightly (ob)ovate, terminal one 4–6 × 2–4 cm, broadly elliptic to broadly obovate; leaflet apex very abruptly and broadly short-acuminate, the acumen 2–4 mm long and the apex tip glandular-apiculate; lateral leaflet base usually asymmetric, on basals truncate to slightly cordate, on other laterals obtuse to

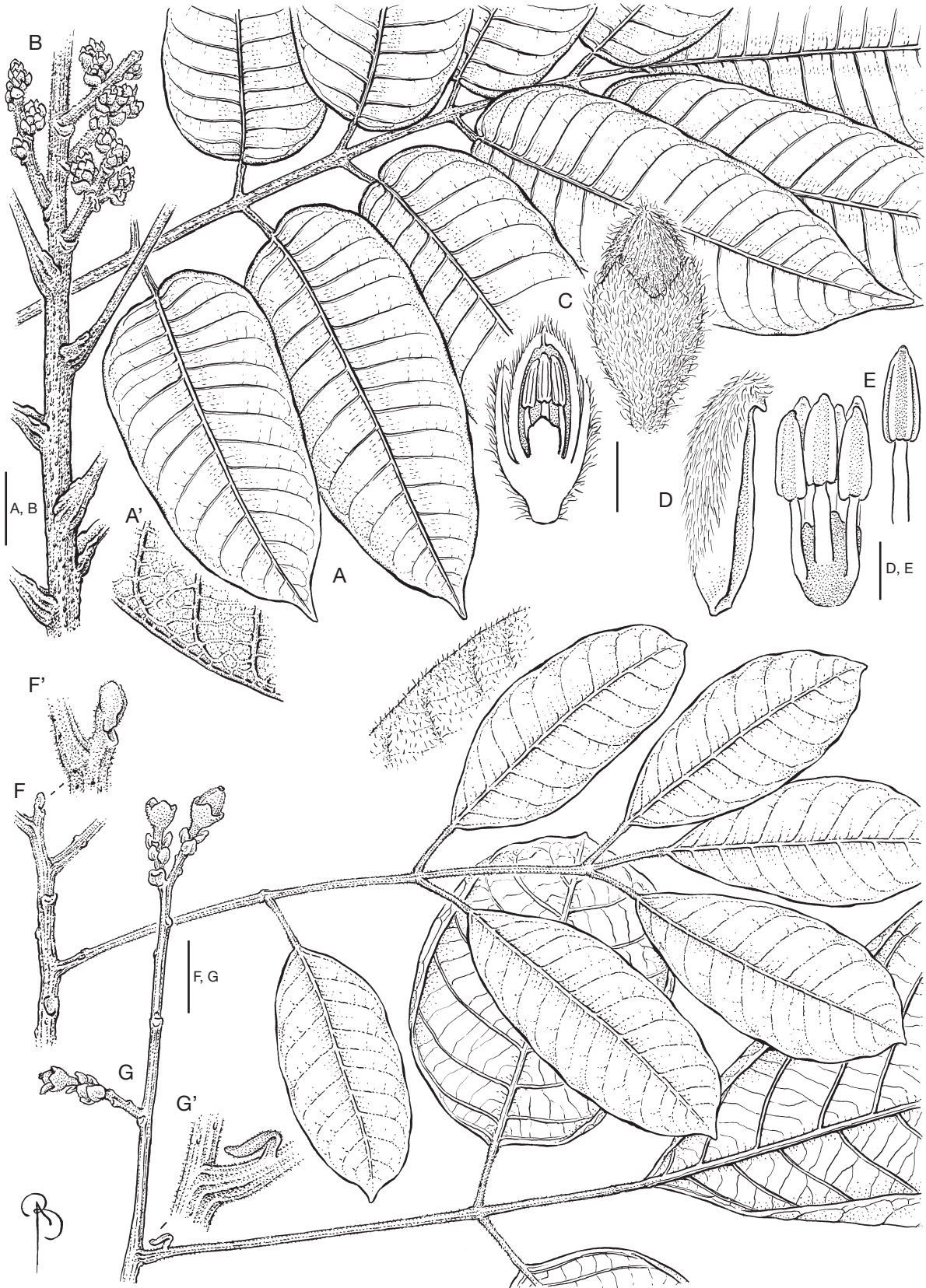


FIG. 23. — **A-E**, *Canarium multinervis* Daly, Raharim. & Federman, sp. nov.: **A**, portion of leaf with detail of leaflet (**A'**); **B**, portion of branchlet with inflorescence; **C**, staminate flower, longisection (left); **D**, lateral view of petal; **E**, stamens and ovariodisk, and adaxial view of stamen (right); **F-G**, *Canarium obovatum* Daly, Raharim. & Federman, sp. nov.: **F**, branchlet with detail of apex and stipules (**F'**); **G**, flowering branchlet with detail of stipule (**G'**). **A, C-E**, *Service Forestier* 16941 (NY); **B**, *Bernard et al.* 1370 (NY); **F**, *Daly et al.* 13064 (NY); **G**, *Capuron (SF)* 27803 (NY). Scale bars: **A, B, F, G**, 2 cm; **C**, 2 mm; **D, E**, 1 mm; **A', F', G'**, not to scale.

acute or sometimes slightly cordate; margin slightly revolute and provided with dense to scattered flexuous ferrugineous hairs to 0.35 mm long near base; leaflets coriaceous, usually drying convex, whitish abaxially (apparently due to waxy deposits) and dark grayish-brown adaxially, adaxial surface often glossy; secondary vein framework brochidodromous, secondaries in 5-9 pairs, spreading to slightly arcuate, insertion usually decurrent (more noticeable on abaxial side), spacing decreasing toward apex and base, angle acute and increasing slightly toward base and apex, perpendicular intersecondaries or perpendicular epimedial tertiaries present (latter sometimes multiple), intercostal tertiaries irregular-reticulate and alternate-percurrent with some opposite-percurrent veins, quaternaries regular-polygonal; on abaxial side usually with a whitish cast due the veins all narrowly prominent, the veins with dense flexuous hairs to 0.3 mm long, also sparse to scattered spiky hairs to 0.1 mm long on all veins; on adaxial side the veins all narrowly prominulous but midvein sunk in a groove, with scattered flexuous hairs to 0.5 mm long on midvein and base of secondaries. Flowers unknown. Infructescences (4.5) 9-19 cm long, secondary axes to 6 cm long, axes with dense, fine, flexuous to ascending, ferrugineous hairs to 0.4 mm; fruiting pedicel 0.7-2.1 cm × 3.1-3.8 mm, cylindrical, fruiting calyx narrowly cupular, the lobes evident and patent, 4-5 mm long. Fruits 2.7-3.5 × 2-2.5 cm, (broadly) ovoid, the apex acute to truncate, the base attenuate, surface smooth and glabrous.

NOTES

Canarium nitidifolium, sp. nov. closely resembles *C. pulchre-bracteatum*; the two are contrasted in the discussion under the latter species.

Canarium obovatum Daly, Raharim. & Federman, sp. nov.
(Figs 1; 23F-G)

Small trees, stipules 5-8 mm long, ovate, stipular scars 1-1.6 mm long, leaflets coriaceous, pistillate inflorescences 13-19 cm long, the axes with dense to sparse flexuous hairs to 0.5 mm long; distinguished from C. lamianum Daly, Raharim. & Federman, sp. nov. *by the leaves 1-2-jugate (vs (2)3-4 jugate in C. lamianum, sp. nov.) on fertile branchlets, petiole usually longer (5.6-19.5 vs 2.5-6.5 cm), lateral petiolules longer (10-27 vs 4-12 mm), terminal petiolules longer (10-27 vs 4-12 mm), leaflets usually (oblong-)obovate (vs at least some leaflets shaped otherwise), the apex narrowly (not broadly) short-acuminate, intercostal tertiary venation mixed opposite-alternate percurrent (vs irregular-reticulate), pistillate calyx 5.6-6 vs 6.8-8 mm long.*

TYPE. — Madagascar. [Toamasina,] Est (Nord): Environs Ouest d'Andasibe (à l'Ouest d'Andapa), sur la piste de Bealanana, 24.IV.1967, R. Capuron (Service Forestier) 27803 (holo-, NY!; iso-, P!).

PARATYPE. — Toamasina, Ambodirina, Réserve Naturelle Intégrale Betampona, 325-375, 17°55'53"S, 49°12'12"E, 02.II.2006, D.C. Daly, R. Ranaivojaona & R.B. Lambana 13064 (MO, NY, P[P04799624]).

DISTRIBUTION AND ECOLOGY. — *Canarium obovatum*, sp. nov. is known from only two localities, south of Andapa and in Betampona National Park, in moist forests on steep slopes at 325-375 m elevation. Flowering Apr.

ETYMOLOGY. — The specific epithet refers to the predominant leaflet shape.

DESCRIPTION

Trees, reproductive size 10-15 m. Outer bark gray, sparsely cracked, sparsely lenticellate. Leaves 25-34 cm long, 1-2-jugate (to 4-jugate on sterile branchlets); petiole 5.6-19.5 cm long, petiole and rachis with dense erect (some flexuous) golden hairs 0.3-0.5 mm long also with scattered raised ferrugineous lenticels; stipules 5-10 mm from petiole insertion, 5-8 mm long, ovate, constricted at base and often appearing stipitate, with erect to ascending golden hairs to 0.2 mm long, the scar 1-1.5 mm long; basal petiolules 10-25 mm long, other laterals 10-27 mm long, terminal one 23-50 mm long (to 60 mm on sterile branchlets), petiolules not canaliculate, pulvinuli relatively inconspicuous; basal leaflets 6-9.5 × 4-8 cm, broadly (ob)ovate to subrotund, other laterals 9-13 × 3.8-8.4 cm, (broadly) obovate to oblong-obovate to oblong, terminal leaflet 12-16.5 × 3.9-10.6 cm, (broadly) obovate; leaflet apex abruptly and narrowly short-acuminate, the acumen 2-12 mm long, apex tip acute, glandular-apiculate; leaflet base symmetric, acute or less often obtuse; margin flat; leaflets coriaceous, drying brown sometimes glossy on abaxial side; secondary vein framework brochidodromous but looping at margin, secondaries in 7-12 pairs, spreading to arcuate, not discolorous, spacing abruptly decreasing at base, angle slightly acute to perpendicular and decreasing toward apex and usually toward the base; intercostal tertiaries opposite- or alternate-percurrent, some perpendicular intersecondaries and epimedial tertiaries present, quaternaries irregular-reticulate; on abaxial side all veins narrowly prominent except midvein broader, the midvein with sparse spiky golden hairs to 0.5 mm long, rest of veins and surface with such hairs to 0.2 mm long; on adaxial side the midvein narrowly prominulous but usually sunk in a groove, secondaries narrowly prominulous and sometimes sunk, rest flat to narrowly prominulous, with scattered flexuous golden hairs to 0.3 mm long on midvein and base of secondaries (to 0.5 mm on sterile specimen). Pistillate inflorescences 13-19 cm long, secondary axes to 7 cm long, axes with dense flexuous hairs to 0.5 mm long; bracts on primary and secondary axes to 8 mm long, rotund and slightly acuminate, semi-clasping, persistent in young fruit, bracteoles 4.7-5 mm long, much shorter than buds, ovate, constricted at base, persistent in young fruit, on all bracts the abaxial side with ascending flexuous golden hairs to 0.2 mm long, adaxially with erect to ascending flexuous golden hairs to 0.25 mm long; pedicel 5-10 mm long, clavate. Pistillate flowers c. 9 mm long at anthesis; calyx 5.6-6 mm × 7.1-8.3 mm overall, campanulate, the lobes 2.7-3.1 mm long, rounded depressed-deltate, abaxial surface with pubescence as on inflorescence axes but shorter, to 0.3 mm long, adaxial surface with dense appressed hairs to 0.6 mm long; corolla spreading at anthesis, exposed portion only 3 mm beyond calyx, abaxial surface with dense, flexuous or ascending, pale golden hairs to 0.5 mm long. Immature fruits oblong (some slightly obovoid), with dense golden hairs to 0.6 mm long, descending near base of fruit, ascending near apex.

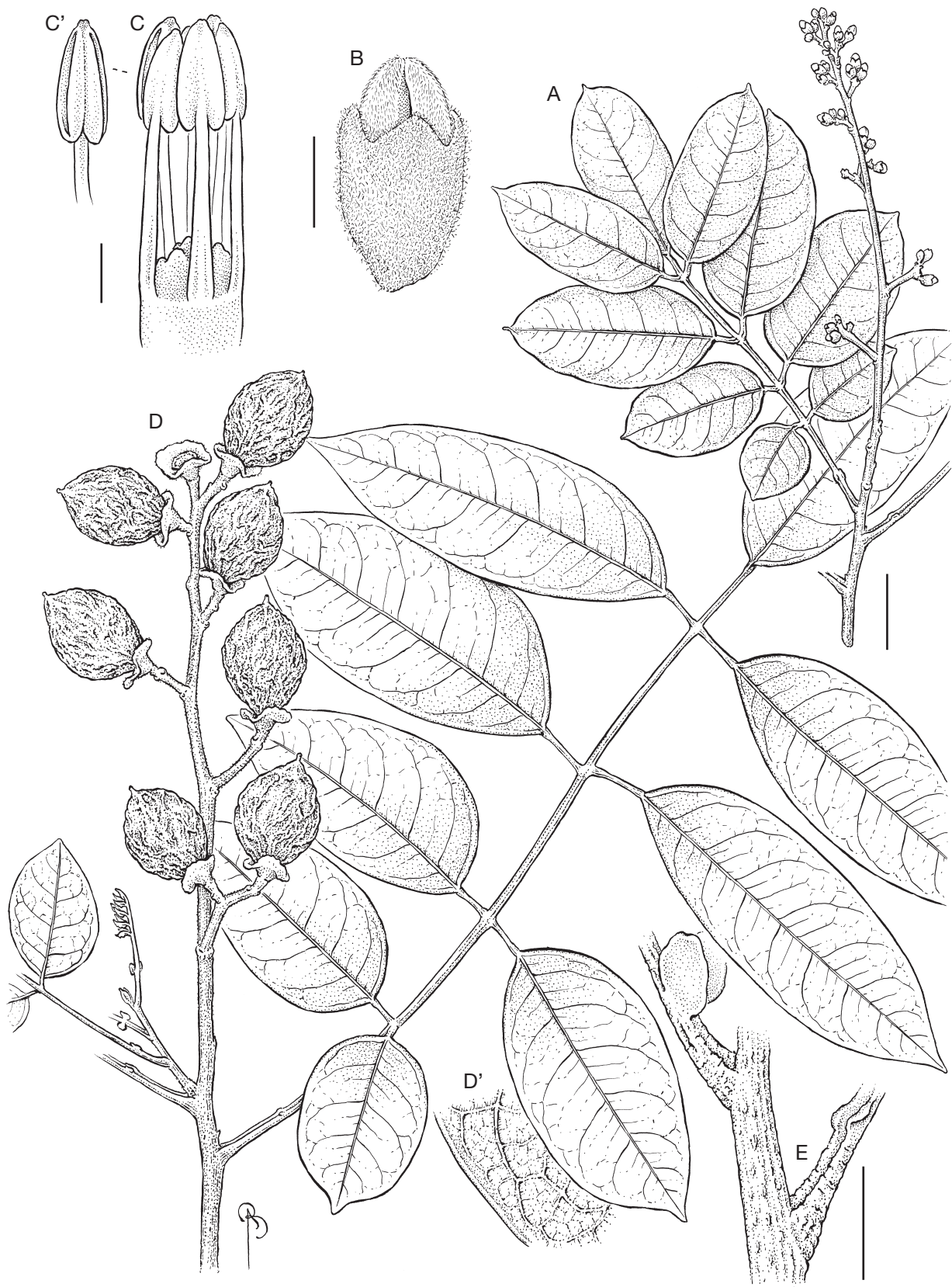


FIG. 24. — *Canarium nitidifolium* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet; **B**, staminate bud; **C**, stamens and ovariodisk, plus adaxial view of anther (**C'**); **D**, fruiting branchlet with detail of leaflet (**D'**); **E**, petiole bases with stipules (left) and stipular scars; **A–C**, *McPherson 14403* (MO); **D**, *Rabenantoandro et al. 88* (MO); **E**, *Randrianasolo et al. 188* (MO). Scale bars: **A**, 2 cm; **B**, 3 mm; **C**, 1 mm; **E**, 1 cm; **D**, **D'**, not to scale.

NOTES

Like *C. pulchrebracteatum*, *C. obovatum*, sp. nov. has stipules 5–8 mm long, terminal leaflets obovate (to elliptic or rarely ovate in *C. obovatum*, sp. nov.), a comparable number of secondary veins (collectively 5–12) and fine, stiff hairs on the abaxial midvein (to 0.5 mm long in *C. obovatum*, sp. nov., to 0.25 mm long in *C. pulchrebracteatum*). *Canarium obovatum*, sp. nov. is distinguished by the stipular scar shorter (1–1.5 vs (1) 2–3.5 mm), fewer leaflet pairs (1–2 vs (1) 3–4), longer lateral petiolules (10–27 vs 4–17 mm), the basal petiolules longer (10–25 vs 4–11), all leaflets usually obovate (vs at least some leaflets shaped otherwise), and the fruit densely pubescent (vs glabrous).

Like *C. lamianum*, sp. nov., *C. obovatum*, sp. nov. has small stipules 0.3–0.8 mm long and ovate (to orbicular in *C. lamianum*, sp. nov.) with constricted base, short stipular scars 1–1.6 mm long, coriaceous leaflets of similar size, inflorescences of comparable length (up to 19 cm), the axes with dense to sparse flexuous hairs (but up to 0.5 mm long in *C. obovatum*, sp. nov. and to 0.25 mm long in *C. lamianum*, sp. nov.). *Canarium obovatum*, sp. nov. is distinguished by having fewer leaflet pairs (1–2 vs (2) 3–4), the petiole usually longer (5.6–19.5 vs 2.5–6.5 mm), the lateral petiolules longer (10–27 vs 4–12 mm long), terminal petiolules longer (10–27 vs 4–12 mm), leaflets usually (oblong-)obovate (vs at least some leaflets shaped otherwise), the apex narrowly (not broadly) short-acuminate, the intercostal tertiary venation mixed opposite-alternate percurrent (vs irregular-reticulate), the midvein abaxially with sparse spiky golden hairs to 0.5 mm long (vs scattered appressed hairs and occasionally scattered bristles to 0.05 mm), and pistillate calyx 5.6–6 vs 6.8–8 mm long.

Canarium obtusifolium Scott-Elliot

(Fig. 20)

Journal of the Linnean Society, Botany 29: 10. 1891. — Typus: **Madagascar**. [Toliara], Fort Dauphin, (without date), *G. F. Scott-Elliot* 2933 (holo-, K, n.v.).

SELECTED MATERIAL EXAMINED. — **Madagascar**. Antsiranana, Sava, Sambava, Bemanevika, Antsakajohy, Ambatobiribiry, 100 m, 14°10'53"S, 50°05'05"E, 25.III.2001, *J. Rabenantoandro, R. Ranai-vojaona, F. Jaoby & F. Malandy* 458 (NY). Fianarantsoa, Vatovavy-Fitovinany, Nosy Varika, Ambahy, 9 m, 20°48'07"S, 48°28'56"E, 15.IX.2004, *D. Rabehevitra, R. Ludovic & S. Boto* 908 (MO, NY, P, TEF); Mahanoro, Ambodibonara, Forêt de Nakinana, 5 km from Ambalavontaka, 20°21'34"S, 48°36'21"E, 13.XI.2003, *R. Rabevohitra, D. Rabehevitra, R. Ludovic & R. Razakamalala* 4776 (MO, NY, P, TEF); Vatovavy-Fitovinany, Mananjary, Ankatafana, Marohita, Anato, Ambahisosotra, 13 m, 21°29'12"S, 48°16'20"E, 19.VI.2004, *R. Ranaivojaona et al.* 489 (NY, MO, P, TEF). Toamasina, S of Mangoro, XI.1921, *H. Perrier de la Bâthie* 14212 (US); Atsinanana, 1 km N of Ambila-Lemaitso (10 km E of Brickaville), 0–50 m, 18°51'S, 49°08'E, 04.04.1987, *G. E. Schatz & P. P. Lowry* 1315 (MO, NY). Toliara, Taolagnaro, Sainte Luce/Ambatoatsinanana, 0 m, 24°47'38"S, 47°10'15"E, 19.XII.2000, *L. Faliniaina, J. Rabenantoandro & E. Ramisy* 70 (MO, TEF).

DISTRIBUTION AND ECOLOGY. — *Canarium obtusifolium* is widely distributed in eastern Madagascar, from Fort-Dauphin in the south

to Vohémar in the north, and disjunct in the NW in the subhumid mountains of Tsaratanana and Manongarivo. It is found in (sub-) littoral and montane forests at 0–100 m elevation, although there are two collections of less than certain identification that are from montane forests up to 1150 m. Flowering Nov.–Feb. (Jun.), fruiting Dec.–Sep.

COMMON NAMES AND USES. — Ramyfotsy, ramy. Resin used for incense; wood used for construction.

DESCRIPTION

Trees, reproductive size 5–20 m tall, to 60 cm diam. Trunk with branched plank buttresses. Outer bark gray, densely lenticellate, shed in large, thin, irregular plates; inner bark light orange, fibrous. Resin white. Leaves 7–28 cm long, 2–3-jugate (4-jugate on *Service Forestier* 19784); petiole (0.8) 1.8–6.5 (8) cm long, petiole and rachis with sparse thick golden hairs to 0.05 mm long, also sparse snail-shaped glands; stipules 3–16 mm from petiole insertion, 3–7 mm long, obovate to orbicular, laterally revolute and glabrescent with age, both surfaces with sparse ascending or flexuous fine hairs to 0.1 mm long and thick short hairs to 0.1 mm long (sometimes only the latter), the scar 0.5–1.5 mm long; basal petiolules (1) 3–15 mm long, other laterals (1) 3–15 (19) mm long, terminal one (6) 11–37 mm long, petiolules canaliculate, lateral pulvinuli usually conspicuous; basal leaflets 1.6–7.3 × 1–3.5 cm, broadly obovate or rarely broadly ovate or broadly oblong, other laterals 2.2–9.6 (12) × 1.2–3.6 (5.7) cm, oblong(-obovate) to oblong-elliptic, terminal one 3.4–9.6 × 1.7–4.2 cm, obovate; leaflet apex rounded to truncate to slightly retuse, rarely some leaflets very broadly and short-acuminate, (then the acumen to 2 mm long); leaflet base usually symmetrical, obtuse to truncate to slightly cordate (to acute on terminal leaflet); margin often slightly revolute; leaflets coriaceous, usually drying light brown, dull; secondary vein framework festooned-brochidodromous, secondaries in 6–10 pairs, usually almost straight but the course concave toward base, insertion decurrent, often slightly discoloured, spacing decreasing toward apex, angle perpendicular to broadly acute, essentially uniform; intercostal tertiaries alternate-percurrent and irregular-reticulate and admedially branched; quaternaries irregular-reticulate; on abaxial side the midvein broadly prominent (sometimes sunk in a groove), secondaries (broadly) prominulous, tertiaries (narrowly) prominulous, surface essentially glabrous except for a few fine pale hairs to 0.05 mm long; on adaxial side all veins broadly prominulous to nearly flat (midvein sunk in a groove), sometimes narrowly prominulous, surface essentially glabrous. Staminate inflorescences (7.5) 12–20 cm long, secondary axes to 6 cm long, axes with sparse flexuous hairs to 0.1 mm long and sparse snail-shaped glands (both denser at insertion of pedicels and dense on pedicel), also with small raised round ferruginous lenticels at base of inflorescence; bracts on primary axes 2.5–3.8 mm long, (ob)ovate, constricted at base, not semi-clasping, fleshy and often persistent, other bracts 1.7–2.7 mm long, lanceolate to ovate, bracteoles 1.3–1.5 mm long, subulate; pedicel 0.9–1.2 × 0.5–0.8 mm. Staminate flowers 5–5.5 (6.9) mm long; calyx 2–2.9 × 3–4.6 mm overall, taller than ovariodisk, shallowly cupular, green, the



FIG. 25. — *Canarium pallidum* Daly, Raharim. & Federman, sp. nov.: **A**, branchlet with buds, with detail of leaflet (**A'**); **B**, detail of inflorescence with buds; **C**, basal portion of petiole showing stipular scar and insertion on branchlet; **A-C**, Humbert & Cours 22829 [P05311925]. Scale bars: A, 2 cm; B, 2 mm; C, 5 mm; A', not to scale.

lobes 0.4–0.8 mm long, rounded depressed-deltate, slightly spreading, abaxial surface with dense thick hairs to 0.05 mm long and sparse snail-shaped glands, usually also with flexuous hairs to 0.1 mm long, adaxial surface with dense appressed fine hairs to 0.2 mm long; petals 4.7–5.2 (6.5) × 2.2–3.2 mm, exposed part much longer than calyx, narrowly ovate or less often slightly obovate, apex rounded to obtuse, cream, abaxial surface with dense flexuous ascending pale hairs to 0.2 mm long; stamens inserted at base of ovariodisk, 3.5–4.3 (5.3) mm long, anthers 1.4–1.9 mm long, (narrowly) ovate to somewhat oblong in dorsiventral view, lanceolate to narrowly ovate in lateral view; ovariodisk 0.6–1.4 × 0.6–1.7 mm, thickly discoid, apex craggy. Pistillate inflorescences 3–15 cm long, secondary axes to 4 cm long, bracts 25–2.7 mm long, ovate, bracteoles *c.* 2 mm long, oblanceolate, most longer than buds; pedicel 2.3–5.7 × 1–1.1 mm. Pistillate flowers 6.6–6.7 mm long; calyx

3.2–3.6 × 4.7–5 mm overall, slightly taller than staminodes and nearly level with base of stigma, deeply cupular, the lobes 1.2–1.6 mm long, rounded depressed-deltate; petals 6–6.2 × 2.7–3 mm, exposed part about as long as calyx, ovate, apex acute, fleshy; staminodes 2.2–2.5 mm long, inserted on rim of annular disk, anthers 1–1.1 mm long, oblong; disk 0.5–0.8 mm tall × 0.1 mm thick, receptacle flat; pistil 3.7–4.1 × 1.7–2.4 mm, ovary depressed-ovoid, substipitate, with dense appressed brown hairs to 0.1 mm long, the style 1.3–1.5 × 0.6 mm, the stigmal area 0.4–0.5 mm tall, 3-lobed. Fruiting pedicel (0.8) 1.4–4.4 mm (can appear up to 9 mm long when bracts along inflorescence are obscured), subcylindrical, fruiting calyx 6–11 mm long, deeply cupular but distally spreading to patent, lobes indistinct, surface with sparse raised round lenticels. Fruits 2.7–4.2 (4.7) × 1.6–2.2 (2.5) cm, beige, usually (oblong-)obovoid, sometimes oblong-ovoid or

oblong-ellipsoid, the apex truncate or obtuse, less often acute, the base obtuse, lenticels on surface sparse to relatively dense, round, small, raised, ferrugineous, surface also with golden hairs to 0.4 mm long, ascending near apex and descending near base (denser on young fruit).

NOTES

Canarium obtusifolium is most easily confused with *C. lamianum*, sp. nov., with which it shares these characters: leaves 2-4-jugate, stipules 3-16 mm from petiole insertion, lateral leaflets usually (oblong-)elliptic or oblong-obovate, leaflet secondary veins in 6-10 pairs and on adaxial side very broadly prominulous to flat, the spacing (slightly) decreasing toward the apex, and the fruits 3.3-5 cm long, (oblong-) ovoid to (oblong-)obovoid, with small raised lenticels. *Canarium obtusifolium* can be distinguished from the latter by its leaflets drying a lighter brown and dull (vs often glossy in *C. lamianum*, sp. nov.), the apex usually rounded (vs usually broadly short-acuminate), the secondary veins usually wavy (vs not), discolorous (vs concolorous), and branching far from the margin, the abaxial surface micro-pitted (vs smooth), the margin often revolute when dry (vs flat), and the fruit more often oblong (vs more often (ob)ovoid).

Like *C. planifolium*, sp. nov., *C. obtusifolium* has stipules 3-7 mm long, leaflets coriaceous and the laterals 2.2-9.6 cm long and usually oblong(-elliptic), and the fruits 3.5-5.5 cm long with small ferrugineous lenticels. The latter can be distinguished from *C. planifolium*, sp. nov. by the leaves 2-4(5)-jugate (vs 5-7 in *C. planifolium*, sp. nov.), the stipules usually farther from petiole insertion (3-16 vs 2-6 mm), the leaflet margin often slightly revolute (vs flat), fewer pairs of secondary veins (5-10 vs 9-14), the inflorescence hairs shorter (sparse, to 0.1 mm long vs dense, to 0.3 mm long), the staminate flowers shorter (5-5.5 (6.9) mm vs 7-10.5 mm), the bracts narrower and constricted at base, and the fruit usually ellipsoid (vs oblong).

Canarium pallidum Daly, Raharim. & Federman, sp. nov.
(Figs 1; 25)

Small trees, leaves 1-2-jugate, stipules c. 3 mm long, leaflets glabrous, the apex gradually and broadly acuminate, the base symmetric, secondary veins in 7-10 pairs and the spacing decreasing toward apex and base, perpendicular epimedial tertiary veins present; distinguished from C. subtilis Daly, Raharim. & Federman, sp. nov. *by the petiole 2.5-3.5 (vs 1.8-2) mm long, stipules ovate (vs subulate in C. subtilis, sp. nov.), terminal leaflet larger than the laterals, on adaxial surface the secondary and higher-order veins narrowly prominent (vs impressed), leaflets drying whitish-green above (vs dark brown), and inflorescence axes subglabrous with elongate lenticels (vs with sparse ascending golden hairs to 0.35 mm long, not lenticellate).*

TYPUS. — **Madagascar.** Antsiranana, Vallée de la Lokoho (Nord-Est), near Ambalavonio, [14°34'S, 49°44'E according to the botanical gazetteer of Madagascar (<http://www.mobot.org/mobot/gazetteer/>)], 75-300 m elev., 9-10.I.1949 (buds), *H. Humbert & G. Cours* 22829 (holo-, P[P05311925]!).

DISTRIBUTION AND ECOLOGY. — A small tree known only from the type, in moist forest. Buds in Jan.

ETYMOLOGY. — The specific epithet refers to the pale color of the dry leaflets.

DESCRIPTION

Trees, reproductive height to 6 m. Leaves 13.5-16.5 (21) cm long, 1-2-jugate; petiole 2.5-3.5 cm long, petiole and rachis glabrous; stipules 10-14 mm from petiole insertion, c. 3 mm long, ovate, constricted at base, glabrous, the scar 1-1.2 mm long; all lateral petiolules 4-10 mm long, terminal one 2-3.5 mm long; basal leaflets 2.8-4.3 × 1.1-2 cm, ovate, other laterals 4.7-6.3 × 1.6-3 cm, elliptic to narrowly ovate, terminal one 6.4-8 × 2.8-4.5 cm, obovate to elliptic; apex gradually and broadly long-acuminate, the acumen 4-10 mm long; leaflet base symmetrical, acute; margin flat; leaflets chartaceous, drying whitish green above, dull, glabrous on both sides; secondary vein framework festooned-brochidodromous, secondaries in 7-10 pairs, spreading or sometimes almost straight, spacing somewhat irregular but decreasing toward apex and base, angle acute, slightly increasing toward base, perpendicular epimedial tertiaries present, intercostal tertiaries irregular-reticulate with some alternate-percurrent, quaternaries regular-polygonal; on abaxial side the midvein broadly prominulous, rest of vein orders narrowly prominent, on adaxial side the midvein narrowly prominulous, rest of vein orders narrowly prominent; flower pedicel 2-3 mm long, cylindrical. Inflorescences 5-9 cm long, secondary axes poorly developed, axes with a few scattered thick, appressed, white hairs to 0.1 mm long, also with lenticels (scattered large, flat, elongate, whitish); bracts c. 1 mm long, subulate, bracteoles 0.2-0.4 mm long, linear, with a few hairs on margin; pedicel 2-3 mm long, cylindrical. In staminate buds the calyx c. 2.3 × 1.8 mm overall, cupular, the lobes c. 0.4 mm long, broadly rounded-deltate, glabrous; petals glabrous; stamens 3, the anthers 1.15-2 mm long, lanceolate in dorsiventral view, oblong in lateral view; ovariodisk 0.55-0.7 × 0.6 mm, subcylindrical (slightly obovoid). Open flowers and fruits unknown.

NOTES

Like *C. subtilis*, sp. nov., *C. pallidum*, sp. nov. has 1-2-jugate leaves, stipules c. 3 mm long, the leaflet apex gradually and broadly acuminate and the base symmetric, the secondary veins in 6-10 pairs, the spacing decreasing toward apex and base, perpendicular epimedial tertiaries present, on the abaxial surface the secondary and higher order veins narrowly prominent, and the leaflet surfaces (sub)glabrous. The latter can be distinguished by the petiole 2.5-3.5 (vs 1.8-2 in *C. subtilis*, sp. nov.) mm long, the stipules ovate and glabrous, the stipular scars relatively flat (vs stipules subulate and the scars elevated and swollen), the terminal leaflet larger than the laterals, on the adaxial surface the secondary and higher-order veins narrowly prominent (vs impressed), the leaflets drying whitish-green above (vs dark brown), the inflorescence axes subglabrous and with elongate lenticels (vs with sparse ascending golden hairs to 0.35 mm long and not lenticellate).



FIG. 26. — *Canarium pilicarpum* Daly, Raharim. & Federman, sp. nov.: **A**, branchlet; **B**, branchlet apices with detail of apex and stipules (**B'**); **C**, leaflet with detail of margin (**C'**); **D**, staminate inflorescence; **E**, staminate flower and with bracteole; **F**, staminate flower with part of calyx and one petal removed, and longitudinal section of ovariodisk with half of stamens (left); **G**, adaxial and lateral views of stamen; **H**, portion of infructescence with detail of fruit surface (above); **A**, field photo of Daly et al. 13052 (NY); **B**, Daly et al. 13057 (NY); **C-G**, Rakotomalaza 1108 (NY); **H**, Capuron (Service Forestier) 27662 (NY). Scale bars: A, C, D, H, 3 cm; B, 1 cm; E, F, 3 mm; G, 2 mm.

Canarium pilicarpum

Daly, Raharim. & Federman, sp. nov.

(Figs 8; 26)

Small trees, leaves 4-5-jugate, stipules 5-8 mm long, leaflets coriaceous, the apex broadly and usually abruptly short-acuminate, the base truncate to slightly cordate, and secondary veins in 8-13 pairs; distinguished from C. scholasticum Daly, Raharim. & Federman, sp. nov. by the stipular scar 1-3 (vs 3-5) mm long, the terminal leaflet usually ovate (vs usually obovate in C. scholasticum, sp. nov.), and the fruit 5-5.5 × 2-2.2 cm (vs 3.5-5.1 × 2.3-3.5 cm), ellipsoid or less often slightly obovoid (vs ovoid to broadly oblong-ellipsoid to slightly obovoid) and lenticels on the fruit dense, relatively large, and raised (vs fruit surface densely micro-pustulate and becoming finely lenticellate).

TYPUS. — **Madagascar.** Toamasina, Phelps Dodge project site, c. 15 air-km [sic] NE of Moramanga, c. 11 km E of Antanambao, Analamay, near zoology camp, 1000 m elev., 18°49'46" S, 48°19'49" E, 5.II.1997, P.-J. Rakotomalaza et al. 1108 (holo-, NY!; iso-, MO, TAN).

MATERIAL EXAMINED. — **Madagascar.** Antsiranana, Diana, Montagne D'Ambre National Park, 800-1100 m, 12°32'S, 49°07'E, 19-27.VI.1993, O. Andrianantoanina & A. Solotiana 94 (MO, NY, P, TAN); Diana, Montagne D'Ambre National Park, 990 m, 12°30'48"S, 49°10'59"E, 15.IV.1994, D. K. Harder, M. C. Merello, S. G. Razafimandimbison & T. G. Razafindrabeaza 1586 (MO, US). Mahajanga, Sofia, Réserve Spéciale d'Anjanaharibe-Sud, 961 m, 14°48' S, 49°27'20", 03-07.II.1997, D. Ravelonarivo et al. 1075 (MO, NY, P, TAN). Toamasina, Alaotra-Mangoro, Andasibe, Réserve Spéciale Analamazaotra, 960 m, 18°56'13"S, 48°24'50"E, 31.I.2006, D. C. Daly & R. Ranaivojaona 13052 (MO, NY, TEF), 13057 (MO, NY, TEF); Atsinanana, Réserve Naturelle Intégrale Betampona, 400-600 m, 17°54'56"S, 49°12'28"E, 10.III.2008, S. Federman, T. Treuer & J. Sylvain 64 (NY); Alaotra-Mangoro, 15 km NE of Moramanga, 11 E of Antanambao, 1000 m, 18°49'46"S, 48°19'49"E, 05.II.1997, P.-J. Rakotomalaza et al. 1108 (MO, P, TEF); Alaotra-Mangoro, Parc National Zahamena, 950 m, 17°43'30"S, 48°46'14"E, 04.III.2001, R. Rakotondrajaona, F. Ratovoson, L. Randrianjanaka & P. Andriamamonjisoa 152 (MO); Atsinanana, Réserve Naturelle Intégrale Betampona, 400-600 m, 17°54'27"S, 49°12'17"E, 11.II.2008, T. Treuer, S. Federman & J. Sylvain 3 (NY).

DISTRIBUTION AND ECOLOGY. — *Canarium pilicarpum*, sp. nov. ranges from the Moramanga-Andasibe Reserve, Marojejy National Park, and Anjanaharibe Sud Reserve north to Montagne d'Ambre, in montane forests 960-1000 m. Flowering Feb.-Mar., fruiting Apr.

ETYMOLOGY. — The specific epithet refers to the fruit's resemblance to the pili nut (*Canarium ovatum*), which tends to be trigonous.

DESCRIPTION

Trees, reproductive size 10-16 m. Leaves 7.8-31.6 cm long, 4-5-jugate; petiole 1.8-6 cm long, petiole and rachis with sparse capitate glands and sparse thick appressed hairs to 0.5 mm long; stipules 5-16 mm from petiole insertion, 5-8 mm long, broadly obovate to suborbicular, constricted at base, both surfaces with dense appressed hairs to 0.15 mm long, the scar 1-3 mm long; basal petiolules 2-6 mm long (to 14 mm long on sterile branchlets), other laterals 3-12 mm long, terminal one 8-35 mm long, petiolules not canaliculate, lateral pulvinuli inconspicuous; basal leaflets (2.1) 3.6-5.8 × (1.1) 2.6-5.6 cm, very broadly ovate to suborbicular, other laterals (3) 5.4-11.2 × (1.8) 3-5.5 cm, usually oblong-elliptic to (oblong-)ovate, terminal one 6.4-10.2 × 2.4-4.7 cm, usually ovate, sometime elliptic or obovate; leaflet apex abruptly and

broadly short-acuminate (rarely long-acuminate), the acumen 2-6 mm long; leaflet base subsymmetric to (slightly) oblique, truncate to cordate; margin flat; leaflets coriaceous, drying light brown, dull; secondary vein framework brochidodromous, often looping near margin, secondaries in 8-13 pairs, spreading or almost straight, spacing abruptly decreasing at apex and base, angle decreasing slightly toward apex, intercostal tertiaries opposite-alternate percurrent and irregular-reticulate, quaternaries random-reticulate to somewhat regular-polygonal; on abaxial side the midvein acutely prominent, secondaries prominent and often dark, rest narrowly prominulous, surface with capitate glands and thick appressed hairs to 0.05 mm long, both these types scattered on midvein and a few scattered on secondaries and rest of surface, on adaxial side the midvein narrowly prominulous but sunk in a groove, secondaries prominulous, rest of veins nearly flat or (broadly) prominulous, surface with some hairs as on abaxial side, scattered on base, midvein and margin. Staminate inflorescences 11-26 cm long, secondary axes 4-12 cm, axes with dense to sparse, flexuous, ferrugineous hairs to 0.3 mm long; bracts c. 4.3 mm long, linear to lanceolate, surface with dense, ascending, flexuous, ferrugineous hairs to 0.3 mm long; pedicel 0.6-1.3 × 0.4-0.5 mm. Staminate flowers 4.8-5 mm long, overall; calyx (1.4) 2.8-4 × 4-4.5 mm overall, taller than ovariodisk, lobes (0.4) 1.3-2.6 mm long, rounded depressed-deltate; petals 4.6-4.8 × 2.5 mm, far exceeding the calyx, ovate, apex acute; stamens 3.2-4.2 mm long, inserted at base of ovariodisk, sometimes dimorphic in length, the anthers 1.3-1.8 mm long, ovate in dorsiventral view, lanceolate in lateral view; ovariodisk 0.7-1.2 × 1.2-1.5 mm, thickly discoid to slightly obovoid with truncate, craggy apex. Pistillate inflorescences and flowers unknown. Infructescences 8-13 cm long, secondary axes to 8 cm long, axes with lenticels sparse, large, ferrugineous, flat; fruiting pedicel 4-10 × 2.5-3.1 mm; fruiting calyx 5-7 mm long, not deeply cupular, the lobes distinct, 1.7-2.1 mm long, pedicel and calyx of young fruits with dense erect to ascending flexuous ferrugineous hairs to 0.2 mm long, also with scattered, slightly elongate, raised lenticels. Fruits 5-5.5 × 2-2.2 cm, ellipsoid or less often slightly obovoid, trigonous, surface with lenticels dense to sparse, flat, ferrugineous, also with dense, fine, descending, whitish hairs to 0.5 mm long.

NOTES

Canarium pilicarpum, sp. nov. belongs to a group of 10 species that all have relatively large, broad leaflets with truncate to slightly cordate base. Of these, *C. bullatum*, comb. et stat. nov., *C. madagascariense*, *C. scholasticum*, sp. nov., *C. velutiniifolium*, sp. nov. and *C. pilicarpum*, sp. nov. usually have the leaflet apex broadly and usually abruptly short-acuminate (acumen 2-6 (8) vs (4) 10-30 mm long in the others). *Canarium pilicarpum*, sp. nov. can usually be distinguished from the rest by its long, narrow fruit (5-5.5 × 2-2.2 cm dry vs 3-5.1 × 2.3-3.5 cm in the others). Moreover, like *C. scholasticum*, sp. nov., *C. pilicarpum*, sp. nov. has 3-5 (6)-jugate leaves, the stipules 5-8 mm long, usually obovate and constricted at base, coriaceous leaflets, secondary veins in 8-13 pairs, the inflorescence axes with sparse flexuous, ferrugineous hairs to

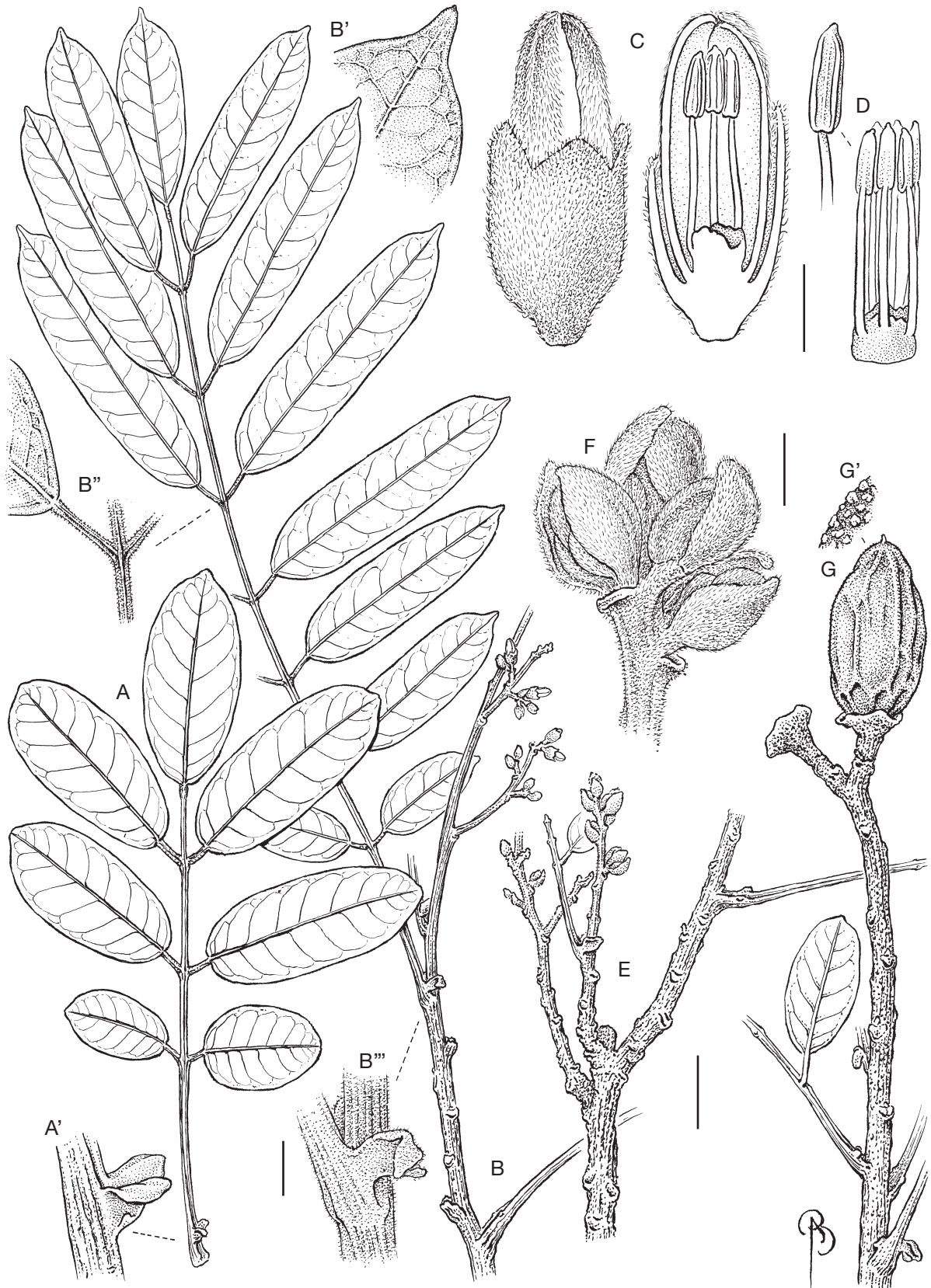


FIG. 27. — *Canarium planifolium* Daly, Raharim. & Federman, sp. nov.: **A**, leaf with detail of stipules (**A'**) and of petiolule base (**B''**); **B**, flowering branchlet with detail of leaflet apex (**B'**), and of petiolule base (**B''**) and stipule (**B'''**); **C**, staminate bud and longisection (right); **D**, stamens and ovariodisk with adaxial view of anther (left); **E**, immature inflorescence including bracts; **F**, detail of portion of immature inflorescences with bracts; **G**, portion of infructescence with detail of fruit surface (above); **A**, *Serville Forestier* 21835 (NY); **B-D**, *SF* 10862 (NY); **E, F**, *Rakotomalaza* 1542 (NY); **G**, from *Türk et al.* 476 (NY). Scale bars: **A, B, E, G**, 2 cm; **C, D**, 3 mm; **F**, 5 mm; **A', B'', B'''**, 2 mm; **B', G'**, not to scale.

0.3 mm long, and the fruiting pedicel 3–10 mm long. The latter can be distinguished by the petiole 1.8–6 cm long (vs (1.4) 5–10 cm in *C. scholasticum*, sp. nov.), with sparse capitate glands and sparse thick appressed hairs to 0.5 mm long (vs sparse to scattered erect ferrugineous hairs to 0.05 mm long, also sparse snail-shaped glands), the stipular scar 1–3 (vs 3–5) mm long, the terminal leaflet usually ovate (vs usually obovate), the midvein abaxially with scattered capitate glands and thick appressed hairs to 0.05 mm long (vs sparse to scattered erect ferrugineous hairs to 0.05 mm long, also flexuous ferrugineous hairs to 0.2 mm long, also sparse snail-shaped glands), and lenticels on the fruit dense, relatively large, and raised (vs fruit surface densely micro-pustulate and becoming finely lenticellate).

Canarium planifolium Daly, Raharim. & Federman, sp. nov.
(Figs 17; 27)

Large trees, leaflets coriaceous, (sub)glabrous, with an abruptly and very broadly short-acuminate apex, calyx deeply tubular and far exceeding the ovariodisk, fruits broadly oblong(-ovoid) with densely lenticellate surface; distinguished from C. obtusifolium Scott-Elliot by the leaves (3)5-7-jugate (vs 2-4(5)-jugate in C. obtusifolium), petiole and rachis more lignified, lateral leaflets usually oblong (vs obovate to oblong-elliptic), and the fruit (very) broadly oblong(-ovoid) (vs oblong-ellipsoid to (oblong)-obovoid).

TYPUS. — **Madagascar.** Fianarantsoa, Ranomafana National Park, parcelle 3, S of National Road 25 7 km W of Ranomafana, Talataky trail system, 950–1150 m elev., 21°15'30"S, 47°25'00"E, 18.V.1993, D. Turk, J. Solo & D. Randriamanatena 476 (holo-, NY!; iso-, MO, P[P05311933], TAN).

PARATYPI. — **Madagascar.** Antsiranana, SAVA, 1.5 W of Cap Est, 35 m, 15°16'30"S, 50°28'09"E, 24.I.1999, G. E. Schatz *et al.* 3801 (NY). Fianarantsoa, Parc National de Ranomafana, E of Fianarantsoa, Vatoharanana, Parcelle III, W of Ranomafana, 4 km S of Ambodiamontana, 900–1100 m, 21°16'S, 47°26'E, 11.III.1994, A. Kotozafy & P. Rasabotsy 501 (MO); Ihorombe, Réserve Spéciale Ivohibe, 975 m, 22°25'36"S, 46°56'18"E, 17.XI.1997, P.-J. Rakotomalaza, N. Messmer & C. Rakotovoao 1542 (NY); Forêt d'Ifanadiana, 5.I.1953, *Service Forestier* 9897 (NY, TEF); Vatovavy-Fitovinany, Sakahavia, Tolongoina, Fort Carnot, 878–1000 m, 21°31'30"S, 47°45'30"E, 17.XI.1954, *Service Forestier* 13652 (NY, P, TEF [not seen]). Toamasina, Alaotra-Mangoro, Perinet, Analamazaotra, 1000m, 18°56'S, 48°26'E, 20.V.1964, *Service Forestier* 21835 (NY, TEF [not seen]); Analanjirifo, Masoala peninsula, S. of Ambanizana, 110–260 m, 15°40'24"S, 49°57'51"E, 22.XII.1994, N. Vasey & N. Velo 266 (NY). Toliara, Anosy, Taolagnaro/Fort Dauphin, Ranomafana, Mangatsiaka, 201 m, 24°34'39"S, 47°01'41"E, 23.XI.2009, R. Razakamalala 4882 (MO, NY, P, TAN); Anosy, Mahatalaky, near Amborokozotsy, Forêt de Bero, 739 m, 24°42'S, 47°04'E, 19.X.1954, *Service Forestier* 10862 (NY, TEF [not seen]).

DISTRIBUTION AND ECOLOGY. — *Canarium planifolium*, sp. nov. has a broad range in eastern Madagascar, from Fort-Dauphin N to Ranomafana National Park, Tolongoina, and Réserve Spéciale Vohibe, to Cap Est Masoala. This rare but ecologically versatile species has been found in primary or disturbed, lowland or montane forests at elevations between 35–1150 m. Flowering Oct.–Jan., fruiting Nov.–May.

ETYMOLOGY. — The specific epithet refers to the markedly flat appearance of the compound leaves.

DESCRIPTION

Trees, reproductive size 18–35 m × 38–94 cm diam. Resin white. Leaves 14–32 cm long, (3)5–7-jugate; petiole 3–5 cm long, woody and stout, base often dilated below stipule insertion, petiole and rachis and petiolule surface on younger leaves with dense flexuous golden hairs to 0.2 mm long, also sparse white bristles to 0.1 mm long, but soon (sub)glabrescent; stipules 2–6 (8) mm from petiole insertion, 3–6 mm long, subulate to obovate, base not constricted, often fleshy (especially in fruit), surface with dense, thick, appressed, often whitish hairs 0.1–0.2 mm long, sometimes also capitate glands, stipule scar 1.5–2 mm long; basal petiolules 2–7 mm long, other laterals 5–11 mm long, terminal one 11–22 mm long, petiolules sometimes woody, sometimes shallowly canaliculated, pulvinuli often conspicuous; basal leaflets 1.6–4.3 × 1.3–2.4 cm, ovate to broadly elliptic or rarely oblong-obovate (*Service Forestier* 10862), other laterals 3.2–9.5 × 1.7–4.5 cm, (narrowly) oblong, rarely oblong-elliptic, terminal one 4.7–12.5 × 1.8–5.4 cm, obovate or less often elliptic or oblong; leaflet apex abruptly and very broadly (rarely narrowly) short-acuminate, the acumen 2–6 mm long, apex tip glandular; lateral leaflet base often asymmetric, the acroscopic side truncate to obtuse, basiscope side obtuse, rarely acute or slightly cordate; margin flat; leaflets coriaceous, drying medium to dark brown, dull; secondary vein framework brochidodromous, secondaries in (8) 9–14 pairs, spreading or rarely arcuate, spacing somewhat irregular but decreasing toward apex and base, angle acute, increasing toward apex and decreasing toward base, intercostal tertiaries opposite-alternate percurrent and admedially ramified; on abaxial side the midvein broadly prominent, secondaries prominulous and usually sunk in a groove, rest of veins flat or broadly prominulous, midvein (and less so on secondaries) with dense to scattered, flexuous to ascending, golden hairs to 0.15 mm long, or rarely glabrous; on adaxial side the midvein narrowly prominulous but sunk in a groove, secondaries slightly impressed or flat, sometimes the proximal part narrowly prominulous, glabrous. Staminate inflorescences 15–18 cm long with secondary axes to 6 cm long, the axes with sparse, fine, flexuous to ascending golden hairs to 0.5 mm long; inflorescence bracts to 10 mm long, lanceolate to ovate, long-acuminate and base constricted, bracteoles 4–6.5 mm long, broadly subulate to ovate, chartaceous, on all bracts the abaxial side with dense flexuous ascending or descending golden hairs to 0.3 mm, adaxial side with dense retrorse-appressed golden hairs to 0.6(0.7) mm; pedicel 2–3 × 1.2–1.3 mm. Staminate flowers 7–10.5 mm long; calyx 4.5–7 × (3)3.5–5.5 mm overall, deeply tubular, far exceeding the disk, the lobes 1.4–2.7 (3.5) mm long, (broadly) ovate, abaxial side with dense appressed fine golden hairs to 0.4 mm long, near the apex retrorse-appressed, adaxial side with dense appressed golden hairs 0.15–0.2 mm long; petals 6.8–10 cm × 3–3.1 mm, lanceolate, exposed portion somewhat shorter than the calyx, fleshy, with an inflexed apiculum 0.7 mm long; abaxial surface as on calyx but up to 0.5 mm long; antesealous stamens 8–8.2 mm long with anthers 2.4 mm long, antepetalous stamens 7–7.4 mm long with anthers 2–2.2 mm long, anthers very slightly oblong-lanceolate in dorsiventral view, narrowly

oblong in lateral view; ovariodisk $2.1\text{--}2.7 \times 1.5\text{--}2.2$, columnar to slightly obovoid with central depression and craggy apex. Infructescences (8) 25–30 cm long with secondary axes to 4 cm long, pubescence becoming sparse; fruiting pedicel 4–7 \times 4–5 mm, slightly clavate, fruiting calyx 7–9 cm long overall, shallowly cupular, the lobes relatively distinct, 3–4 mm long. Fruits $3.5\text{--}5.5 \times 2.1\text{--}3.2$ cm, (very) broadly oblong(-ovoid), apex round, base obtuse, surface often densely lenticellate, the lenticels round, relatively small, ferrugineous to reddish, surface also with dense, appressed, white hairs to 0.5 mm long among the lenticels (scattered when lenticels quite dense).

NOTES

Canarium planifolium, sp. nov. and *C. obtusifolium* both have relatively small, coriaceous, mostly or entirely glabrous leaflets with an abruptly and very broadly short-acuminate apex (or rounded in the latter), but *C. planifolium*, sp. nov. has more leaflets ((3)5–7-jugate vs 2–4 (5)-jugate in *C. obtusifolium*), more lignified petiole and rachis, pseudostipules closer to the petiole base (2–6 (8) vs 3–16 mm from base), the lateral leaflets usually oblong (vs obovate to oblong-elliptic), fruit broadly oblong(-ovoid) (vs oblong-ellipsoid to (oblong)-obovoid), and the fruit surface densely lenticellate and densely pubescent (vs sparsely lenticellate with scattered pubescence).

Canarium planifolium, sp. nov. also resembles *C. boivinii* Engl. because both have leaves up to 7-jugate, similar placement of the stipules, coriaceous leaflets of similar shape, and large ovoid-ellipsoid fruits, but in *C. planifolium*, sp. nov. the stipules are fleshy (vs somewhat coriaceous in *C. boivinii*) and with sparse to scattered, erect, thick, whitish hairs to 0.2 mm long (vs dense, ascending to appressed, fine, ferrugineous hairs to 0.15 mm, the leaflets are dull (vs glossy but sometimes dull adaxially), the secondary veins are broader, somewhat irregularly spaced while decreasing toward apex and base (vs more regularly spaced), arcuate and the angle acute and increasing toward apex and decreasing toward base (vs straight and the angle usually almost perpendicular and increasing toward the base), and the inflorescence hairs are longer (up to 0.5 mm vs up to 0.25 mm long).

Canarium pulchrebracteatum Guillaumin

(Fig. 8)

Notulae Systematicae 1: 72 (1909). — Typus. Madagascar, Farafangana, s.d., anon. s.n. (holo-, P[P00048870]).

SELECTED MATERIAL EXAMINED. — **Madagascar.** Antsiranana, Sava, Beankoraka-Vinanivao road, Masoala peninsula, 10–60 m, $15^{\circ}57'S$, $50^{\circ}12'E$, 17.XI.1994, *J. Rabe* 155 (NY, MO, P, TAN); Antalaha, Mouth of Ambohitratanana, Masoala Peninsula, 0–15 m, $15^{\circ}13'S$, $50^{\circ}28'E$, 23.IV.1994, *G. Rahajao* 296 (MO); Ambatoasana, Ambodigavo-Tsaratana, Antananambo, Antalaha, Diego, 230 m, $14^{\circ}52'05"S$, $50^{\circ}05'44"E$, 12–13.V.1999, *F. Ratovoson*, *J. Rabenantoandro*, *F. Randriantafika*, *T. Fevilice* & *J. J. Sylvain* 77 (MO, NY, P, TAN). Fianarantsoa, Atsimo-Atsinanana, S of Farafangana near Manombo Reserve, 100 m, $23^{\circ}03'16"S$, $47^{\circ}40'28"E$, 15.XI.2001, *G. McPherson* & *J. Rabenantoandro* 18430 (MO, NY, P, TEF). Toamasina, Atsinanana, Réserve Naturelle Intégrale Betampona,

400–600 m, $17^{\circ}55'19"S$, $49^{\circ}11'58"E$, 11.II.2008, *S. Federman*, *T. Treuer* & *J. Sylvain* 4 (NY), Réserve Naturelle Intégrale Betampona, 400–600 m, $17^{\circ}53'54"S$, $49^{\circ}12'34"E$, 04.IV.2008, *T. Treuer*, *S. Federman* & *J. Sylvain* 64 (NY).

DISTRIBUTION AND ECOLOGY. — *Canarium pulchrebracteatum* has a broad distribution in eastern Madagascar, ranging from Farafangana in the south to Ranomafana National Park and Andasibe National Park in the east-central part of the country, north to the Baie d'Antongil and Maroantsetra and to Vohémar and the Sambava region. It is found in moist forest on steep terrain between 50–375 m elevation. Flowering Nov.–Feb. (Jun.), fruiting Mar.–Aug.

COMMON NAMES. — Tsiramiramy, ramy mainty.

DESCRIPTION

Trees, reproductive height 12–30 m \times 12–50 cm diam; plank buttresses to 1.2 m high. Outer bark gray, thick or thin, rough due to raised sparse lenticels, also with hoop marks, thin, shed as large irregular spongy plates; inner bark brittle, beige to orange, oxidizing reddish. Resin clear. Leaves 11.8–39.8 cm, 1–3(4)-jugate; petiole 2.5–10 cm long, petiole and rachis with dense, fine, flexuous hairs to 0.15 mm long; stipules 5–13(23) mm from petiole insertion, 3.5–7 mm long, orbicular or less often broadly ovate, usually constricted at base, pubescence as on petiole, the scar (1) 2–3.5 mm long; basal petiolules 4–11 mm long, other laterals 5–17 mm long, terminal one 11–45 mm long, sometimes shallowly canaliculate, lateral pulvinuli inconspicuous; basal leaflets $1.9\text{--}7 \times 1.5\text{--}5.4$ cm, nearly orbicular to ovate, very rarely lanceolate, other laterals $3.8\text{--}15.2 \times 2\text{--}4.6$ (6.9), elliptic to obovate, rarely ovate or lanceolate, terminal one $4.6\text{--}14 \times 1.8\text{--}6.8$ cm, obovate to elliptic or rarely ovate; leaflet apex abruptly short-acuminate or often gradually and narrowly long-acuminate, the acumen (1) 2–13 mm long; leaflet base symmetrical or often slightly oblique, obtuse to truncate or acute, on basal leaflets sometimes slightly cordate; margin flat and sometimes with scattered flexuous hairs to 1.0 mm long; leaflets chartaceous to slightly coriaceous, drying brown, dull, occasionally slightly glossy; secondary vein framework brochidodromous but looping near margin, secondaries in 5–10 pairs, arcuate to spreading, slightly discolored abaxially, spacing decreasing toward apex and base, angle increasing toward apex and decreasing toward base, intersecondaries average less than 1 per pair of secondaries and usually perpendicular, usually reticulating, intercostal tertiaries opposite-alternate percurrent, tertiary angle decreasing exmedially, quaternaries regular-polygonal; on abaxial side all veins prominent, midvein and secondaries with sparse to dense, stiff, relatively fine erect hairs to 0.25 mm long, rest of surface papillate and glabrous or with sparse stiff hairs; on adaxial side all veins narrowly prominent except the midvein sometimes sunk in a groove, midvein with sparse to dense, appressed to ascending, thick whitish hairs to 0.3 mm long, scattered on secondaries, rest of surface glabrous or sometimes rest of blade like the abaxial blade, rarely the midvein and secondaries with sparse fine erect golden hairs to 0.7 mm long. Staminate inflorescences to 28 cm long, secondary axes to 7.5 cm long, axes with dense flexuous ferrugineous hairs to 0.4 mm long, also with dense capitate glands; bracts

on primary axes *c.* 3.5 mm long, lanceolate, other bracts 2.5–3.5 mm long, lanceolate to subulate, bracteoles 2.7–4 (5) mm long, ovate to (narrowly) elliptic. Staminate flowers 10–13.5 mm long; calyx (3.4) 4.4–5 × (4) 5.3–6.2 mm overall, (deeply) cupular, the lobes 0.8–1.4 mm long, rounded depressed-deltate, abaxial surface with dense flexuous ferrugineous hairs to 0.4 mm long, ascending near apex and descending near base, the adaxial side with dense appressed hairs to 0.3 mm long; petals 9.2–11.7 × 3–5 mm, exposed part much longer than calyx, oblong to slightly (ob)ovate, cream-colored, abaxial surface with straight fine golden hairs to 0.4 mm long, appressed toward apex and retrorse-appressed toward base, the apex with an inflexed apiculum 0.4–0.7 mm long; antesealous and antepetalous stamens 7.2–10 mm and 6.6–9.3 mm long, respectively, anthers 2.2–2.5 mm long, slightly lanceolate in dorsiventral view and oblong in lateral view, the apex apiculate; ovariodisk 1.3–2.2 × 1.7–2.2 mm, shortly columnar, yellow, the apex craggy. Pistillate inflorescences 5.5–16 (23) cm long, secondary axes to 6 cm long, with few flowers; bracteoles *c.* 3.8 mm long, oblanceolate; Pistillate flowers *c.* 11 mm long; calyx *c.* 5.4 × 5 mm overall, deeply cupular, the lobes *c.* 1.2 mm long, rounded depressed-deltate; petals *c.* 9.4 × 2 mm, exposed part slightly longer than calyx, oblong-lanceolate with an inflexed apiculum *c.* 0.5 mm long; antesealous stamens *c.* 5 mm long with anthers *c.* 1.7 mm long, antepetalous stamens *c.* 4.1 mm long with anthers *c.* 1.4 mm long, the anthers oblong, the filament bases slightly swollen; disk lacking and the stamens inserted on a shallow hypanthium; pistil *c.* 5 × 2 mm, the ovary ovoid, substipitate, the style *c.* 1.5 mm long, the stigmatal area *c.* 0.6 mm long. Fruiting pedicel 2–6 × 4–5 mm, slightly clavate, fruiting calyx (4) 5–6.5 mm long, often slightly cupular, the lobes sometimes distinct. Fruits 3–4.7 × 1.8–2.5 cm, (broadly) ovoid and usually trigonous, rarely narrowly ovoid (dry), the apex acute to acuminate or rarely rounded, the base obtuse, less often truncate; surface usually glabrous and smooth; lenticels very few, raised, somewhat foveolate.

NOTES

Like *Canarium nitidifolium*, sp. nov., *C. pulchrebracteatum* has the stipules inserted 5–18 (23) mm from petiole insertion, the lateral petiolules 5–18 mm long, similarly shaped leaflets (although narrower in the latter), 5–10 secondary vein pairs, the leaflets markedly pubescent abaxially, the fruiting calyx cupular and lenticellate, and the fruit ovoid with the surface smooth and glabrous. The latter can be distinguished by the petiole and rachis with dense, fine, flexuous hairs to 0.15 mm long (vs with sparse to scattered flexuous ferrugineous hairs to 0.3 mm long, also fine erect to ascending hairs to 0.2 mm long in *C. nitidifolium*, sp. nov.); stipules longer (5–7 vs 2–3 mm long), leaflet acumen usually narrow (vs usually broad) with the apex tip glandular-apiculate (vs eglandular), lateral leaflet base rounded to obtuse or acute (vs truncate to cordate or less often acute), and the secondary veins usually spreading (vs usually arcuate) and the angle increasing (vs decreasing) toward the base, and the fruit base obtuse to truncate (vs attenuate).

Canarium laxiflorum, sp. nov. and *C. pulchrebracteatum* have chartaceous leaflets of similar size, with the leaflet secondary veins in 5–9 pairs, arcuate, and the spacing and angle decreasing toward the base, and the inflorescences long with well-developed secondary axes. The latter can be distinguished by the stipules 5–13 (23) (vs 18–20 in *C. pulchrebracteatum*) mm from petiole insertion, the basal leaflets nearly orbicular to ovate or rarely lanceolate (vs ovate or broadly elliptic), the other laterals elliptic to obovate, rarely ovate or lanceolate (vs narrowly oblong(-elliptic) to oblanceolate), the leaflet apex narrowly (vs broadly) acuminate, the midvein on the abaxial leaflet surface with sparse to dense stiff, relatively fine erect hairs (vs scattered, thick, ascending to appressed hairs), the inflorescence somewhat shorter (up to 28 cm vs up to at least 34 cm), the bracteoles ovate to (narrowly) elliptic (vs almost linear), the flowers longer (10–13.5 vs 7.6–8 mm), and the calyx deeper and broader ((3.4) 4.4–5 × (4) 5.3–6.2 vs 2.8–3.1 × 4.5–4.8 mm overall).

Canarium scholasticum Daly, Raharim. & Federman, sp. nov. (Figs 10; 28)

Small to very large trees, leaves 3–4(6)-jugate, terminal leaflet usually obovate, leaflet apex usually abruptly and broadly short-acuminate with the acumen 2–6 mm long; distinguished from C. lamianum Daly, Raharim. & Federman, sp. nov. *by the bark finely fissured or smooth (vs deeply fissured in C. lamianum, sp. nov.), lateral leaflets (oblong-)ovate (vs variously shaped but not ovate), lateral leaflet base cordate or less often truncate, very rarely acute (vs obtuse, truncate, or acute), secondary vein angle decreasing toward the base (vs increasing or uniform), on staminate inflorescences the secondary branch endings not congested (vs often congested).*

TYPUS. — **Madagascar.** [Toamasina] Tamatave, District Tamatave II, Commune Ambodirina, Réserve Naturelle Intégrale Betampona, on mild slope 3.7 km N of reserve base, 325–375 m elev., 17°55'53"S, 49°12'12"E, 3.II.2006, D. C. Daly, R. Ranaivojaona, R. B. Iambana & C. Razafy 13075 (holo-, NY!; iso-, G!, MO!, TEF!).

PARATYPI. — **Madagascar.** Mahajanga, Sofia, Mangindrano, 1855 m, 14°13'17"S, 49°03'47"E, X.2005, M. Callmander, S. Buerki, C. Rakotavao, Joro & Jovazaha 429 (G, MO, NY, P, TAN). Fianarantsoa, Vatovavy-Fitovinany, Between Fianarantsoa and Ifanadiana, Parc National Ranomafana, 1100 m, 21°15'S, 47°27'E, 11–15.XI.1991, S. T. Malcomber 1046 (NY, MO). Toamasina, Analanjirofo, Maroantsetra, Ampokafo, Ambatoledama, 15°17'S, 50°00'E, 15.VIII.2003, P. Antilahimena 2051 (MO); Alaotra-Mangoro, Moramanga, Andasibe, Menalamba, between Analamay and Ambatovy, 1221 m, 18°49'52"S, 48°18'43"E, 21.V.2007, P. Antilahimena, F. Edmond & Tojoniaina 5540 (MO, P, TAN, TEF); Alaotra Mangoro, Moramanga, Ambohibary, Ampitambe, Ambatovy, Andranoverly forest, 1028 m, 18°52'06"S, 48°18'14"E, P. Antilahimena *et al.* 7098 (US); Analanjirofo, Befandriana Nord, Antsakabary, Andapanomby, Ampandisana River, 149 m, 15°19'44"S, 49°08'15"E, 30.IV.2007, R. Bernard & C. Birkinshaw 502 (MO, P, TAN); 3 km E of Mandraka, along Antananarivo-Toamasina highway, 1090 m, 18°56'S, 47°56'E, 27.I.1993, G. E. Schatz, W. D. Stevens & J. P. Rakotomazaza 3425 (MO, NY, P, TAN); Atsinanana, Réserve Naturelle Intégrale Betampona, 400–600 m, 17°55'23"S, 49°11'57"E, 11.II.2008, T. Treuer, S. Federman & J. Sylvain 4 (NY).

DISTRIBUTION AND ECOLOGY. — *Canarium scholasticum*, sp. nov. has one of the broadest distributions of the genus in Madagascar.

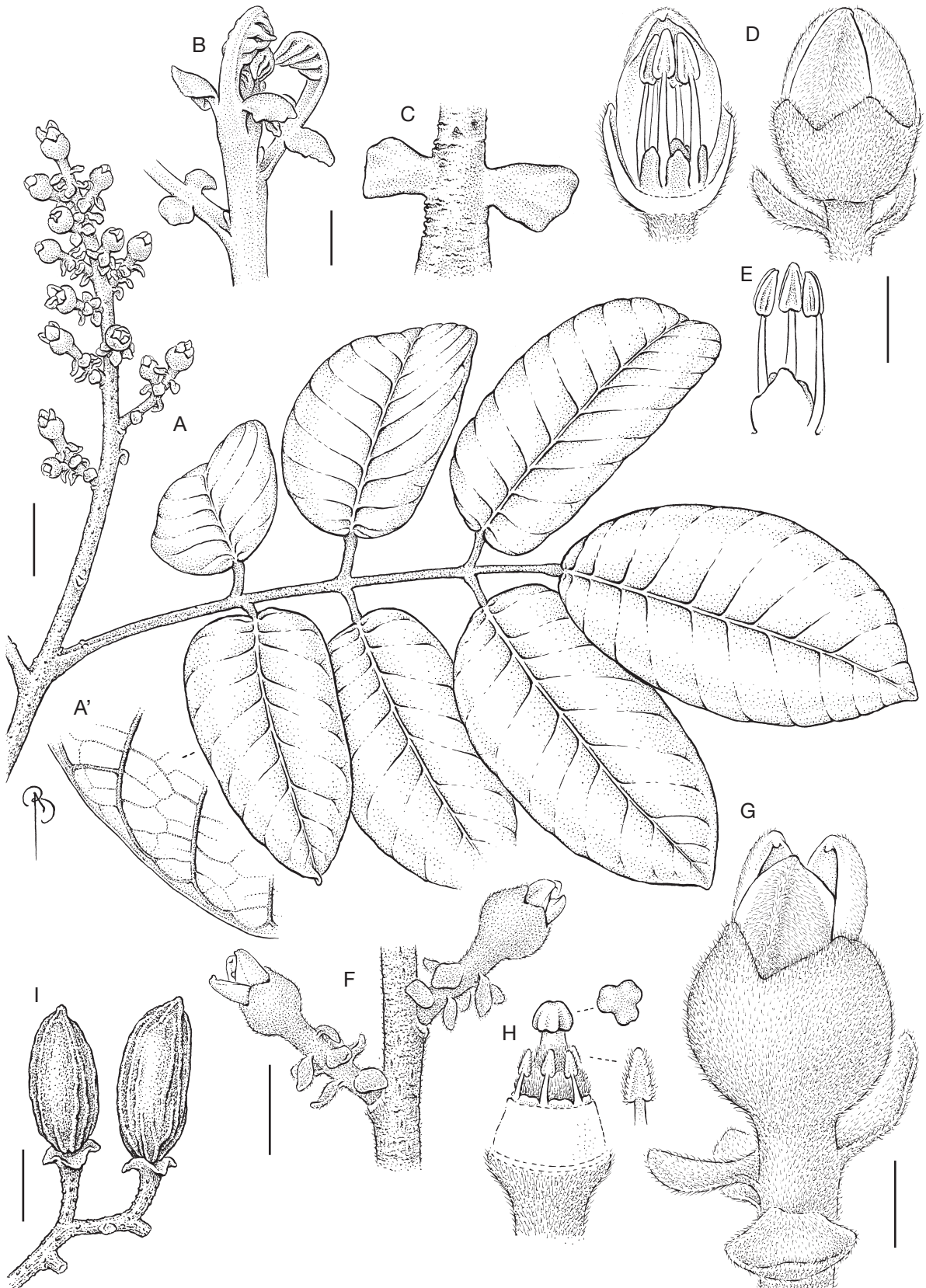


FIG. 28. — *Canarium scholasticum* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet with detail of leaflet (**A'**); **B**, detail of shoot apex with stipules; **C**, apical view of stipules; **D**, staminate bud with bracteoles (right) and with part of calyx and two petals removed (left); **E**, longisection of ovariodisk and half of stamens; **F**, portion of pistillate inflorescence; **G**, pistillate flower with bracts and bracteoles; **H**, pistillate flower with perianth removed, plus apical view of stigma and abaxial view of pubescent staminode anther (right); **I**, portion of infructescence; **A**, **F**–**H**, *Daly et al.* 13075 (NY and field photos); **B**, *Daly et al.* 13015 (field photo by D. Daly); **C**, *Daly et al.* 12968 (field photo by D. Daly); **D**, **E**, from *Service Forestier* 2088 (NY); **I**, *Malcomber* 1046 (NY). Scale bars: **A**, **I**, 2 cm; **B**, **C**, 5 mm; **D**, **E**, **G**, **H**, 3 mm; **F**, 1 cm; **A'**, not to scale.

It ranges from Ranomafana National Park in the south, to Tsiroanomandidy in the west and Analamazaotra National Park in the center, to Maroantsetra, Vohémar and Sambava in the North; it is also broadly distributed in the Sambirano-Ambanja region. It is usually found in montane forests between (325) 800-1600 m elevation. Flowering Jan.-Mar., fruiting Nov.-Apr.

COMMON NAMES. — Ramy blanc, ramy mena, ramy, tsiramiramy, aramy.

ETYMOLOGY. — The specific epithet refers to the occurrence of the species near places of study, the Cabine de Recherche and the Vato camp used by primatologists in Ranomafana National Park.

DESCRIPTION

Trees, reproductive size 3-35 m, to 300 cm diam, with low plank buttresses. Outer bark gray, thick, deeply fissured, lenticellate, shed in thick irregular plates, inner bark light orange. Resin white, flammable. Leaves 8.5-36.5 cm long, 3-4(6)-jugate; petiole (1.4) 5-10 cm, petiole and rachis with sparse to scattered erect ferrugineous hairs to 0.05 mm long, also sparse snail-shaped glands, in fruit often woody and lenticellate; stipules (1) 5-13 mm from petiole insertion, 5-6 mm long, obovate and usually constricted at base, surfaces with dense ferrugineous ascending to appressed hairs to 0.25 mm long, the scar 3-5 mm long; basal petiolules (2) 4-14 (20) mm, other laterals (3) 6-20 mm long, terminal one (10) 14-40 (56) mm long, not canaliculate, lateral pulvinuli sometimes conspicuous; basal leaflets (1.8) 3-10.5 × (1.1) 1.8-5.6 cm, (broadly) ovate to suborbicular, other laterals (3.5) 5.8-13 × (1.7) 2.5-6.2 cm, (oblong-)ovate, less often (oblong)obovate or rarely broadly elliptic, terminal one 4.7-14 × 2.4-8.2 cm, obovate, less often broadly elliptic, rarely ovate; leaflet apex rounded to abruptly and broadly short-acuminate, the acumen 2-6 mm long, leaflet base usually symmetric, sometimes basal insertion slightly asymmetric, cordate or less often truncate, very rarely acute; margin flat; leaflets coriaceous, sometimes splitting along midvein when pressed and dried, drying (greenish) brown, dull or sometimes glossy on adaxial side and rarely on abaxial side; secondary vein framework brochidodromous but usually looping near the margin, secondaries in 8-13 pairs, slightly arcuate to spreading, spacing decreasing toward apex and markedly toward base, angle increasing toward base, intercostal tertiaries alternate-percurrent or sometime irregular-reticulate, quaternaries regular-polygonal; on abaxial side the midvein narrowly prominent, secondaries prominent but slightly sunk in a groove, tertiaries usually narrowly prominulous and then often sunk, sometimes flat or broadly prominulous, the midvein with sparse to scattered erect ferrugineous hairs to 0.05 mm long, also flexuous ferrugineous hairs to 0.2 mm, also sparse snail-shaped glands, rest of surface with scattered short thick appressed hairs; on adaxial side the midvein narrowly prominulous but sunk in a groove, secondaries narrowly prominulous but usually sunk, rest of veins broad and almost flat, surface subglabrous or with fine erect or ascending white hairs, these sparse to scattered on midvein, relatively dense on petiolules, scattered on rest of surface plus a few along the margin. Inflorescences 5-25 cm long, axes with dense flexuous ferrugineous hairs to 0.3 mm

long, also some elongate lenticels; staminate inflorescences with secondary axes to 9 cm long; bracts on axes *c.* 7.8 mm long, with dense flexuous golden hairs to 0.2 mm long, narrowly elliptic, some ovate (especially on primary axes); bracteoles *c.* 3.7 mm long, obovate and acuminate, often longer than buds; pedicel 3.4-4.6 × 0.9-1.3. Staminate flowers 4.8-5.5 mm long overall; calyx 2.1-2.6 × 3.6-4 mm, taller than ovariodisk, deeply cupular, lobes 0.6-1.7 mm long, (depressed) rounded-deltate, abaxial surface with dense appressed flexuous ferrugineous hairs to 0.15 mm long, adaxial surface with dense ascending to appressed golden hairs to 0.3 mm long; petals 5-5.3 × 3.4 mm, exposed part slightly shorter than or equal to calyx, ovate, abaxial surface with appressed golden hairs to 0.3 mm long, these retrorse at apex, oriented toward the apex up the center of the petals, and exmedial up the sides of the petals; stamens 3.4-3.5 mm long (sometimes stamens slightly dimorphic in length), anthers 1.2-1.4 mm long, narrowly oblong-ovate in dorsiventral view, lanceolate to narrowly ovate in lateral view; ovariodisk 0.8-1.5 × 1.2-1.6 mm, short-columnar to perdepressed-obovoid, apex truncate and craggy. Pistillate inflorescences with secondary axes to 5.5 cm long; bracts on axes 6.1-8.1 mm long, ovate to obovate and foliose, with ascending to appressed flexuous golden hairs to 0.3 mm long; bracteoles 5-6 mm, shorter than buds, obovate and acuminate; pedicel 2 × 1-1.5 mm, slightly clavate. Pistillate flowers 9.4-9.5 mm long overall; calyx 5.5-6.5 × 5.8-6.6 mm overall, the lobes 0.8-1.2 mm long, rounded perdepressed-deltate; petals 6 × 3.8 mm, exposed part much shorter than calyx, ovate, fleshy; staminodes 2.4-2.8 mm long, inserted around rim of a hypanthium 1.3-1.5 mm deep, level with the base of the stigmas, the anthers 1-1.1 mm long, ovate in dorsiventral view and oblong in lateral view, pubescent; pistil 5-5.4 × 2.6-3.2 mm overall, ovary ovoid and with appressed golden hairs to 0.2 mm long, the style 1.1 × 1-1.6 mm long, the stigmata area 1.1-1.4 tall, 3-lobed. Fruiting pedicel 3-10 × 3-4.2 mm, slightly clavate, with scattered erect ferrugineous to golden hairs 0.25 mm long, fruiting calyx 4-10 mm, shallowly cupular, lobes sometimes distinct, 2-4 mm long, patent, with scattered lenticels. Fruits 3.5-5.1 × 2.3-3.5 cm, brown or gray, ovoid to broadly oblong-ellipsoid to slightly obovoid, sometime slightly angular, rarely broadly ovoid, apex (slightly) tapering to rounded, base truncate to obtuse, surface with lenticels usually dense, relatively large, very raised, slightly ferrugineous, among the lenticels glabrous or some fine white hairs to 0.8 mm long.

NOTES

Canarium scholasticum, sp. nov. belongs to a group of 10 species that have relatively large, broad leaflets with truncate to slightly cordate base; within that group, it is contrasted with *C. pilicarpum*, sp. nov. in the discussion under that species, and outside that group it is contrasted with *C. ferrugineum*, sp. nov. in the discussion under that species.

Both *C. lamianum*, sp. nov. and *C. scholasticum*, sp. nov. for the most part have usually 3-4-jugate leaves, stipules 4-13 mm from petiole insertion and 3-7 mm long, basal petiolules 4-14 mm long, terminal leaflet obovate, leaflet



FIG. 29. — *Canarium subsidarium* Daly, Raharim. & Federman, sp. nov.: **A**, flowering branchlet with detail of leaflet margin (**A'**) and petiole base with stipular scar (**A''**); **B**, detail of leaf rachis, petiolule and leaflet base; **C**, staminate inflorescence and apical view of stipular scars (**C'**); **D**, portion of immature inflorescence; **E**, staminate bud; **F**, longitudinal section of staminate flower; **G**, stamens and ovariodisk; **H**, abaxial, adaxial and lateral views of stamen; **I**, leaf minus base of petiole; **J**, portion of infructescence; **K**, pyrene; **A, B**, *Malcomber* 2596 (NY); **C-H**, *Capuron* (SF) 11513 (NY); **I, J**, *Rakotomalala & Narison* 106 (MO); **K**, from *Malcomber et al.* 920 (NY). Scale bars: A, C, I, J, K, 2 cm; B, D, 5 mm; E, F, G, 2 mm; H, 1 mm; A', A'', C', not to scale.

apex abruptly and broadly short-acuminate with the acumen 2-7 (11) mm long, and calyx deeply cupular in pistillate flowers. The latter differs by the bark finely fissured if at all (vs deeply fissured in *C. lamianum*, sp. nov.), the lateral leaflets (oblong-)ovate (vs variously shaped but not ovate) and often folding lengthwise when dry (vs flat), the lateral leaflet base cordate or less often truncate, very rarely acute (vs obtuse to truncate to acute, sometimes short-attenuate), the secondary vein angle decreasing toward the base (vs increasing or uniform), on abaxial surface the secondary veins more prominent and the lamina often corrugated between secondary veins, on adaxial surface the secondary veins discolorous, and in staminate flowers the stamens inserted around the base of the ovariodisk (vs inserted on the side).

Canarium subsidarium Daly, Raharim. & Federman, sp. nov. (Figs 4; 29)

Small trees, leaves 3-4(5)-jugate, stipular scars 2-3 mm long, fruits ovoid, green, glabrous, becoming finely lenticellate; distinguished from C. betamponae Daly, Raharim. & Federman, sp. nov., *C. galokense* Daly, Raharim. & Federman, sp. nov., *C. globosum* Daly, Raharim. & Federman, sp. nov., and *C. manongarivum* Daly, Raharim. & Federman, sp. nov. by the petiole and rachis with dense to scattered hairs to 0.5 mm long (vs scattered to sparse hairs to 0.25 mm long in the others) and occurrence in montane forests 1000-1600 m elevation (vs maximum recorded 875 m), further distinguished from *C. galokense*, sp. nov. by the fruit ovoid (vs broadly oblong or broadly ovoid) with the surface coarsely (vs finely) lenticellate.

TYPUS. — **Madagascar.** Antsiranana, Réserve Spéciale de Manongarivo, E d'Ankaramibe; Bekolosy, 850 m elev., 14°03'05"S, 48°17'07"E, 10.I.1994, L. Rakotomalala & Narison 106 (holo-, MO!; iso-, TAN).

PARATYPI. — **Madagascar.** Antsiranana, Diana, Massif de l'Antsatro-tro (Manongarivo), c. 1100 m, XI.1954, Capuron (*Service Forestier*) 11513 (NY); Réserve Spéciale Manongarivo, SE of Beraty, 1350-1600 m, 14°06'S, 48°21'E, 29.IX.1991, S. Malcomber & S. Razafimandimbison 920 (MO, NY); E of Ankaramibe, 1000-1200 m, 14°02'S, 48°18'E, 04.XII.1993, S. Malcomber & L. Rakotomalala 2596 (MO, NY, P, TAN).

DISTRIBUTION AND ECOLOGY. — *Canarium subsidarium*, sp. nov. appears to be restricted to Manongarivo in N Madagascar. It is usually found in montane moss forest on ridgetops, between 1100-1600 m (collected once at c. 850 m). Flowering Nov.-Dec., fruiting Jan.-Sep.

ETYMOLOGY. — The specific epithet, meaning "in reserve," derives from the fact that the species is known only from the area of the Réserve Spéciale Manongarivo.

DESCRIPTION

Trees, reproductive height 5-12 m, to 40 cm diam. Leaves 15-25 cm long, 3-4(5)-jugate; petiole 2.5-4.5 cm long, petiole and rachis with dense to sparse capitate glands and bristles (fine erect hairs to 0.05 mm), also with dense to scattered fine erect hairs to 0.5 mm; stipules 4-9 mm from petiole insertion, caducous, the scar c. 2-3 mm long, raised; basal petiolules 3-6 mm long, other laterals 6-11 mm long, terminal one 10-25 mm long, pulvinuli distal and moder-

ately conspicuous; basal leaflets 3-6.5 × 1.5-2.5 cm, ovate to elliptic, other laterals 4.4-9.8 × 2.4-3.2 cm, oblong(-lanceolate) to elliptic, terminal one 5-8.7 × 3-4.3 cm, elliptic to oblanceolate; leaflet apex gradually and broadly short-acuminate, the acumen 2-6 mm, apex tip glandular; base truncate to rounded or obtuse, basally symmetrical or less often slightly oblique; margin flat; leaflets somewhat coriaceous, drying dark grayish-brown; secondary vein framework brochidodromous but looping near margin, secondaries 7-11 per side, spreading, discolorous, spacing usually decreasing toward apex and base, angle acute and increasing toward base; tertiary venation random-reticulate to alternate-percurrent; on abaxial side the midvein acutely prominent, secondary veins broadly prominulous, remainder narrowly prominent to prominulous, midvein with scattered ascending hairs to 0.15 mm and rest of surface with a few capitate glands and scattered thick appressed hairs to 0.05 mm long (sparse near base), the surface also appearing papillate; on adaxial side the midvein narrowly prominulous and sunk in a groove, rest of veins narrowly prominulous, surface glabrous. Inflorescences 8.5-25 cm long, axes with sparse to dense bristles and capitate glands and with dense to sparse flexuous hairs to 0.3 mm; staminate inflorescences with secondary axes to 9.5 cm long; bracts on secondary axes 2.8-3 mm long, ovate and acuminate with constricted base, longer than subtended buds, bracteoles 1.7-2.2 mm, subulate, shorter than buds, bracts and bracteoles usually semi-clasping; pedicel 1.2-3.0 × 0.5-0.8 mm. Staminate buds (flowers unknown) 5-5.2 mm long; calyx 3-4.5 × 2.2-2.9 mm overall, much taller than the ovariodisk, lobes 0.6-1.6 mm long, deltate, abaxial surface with dense capitate glands and dense to sparse flexuous ascending to appressed golden hairs to 0.2 mm long, adaxial surface with dense retrorse-appressed pale golden hairs to 0.2 mm long; petals cream, with flexuous ascending to appressed golden hairs to 0.3 mm; stamens inserted at two different levels toward base of ovariodisk, the antesealous stamens 3.1-3.3 mm long, the antepetalous stamens 2.9-3.1 mm long, anthers c. 1.4-1.6 mm long, oblong to ovate in dorsiventral view, oblong-lanceolate in lateral view; ovariodisk 1.3-1.6 × 0.6-1.5 mm, essentially obovoid to columnar, apex truncate and craggy to bluntly and abruptly short-attenuate. Fruiting pedicel 3-5(6.5) × 3.4-3.5 mm; fruiting calyx patent, the lobes 2-3 mm long. Fruits 3.6-3.8 × 2.3-2.8 cm, ovoid, green, glabrous, densely micro-pustulate and becoming finely lenticellate.

NOTES

Canarium subsidarium, sp. nov. is part of a complex of species including *C. betamponae*, sp. nov., *C. galokense*, sp. nov., *C. globosum*, sp. nov., and *C. manongarivum*, sp. nov. that all have 3-5-jugate leaves with short stipular scars (except *C. manongarivum*, sp. nov.), small and often oblong leaflets, and relatively small fruits. They are compared in Table 1 under *C. betamponae*, sp. nov. *Canarium subsidarium*, sp. nov. is also contrasted with *C. moramangae*, sp. nov. in the discussion under the latter species.



FIG. 30. — **A-C**, *Canarium subtilis* Daly, Raharim. & Federman, sp. nov.: **A**, branchlet with detail of leaflet margin (**A'**); **B**, detail of petiole base and stipules; **C**, fruiting branchlet; **D, E**, *Canarium velutinifolium* Daly, Raharim. & Federman; **D**, flowering branchlet with detail of leaflet (**D'**); **E**, portion of immature inflorescence; **A, B**, *Antilahimena* 1650 (NY); **C**, from *Antilahimena et al.* 1450 (NY); **D, E**, *Meyers* 1 (NY). Scale bars: **A, C, D**, 2 cm; **B, E**, 5 mm; **A', D'**, not to scale.

Canarium subtile Daly, Raharim. & Federman, sp. nov.
(Figs 1; 30)

Small to medium-sized tree, leaves c. 2-jugate, stipules c. 3 mm long, leaflets glabrous, the apex gradually and broadly acuminate and the base symmetric, secondary veins in 6-10 pairs, the spacing decreasing toward apex and base; distinguished from C. pallidum Daly, Raharim. & Federman, sp. nov. *by the petiole 1.8-2 (vs 2.5-3.5) mm long, stipules subulate (vs ovate in C. pallidum, sp. nov.), leaflets drying dark brown above (vs whitish-green), terminal leaflet smaller than the laterals, on leaflet adaxial surface the secondary and higher-order veins impressed (vs narrowly prominent), and inflorescence axes with sparse ascending golden hairs to 0.35 mm long and not lenticellate (vs subglabrous and with elongate lenticels).*

TYPUS. — **Madagascar.** Toamasina, Maroantsetra, Ambinanitelo, Marovovonana, Ambodivato, 420 m, 15°18'13"S, 49°33'13"E, 21.XI.2002, P. Antilahimena, G.E. Schatz & Niovoson 1450 (holo-, NY!; iso-, MO, P[P05280197]!, TAN).

PARATYPI. — Toamasina, Analanjirofo, Maroantsetra, Antsirabesahatany, Anjahely, Vohitaly Forest, 600 m, 15°26'22"S, 49°32'03"E, 29.XII.2002, P. Antilahimena 1650 (NY).

DISTRIBUTION AND ECOLOGY. — *Canarium subtile*, sp. nov. appears to be restricted to a small area near Maroantsetra. It is a modest-sized tree known to date from disturbed moist forest at 420-600 m elevation. Fruiting Nov.-Dec.

ETYMOLOGY. — The specific epithet refers to the understated morphology of this taxon.

DESCRIPTION

Trees, reproductive size 14-20 m × 14-40 cm diam. Leaves 16-28 cm long, 2-jugate; petiole 1.8-2 cm long, petiole and rachis glabrous or with scattered thick appressed hairs to 0.05 mm long, also scattered elongate raised lenticels; stipules 6-10 mm from petiole insertion, c. 3 mm long, subulate, fleshy, surfaces with scattered fine appressed pale golden hairs to 0.1 mm long, scar 1.5 mm long; all lateral petiolules 6-8 mm long, terminal one 18-22 mm long, petiolules canaliculate, lateral pulvinuli conspicuous; basal leaflets 2.5-4.5 × 1.5-2.2 cm, elliptic to ovate, other laterals 4-9 × 1.7-3.2 cm, elliptic, terminal one 4.5-8.1 × 1.9-3.5 cm, oblanceolate to elliptic; leaflet apex gradually (sometimes abruptly) and broadly short-acuminate, the acumen 2-5 mm long; leaflet base symmetrical, cuneate to acute; margin flat, leaflets chartaceous, drying dark brown, glossy (at least abaxially); secondary vein framework festooned-brochidodromous, secondaries in 6-10 pairs, discolorous, nearly straight, spacing decreasing toward apex and base, angle nearly perpendicular and increasing slightly toward apex, perpendicular epimedial tertiaries (and a few intersecondaries) present; intercostal tertiaries irregular-reticulate, quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, surface glabrous or with scattered capitate glands; on adaxial side the midvein narrowly prominent but sunk in a groove, rest of veins impressed, surface glabrous. Flowers unknown. Infructescences 6-9 cm long, with few fruits, axes with sparse ascending golden hairs to 0.35 mm long; fruiting pedicel 4-5 × 2-3 mm, cylindrical or slightly clavate; fruiting calyx 5-6 mm long, not cupular, the lobes 2-3 mm long. Fruits 2-2.8 × 1.9-2.4 cm, broadly

ovoid to subglobose, apex obtuse or rounded, sometimes the tip apiculate, the base truncate, the surface glabrous or with scattered capitate glands, maturing fruits with scattered light-colored pustules.

NOTES

Canarium subtile, sp. nov. is distinguished from *C. manongarivum*, sp. nov. in the discussion under the latter species and from *C. pallidum*, sp. nov. in the discussion under that species.

Canarium velutinifolium

Daly, Raharim. & Federman, sp. nov.
(Figs 1; 30D-E)

Relatively small trees, leaves 4-5-jugate, leaflet apex broadly and usually abruptly short-acuminate, and the base truncate to slightly cordate; distinguished from C. bullatum, comb. et stat. nov., C. madagascariense, C. pilicarpum Daly, Raharim. & Federman, sp. nov., and *C. scholasticum* Daly, Raharim. & Federman, sp. nov. *by the leaflet abaxial surface velvety, with dense fine, ascending, pale golden hairs (reddish on midvein) to 0.5 mm long (vs not velvety, the leaflet abaxial pubescence sparse to scattered or the surface glabrous in the others), adaxial leaflet surface with all veins impressed (vs at least some vein orders prominent) to prominent, and larger fruit (5.5-5.9 vs 3-5.5 cm long when dry).*

TYPUS. — **Madagascar.** Antsiranana, Analamazava, part of Binara Range, 8 km SW of Daraina (Vohémar), 300 m elev., 13°15'S, 49°38'E, 24.XI.1989, D. Meyers 1 (holo-, NY!; iso-, MO, P[P05280196]!, TAN).

PARATYPI. — **Madagascar.** Antsiranana, Sava, Vohémar, Commune Antsirabe-Nord, Fokontany Andravonambo, Massif Antsolaratra, 398 m elev., 14°06'S, 57°38'E, 28.II.2013, C. Birkinshaw, Martial, C. Z. Rakotonirina & G. Be 1969 (MO [not seen], NY, TAN [not seen]).

DISTRIBUTION AND ECOLOGY. — As it is known to date, *Canarium velutinifolium*, sp. nov. is a modest-sized tree, locally dominant in dry forest c. 300-400 m elevation in Sava and Daraina regions in Antsiranana Province. Flowering Nov., fruiting Feb. "Many lemurs eat fruits" (Meyers 1).

COMMON NAMES AND USES. — Haramy-i, ramy. The resin "burns like kerosene" when dry (Meyers 1), used to fill gaps in canoes and to light fires (Birkinshaw et al. 1969)

ETYMOLOGY. — The specific epithet refers to the velvety texture of the leaflet abaxial surface.

DESCRIPTION

Trees, reproductive size c. 15-16 m. Leaves 21-35.5 cm long, 4-5-jugate; petiole 4-7 cm long, 2.5-4 mm diam, petiole and rachis with dense, fine, ascending, golden hairs to 0.3 mm long; stipules 5-10 mm from petiole insertion, caducous (not seen), the scar 2-4 mm long; lateral petiolules 3-8 mm long, terminal one 12-15 mm long, lateral pulvinuli inconspicuous; basal leaflets 2.6-5.2 × 1.7-6.4 cm, ovate to suborbicular, other laterals 4.8-15 × 3-8.5 cm, broadly (oblong-)ovate to oblong, terminal one 7.3-7.5 × 4.1-4.4 cm, broadly elliptic to slightly obovate; leaflet apex abruptly short-acuminate to rounded, the acumen 0-5 mm long; lateral leaflet base symmetrical, cordate (rounded on terminal leaflet); margin flat; leaflets chartaceous, drying light brown abaxially, (dark)

brown adaxially, dull; secondary vein framework eucamptodromous to weakly brochidodromous basally, distally brochidodromous but looping at the margin, secondaries in 11-21 pairs, almost straight, spacing slightly decreasing toward base, angle decreasing toward apex and increasing toward base, multiple perpendicular epimedial tertiaries present per pair of secondaries; intercostal tertiaries mixed opposite-alternate percurrent; quaternaries regular-polygonal; on abaxial side all veins narrowly prominent, surface with dense fine, ascending, pale golden hairs (reddish on midvein) to 0.5 mm long, also dense, thick, ascending pale golden hairs to 0.1 mm long; on adaxial side all veins flat to impressed, surface with sparse ascending to appressed white hairs to 0.15 mm long. Inflorescences terminal, staminate inflorescences *c.* 23 cm long and 5 mm diam at base, secondary axes to 10 cm long, axes with dense ascending to flexuous golden and ferrugineous hairs to 0.5 mm long, bracts 3.1 mm long, slightly obovate to subulate, with dense ascending flexuous golden hairs to 0.2 mm long. Only staminate buds known; calyx with dense flexuous golden hairs to 0.1 mm. Infructescences *c.* 22.5 cm long and 10 mm diam at base, secondary axes to 3 cm long (without fruit), pedicel *c.* 4-6 × 6 mm; calyx 9-12 mm long, lobes to 2 mm long when distinct. Fruit 5.5-5.9 × 1.9-2.1 cm (dry), narrowly obovoid, surface gray with dense, small, red-brown lenticels, with persistent dense, flexuous, golden hairs to 0.5 mm long at apex and on style.

NOTES

Canarium velutinifolium, sp. nov. belongs to a group of 10 species that all have relatively large, broad leaflets with truncate to slightly cordate base. Of these, *C. bullatum*, comb. et stat. nov., *C. madagascariense*, *C. pilicarpum*, sp. nov., *C. scholasticum*, sp. nov., and *C. velutinifolium*, sp. nov. usually have the leaflet apex broadly and usually abruptly short-acuminate (2-6 (8) vs (4) 10-30 mm long in the remaining species with truncate to cordate leaflet base). *Canarium velutinifolium*, sp. nov. is easily distinguished from the rest of the “cordate group” by the leaflet abaxial surface velvety, with dense fine, ascending, pale golden hairs (reddish on midvein) to 0.5 mm long; also dense, thick, ascending pale golden hairs to 0.1 mm long (vs leaflet abaxial pubescence sparse to scattered or the surface glabrous). Moreover, on the adaxial leaflet surface all veins are impressed (vs at least some vein orders prominulous to prominent).

EXCLUDED SPECIES

Canarium harami Bojer

Hortus mauritanus: 83 (1837). No type cited or located.

Canarium greveanum Engl., Engl. & Prantl

Natürlichen Pflanzenfamilien, Nachträge 3 (4): 241 (1896). *Nomen nudum* “= *C. multiflorum* Engl.”.

Canarium liebertianum Engl.

Notizblatt des Königlichen botanischen Gartens und Museums zu Berlin 2: 270 (1899). — Typus: Zanzibar, bei Mbaffu südlich von Dar-es-Salâm [sic], 1898, *F. Stuhlmann s.n.* Cited by Leenhouts (1959) as synonym of *C. madagascariense*. Type probably destroyed, and distribution improbable.

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