Scientific Note

Conservation Note on the Status of the Rare Endemic Marquesan Snout Butterfly, *Libythea collenettei*

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Abstract. The Marquesan snout butterfly (*Libythea collenettei*) also known as "Papillon à museau des Marquises," is the only endemic butterfly from the Marquesas Islands, French Polynesia. The butterfly is known from just five historic records. We report results from an intensive two–week survey in 2018. Our survey took place on the two islands where historic collection records exist (Nuku Hiva and Ua Pou), plus Hiva Oa and Tahiti, where the species has been thought to exist. Despite visiting multiple localities including sites where the species was previously observed, we were unsuccessful at detecting this species. The larval host plant, *Celtis pacifica* (Cannabaceae), can still be found on the Marquesas, indicating that the butterfly might still exist in the archipelago. Because the phenology of this species is unknown, future surveys should be conducted on the same islands but during different seasons. Given the very restricted geographic range of this species and threats to its habitat, we suggest that it be listed as endangered on the IUCN Red List.

Keywords: French Polynesia, *Danaus plexippus, Hypolimnas bolina otaheitae,* IUCN Red List; Lepidoptera, Libytheinae, Marquesas Islands, Nymphalidae

The Marquesas Islands are an extremely remote archipelago located ca. 4000 kilometers southeast of Hawaii, ca. 1500 kilometers northeast of the Society Islands and ca. 5000 kilometers southwest of Mexico. This archipelago is comprised of twelve small volcanic islands formed over the past ca. 6 million years (Maury et al. 2016), with rugged landscapes and dense natural forests. Although a large fraction of the flora is endemic (48%, Lorence et al. 2016), anthropogenic disturbance, in the form of native ecosystem destruction (forests, lakes, etc.) has shaped a very different landscape than what the islands were before the first Polynesian colonization 800–900 years ago (Allen 2014). Humans introduced pigs and rats before bringing horses, cattle, and goats to the islands. Centipedes and lizards were accidental introductions that deeply altered the native biota (Adamson 1939, Cheesman 1927, Lorence et al. 2016). The first major human colonizations on the largest islands (i.e., Nuku Hiva, Hiva Oa, Ua Pou) took place around 1200 AD, and their ecosystems have been continuously degraded by logging, fires, and plantations (Wilmshurst et al. 2011, Lorence et al. 2016). In particular, the planting of Caribbean pine (*Pinus caribaea*, Pinaceae) since 1974 on Nuku Hiva and Hiva Oa (Allen et al. 2011), and of *Leucaena leucocephala* (Caesalpinioideae) on Ua Pou (Butaud and Jacq 2013, Lorence et al. 2016) have triggered major ecosystem shifts that significantly impacted wetlands, native flora, and associated fauna.

The Caribbean pine was planted to initiate a new forestry industry in the Marquesas in the 1970s, but due to abrupt economic changes, mature pine plantations remained unharvested across the archipelago, especially on Nuku Hiva (Meyer 2007). Aquatic ecosystems that once prevailed on the Toovii Plateau have suffered from the dessication of phreatic tables and acidification of soils where these trees grow (Meyer 2016, de Grandmont 2018). The drying–out of phreatic tables was likely caused by vegetation changes driven by enhanced soil leaching (Fossati and Marquet 1998, Meyer 2016). The continuous presence of grazing cattle and horses on Nuku Hiva has accentuated the demise of the mid–elevation swamp "Vaihakaomeama," which harbored a rich endemic diversity of animals and plants, including populations of the Pacific black duck, *Anas superciliosa* (Brown 1931, Adamson 1936, Meyer 2016). Similarly, the invasion of Nuku Hiva and Ua Pou by *L. leucocephala* was fueled by grazing and fires. This plant has now spread across these two islands and contributed to the dessication of habitats (Butaud, pers. comm.).

The Marquesan endemic insect fauna is diverse but equally threatened by human activities (Florence and Lorence 1997, Gargominy et al. 2016; but see Polhemus and Englund 2016, Roderick and Gillespie 2016 on the exceptionally well–preserved aquatic entomofauna of the Marquesas Islands). The insect fauna of the Marquesas was first documented in 1924–1925 during the St George Expedition that was inaugurated by the Scientific Expeditionary Research Association. During that expedition, the British Natural History Museum entomologists Lucy Evelyn Cheesman OBE, Cyril Leslie Collenette, and Cynthia "Madame Dragonfly" Longfield collected insects for five weeks on the islands of Fatu Hiva, Hiva Oa, Nuku Hiva, and Tahuata (Hornell 1924, Cheesman 1928, Adamson 1939). The Pacific Entomological Survey (1927–1932) organized by the Bernice Pauahi Bishop Museum and Hawaiian Sugar Planters' Association allowed for the description of many new Marquesan insects (Adamson 1939).

Insect diversity in the Marquesas is depauperate in many groups but diverse in others (Gillespie et al. 2008). For instance, there are radiations of *Rhyncogonus* weevils (Claridge et al. 2017) and *Simulium* black flies (Craig et al. 2001). Among Lepidoptera (>300 species in the Marquesas including ca. 240 endemic species), butterflies (Papilionoidea) are poorly represented, with records of only five species (Holloway 1983, Adler and Dudley 1994, Patrick and Patrick 2012, Ramage 2017). These species are *Libythea collenettei*, *Danaus plexippus* (Nymphalidae, Danainae), *Hypolimnas bolina otaheitae* (Nymphalidae, Nymphalinae), *Phalanta marquesana* (Nymphalidae, Heliconiinae), and *Badamia exclamationis* (Hesperiidae, Coeliadinae). *Phalanta marquesana* and *B. exclamationis* have not been found since the 1920s; the former was originally described in *Atella* by Riley as an endemic species to the Marquesas (Poulton and Riley 1928), but was later also reported from the Society Islands (Holloway 1983). *Badamia exclamationis* was found on Hiva Oa in February 1925, but no additional specimens have been reported since then (Poulton and Riley 1928). This skipper is currently found across the Indo–Australian archipelago with a geographic range stretching from India to Japan, and from China to Australia and some Oceanian islands such as Fiji. (Another species of *Badamia*, *B. atrox,* is widespread in the South Pacific and occasionally listed as occurring in the Marquesas (e.g., Holloway and Peters 1976, Patrick and Patrick 2002), but these reports could not be verified.)

The Marquesan snout butterfly (*Libythea collenettei*, Nymphalidae, Libytheinae) is the only butterfly endemic to the Marquesas (Shields 1987, Kawahara

Figure 1. Habitus of the Marquesan snout butterfly, *Libythea collenettei*, known as "Papillon à museau des Marquises" and its putative host plant, *Celtis pacifica*. Upper photo: dorsal view of *L. collenettei* Holotype, lower photo: ventral view of *L. collenettei* Holotype.

2006a). Little is known about its biology, except that the larval host–plant might be *Celtis pacifica* (Rosales, Cannabaceae) (Shields 1987), a plant that is widespread in the Pacific islands (Figure 1). This tree is found at low elevations between sea level and ca. 550 m in semi–xerophilic to mesophilic forests on the six main Marquesas islands (Fatu Hiva, Hiva Oa, Nuku Hiva, Tahuatu, Ua Huka, and Ua Pou) and Mohotani (Butaud et al. 2008, Butaud pers. comm.). The only information available on the behavior of this butterfly can be gleaned from Cyril Leslie Collenette's notes from the 1925 St George expedition, published in Poulton and Riley (1928):

> "Three specimens taken and two or three others seen in the Hooumi Valley, Nuka Hiva Island, Marquesas, on 18.i.25. They frequented a stream–bed near sea–level. They were attracted by some flowering plants growing in the water, but flew round them only a few seconds at each visit, settling very rarely. On 16.i.25, 5 or 6 specimens were seen, on a ridge above the Typee Valley, at about 1200 ft. They flew against the wind, fairly rapidly and without settling. A considerable search was made for the insect on other days, especially in the hills, but no others were seen. In flight they were often confused with the introduced *Polystes* wasp, the speed of flight and apparent size being much the same, although I do not think that this was a definite example of mimicry."

Only five specimens of this butterfly have been collected to date, from the islands of Nuku Hiva and Ua Pou (Figure 1). Three female specimens are known from the type series from Nuku Hiva, collected on January 18, 1925, by Cyril Leslie Collenette, and two specimens were sampled in August 2001 from Ua Pou (one male, August 20, 2001), and Nuku Hiva (one female, August 28, 2001) by Ronald Englund. The specimen collected on Ua Pou in 2001 is the only known male specimen and is currently stored in the collection of the Bernice P. Bishop Museum, Honolulu, HI, USA (Kawahara 2003). Because this species has been observed and collected in January and August, it may be multivoltine. However, many *Libythea* species are univoltine, emerging in the early summer and overwintering as adults until the early spring (Kawahara 2006a, b). Further

surveys are clearly needed to shed light on this species' natural history.

Morphologically, *L. collenettei* lacks two characters that are present among other *Libythea* species: the single wide band across hindwing cells M1–M3, and the spine at the apex of the valva (Kawahara 2013). Based on a morphological phylogeny of the Libytheinae, Kawahara (2009) inferred *L. collenettei* to be sister to the remainder of *Libythea*. However, it is possible that *L. collenettei* is recovered in this position because it shares morphological characters with included outgroups although they may be homoplasies (Kawahara 2009). Overall, *L. collenettei* is morphologically similar to the Southeast Asian *L. geoffroyi* whose easternmost distribution stretches as far as the Solomon Islands and New Caledonia. It is therefore possible that *L. collenettei* is the Pacific Island allopatric sister species of *L. geoffroyi* (Waterhouse 1937, Shields 1987). Preliminary molecular evidence supports this relationship (N. Wahlberg, pers. comm.), although additional data will be needed to firmly confirm the placement of *L. collenettei* within the genus. Despite its unique morphology, distribution, and rarity, this species has not been the focus of conservation initiatives, and as a result, is not listed on the IUCN Red List.

To assess the possible conservation need for *L. collenettei*, the authors visited Hiva Oa, Nuku Hiva, and Ua Pou (Marquesas Islands) and Tahiti (Society Islands), French Polynesia, between February 3 and February 12, 2018. Although Hiva Oa and Tahiti do not have known collection records of *L. collenettei*, we visited these islands because of their size, remaining natural habitat, and their proximity to the islands from which the butterfly has been recorded. We searched extensively for this butterfly, and visited the islands during the following dates: Tahiti: February 2; Nuku Hiva: February 3–6; Hiva Oa: February 6–9; Ua Pou: February 9–12. We conducted visual searches of habitats by walking in fields, along trails, and on roads for 2–3 hours at each visited site (Table 1) and used butterfly nets to tap vegetation to allow perched butterflies to fly. Although it rained occasionally in Nuku Hiva and Hiva Oa during our fieldwork (albeit never during a whole day), most days when surveys took place were sunny. We visited sites on each island that had historical collection records. We also visited pristine patches of native forest and open areas, including disturbed ones, such as the one found near Mount Pouhekaei in Ua Pou, near the site at which *L. collenettei* was found in 2001 (Figures 2 and 3). We decided to survey the islands in early February, one week after the St George Expedition survey dates from late–January 1928. While it would have been best to survey multiple weeks during the time of the historic collection dates, this could not be done due to limitations of funds for fieldwork. We are currently seeking funding to conduct a future survey on Ua Pou in August, the island and month from which *L. collenettei* was last collected.

Figure 2 shows a map of localities surveyed, and Table 1 provides details of sampling localities across the archipelago. Despite our searches, *L. collenettei* could not be found on any of the islands that we visited, although its putative host–plant, *Celtis pacifica*, is still found in the Marquesas (Butaud et al. 2008, Butaud pers. comm.) (Figure 1).

The Marquesas Islands have been significantly altered by human disturbance since the 1920s. Our observations confirm earlier reports (e.g., Meyer 2007, 2016; de Grandmont 2018) of significant anthropogenic disturbance on Nuku Hiva, where Caribbean pine trees, introduced from the Caribbean Islands and planted ~1970s, cover most of the Toovii Plateau. The landscape is also altered by grazing cattle, goats, horses, pigs, and chickens, making the understory nearly completely barren (see also Meyer 2016). Some en-

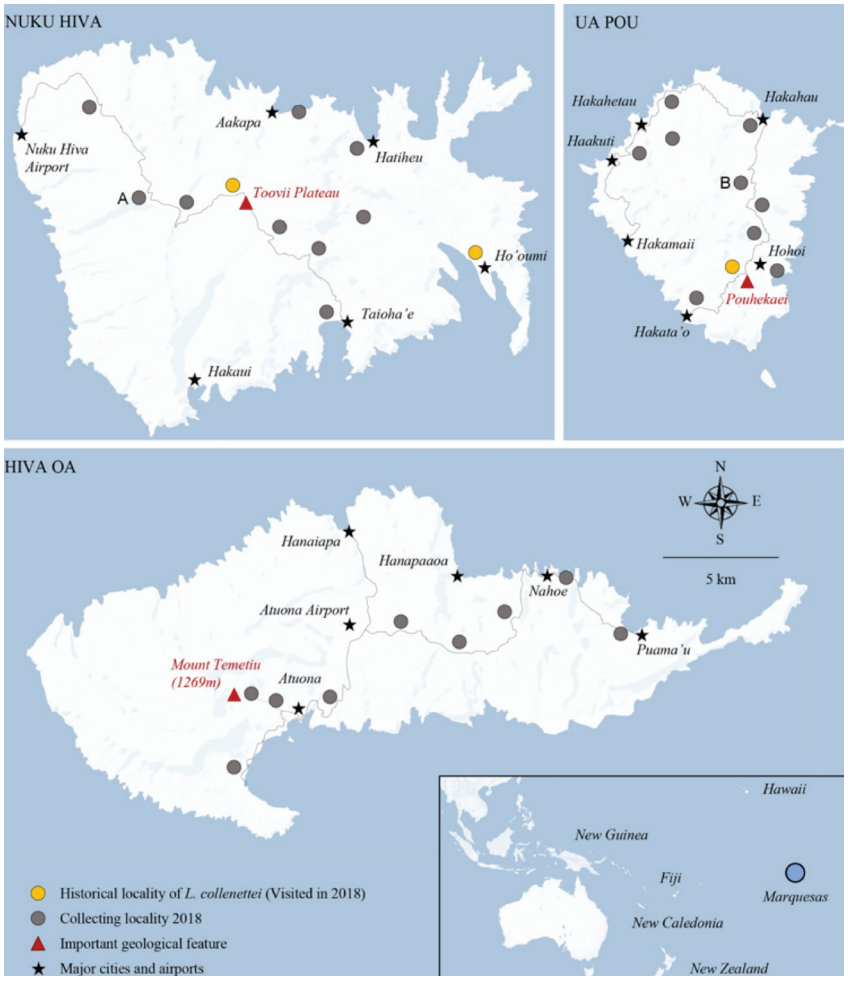

Figure 2. Maps highlighting sampling localities for the three islands visited in February, 2018.

demic plants remain along steep slopes and valleys (Figure 3), but conservation regulations, despite existing, are often not enforced, and the islands are isolated, making it difficult to protect the butterfly and its habitat. Some sites where *L. collenettei* was once observed (e.g., on the Toovii Plateau) have been substantially affected by recent species introductions and land management policies. However, the putative host–plant *Celtis pacifica* is not found on the Toovii Plateau, which is a hydrophilic to ombrophilous forested area (Butaud pers. comm.). Therefore it is possible that historical reports of *L. collenettei* on the Toovii Plateau were of individuals that had traveled from other parts of Nuku Hiva. Other areas on this island where the plant has been reported, such as the dry forest of "Terre déserte" between 300–500 m (Butaud pers. comm.), could not be sampled during this expedition due to time and resource limitations. These sites and similar ecosystems on other islands should be the focus of future surveys (e.g., forest patches

Table 1. Localities visited in the Marquesas Islands and Tahiti, French Polynesia, in 2018.

Site Code	Locality	Region	Lat.	Long.
FRP001	Centre spirituel de Supermahina, Fraternité de la Sainte Famille, Archevêché de Papeete	Tahiti	–17,5242	–149,4751
FRP002	Dirt road near Papeno'o toward National Park, large river and lowland ecosystem	Tahiti	–17,552	–149,4328
FRP003	Main road between the airport and Taioha'e, lowland near river with a bridge, south of the Toovii Plateau	Nuku Hiva	–8,9169	–140,1097
FRP004	Main road between the airport and Taioha'e, mid elevation slope with grassy vegetation, north of the Toovii Plateau	Nuku Hiva	–8,8647	–140,1743
FRP005	Main road between the airport and Taioha'e, mid elevation, house «Tekeika», south of the Toovii Plateau	Nuku Hiva	–8,8853	–140,1135
FRP006	Dirt road at mid elevation off the main road between the airport and Taioha'e, north of the Toovii Plateau	Nuku Hiva	–8,8622	–140,1804
FRP007	Main road between the airport and Taioha'e, lowland on the Toovii Plateau with muddy ponds	Nuku Hiva	–8,8591	–140,1429
FRP008	Hee Tai Inn pension in Taioha'e, lowland urban area, south coast of the island	Nuku Hiva	–8,8591	–140,1429
FRP009	Huemo'o near the beach, north coast of the island	Nuku Hiva	–8,8876	–140,0296
FRP010	Rain puddles on a road side near Taaoa, lowland	Hiva Oa	–9,8343	–139,0635
FRP011	Trail to Mount Temetiu starting from the ancient cemetery of Atuona, mid elevation	Hiva Oa	–9,8017	–139,0695
FRP012	Temetiu Village pension in Atuona, lowland	Hiva Oa	–9,8008	–139,0321
FRP013	Rainforest on top of Mount Temetiu, 1200–1300 m	Hiva Oa	–9,799	–139,0765
FRP014	Trail east of Atuona airport, dirt road with yellow *Hibiscus* bushes	Hiva Oa	–9,7664	–138,9892
FRP015	Dirt road toward Nahoe, curve with road puddles and yellow *Hibiscus* bushes	Hiva Oa	–9,7624	–138,9338
FRP016	Nahoe village, edges of a stream connected to the ocean	Hiva Oa	–9,7394	–138,928
FRP017	Dirt road between Nahoe and Puama'u with puddles on the edge of the cliffs	Hiva Oa	–9,7401	–138,914
FRP018	Puama'u village, on the edge of the road near the beach	Hiva Oa	–9,7656	–138,8809
FRP019	Road between Nahoe and Atuona, very large swampy puddles on the road with aquatic vegetation	Hiva Oa	–9,7726	–138,9444
FRP020	Road between Hakahau and Hakata'o near Pouhekaei mount, mid elevation with ferns and disturbed ecosystem	Ua Pou	–9,4162	–140,0476
FRP021	Disturbed forest toward Hakahau after the junction for Hohoi from Hakata'o	Ua Pou	–9,4104	–140,05
FRP022	Summit in front of Pouhekaei above the road to Hakata'o with ferns and bushes	Ua Pou	–9,4344	–140,0639
FRP023	Hakata'o village, small creek on the road with stream and plantations	Ua Pou	–9,4458	–140,0791
FRP024	Road before junction for Hohoi from Hakata'o	Ua Pou	–9,4242	–140,0567
FRP025	Creek near Hohoi beach with bushes of yellow *Hibiscus*	Ua Pou	–9,4308	–140,0472
FRP026	Road after junction for Hohoi toward Hakahau	Ua Pou	–9,4021	–140,0538
FRP027	Trail from Hakahetau to Manfred Ville and the waterfall	Ua Pou	–9,368	–140,0963

along "La Traversière" trail on Ua Pou, visited on February 11 2018). Nevertheless, during the course of our fieldwork, we rediscovered some endemic invertebrates such as endangered damselflies and dragonflies (Polhemus and Englund 2016) at small pools of standing water on Toovii Plateau, land snails (Gargominy et al. 2016), and weevils (Roderick and Gillespie 2016) at the highest and most inaccessible parts of Mount Temetiu in Hiva Oa (Figure 3). A new endemic species of *Tropidomantis* praying mantis was also discovered in Atuona Bay and is awaiting a formal description (Sydney Brannoch, pers. comm.). Endemic plants, such those in the genera *Glochidion* and *Pipterus*, were found along a ~1000–m dirt road on the eastern slope of Nuku Hiva (Point A, Figure 2) and along trails near rivers of central Ua Pou (Point B, Figure 2), but this ecosystem is disturbed with shrubs and trees of citrus, coconut, cacao, mango, and banana. During our survey, we observed two other butterfly species, *Danaus plexippus* and *Hypolimnas bolina otaheitae*. The only adult specimen of *D. plexippus* was observed during our survey of Toovii Plateau in Nuku Hiva, and this species has historically been relatively rare in the Marquesas and Tahiti depending on the availability of its host plant, *Asclepias* (Collenette 1925, Buteau, pers. comm.). *Hypolimnas bolina otaheitae* was relatively common in both lowland and highlands, including disturbed areas on all islands visited. The sex ratio of captured specimens was male–biased (27 males to 4 females), as previously documented for this species in the Marquesas (Poulton and Riley 1928). *Badamia exclamationis* and *P. marquesana* were not encountered during our fieldwork. During our survey, we spoke to locals on each island and many of them reported sightings of *D. plexippus* and *H. bolina otaheitae* in the past decade, but no one had seen *L. collenettei*.

Due to the restricted remaining natural habitat and unenforced environmental regulations in the Marquesas, we believe that *L. collenettei* should be listed on the IUCN Red List. These habitats on Nuku Hiva and Ua Pou are quickly disappearing, and it is possible that *L. collenettei* may now be extinct. However, we are cautious to declare the species extinct, given the limited amount of data regarding its phenology and the short sampling period of our fieldwork. Existing records are too scarce to infer any potential population size change over the past century, but the total surface area of Nuku Hiva and Ua Pou and the total number of specimens of *L. collenettei* collected to date would allow for a classification of this species as "Endangered" under the IUCN Red List Criterion 3.1. According to this criterion, a taxon is "Endangered" when the best available evidence indicates that it meets specific criteria and is considered to be facing a very high risk of extinction in the wild (see criteria A to E in the 2001 Categories and Criteria version 3.1 for more details). In the case of *L. collenettei*, criterion B is met based on our current knowledge of the species. The species' putative range encompasses Nuku Hiva and Ua Pou for a total of <500 km^2. Moreover, limited patches of remaining native forest exist, and remaining populations of *L. collenettei* may be severely fragmented. The species' restricted distribution, our observations, and loose environmental policies in French Polynesia make us believe that a continued decline in native habitat is inevitable. During our visit to the islands, we developed a small initiative to search for the species with help from locals. We created an illustrated booklet and a poster with photographs of *L. collenettei* and its host plant to help identify and report any sighting of *L. collenettei* in Nuku Hiva, Hiva Oa, and Ua Pou with the hope to find this species throughout the year. A targeted scientific expedition should be conducted in August, the month that the

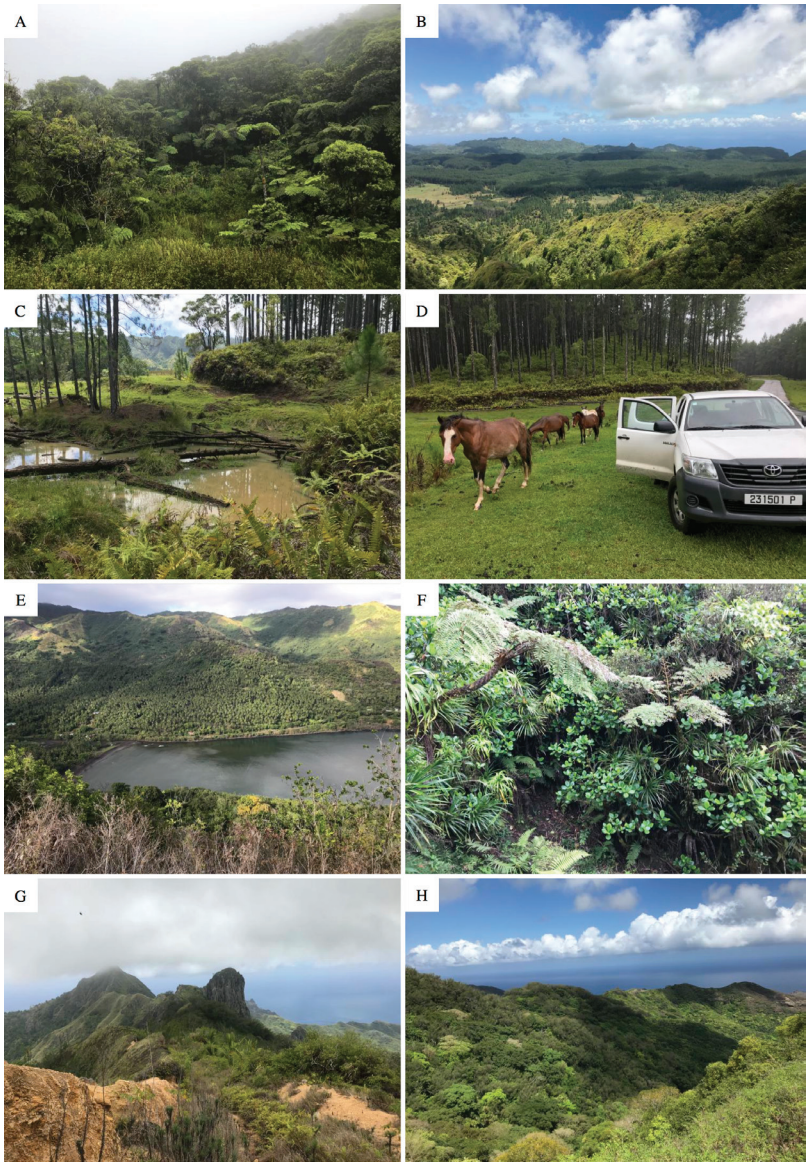

Figure 3. Images of the Marquesas Islands, close to localities where *L. collenettei* has been previously found. A. Nuku Hiva, partially preserved ecosystem near Mount Tekao. B–D. Nuku Hiva, Toovii Plateau with extensive Caribbean pine forests, feral horses, and intensive grazing damages the native ecosystem. E. Nuku Hiva, view of Ho'oumi Bay (type locality) now covered by coconut tree plantations. F. Hiva Oa, Mount Temetiu cloud forest where endangered endemic invertebrates can still be found. G. Ua Pou, site where *L. collenettei* was found in 2001 in front of Mount Pouhekaei. H. Ua Pou, west side of Hakahetau Valley along "La Traversière" trail with some remaining endemic vegetation. Photograph credit: Emmanuel F.A. Toussaint.

butterfly was last observed in 2001 on Nuku Hiva and Ua Pou (Kawahara 2003).

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