Palms on the Nickel Island: An Expedition to Gag Island, Western New Guinea

by Charlie Heatubun

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This is an account of an exciting expedition to an off-shore island in northwestern New Guinea. The relatively isolated position, small size, unusual geological formation, including limestone and nickel-rich mineral deposits, and the peculiarities of its palms make Gag Island one of the most threatened palm habitats in New Guinea.

Gag Island is a small island about 11.5 × 8 km, lying at 0°25′00″S and 129°53′00″E and belonging to the Raja Ampat Archipelago. Administratively, Gag is part of Kabupaten (regency) Raja Ampat, in the Indonesian province of Papua Barat (West Papua). The island is about 160 km NW of Sorong on the New Guinea mainland, and it can be reached in 12–18 hours by using a traditional *pinisi* boat, or about 5 hours by speedboat, or 35 minutes in a small aircraft. Sea travel to this area is totally dependent on the "wind-season" or monsoon, so at particular times of the year, usually during *musim angin selatan* (the south-wind season) there is almost no sea transport serving the island.

Gag Island has been famous since 1969, when a large deposit of nickel was discovered by the Pacific Nickel Co., and according to their estimate, deposits were sufficient for at least 30 years mining. However, mining activity has been postponed for several years due to environmental and biodiversity issues, especially after the forest on Gag was declared a protected area by the Indonesian Ministry of Forestry. The mining concession overlaps the protected forest on the island, but a special regulation was issued recently by the central government to accommodate "mining in protected areas," and the status of the forests on Gag Island changed into a mining concession. As a result, the concession holder has started to build the mining infrastructure, even though many conservationists and environmentalists still disagree with the plan to exploit the minerals on Gag.

The position of Gag and other islands of Raja Ampat is biogeographically significant, especially the roles these islands play as a connection between the main island of New Guinea and areas farther west. Recent biodiversity studies conducted by Conservation International (McKenna et al. 2002) and the Nature Conservancy (Takeuchi 2003, Webb 2005) demonstrate that the Raja Ampat Islands are unique and have high biodiversity. The conservation agencies together with the Government of Indonesia have recommended the Raja Ampat Islands (including Gag) to be designated by UNESCO as a World Heritage Site (McKenna et al. 2002, Takeuchi 2003).

Raja Ampat Archipelago is the one of several areas in western New Guinea that are undercollected according to Conn (1996) and Johns (1997). However, several collecting trips have now been conducted to the area, such as trips to Salawati and Batanta (1996), Waigeo (1997) and Misool (2002) by Herbarium Manokwariense (Universitas Papua, Manokwari), by The Nature Conservancy (Takeuchi 2003, Webb 2005), and most recently by the Indonesian Institute of Sciences (LIPI) to Waigeo in 2007. However, none of these trips visited Gag, and thus the flora of this island (including palms) was poorly known. During our expeditions, we were really privileged to explore, collect and make an account of Gag's palms for the first time and also to make important discoveries, such as a new record of *Heterospathe elata* for New Guinea (Heatubun et al. 2012), a new record of *Calamus zollingeri* and *Calyptrocalyx spicatus* for New Guinea and extended range of *Saribus brevifolia* (in this paper) and a new taxon of Ptychospermatinae (Heatubun et al., in press).

The expeditions

Two palm expedition have been carried out to Gag Island. The first expedition was conducted in 2006, as part of Palms of New Guinea project (Baker 2000, 2002) and to support CDH's PhD research project on the genus *Areca*

1. The *pinisi* boat KLM Febry Jaya, the wooden vessel which used in the expedition to Gag Island. (Photo by Charlie D. Heatubun).

L. (Heatubun 2009, Heatubun et al. 2012b), and also together with colleagues from the Balai Penelitian Kehutanan (Forestry Research Institute), aiming to get information about existing terrestrial biota of the island. The second expedition was in 2011, as part of a project on the taxonomy, ecology and conservation of palms on Gag Island with funding from the International Palm Society (IPS Endowment Fund 2010 to CDH and William J. Baker). This paper tells the story of our unforgettable experiences in reaching and escaping Gag Island, mostly from the first expedition, and about its unique palms and their recent taxonomic status.

The first expedition began on 18 July 2006, when two of us (KL and OPM) and other expedition members travelled to Sorong from Manokwari by regular ferry boat, arriving in Sorong on the following day. In the meantime, CDH undertook the long journey from Bogor in West Java, staying overnight in Manado in North Sulawesi before joining the expedition team in Sorong. In Sorong, we spent three days prior to departure to Gag. We needed time to prepare all the permits and logistics and, most importantly, to find a sea-worthy boat to ferry us safely over the ocean to Gag. At the same time, we paid attention to the weather forecast and tried to decide when exactly would be the best time for us to travel. Although the authorities suggested we should postpone our expedition until the sea condition was more favorable to travel, we had to do our fieldtrip as soon as possible because we had tight schedules, with other commitments planned for the time after the trip. After we had a short discussion and made some observations, we finally decided that we should use a big boat to cross the ocean, and our choice was a 45-ton wooden vessel, the *KLM Febry Jaya* – a *pinisi* boat (Fig. 1). The *pinisi* is a type of traditional sailing boat of the Makassar Bugis people of South Sulawesi. *Pinisi* have served the traditional trading routes among the islands for centuries and are famous for crossing the Indian Ocean to Madagascar and Africa in medieval times. Our boat was 20 m long and 8 m wide and equipped with an 8 × 4 m main sail and one supporting engine, and it had the potential to reach seven knots in normal conditions.

Just after midnight on 22 July 2006, we started to load the vessel with all our gear and personal belongings, and finally the boat departed at three o'clock in the morning. The *pinisi* moved out slowly from the pier and sailed, following the bay in front of the town of Sorong. In minutes, we were already headed north to Waigeo Island. In our first six hours, it was relatively windless and our vessel sailed normally. We reached the town of Waisai (the capital of Kabupaten Kepulauan Raja Ampat) in the south of Waigeo Island at mid-day. Because there was no pier at the time, we just dropped anchor and landed on the beach using a small canoe. We tried to meet the authorities in the town; unfortunately, we had arrived on a Saturday when the main office of the local government was closed, so all we could do was to drop off our information and return to the boat.

The trip continued, and we sailed straight to the west to Gag. After passing Saunek Island, we entered the Dampier Strait, which separates Waigeo in the north from Batanta to the south. The strait is named for Captain William Dampier (1651–1715), the author and seaman who visited the area and collected algae along the north coast of New Guinea's Kepala Burung (Bird's Head Peninsula) in 1700 on the *HMS Roebuck*. The Dampier Strait is famous for having been visited by the great British naturalist and co-discoverer of the mechanism of evolution, Sir Alfred Russell Wallace, in 1859 (Wallace 1874).

We all had a great time on this crossing; we saw spectacular scenery on several small islands along the Dampier Strait: the bluish crystal-clear sea water with magnificent coral reefs, the white sand beaches clinging to the islands and the coconut trees pointing to the sky, the perpendicular limestone-cliffs just bursting out from the sea and an unexpectedly beautiful sunset over Merpati Island. We really enjoyed our journey and were astonished by what we saw. Our *pinisi* moved slowly and reached Merpati Island in the late afternoon, and soon we cast anchor off the island. Although the island was suitable for landing, we decided to sleep on the boat.

Early morning on the next day, we continued our expedition to our destination, Gag Island. It was about four o'clock in the morning, when our vessel left Merpati Island. The captain said that we had to rush to cross the ocean and reach Gag Island before mid-day, because strong winds usually blow at noon and the resulting big waves could be really dangerous. There was no land between Merpati and Gag, and the distant open-sea water was waiting to be crossed. However, the ocean was very friendly, the breeze blew from behind and

2. An ultramafic hill on Gag Island with palms emerging from the forest canopy. (Photo by C.D. Heatubun).

small waves helped to push us on. Finally, Gag Island appeared, a small dot in the distance rising up from the horizon, and becoming clearer and clearer. In just a few hours, we were approaching the shore.

The scenery was unusual; ultramafic rocks and brown clay soil was exposed, contrasting with the sea water and blue skies in the background (Fig. 2). Shrubs and dwarf trees were dominant in the grayish heath forest vegetation. The different colors of vegetation were scattered in the lowlands to the limestone hills on the other side of the island, while coconut groves camouflaged the heavily disturbed lowland forest just behind the village. We were close to shore, and the village stretched along the coastline of a small bay, Gambir Bay. On the other side of the bay, just opposite the village, were the facilities of the base camp of the mining company, PTGN, with a small pier, the only one on the island. We had arrived at mid-day. The boat was tied up at the pier, and a few people were waiting to see us; they were the camp manager of PTGN and the local authorities of Gag Island. Then we discussed our collecting plan, including collecting sites inside the mining concession area. Soon after the meeting, we unloaded our personal belongings from the boat and stayed overnight at base camp.

We started our collecting activity on the morning of 24 July 2006, when a few members of the expedition team went to the northern part of the island and set up our camp. After a quick exit from PTGN's base camp, all the members of the expedition team met together in our camp in the north of the island. Actually, our camp was set up close to a small spring and also very close to the beach (about 20 m from the water's edge) under coconut trees, at a place called Kapatpapo. This area was dominated by heavily disturbed old garden vegetation, coconut plantation and fragments of lowland forest along a small creek and forest on the limestone hill. The lowland rainforest and limestone hill forest were top priority for exploration.

We divided into two small groups; one was led by KL with the main task of making a forest inventory and vegetation analysis of the island. The other group, led by CDH and OPM, aimed to collect any interesting plants found during the fieldtrip, including palms and gingers. We walked out from our camp, passed the coconut trees and straight to the west, crossing contours, and tried to reach the other side of the island. That forest was lowland rainforest on the small limestone hill, but the condition was heavily disturbed by local mixed-cultivation gardens, expansion of

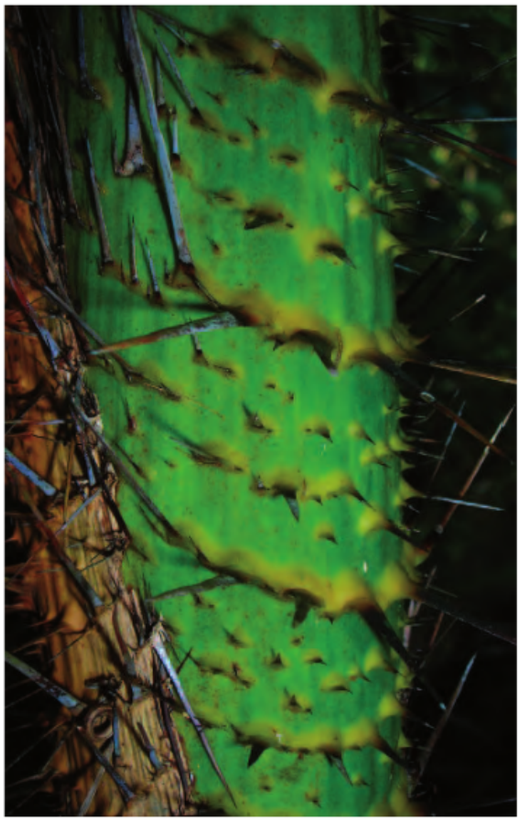
coconut plantation and firewood extraction by local people. After a half day of walking, we realized there was no forest left on the other (western) side of the island, so we went no farther. The forest had been converted to mixed-garden and coconut plantation. We decided to go back to camp and did some collecting on the way. On this occasion, we made collections of several palms such as *Calamus zollingeri*, *Calamus* sp. 1, *Daemonorops* sp., *Heterospathe elata, Licuala* sp. and a few individuals of very unusual young palms (and seedlings) with the appearance of *Hydriastele* or *Ptychococcus* but we failed to find the mature palm. We also made collections of a giant ginger (possibly a species of *Alpinia*) with leafy stems shooting out to 10 m high from the ground, as well as collections of interesting bamboos and other grasses and several trees.

Calamus zollingeri Becc. is a Sulawesi rattan species, which is solitary in Gag (but often clustering in Sulawesi). It is a rattan climbing to 20 m high, with a cane diameter of about 6 cm with sheaths and 4 cm without sheaths. The leaves are about 475 cm long with cirrus and bearing about 100 pairs of regular leaflets, white powdery and waxy underneath and the petiole about 40 cm long. The inflorescence can reach 200 cm long with several partial inflorescences, the first branch of the partial inflorescence 65 cm long. This is the largest rattan on the island and is usually found in lowland rainforest and/or limestone forest. Cane from this species is used as rope or binding material for traditional construction and is called *wala dou* in Gebe dialect. This represented an important new record of this species for New Guinea (Fig. 3).

Calamus sp. 1 is a small clustering rattan with very distinctive dense white velvet-like hairy sheaths and almost erect stems to 3 m high. This rattan is found mainly in forest gaps or in old secondary forest on alluvium or limestone areas and is locally called *wala molo* in Gebe dialect. It is also used as rope and binding material.

Daemonorops sp., or *sane* in Gebe dialect, is a clustering moderate rattan, climbing to 30 m high in alluvial forest and/or limestone hill forest. Diameter of the canes with sheaths is

3 (below left). Leaf sheath of rattan *Calamus zollingeri*. 4 (below right). Cane with sheath of rattan *Daemonorops* sp. (Photos by Charlie D. Heatubun).



5 (top). Fuits of a rattan, *Daemonorops* species. 6 (bottom). *Licuala* sp. (Photos by Charlie D. Heatubun).

7 (left). Undescribed species of Ptychospermatinae. 8 (right). Triads in bud of the undescribed species of Ptychospermatinae. (Photos by Charlie D. Heatubun).

3–5 cm, and without sheaths about 2 cm, the sheath covered with dense brown powder on top of blackish bristly hairs (Fig. 4). Leaves with cirrus are about 450 cm long and bearing 69 pairs of regularly-arranged leaflets. The inflorescence is the main character to distinguish it from *Calamus*; in *Daemonorops* it is pendulous and enclosed by many persistent very spiny bracts. The inflorescence hangs down to about 1 m long and bears globose fruits about 2 cm in diameter and covered with milky brown, shiny scales (Fig. 5). The cane of this rattan is also used as weaving material for making baskets.

Licuala sp. (*pesem* in Gebe dialect) is a solitary moderate tree palm to 10 m tall with numerous fan leaves (Fig. 6). The leaf is 220–235 cm long and bears about 39 segments. The segments split deeply to the hastula and all segments have a similar dimension. The interfoliar inflorescence is borne among the leaves about 230 cm long with a peduncle around 55 cm long and prophyll 33 cm long. The flowers are small, cream in color and the fruits are small, green, and ripening orange. This *Licuala* occupied lowland areas up to the forest on limestone hill and locally the stem or wood from this palm is used as piles and/or planks for traditional construction.

In the following days, we spent our time searching for and finding a few patches of lowland forest; they were close to the airstrip and Kablebet River. It was amazing that we found a few mature stands of *Heterospathe elata* in secondary forest (see Heatubun et al. 2012). We also found an emergent tree species of undescribed Ptychospermatinae palm (Figs. 7–11). The palm was also present in secondary forest and old, abandoned gardens, where it persists as a relict from the original forest. This new taxon, or *gul botom* in Gebe dialect, is a large solitary tree palm to 25 m tall with a conspicuous crownshaft and about 12 leaves with strikingly pendulous leaflets, forming the hemispherical crown. The leaf is about 275 cm long and bears 55 pairs of regular praemorse leaflets. The inflorescence is infrafoliar and about 75 cm long with third order branches, and the peduncle is shorter than the rachis. The fruit is mid to light green, orange and red when ripe, and the seed ellipsoid with ruminate endosperm. Another population of this mysterious palm (*CH 746*) was also found in patchy lowland forest near Kablebet River

9 (top). Detail of pistillate flowers after anthesis of the undescribed species of Ptychospermatinae.
10 (bottom). Ripe fruits of the undescribed species of Ptychospermatinae. (Photos by Charlie D. Heatubun).

where the population was healthy with several mature trees in full fruit. From this area, we also collected two species of *Areca*, One is the native *Areca macrocalyx*, a small to medium solitary palm with stem to 5 m tall, internodes 4–15 cm long and about 5 cm in diameter, 7 leaves in the crown and bearing about 19 pairs of leaflets, the crownshaft 90 cm long and leaf sheath 70 cm long. Inflorescence is colorful, hanging down about 53 cm long and 14 cm width, with a caducous bract and congested rachillae (Fig. 12). This *Areca* is native to Gag

Island and mainly grows on stream banks in lowland forest in limestone areas and is quite distinct from typical *A. macrocalyx* in its colorful inflorescence and rachillae of the second and third order. Sometimes, the fruits are used by local people as a substitute for betel nut (*A. catechu*). It is also locally known as *pinang hutan* or *kasimya* in Gebe dialect.

The other species of *Areca* was *Areca* sp.; this solitary moderate palm with stem reaching up to 15 m high was planted by local people in their gardens together with common betel nut (*A. catechu*). This species of *Areca* is easily distinguished from the true *A. catechu* by its short internodes and distinctive recurved leaves in the crown, and also the inflorescence is robust with staminate flowers arranged on one side of rachillae (unilateral), and has three conspicuous scars on the egg-shaped fruit caused by woody sepals scratching the epicarp during the development fruit from the gynoecium. However, this species is treated as *A. catechu*, in the recent monograph of the genus *Areca* from East Malesia (see Heatubun et al. 2012b for explanation). This palm is not native to Gag Island. Local people said that they had brought seeds and seedlings from Gebe Island in North Moluccas and planted them on Gag Island. The same species has been recorded and collected from cultivation on the North Coast of Yapen Island in Cenderawasih Bay (Geelvink Bay), Papua Province by the CDH. Usually on Gag, local people called this palm *pinang gebe* or *mala lolef* in Gebe dialect.

Another interesting palm also found during this occasion was *Calyptrocalyx spicatus* (Lam.) Blume (Figs. 13 & 14). This solitary moderate palm grows along stream banks on alluvial soils in the limestone forest and it can reach up to 15 m tall. There is no crownshaft and the leaves are about 400 cm long and bear about 50 pairs of leaflets. The 3-spiked inflorescence is about 250 cm long and has persistent bracts borne between the leaves. Although this is a new record of *C. spicatus* for New Guinea, this taxon needs further investigation because it can be distinguished from typical Moluccan *C. spicatus* in inflorescence and fruit characters. The inflorescence of this taxon is always 3-spiked, and the fruit has thick brown indumentum on the surface of epicarp, and also whitish cream color when ripe, while, the Moluccan *C. spicatus* has 1- or 2-spiked inflorescences, and fruits that are smooth and red when ripe according to Dowe & Ferrero (2001) in their revision of the genus *Calyptrocalyx*.

11. Endocarp, seed and endosperm of undescribed species of Ptychospermatinae. (Photo by C.D. Heatubun).

12. Inflorescence of *Areca macrocalyx* showing rachillae with staminate flowers at anthesis and pistillate flowers after anthesis. (Photo by Charlie D. Heatubun).

Before moving to another part of the island, we listed without collecting the common and/or cultivated palms that we found, such as *Areca catechu*, *Caryota rumphiana*, *Metroxylon sagu*, *Nypa fruticans* and *Salacca zalacca*. Besides the palms, we also collected other plants from coastal vegetation, mangroves and swampy areas including a beautiful terrestrial orchid, *Arachnis beccarii* – this species grew on the karst limestone on the beach, its beautiful flowers dominated by yellow and red leopard-spotting on the adaxial (upper) surface of its tepals while being purple-colored on the abaxial (lower) surface.

13 (top). Staminate flowers at anthesis of *Calyptrocalyx spicatus*. 14 (bottom). Ripe fruits of *Calyptrocalyx spicatus*. (Photos by Charlie D. Heatubun).

After spending five days in Kapatpapo, we moved to the heath forest on ultramafic and volcanic formations inside the mining concession of PT. Gag Nikel. Due to strict regulations from the company, we had to stay in a village with local people and walk to the

concession area for collecting. We started collecting on the ultramafic area by walking along the main mining road, from base camp uphill. The road was in good condition, with gravel and limestone construction, but sometimes with laterite soils. The area was fantastic! The demarcation of each type of vegetation was so clear from a distance. From the highest point, the summit of Mt. Susu (275 m elevation), we saw the entire island as a huge puzzle of vegetation types, and each piece of the puzzle represented one specific plant community. The heath forest comprises small trees and woody shrubs, such as *Alstonia beatricis* and *A. rubiginosa* (Apocynaceae), *Calophyllum* sp. (Calophyllaceae) with tiny yellowish foliage and fruits, the tree *Gnetum gnemon* and the liana *Gnetum gnemonoides* (Gnetaceae), *Pouteria* sp. (Sapotaceae) and others; they all had an unusual appearance, being small and short in all dimensions or of a dwarf habit.

From this habitat, we collected two species of *Hydriastele*. The first one was *Hydriastele* sp. 1 (Figs. 15–17) from swampy and water-logged areas behind the main camp of PT. Gag Nickel. This palm is distributed from swamp forest to the slopes on heath forest and it resembles *Hydriastele brassii* (Burret) W.J.Baker & Loo from the mainland of New Guinea.

The second species, *Hydriastele* sp. 2 (Figs. 18 & 19), occurred in the heath forest along the main road from base camp up to the mining area on the slope and up to the hill of the heath forest on ultrabasalt soil. This handsome palm is a large solitary tree palm tall to 25 m tall with conspicuous crownshaft and about eleven recurved leaves that form a beautiful crown, spherical in outline. The leaf is about 200 cm long and bears 34–44 pairs of regularly arranged leaflets. The horsetail-like inflorescence is pendulous, as is typical of *Hydriastele,* hanging down to 50 cm below the crownshaft. The fruits are colorful, yellowish metallic green and orange near the tip (see Front Cover). The seedling of this species has an entire bifid leaf and becomes pinnate after the rosette phase. We also found this taxon later in heath forest on ultramafic areas in Halmahera, North Moluccas (Heatubun 2011).

After we spent a whole day searching this area, we went back down to Gambir village, collecting *Saribus brevifolius* (Figs. 20 & 21) on the way. This fan palm has relatively small

15. *Hydriastele* sp. 1. in the swampy habitat. (Photo by Charlie D. Heatubun).

16 (left). Pistillate flowers at late anthesis of *Hydriastele* sp. 1. 17 (right). Ripe fruits of *Hydriastele* sp. 1. (Photos by Charlie D. Heatubun).

leaves and dominates slopes and ridges on the ultramafic rocks. The seedling of *Saribus brevifolius* shares the same habitat with *Hydriastele* sp. 1 and *Hydriastele* sp. 2, as shown in Fig. 22.

After ten days on the island, we had sampled all the palms we had encountered, including all introduced palms (see Table 1 for the entire list). Before we went back to Sorong, the villagers of Gambir gave us a special farewell party. We had dinner together; they served us with enormous local dishes and several traditional cakes and, of course, palm wine. The palm wine was made from the sap of the coconut and nipah palm (*Nypa fruticans*), naturally fermented. When three of us (CDH, KL and OPM) finished our supper and went back to our accommodation to pack our belongings, some of expedition team members stayed on partying, dancing till midnight. Before 2 a.m. the party was over and all expedition members headed off to our *pinisi* at the pier. It took almost one hour to embark and set sail to leave Gag.

Soon, after leaving Gag, we were in the middle of a heavy storm. The wind blew strongly and the waves reached about 3 m high. Our vessel was struck by huge waves, and we rocked about in the dark. We were terrified because we had never experienced anything like this; within just a few minutes, the *pinisi* boat was hit by big waves again and again, from the front, left side and right side. All passengers had been ordered to wear life jackets and to stay calm; some were terribly sea-sick. We were all silent; the only sounds were the boat's engine, the wind and the waves. Although it was early morning it was still dark, and we waited anxiously for sunrise, constantly checking our watches. We were reminded of the old Christian hymn "Above the Hills of Time" by Thomas Tiplady (1886) "*As ship-wrecked seamen yearn for morning light....*" That summed up almost exactly what we felt!

The sun finally rose together with the ending of the storm and clearing the morning mists. The captain had taken the wheel himself, and together with his crew, they sailed the boat safely through the stormy sea. We were all relieved and happy to see the *pinisi* had already entered the Dampier Strait and the weather became friendly. After we passed Kri Island, the *pinisi* turned right following the tip of the East Cape of Batanta Island, and we then sailed

18. *Hydriastele* sp. 2. in heath forest at ultramafic. (Photo by Charlie D. Heatubun).

straight to the south to Sorong. Thus ended our first expedition to Gag Island.

Palm diversity, ecology and biogeography

In general, the palm flora in the Gag Island is not very rich – 19 species of palm have been encountered during the expedition, and 14 species (74%) are native (see Table 1). Of the native palms, seven species (50%) are particularly interesting and need further investigation, especially taxa in the genera of *Calamus*, *Calyptrocalyx*, *Daemonorops*, *Hydriastele* and *Licuala*. One taxon (*CH 741, 742*) has already been confirmed as a new genus of subtribe Ptychospermatinae from molecular evidence and a manuscript is in the works (Heatubun et al. in press) – this taxon was also found and collected by CDH from a limestone hill in southwest Waigeo Island. There is no palm species endemic to Gag. However, Gag shares several species with islands nearby, and these species have restricted areas of distribution. For example, *Saribus brevifolius* was known before only from the small island of Kawe in the north of Batanta Island (Dowe & Mogea 2004) and is now confirmed from Gag Island; this species is thus endemic to Raja Ampat Islands. Similarly, *Hydriastele* sp. 2 is found on Gag Island and also in East Halmahera (Heatubun 2011), while *Hydriastele* sp. 1 resembles *H. brassii* from mainland New Guinea (Baker & Loo 2004) – the identity of these palms will be determined in a forthcoming monograph of *Hydriastele* (Heatubun & Baker in prep.). The palm's occurrence on Gag is correlated with the soils and geological formation. There is a clear separation between palm species growing on ultramafic/ultrabasalt and limestone substrates. Only three species of palms are adapted to ultramafic/ultrabasalt, and the rest grow on limestone and/or are cultivated near the village (see Table 1).

Gag Island is actually located between two different palm floristic regions, namely Moluccas to the west and New Guinea (and Bismarck Archipelago) to the east. At the generic level, all native palms on Gag have affinities to both floristic regions as listed in Dransfield et al. (2008: 649), except for the new taxon of Ptychospermatinae, which is distributed only in the Raja Ampat Islands (Gag and Waigeo Islands), never found on mainland New Guinea. The discovery of this new palm also supports an explanation of phylogeography for the subtribe Ptycho-

19. Young palm of *Hydriastele* sp. 2. (Photo by Charlie D. Heatubun).

spermatinae with special reference to Raja Ampat Islands as a connecting bridge for species dispersal from the east to the west (Zona et al. 2011), as evidenced by *Adonidia* (Baker & Heatubun 2012) with a disjunct distribution pattern (Baker & Couvreur 2012, Zona et al. 2011). However, the generic placement of the Biak *Adonidia* will have to be

20 (top). *Saribus brevifolius*. 21 (bottom). Seedliings of *Saribus brevifolius*. (Photos by Permenas Dimonmou).

22. Seedlings of *Saribus brevifolius* and two species of *Hydriastele* on ultramafic soil. (Photo by C.D. Heatubun).

changed in response to recent findings from molecular phylogenetic studies in Ptychospermatinae (Alapetite et al. 2014, Heatubun et al. in press). At the species level, the occurrence of *Calamus zollingeri*, *Calyptrocalyx spicatus*, *Daemonorops* sp., *Heterospathe elata* and *Hydriastele* sp. 2 define the Moluccan element rather than the New Guinean in the palm flora of Gag. The replacement of the New Guinean emergent tree palm species, such as *Cyrtostachys* spp., *Hydriastele costata* and *Rhopaloblaste* spp., by *Heterospathe elata*, *Hydriastele* sp. 2 and *Saribus brevifolius* and a new taxon of Ptychospermatinae makes more clear the oceanic connection to Gag Island. However, these all support palm distribution patterns in general in the Malesian region (Baker & Couvreur 2012) and show the important role played by Raja Ampat Islands in connecting mainland New Guinea to the islands farther west and north, including the Philippines (Webb 2005).

Uses and folk taxonomy

In general, palms are of major economic importance on Gag Island. For example, the sago palm (*Metroxylon sagu*) has provided a staple food for the people on the island. The coconut palm (*Cocos nucifera*) and the betel nut palm (*Areca* spp.) are "cash crops" and they give direct income to local people who sell the copra (dried coconut) and betel nut outside the island, usually to Menado in North Sulawesi. Rattan and wild tree palms have provided weaving and construction materials for daily needs.

Most people who live on Gag originally migrated from Gebe Island in North Moluccas, so all the local or vernacular names are in the Gebe dialect. Often local names comprise a single-word or basic name and the basic name plus prefixes. The prefixes usually relate to habit or typical taxon. For example *wala* (= rope) is a prefix to the rattan genus *Calamus* referring to the climber or liana habit. Similarly

Table 1. List of palm species in Gag Island.

No.	Species	Collections or Records	Local name (Gebe dialect)	Geological substrate
1.	*Areca catechu* L.	Sight records (cultivated)	*mala chu'* (*pinang*)	Cultivated (Limestone)
2.	*Areca catechu* cv. Gebe	*Heatubun et. al. CH 751, CH 752* (cultivated; said originally from Gebe Isl.)	*mala lolef* (*pinang gebe*)	Cultivated (Limestone)
3.	*Areca macrocalyx* Zipp. ex Blume	*Heatubun et. al. CH 747, CH 748*	*kasimnya*	Limestone
4.	*Calamus zollingeri* Becc.	*Heatubun et. al. CH 733, CH 734*	*wala douw*	Limestone
5.	*Calamus* sp. 1	*Heatubun et. al. CH 736*	*wala molo'*	Limestone
6.	*Calyptrocalyx spicatus* Blume	*Heatubun et. al. CH 749, CH 750*	— (unknown)	Limestone
7.	*Caryota rumphiana* Mart.	Sight records	*bali'*	Limestone
8.	*Cocos nucifera* L.	Sight records (large-scale plantations)	— (not recorded)	Cultivated (Limestone)
9.	*Daemonorops* sp.	*Heatubun et. al. CH 738*	*sane'*	Limestone
10.	*Heterospathe elata* Scheff.	*Heatubun et. al. CH 735, CH 739, CH 740*	*gul ways*	Limestone
11.	*Hydriastele* sp. 1	*Heatubun et. al. CH 759, CH 764, CH 765*	*gul botom*	Ultramafic (Ultrabasalt)
12.	*Hydriastele* sp. 2	*Heatubun et. al. CH 760, CH 761*	*gul botom*	Ultramafic (Ultrabasalt)
13.	*Licuala* sp.	*Heatubun et al. CH 737, CH 745*	*pesem'*	Limestone
14.	*Saribus brevifolius* (Dowe & Mogea) C.D. Bacon & W.J. Baker	*Heatubun et. al. CH 762, CH 763*	*ngawan'* (unarmed petiole)	Ultramafic (Ultrabasalt)
15.	*Saribus rotundifolius* (Lam.) Blume	Sight record (cultivated; said to be originally from Gebe Isl.)	*matmet'* (armed petiole)	Cultivated (Limestone)
16.	*Metroxylon sagu* Roetb.	Sight records	*yof*	Swamp (Limestone)
17.	*Nypa fruticans* Wurmb	Sight records	— (not recorded)	Mangrove (Limestone)
18.	*Salacca zalacca* (Gaertn) Voss	Sight records (cultivated; seeds originally from the market in Menado, North Sulawesi).	— (not recorded)	Cultivated (Limestone)
19.	Ptychospermatinae gen. nov.	*Heatubun et. al. CH 741, CH 742, CH 746*	*gul botom*	Limestone

mala is the prefix for typical *pinang* (= source of the betel nut) and *gul* is applied to a slender tree palm. However, the cosmology of the local people, their knowledge about plants and their classification of plants need to be studied further.

Conservation

A conservation assessment of palms on Gag is urgently needed in relation to land conversion and mining activities. Based on our field observations, almost all native palms were highly threatened in both the limestone and the ultramafic (ultrabasalt) habitats. Almost 20 percent of land in the limestone area in Gag Island has been converted to coconut plantations. A few varieties of *C. nucifera* were planted to produce copra as raw material for the cooking oil industry. Coconut plantations and traditional mixed-cultivation gardens are a serious threat to the forest or vegetation on the limestone formations. *Calyptrocalyx spicatus* and a new taxon of Ptychospermatinae are high priority species in our list from this area. The total number of individuals of adult *C. spicatus* is fewer than five, and there is no sign of seedlings, while its habitat is being cleared for mixed-cultivation gardens. The new taxon of Ptychospermatinae has fewer than 50 adult palms.

However, the real threat is mining activity not only for the palms but also to the entire ecosystem on the island and in the region of Raja Ampat, if the central government approves the permit to allow PT. Gag Nikel to exploit nickel ore on Gag. Land clearance and top soil removal will be required to extract the nickel ore on Limonite and Saprolite soils, so the whole ecosystem on the ultramafic / ultrabasalt areas will disappear. The initiative to propose Raja Ampat Islands as a World Heritage Site to UNESCO (McKenna et al. 2002, Takeuchi 2003) is encouraging and if it happens would make Gag Island (and Raja Ampat Islands) a field laboratory to study evolution and natural history – another Galapagos Islands on the other side of the world.

The process of establishing the conservation status of the palms of Gag with IUCN red list categories and criteria (IUCN 2012) will need to wait until the taxonomic status of each taxon becomes clear.

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