



**TRIP REPORT FOR 1999 ENTOMOLOGICAL AND FRESHWATER SURVEYS OF THE  
SMITHSONIAN INSTITUTION AND BISHOP MUSEUM EXPEDITION TO  
THE MARQUESAS ISLANDS AND TAHITI<sup>1</sup>**

Report prepared for the  
Ministere de la Sante et de la Recherche, Delegation a la Recherche  
B.P. 20981-98713 Papeete - Tahiti

February 2000

Dan Polhemus, Ron Englund, Steve Jordan, John Polhemus

<sup>1</sup>Contribution No. 2000-002 to Pacific Biological Survey  
Bishop Museum

## Cover

Upper left: Vaiee Cascade in upper Vaipae Valley, 215 m elevation, Ua Huka. Upper right photograph: *Hemicordulia* sp.? dragonfly taken in Taipi Valley, Tehua Falls, Nuku Hiva, 180 m elevation. Lower left photograph: *Bedfordia* sp.? damselfly taken in Taipi Valley, Tehua Falls, Nuku Hiva, 180 m elevation. Photographs by R. Englund.

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## RÉSUMÉ

Du 17 octobre au 6 novembre 1999, nous avons récolté des insectes et des macro-invertébrés aquatiques des ruisseaux et des milieux semi-aquatiques des Iles Marquises et de l'île de Tahiti de la Polynésie Française. Nous avons également recueilli des heteroptères des forêts nuageuses des montagnes.

Les objectifs de cette expedition du Smithsonian Institution (Washington DC) et du Bishop Museum (Honolulu) étaient 1) de dresser l'inventaire de la faune entomologique aquatique native et de mieux comprendre la diversité de ces organismes, 2) d'évaluer les impacts des espèces exotiques sur les organismes aquatiques natifs, 3) d'évaluer d'une façon qualitative les impacts des ongulés sauvages, de l'urbanization, et des détournements d'eau sur les organismes aquatiques natifs, et 4) de fournir des spécimens aux musées et une base d'information aux chercheurs futurs.

Nous avons récolté des insectes dans 25 localités uniques sur quatre des Iles Marquises dans 3 localités sur l'île de Tahiti. Nos récoltes comprennent des espèces nouvelles pour la science ainsi que des échantillons représentant des familles d'odonates, d'hétéroptères, et de diptères non encore recensées de ces îles. Ces collections comprennent des espèces qui sont uniques et extrêmement importantes au niveau mondial. L'observation sans aucun doute la plus remarquable car non attendue est l'état quasi "virginal" des eaux douces des Marquises ; un tel état sanitaire est en effet inconnu ailleurs en Océanie. Il est dès lors souhaitable et important que ces ruisseaux soient protégés des impacts humains et d'espèces exotiques dans le futur. Une telle protection permettra d'éviter un taux d'extinction catastrophique tel qu'il est enregistré actuellement dans les îles Hawaii.

## ABSTRACT

From 17 October to 6 November 1999, collections of aquatic insects and other aquatic macroinvertebrates were made from streams and wetlands in the Marquesas and Society island groups of French Polynesia. Additionally, collections were also made of Heteroptera occurring in montane cloud forest habitats.

The objectives of these joint Smithsonian Institution and Bishop Museum surveys in the Marquesas were: 1) to assess the native aquatic insect fauna and describe the overall biodiversity of this fauna, 2) to assess the impacts or lack of impacts of introduced aquatic species on native stream biota, 3) to qualitatively assess the impacts of feral ungulates,

urbanization, and diversions on native stream organisms, and 4) to provide museum specimens and an information baseline for future researchers.

We collected insects from 25 sites in the Marquesas. New species and archipelago collections were recorded for Odonata, Heteroptera, and Diptera. These collections included species that are extremely unique and important on a global scale. Perhaps the most significant finding of our surveys is that freshwater aquatic habitats of the Marquesas are extremely pristine and may represent the most natural freshwater systems in all of Oceania. It is exceptionally important that these streams be protected from human impact and exotics as visitation to the Marquesas increases in coming years. An extinction catastrophe similar to the one that is now occurring in Hawaii could be averted in the Marquesas with careful planning.

## **INTRODUCTION**

From 17 October to 6 November 1999, collections of aquatic insects and other aquatic macroinvertebrates were made from streams and wetlands in the Marquesas and Society island groups of French Polynesia. Additionally, collections were also made of Heteroptera occurring in montane cloud forest habitats.

The objectives of these joint Smithsonian Institution and Bishop Museum surveys in the Marquesas were: 1) to assess the native aquatic insect fauna and describe the overall biodiversity of this fauna, 2) to assess the impacts or lack of impacts of introduced aquatic species on native stream biota, 3) to qualitatively assess the impacts of feral ungulates, urbanization, and diversions on native stream organisms, and 4) to provide museum specimens and an information baseline for future researchers.

Although Tahiti was sampled for two days, most sampling effort during this trip was directed to the Marquesas Islands, and unless otherwise stated the discussions and conclusions in this report refer to the Marquesas only.

## **MATERIALS AND METHODS**

Sampling occurred in the Marquesas Islands from October 17 to November 4, 1999, and on Tahiti from November 5 and 6, 1999. Sampling locations were somewhat dependent upon the constraints of private property, water depth, topographic barriers, and vegetation, but included a complete range of stream habitats. Riparian vegetation composition and stream substrate were evaluated at each stream that was assessed, and general aquatic habitat conditions were also

evaluated. GPS coordinates at specific sampling sites on each stream were recorded, as were the local stream names or waterfalls if these geographic features were not on published topographic maps. Altitude ranges were also taken with a handheld Casio altimeter at each sampling station where GPS coordinates were recorded.

### **Insect Sampling**

Collections of both immature and adult specimens were made with aerial sweep nets, aquatic dip nets, and by taking benthic samples. Visual observations of aquatic insects were also conducted above the waterbody. The sampling of damselflies and dragonflies (Odonata) was emphasized since we are interested in assessing the evolution and biogeography of Odonata in the Pacific Islands, and particularly in any similarities or differences between the faunas of Hawaii and French Polynesia. Photographs were taken of live Odonata when possible to document color patterns. All insect specimens were stored in 75% ethanol and subsequently transported to the Bishop Museum or Smithsonian Institution for curation and identification. Voucher specimens are currently housed in both the Bishop Museum and Smithsonian Institution collections; identified specimens will be returned to the collection at Paea on Tahiti and the Museum National d'Histoire Naturelle in Paris as identification and description of species permits.

### **Fish Sampling**

Assessments for introduced fish were made in all aquatic habitats assessed during these surveys. Dip netting and above water observations, along with snorkeling were the primary techniques used to identify the fish fauna. Additionally, observations were also made for native fish species.

### **Study Area**

Aquatic biota and habitat were assessed on four of the main high Marquesan Islands: Nuku Hiva, Hiva Oa, Ua Huka, and Tahuata. Additionally, aquatic habitats were briefly sampled in Tahiti during our return from the Marquesas.

The following sampling localities were surveyed during the course of this study. Latitude and longitude were taken using a Garmin 48 GPS receiver, and NAD 83 was the GPS datum used. Elevations were taken using a pressure altimeter reading in feet; metric conversions are provided, with the original readings in feet given in brackets. Water temperatures were taken with a hand held mercury bulb thermometer.

MARQUESAS ISLANDS, Nuku Hiva, stream at Taiohae, sea level, water temp. 24°C., 17 October 1999, 17:00-1800 hrs. 08°54'42"S, 140°06'08"W.

MARQUESAS ISLANDS, Nuku Hiva, Taipi Valley, Tehua Falls, 105–150 m. [350–500 ft.], water temp. 24.5°C. (stream in valley bottom), 23°C. (at base of falls), 18 October 1999, 10:00-1500 hrs. 08°52'14"S, 140°06'16"W.

MARQUESAS ISLANDS, Nuku Hiva, small rocky streamlet crossing road above Taiohae in upper Taiohae Valley, 380 m. [1250 ft.], water temp. 23°C., 18 October 1999, 1700 hrs. 08°53'21"S, 140°06'24"W.

MARQUESAS ISLANDS, Nuku Hiva, Hakau Valley, river and tributary in lower section above swamps, 15 m. [50 ft.], water temp. 24°C. (main river), 26.5°C. (isolated side pool), 19 October 1999, 10:00–11:00 hrs. 08°55'38"S, 140°10'11"W.

MARQUESAS ISLANDS, Nuku Hiva, Hakau Valley, river and rocky tributaries in upper midreach, 90 m. [300 ft.], water temp. 24°C. (pools on small rocky tributary), 19 October 1999, 14:00–15:00 hrs. 08°54'46"S, 140°09'52"W.

MARQUESAS ISLANDS, Nuku Hiva, tributary to upper Taipivai River (Tcheco Stream), 485 m. [1600 ft.], water temp. 21.5°C., 20 October 1999, 09:00–12:00 hrs. 08°52'33"S, 140°07'03"W.

MARQUESAS ISLANDS, Nuku Hiva, tributary to upper Vaiohei Valley (Vaikaheke Stream), 610 m. [2000 ft.], water temp. 23.5°C., 20 October 1999, 14:00–15:30 hrs. 08°53'27"S, 140°08'39"W.

MARQUESAS ISLANDS, Nuku Hiva, Tekau Ridge, E. of new road crossing, 1160–1220 m. [3800–4000 ft.], 21 October 1999, 10:00–15:00 hrs. 08°51'39"S, 140°10'24"W.

MARQUESAS ISLANDS, Nuku Hiva, Toovii Plateau Stream, upstream of largest cattle stock pond on plateau, 885 m. [2900 ft.], 21 October 1999, 10:00–13:00 hrs. 08°50'55.0" S, 140°09'40.8" W.

MARQUESAS ISLANDS, Nuku Hiva, stream above Hatiheu, in middle Hatiheu Valley, 30 m. [100 ft.], water temp. 24°C., 22 October 1999, 11:00–12:00 hrs. 08°49'49"S, 140°04'42"W.

MARQUESAS ISLANDS, Nuku Hiva, Taipi Valley, cascade and rocky stream at head of north branch, 180 m. [600 ft.], water temp. 24°C., 22 October 1999, 14:00-16:00 hrs. 08°51'07"S, 140°06'06"W.

MARQUESAS ISLANDS, Hiva Oa, cascade and swift rocky stream in eastern section of Taaoa Valley, 90–150 m. [300–500 ft.], water temp. 23°C., 24 October 1999, 09:00-12:00 hrs. 09°49'26"S, 139°04'15"W.

MARQUESAS ISLANDS, Hiva Oa, Atikua Stream, upper Atuona Valley, 150 m. [500 ft.], water temp. 23.5°C., 24 October 1999, 14:00-16:00 hrs. 09°47'06"S, 139°03'11"W.

MARQUESAS ISLANDS, Hiva Oa, Tapeata summit ridge, 760 m. [2500 ft.], 25 October 1999, 09:00-10:00 hrs. 09°46'11"S, 138°58'00"W.

MARQUESAS ISLANDS, Hiva Oa, stream at Nahoe, mouth of Nahoe Valley, sea level, water temp. 26.5°C., 25 October 1999, 11:00-12:00 hrs. 09°44'24"S, 138°55'24"W.

MARQUESAS ISLANDS, Hiva Oa, fern gullies along headwaters of Vaiahu River system, N. of road, E. of Tapeata summit, 520–580 m. [1700–1900 ft.], 25 October 1999, 13:00-13:30 hrs. 09°46'23"S, 138°57'31"W.

MARQUESAS ISLANDS, Hiva Oa, springs and rocky stream at headwaters of E. fork of Faakua River, 550–565 m. [1800–1850 ft.], water temp. 22°C., 25 October 1999, 14:00-16:00 hrs. 09°45'52"S, 138°59'00"W.

MARQUESAS ISLANDS, Hiva Oa, Temetiu Ridge at trail crossing, NW of Temetiu summit, 1110 m. [3650 ft.], 26 October 1999, 10:00-15:30 hrs. 09°47'54"S, 139°04'44"W.

MARQUESAS ISLANDS, Tahuata, upland reservoir NE of Vaitahu, 400 m. [1300 ft.], water temp. 26.5°C., 27 October 1999, 11:00-12:00 hrs. 09°55'45"S, 139°05'54"W.

MARQUESAS ISLANDS, Tahuata, Vaitahu harbor at boat landing, sea level, sea temp. 27°C., 27–29 October 1999, at night. 09°56'11"S, 139°06'33"W.

MARQUESAS ISLANDS, Tahuata, cascade and small rocky stream above Vaitahu (Teovau region), S. side of Vaitahu Valley, 240 m. [800 ft.], water temp. 22.5°C., 28 October 1999, 09:00–11:00 hrs. 09°56'56"S, 139°06'02"W.

MARQUESAS ISLANDS, Tahuata, Uuao Ridge, north end at antenna site nr. intersection with Amatea Ridge, 850 m. [2800 ft.], 29 October 1999, 09:00–11:00 hrs. 09°56'35"S, 139°05'05"W.

MARQUESAS ISLANDS, Ua Huka, small streams and cascades in upper Hane Valley (Vaihonu and Poiotona cascades), 165 m. [550 ft.], water temp. 23°C., 1 November 1999, 14:00–16:00 hrs. 08°54'50"S, 139°32'15"W.

MARQUESAS ISLANDS, Ua Huka, Hitikau Ridge, west summit, 885 m. [2900 ft.], 2 November 1999, 12:00–14:30 hrs. 08°54'12"S, 139°31'36"W.

MARQUESAS ISLANDS, Ua Huka, Vaiee Cascade and rocky stream in upper Vaipae Valley, 215 m. [700 ft.], water temp. 22.5°C., 3 November 1999, 09:00–12:00 hrs. 08°53'52"S, 139°33'17"W.

SOCIETY ISLANDS, Tahiti, Tahiti Nui, small disturbed tributary to lower Papenoo River, 45 m. [150 ft.], water temp. 32°C., 5 November 1999, 13:30–14:00 hrs. 17°33'02"S, 149°26'04"W.

SOCIETY ISLANDS, Tahiti, Tahiti Nui, Vaiharuru Cascade, trib. to middle Papenoo River, 60 m. [200 ft.], water temp. 23.5°C., 5 November 1999, 14:30–16:30 hrs. 17°34'20"S, 149°26'02"W.

SOCIETY ISLANDS, Tahiti, Tahiti Nui, Mt. Marau, 1160–1340 m. [3800–4400 ft.], water temp. (in small spring at 3800 ft.) 16.5°C., 6 November 1999, 09:00–16:00 hrs. 17°36'26"S, 149°32'15"W (at 1280 m. [4200 ft.] nr. radio towers); 17°36'24"S, 149°32'38"W. (at 1160 m. [3800 ft.], at head of tree fern gully).

## RESULTS

### Aquatic Diptera

Preliminary findings of these surveys indicate a rich variety of undescribed species of aquatic diptera in the family Dolichopodidae. Two new species of water skating *Campsicnemus* flies collected during these surveys have been described by Dr. Neal Evenhuis of the Bishop Museum, in addition to a previously described species from Nuku Hiva (Evenhuis 2000). The two new species were collected from stream pool habitats in Ua Huka and Hiva Oa, and undoubtedly each Marquesan Island has at least one endemic *Campsicnemus* species. The presence of *Campsicnemus* in the Marquesas is noteworthy as this represents the only known population of these flies south of the equator (Evenhuis 2000). More dolichopodid species collected during this

survey are currently being described by Dr. Evenhuis, and the results will be of great use in studying island biogeography and stream ecology in the tropical insular Pacific. Additionally, Dr. Wayne Mathis of the Smithsonian Institution will be describing aquatic ephydrid flies collected in stream habitats during this study.

## **Heteroptera**

As is typical of isolated Pacific island groups, the freshwater aquatic Heteroptera fauna of the Marquesas and Society island groups is limited in comparison to continental areas. The attenuation of lineages becomes progressively more pronounced as one moves northeastward, from the Societies to the Marquesas and then to Hawaii. Freshwater Gerridae, for example, are found in the Societies but do not reach the Marquesas or Hawaii, while Hydrometridae are found in both the Societies and the Marquesas, but are once again absent in Hawaii.

The family Saldidae and the veliid subfamily Microveliinae are ubiquitous components of stream faunas on the high islands of the Pacific, but had never previously been reported from the Marquesas. Both were found during the current survey, with different sets of endemic species apparently present in both the northern and southern sections of the archipelago. In addition, a few coleopteriform saldids apparently representing a new subfamily were taken at Tekau Ridge on Nuku Hiva, and on Mt. Temetiu on Hiva Oa.

The family Hydrometridae has also undergone a small but extremely interesting radiation in the Marquesas, with two endemic and monotypic genera known from the islands: *Dolichocephalometra* from Mt. Hitikau on Ua Huka, and *Chaetometra* from Mt. Temetiu on Hiva Oa. Despite visits to both of these localities, neither of these two genera could be located; however, a third undescribed endemic genus was captured on Mt. Temetiu, and is currently in the process of description. The discovery of these unusual groups of saldids and hydrometrids in the cloud forests of the Marquesas after only brief surveys indicates that more intensive collecting in such areas may produce further significant entomological discoveries.

## **Odonata**

### Dragonflies

The Odonata, or the dragonflies and damselflies, of French Polynesia are poorly understood and have been little studied since Bishop Museum surveys conducted in the late 1920s and 1930s (see *Bishop Museum Bulletins*, Volumes 98, 113, 114, 159). Additionally, species descriptions by

Needham (1935) of Marquesan and Tahitian dragonflies in the genus *Hemicordulia* appear to be flawed. For example, Needham (1932) describes one Marquesan dragonfly (*Hemicordulia assimilis*) only from an immature from Hiva Oa, with no adult description, while another *Hemicordulia* species, *H. mumfordi*, was described from adults from the same locality, Mt. Temetiu on Hiva Oa (Needham 1935). Needham was ill advised in describing two closely related dragonflies using adults and immatures from the same mountain, since the possibility that two separate *Hemicordulia* species are inhabiting the Mt. Temetiu region is low. Additionally, although the probability is high that Marquesan and Tahitian *Hemicordulia* are separate species, Needham did not provide a reasonable basis for their separation. Clearly the entire assemblage of *Hemicordulia* from both the Society Islands and the Marquesas are in need of revision. The results of these dragonfly revisions will be published in peer-reviewed scientific journals, with voucher specimens provided to both the Paea collection facility in Tahiti and the Museum National d'Histoire Naturelle in Paris upon identification and description of new species.

Other interesting findings from these surveys were range extensions for several species of dragonflies previously not observed in the Marquesas (Schmidt 1938). Among these were the large and beautiful Aeschnid dragonfly *Anaciaeschna jaspidea*, collected and observed on the island of Hiva Oa, at the mouth of the Faakua River. This is a new island group record for this species. *Tholymis tillarga* was observed at the Taipi River on Nuku Hiva but was not collected,

Table 1. List of dragonflies caught or observed in the Marquesas Islands

| Island    | Dragonfly Species            | Comments   |
|-----------|------------------------------|--|
| Nuku Hiva | <i>Pantala flavescens</i>    | Abundant everywhere  |
|           | <i>Tholymis tillarga</i>     | (observed only at Taipi River - not collected)             |
|           | <i>Hemicordulia</i> sp.?     | Abundant at edge of pastures/forest of Toovii Plateau      |
| Hiva Oa   | <i>Pantala flavescens</i>    | Abundant everywhere  |
|           | <i>Pantala</i> new sp.?      | Only at Faakua River mouth, but abundant there             |
|           | <i>Hemicordulia</i> sp.?     | Moderately common in upper elevation areas                 |
|           | <i>Anaciaeschna jaspidea</i> | Only at Faakua River mouth, but common there               |
| Tahuata   | <i>Pantala flavescens</i>    | Abundant everywhere  |
|           | <i>Hemicordulia</i> sp.?     | (observed only at summit, but rare, not collected)         |
|           | <i>Tholymis tillarga</i>     | (observed several at Vaitahu ocean springs, not collected) |
| Ua Huka   | <i>Pantala flavescens</i>    | Abundant everywhere  |
|           | <i>Hemicordulia</i> sp.?     | (observed at summit of Hitikau only, not collected)        |

and was previously recorded from the Marquesas by Schmidt (1938). Another previously unrecorded Marquesan dragonfly found at the Faakua River during these surveys was a species resembling *Pantala flavescens* but much smaller and lighter green in coloration. The identity of this species is not yet known.

Another important goal of this and future studies of French Polynesian streams is a first step towards assessing the relationships between highly migratory species of insects such as dragonflies. One of the authors (RE) will be examining genetic flow and phylogenetic relationships between Hawaii and the Marquesas as part of a Ph.D. research project. The collection of many individuals during this recent Marquesas trip of *Pantala flavescens*, a dragonfly species indigenous to both Hawaii and the Marquesas, will allow this interesting question to be investigated. Some preliminary findings of note from this trip have shown a much smaller and less robust *Pantala* sp. found on some of the Marquesan islands. Upon closer examination this dragonfly could potentially be a new species, and at the very least is a new archipelago record for another species of dragonfly from the Marquesas. An extensive morphological and phylogenetic analysis of the collected Marquesan specimens, and previously collected specimens from Hawaii will be conducted by RE in the lab of Dr.'s Gillespie and Roderick at the University of California at Berkeley. For dragonflies and other species it is possible that the Marquesan streams may represent 'stepping stones' to the nearest high islands of Hawaii.

#### Damselflies

Three species of damselflies were previously recorded from the Marquesas, the widespread *Ischnura aurora*, and two endemic taxa described by Needham (1932, 1933) under the names *Pseudagrion demorsum* and *Coenagrion interruptum*. The latter name was shown to be the same as that of another *Coenagrion* species, and was subsequently changed to *Bedfordia halecarpenteri* (Mumford 1942), since it also became apparent that the species in question was not a true *Coenagrion*. Our current studies indicate that *Pseudagrion demorsum* should also be assigned to the genus *Bedfordia* (Polhemus et al., *in press*), which is apparently endemic to the Marquesas. In addition, we have collected five additional new species of *Bedfordia* on Nuku Hiva, Hiva Oa, and Ua Huka. A revision of this group is now in progress, and it seems likely that most of the high islands in the group will prove to harbor endemic species.

#### **Introduced Aquatic Species**

Our preliminary surveys found intact aquatic ecosystems throughout the four Marquesan Islands of Nuku Hiva, Hiva Oa, Tahuata, and Ua Huka. Most importantly, no introduced fish species

were found in even the most highly degraded urban habitats, such as those in the town of Taiohae on Nuku Hiva, or the lowest sections of Hane Stream on Ua Huka, where streams are heavily diverted, and the impact of urban runoff is evident. This lack of introduced fish in the Marquesas Islands is likely the most important conservation-related finding of our study. In regard to the fish fauna, only native gobiid, eleotrid, and anguillid fish were observed in freshwater habitats. Another important finding is that no introduced aquatic insects such as caddisflies, amphibians or crustaceans were observed in aquatic habitats on the four Marquesan Islands surveyed.

Also significant is the lack of many introduced and pernicious species of introduced aquatic vegetation found in Tahiti and/or Hawaii, such as mangroves and California grass (*Brachiaria mutica*), or other noxious riparian grasses and plants including Guinea grass (*Panicum maximum*), Java Plum (*Syzygium cumini*), raspberry, and guava. The vegetation around the stream riparian areas still largely reflects either a Polynesian character in the lowlands, with taro, coconut and other fruit trees common, or is completely native in the upper elevations with hau (*Hibiscus tiliaceus*) and hala (*Pandanus tectorius*) dominating virtually all upper stream corridors.

## DISCUSSION

Species invasions have been particularly devastating both environmentally and economically in freshwater systems, particularly in the tropical insular Pacific. The adverse effects associated with nonindigenous freshwater species have been well documented in the Pacific region, especially in Hawaii (Maciolek 1984; Eldredge 1994; Englund 1999). Nonindigenous freshwater fish, crustaceans, and amphibians now occur in virtually every part of the world, including Australia, New Zealand, and on most Pacific islands with freshwater habitats (Maciolek 1984; Eldredge 1994; Eldredge 1999). They threaten to displace native aquatic species and disrupt aquatic ecosystems throughout the Pacific region. In Hawaii, nonindigenous crustaceans such as the freshwater crayfish (*Procambarus clarkii*) and have caused economic losses to taro farmers because of the burrowing habits of this species and its consumption of taro corms and roots. Chemical controls, such as the poisoning of taro fields with para-dichloro benzene (PDB) or naphthalene were used from 1940 to 1952 control crayfish depredations, with over 1,417 ha of wetland taro fields treated in Hawaii (Devaney et al. 1982). Amphibians introduced in the Pacific region for biological control purposes such as *Bufo marinus* have been shown to have detrimental impacts to native organisms while widely preying on non-target species in Papua New Guinea (Zug et al. 1975). *Bufo marinus* has also been shown to be a carrier of leptospirosis, a serious human health threat (Everard et al. 1990), and in Australia severely impacted the beekeeping industry by consuming large quantities of honeybees (Tyler 1994).

The negative effects of introduced fish such as poeciliids and blackchin tilapia on other vertebrates and invertebrates have also been widely documented (Hurlbert et al. 1972; Meffe and Snelson 1989; Eldredge 1994; Dove 1998; Englund 1999). Howe et al. (1997) documented the negative effects of mosquitofish on native pseudomugilid (blue-eyes) fish species in Australia. Mollusks, such as apple snails introduced into Hawaii, Taiwan, and the Philippines, have caused widespread damage and severe reductions of rice and taro crop yields (Cowie, in press). Mosquitofish (*Gambusia affinis*) also exhibit a wide dietary preference (Miura 1979; Englund et al. 2000) and in California streams were found to prey heavily on native treefrog tadpoles even when mosquito larvae were introduced as alternative prey (Goodsell and Katz 1999).

Nonindigenous species have devastated Hawaiian stream, wetland, and anchialine pond ecosystems, and would similarly devastate the native aquatic fauna of French Polynesia, particularly the Marquesas which lack introduced species. Not only do nonindigenous species compete with and prey upon native species, but they have also brought with them a complement of disease and parasites to which native species have not evolved resistance (Font and Tate 1994). In Hawaii, the severity of alien species impacts varies according to island, elevation, and watershed; with adjacent streams often having a significantly different composition of nonindigenous species. Even the most remote areas of the main Hawaiian Islands with freshwater habitats contain nonindigenous aquatic species. In the Hawaiian Islands, stream and wetland habitats on the heavily developed island of Oahu have suffered the greatest impacts, notably aquatic species introductions and habitat disturbances.

With the exception of nono (Simuliidae) flies and mosquitoes in the Marquesas (Craig et al. 1995, Craig 1997), aquatic insects have often been overlooked both in Hawaii and French Polynesia because of their small size and innocuous nature. Aquatic insects are an important component of the native freshwater fauna as they provide a key food source for many species of native fish, crustaceans, and mollusks. Most native aquatic insects likely arrived in the Marquesas and Hawaii by means of a combination of oceanic currents or wind, with many Hawaiian aquatic insect groups derived from marine species (Howarth and Polhemus 1991). Aquatic insects differ from the diadromous fish, crustaceans and mollusks as access to the ocean is not required to complete their life cycle. This also provides an advantage as many insect species are found in high elevation aquatic habitats that native fish and crustaceans are unable to access.

The stream insect faunas of the Marquesas and the Hawaiian Islands have many similarities, since insect orders dominating the stream fauna in continental areas are naturally absent, including mayflies (Ephemeroptera), caddisflies (Trichoptera), stoneflies (Plecoptera), and

dobsonflies (Megaloptera). In Hawaii, this has led to some unusual speciation patterns in native groups such as the flies (Diptera), damselflies (Odonata), many species of semi-aquatic moths (*Hyposmocoma* sp.), and the world's only aquatic damsel bug, *Nabis gagneorum* (Polhemus 1999).

The decline of the native freshwater biota in Hawaii has been well documented and no pristine aquatic ecosystems remain in Hawaii. Pristine is defined as an ecosystem unaffected by diversions, channelization, or pollution runoff, and lacking introduced aquatic species. Thus, any ecological studies conducted in Hawaii are conducted in systems that have been fundamentally altered, although some aquatic systems may have seemingly benign introductions in upper elevation areas. As stated earlier, virtually every island chain in the tropical insular Pacific area has had a large number of introduced freshwater species, and Eldredge (1994) has thoroughly documented those species introductions. It appears the Marquesas may be the last high island group in the Pacific without any major aquatic species introductions, since even Rapa Nui (Easter Island) has introduced mosquitofish (Steve Montgomery, pers. comm.).

Diversions for hydropower and drinking water are ubiquitous on the larger Marquesan streams such as Taipivai River, Nuku Hiva or Faakua River, Hiva Oa. This has resulted in the loss of habitat for native amphidromous species such as the neritid snails, and these large snails were not observed above the diversion on the Tehua Cascade branch of Taipivai Stream. In sharp contrast to Hawaii, little to no feral ungulate damage from pigs and goats was observed along the stream corridors of the four islands we surveyed. However, pig damage was quite evident and severe at the cloud forest summit area of Mt. Temetiu, Hiva Oa. Mt Temetiu was the only summit area of the four high islands (Nuku Hiva, Hiva Oa, Tahuata, Ua Huka) we surveyed with any observable feral ungulate damage.

Being the nearest high islands to Hawaii, the Marquesas may have played a critical role in the evolutionary history of the Hawaiian and other Pacific Island stream biota. The Marquesas Islands are the nearest high islands to Hawaii with permanently flowing streams and a wide variety of aquatic habitats that potentially remain in a pristine state. Evolutionary and biogeographic studies comparing the Marquesas and Hawaii are of critical importance in allowing for an understanding of evolutionary processes in two of the most isolated archipelagoes in the world. As introduced aquatic species are known to have caused the extinction of species in Hawaii (Englund 1999), it is imperative to obtain a baseline on native and introduced aquatic species in the Marquesas Islands prior to any large-scale introductions. Evidence that the Marquesas have been largely spared from large scale introductions of nonindigenous fishes and other macrofauna such as crayfish can also be found in Fossati and Marquet (1998).

Hawaii is fortunate to have a long history of collections starting in the late 1890s by the British entomologist R.C.L. Perkins (Liebherr and Polhemus 1997) and later with collectors such as F.X. Williams and Timberlake (Englund 1999). These collections, mostly deposited in the Bishop Museum, British Museum of Natural History, and Smithsonian Institution, have proven invaluable in documenting the distributions of many species prior to the introduction of many nonindigenous species. One of the major objectives of our current study was to make collections and observations of native Marquesan aquatic organisms prior to the advent of nonindigenous species introductions. It is imperative to assess such aquatic ecosystems now, since modern transportation, the likely future increase in tourism, and the possibility of direct international flights to the Marquesas greatly increases the probabilities of harmful nonindigenous species introductions.

Marquesan and Society Island streams are significant in an evolutionary and biogeographic context in relation to other Pacific Islands, and management steps should be taken to block the arrival of nonindigenous species. Even though the many of these streams have human perturbations mainly in the form of water and hydropower diversions, during our recent Marquesas surveys we found a complete lack of introduced aquatic macrofauna that has completely devastated certain lowland Hawaiian streams. The introduction of fish species such as tilapia or even mosquitofish would have an immediate adverse impact on the native Marquesan stream fauna, and would adversely impact the culturally important prawn (chevrettes) fishery. Every attempt should therefore be made to discourage introductions of any nonindigenous aquatic species in the Marquesas, as this island group appears to be the last high island group lacking introduced aquatic species in the Pacific.

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