



**REPORT FOR THE 2003 PACIFIC BIOLOGICAL SURVEY, BISHOP MUSEUM AUSTRAL
ISLANDS, FRENCH POLYNESIA EXPEDITION TO TUBUAI AND RURUTU**

Prepared for:
Délégation à la Recherche
(Ministère de la Promotion des Ressources Naturelles),
B.P. 20981 Papeete, Tahiti, Polynésie française.

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September 2004
Contribution No. 2004-001 to the Pacific Biological Survey

Cover pictures, clockwise from upper left: 1) *Coleotichus* new species from Rurutu, 2) *Atylana* new species from *Cyrtandra elisabethae*, from Rurutu, 3) *Ischnura* new species from Puputa Stream, Rurutu, 4) *Ischnura* new species from Rurutu, larva

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RÉSUMÉ

Le programme sur l'Étude Biologique du Pacifique (Pacific Biological Survey ou PBS) du Bishop Museum a mené des prospections biologiques du 9 au 28 Novembre 2003 dans les îles de Tubuai et Rurutu aux Australes dans le cadre du programme de recherche "Inventaire et Valorisation de la Biodiversité" mené en Polynésie française par la Délégation à la Recherche (Ministère de la Promotion des Ressources Naturelles, Gouvernement de la Polynésie française).

Les objectifs du PBS dans les îles Australes étaient : 1) d'évaluer la faune des insectes indigènes d'eau douce et de décrire la biodiversité complète de cette faune, 2) d'évaluer la biodiversité et le statut des Héteroptères et d'autres insectes d'importance dans les zones de forêts naturelles, 3) d'évaluer l'impact ou l'absence d'impact des espèces aquatiques introduites sur la biocénose indigène d'eau douce, 4) d'évaluer de façon qualitative les impacts des espèces introduites, ongulés en liberté et urbanisation sur les insectes indigènes, et 5) de fournir des spécimens de musée et des informations de base pour les recherches futures.

Parmi les découvertes significatives obtenues lors de cette expédition, nous avons observé une faune indigène d'eau douce sans poissons, amphibiens ou reptiles aquatiques introduits à Rurutu mais la présence de deux espèces de poissons introduits communs et envahissants à Tubuai (le tilapia *Oreochromis mossambicus* et le guppy *Poecilia reticulata*). Tubuai est apparemment la seule île des Australes qui possède des espèces de poissons d'eau douce introduits. Il serait nécessaire de mener des échantillonnages complémentaires à Tubuai pour émettre des conclusions définitives sur l'impact de ces espèces introduites. Sur Tubuai, ces poissons introduits ont été trouvés dans tous les habitats aquatiques avec une seule exception, la grande cascade sous le sommet du mont Panee qui constitue les eaux courantes les plus élevées en altitude à Tubuai. Cette cascade coule dans une série de bassins en escalier dont la pente est trop forte et trop haute pour que les poissons introduits puissent y accéder. Elle constitue une zone de refuge potentielle pour les espèces indigènes qui pourraient être sujette à l'impact négatif des poissons introduits, comme les demoiselles endémiques.

De nombreuses espèces d'insectes aquatiques décrits ou non encore décrits appartenant aux Héteroptères, Diptères (mouches aquatiques), Odonates (libellules et demoiselles) et Coléoptères ont été trouvés à la fois à Rurutu et Tubuai, ainsi que des extensions de leur aire de répartition. L'une des découvertes les plus importantes a été celle d'une nouvelle espèce de demoiselle endémique de grande taille trouvée à Rurutu uniquement dans des rivières non détournées, à fort courant et à couvert forestier. Il est possible que les demoiselles endémiques aient été éliminées à Tubuai par les espèces de poissons envahissants, mais des prospections plus intensives seraient nécessaires pour vérifier cela. Bien que généralement peu commun ou absent de plusieurs îles de Polynésie française, une espèce de Coléoptère indigène aquatique (*Rhantus new sp. cf. schereri*) a été trouvé dans la rivière Tamatoa dans des zones de faible altitude et des eaux stagnantes

à *Hibiscus tiliaceus*. Aucun insecte aquatique appartenant aux ordres des Ephéméroptères, Plécoptères et Trichoptères n'a été trouvé à Tubuai et à Rurutu.

Une entomofaune indigène terrestre avec de nombreuses espèces de Coléoptères, Diptères et Hétéroptères a été également trouvée à Rurutu et Tubuai bien que les zones d'habitats forestiers pour ces insectes ont été gravement réduites sur les deux îles, surtout sur Rurutu. Les forêts naturelles de Tubuai possèdent une entomofaune terrestre diversifiée avec quelques nouvelles espèces non décrites qui ont été collectées durant cette expédition. L'un des résultats les plus spectaculaires a été la découverte de deux nouvelles espèces de Coléoptères Réduviidés (« assassin bugs »). Ces espèces ont été trouvées à Rurutu dans des reliques de forêt naturelle dominée par *Metrosideros collina* pas plus grande que 25 x 30 m et semblent donc pouvoir survivre dans des forêts naturelles de très faible superficie. De même ces deux Réduviidés et de nombreuses autres espèces de coléoptères indigènes ont été collectés sur une surface de 75 x 75 m dans une forêt de *Metrosideros collina* et *Xylosma suaveolens* dans la zone sommitale du mont Taitaa à Tubuai. Le goyavier de Chine *Psidium cattleianum* est en train d'envahir progressivement cette petite tache de forêt naturelle et cette invasion devrait être contrôlée avant que le goyavier n'étouffe complètement les plantes indigènes.

Bien que les forêts naturelles humides d'altitude sont actuellement extrêmement limitées à Rurutu et réduites à quelques petits vallons sous les zones sommitales comme le mont Taatioe, une formation végétale naturelle plus étendue subsiste sur plateau calcaire (makatea). Ces taches de végétation subsistent car elles sont situées dans des zones inaccessibles pour le bétail et sont apparemment assez humides pour ne pas brûler régulièrement comme les pâturages. Ces formations ne représentent qu'une zone de moins de 2-3 hectares. Cependant des plantes envahissantes menacent de coloniser ces quelques taches subsistantes de forêt naturelle intacte. Contrairement aux zones élevées de Tubuai qui contiennent de nombreuses reliques de forêts naturelles, peu de végétation indigène avec leur population d'arthropodes associés subsistent dans les vallons situés dans les zones les plus hautes de l'intérieur de Rurutu. Néanmoins, ce qui reste héberge une faune importante d'arthropodes comme cette nouvelle espèce de Réduviidés trouvée uniquement lors d'un échantillonnage de *Metrosideros collina* dans la région sommitale du mont Teape et Rua o Hina, et c'est la troisième île des Australes qui possède des Réduviidés endémiques.

Afin de préserver la biodiversité indigène des Australes, il est impératif de protéger les forêts naturelles de surface limitée qui subsistent à Tubuai et Rurutu. Des réserves forestières devraient être mise en place en collaboration avec les habitants de chaque île, pour protéger les zones les plus importantes et biologiquement les plus riches comme les vallons sommitaux des monts Taitaa, Tonarutu et Taevatu sur Tubuai avec des formations de *Metrodideros collina* et *Xylosma suaveolens*, ainsi que les forêts sur le plateau calcaire Paparai avec une formation arbustive à *Dodonea viscosa* qui est l'une des plus intactes et des plus grandes en Polynésie française et qui contient des insectes endémiques d'importance

biogéographique. Un vallon sous le sommet du mont Taatioe à Rurutu avec l'espèce végétale menacée *Cyrtandra elisabethae* possède également une nouvelle espèce de sauterelle. Cette zone devrait être clôturée afin d'exclure les animaux herbivores et les plantes envahissantes devrait y être contrôlées activement.

ABSTRACT

From 9–28 November 2003, staff from the Pacific Biological Survey (PBS) of the Bishop Museum in cooperation with other biologists conducted biological surveys in the Austral Islands of Tubuai and Rurutu as part of an “Inventaire et Valorisation de la Biodiversité” or inventory and evaluation of biodiversity, a research program conducted in French Polynesia by the Délégation à la Recherche (Ministère de la Promotion des Ressources Naturelles, Gouvernement de la Polynésie française). These floral and faunal surveys were conducted in cooperation with the Bishop Museum, French and British scientists from the Paris Muséum National d'Histoire Naturelle and the University of British Columbia; and local scientists from the Délégation à la Recherche and Service du Développement Rural.

The objectives of this biodiversity assessment of the Austral Islands were: 1) to assess the native aquatic insect fauna and describe the overall biodiversity of this fauna, 2) to assess the biodiversity and status of Heteroptera and other important endemic phytophagous insects in native forest areas, 3) to assess the impacts or lack of impacts of introduced aquatic species on native stream biota, 4) to qualitatively assess the impacts of introduced species, feral ungulates, urbanization, on native insects, and 5) to provide museum specimens and an information baseline for future researchers.

Significant findings of these surveys include a pristine native freshwater fauna lacking introductions of nonindigenous fish, amphibians, or aquatic reptiles on Rurutu, but two harmful invasive fish species were widespread on Tubuai. Tubuai is apparently the only Austral Island currently having introduced freshwater fish species. On Tubuai, alien fish were found in all aquatic habitats sampled with only one exception at the large cascade below the Mt. Panee summit; this was the highest elevation area on Tubuai with flowing water. This cascade flowed into a series of stair-step pools that were too steep and high gradient for introduced fish to access, and was a potential refuge area for native species that could be negatively impacted by introduced fish, such as endemic damselflies.

Numerous undescribed and several described aquatic insect species were found on both Rurutu and Tubuai, including new species and range extensions of Heteroptera (true bugs), Diptera (aquatic flies), and Odonata (dragonflies and damselflies), and Coleoptera (beetles). One of the most important aquatic findings during this expedition was a new species of large endemic damselfly found on Rurutu only in undiverted, forested,

and fast-flowing streams. It is possible that endemic damselflies have been eliminated on Tubuai by invasive fish species, though more intensive surveys are required to verify this. Although generally uncommon and not found in many French Polynesia islands, one species of native aquatic Coleoptera (beetles), *Rhantus* new sp. near *scheneri* was found at Tamatoa Stream in the lower elevation still-water *Hibiscus tiliaceus* areas. Aquatic insects in the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) orders were not found on Tubuai or Rurutu.

Areas that should receive the highest conservation priority on Rurutu include the *makatea* forest at Plateau Paparai with a mixed *Dodonea viscosa* shrubland forest that is one of the largest and most intact in French Polynesia, harboring unique species of biogeographically important endemic insects. A gully below the summit of Mt. Taatioe with the endangered *Cyrtandra elisabethae* plants and new species of green planthopper is of world-wide conservation and biogeographic importance and contains the largest patches of remnant native upland forest remaining on Rurutu, and with it the greatest native insect biodiversity on Rurutu. This area should be immediately fenced to keep grazing cattle out, and weeding could reduce the encroaching invasive plant species. The lack of action in protecting these forest patches from grazing cattle and other feral ungulates will certainly lead to the demise of native plants on Rurutu and the extinction of the unique insects associated with them.

The native species found on both islands are important on a worldwide basis, and the conservation of this rich biodiversity is a critical component of the Polynesian culture found on these islands. It is of global significance to preserve the native biodiversity found on the Austral Islands to allow a greater understanding of the natural biological processes of dispersal and colonization of the fauna to these remote and isolated island areas.

INTRODUCTION

From 9 to 28 November 2003, staff from the Pacific Biological Survey (PBS) of the Bishop Museum in cooperation with other biologists conducted biological surveys in the Austral Islands of Tubuai and Rurutu as part of an “Inventaire et Valorisation de la Biodiversité” or inventory and evaluation of biodiversity, a research program conducted in French Polynesia by the Délégation à la Recherche (Ministère de la Promotion des Ressources Naturelles, Gouvernement de la Polynésie française). These floral and faunal surveys were conducted in cooperation with the Bishop Museum, French, and British scientists from the Paris Muséum National d’Histoire Naturelle; Délégation à la Recherche de la Polynésie française; and the University of British Columbia.

Funding for these biodiversity surveys originated from the Gouvernement de la Polynésie française (Contrat de Développement Etat-Territoire), with matching funding coming from the Pacific Biological Survey of the Bishop Museum. The objectives of this biodiversity assessment of the Austral Islands were: 1) to assess the native aquatic insect fauna and describe the overall biodiversity of this fauna, 2) to assess the biodiversity and status of Heteroptera and other important endemic phytophagous insects in native forest areas, 3) to assess the impacts or lack of impacts of introduced aquatic species on native stream biota, 4) to qualitatively assess the impacts of introduced species, feral ungulates, urbanization, on native insects, and 5) to provide museum specimens and an information baseline for future researchers.

This preliminary report describes general habitats and sampling areas on Tubuai and Rurutu, Austral Islands that were assessed during this expedition, and also reports on some important findings and discoveries made during this trip. A comprehensive list of insect species collected during this expedition is not yet possible because of the great amount of specimens generated, and also because many of these insect species are new to science and undescribed and must be identified by a very limited number of worldwide taxonomic experts.

STUDY AREA

Biodiversity surveys took place on Tubuai and Rurutu, which are located in the Austral Island chain in French Polynesia (Figure 1). Lying at 23° S, Tubuai is tropical in climate and is found at the same latitude as the island of Kauai is located in the northern hemisphere in the Hawaiian archipelago, while Rurutu is located at 22° S, Tubuai is surrounded by an extensive barrier reef that includes a number of low-lying offshore motus (islets) while Rurutu entirely lacks a barrier reef system and has a fringing reef. The Austral Islands span 1500 km in a northwesterly direction starting from the submerged Macdonald Seamount to the Marotiri Rocks lying 90 km from Rapa, to the northernmost coral atoll of Maria. Rurutu has a complex

geological history and has been aged between 0.3 to 12.8 million years (Craig 2003). After full subsidence Rurutu was then uplifted forming impressive raised coral limestone carst cliffs around its seaward edges (Craig 2003). Tubuai is 10.6 million years old and has never been fully submerged as occurred with Rurutu, and consists of two main calderas; the eastern caldera is circular shaped and intact while the western caldera is crescent shaped. On either side of these two Tubuai caldera are two large marsh areas containing some of the largest intact wetlands in French Polynesia. The highest altitude on Tubuai is 390 m, while Rurutu has a maximum elevation of 422 m. At 45 km², Tubuai is the largest of the Austral Islands and is significantly larger than its nearest high-island neighbor Rurutu which is 32.3 km² in size. Although politically the Austral and Cook Islands are two separate entities, geologically they are part of the same hotspot island chain as the Cook-Austral Islands hotspot has been active for at least 18 million years, and extends from Mangaia in the Cook Islands to the Macdonald Seamount (Guille et al. 1998).

All three widely recognized types of tropical island types (Mueller-Dombois and Fosberg 1998) were sampled during the Austral Islands surveys: atoll and reef islands, such as the outlying motu found on Tubuai, the elevated limestone or *makatea* island portions of Rurutu and the high volcanic inner portions of Rurutu and Tubuai. The diversity of geological island types sampled during these Austral surveys has led to a wide array of ecological areas and varying plant and aquatic systems also being assessed. The most noticeable feature of Rurutu are the vertical coastal limestone cliffs ranging in height from 60-90 m tall that were formed from an ancient uplifted reef. The raised limestone regions are called *makatea* and contain razor sharp rocks that make hiking difficult. *Makatea* areas also contain a different plant community not found in caldera areas with developed soil in upland Rurutu.

One of the most unusual hydrogeological features in Polynesia was observed on Rurutu just south of the village of Hauti, with a freshwater stream disappearing directly into a *makatea* cliff. This stream originated in a bowl-shaped depression that supported taro fields in the Plateau Papanai, and flowed in an easterly direction before disappearing into the base of a 100 m tall *makatea* cliff. The stream then discharges underground into the ocean through the *makatea* somewhere along the coast around Pointe Toarepe. Native migratory stream organisms are apparently able to penetrate these underground caverns as crustaceans and fish were observed in the stream prior to its disappearance into the *makatea* cliffs.

Both Rurutu and Tubuai have been inhabited and extensively disturbed for long time periods, with only remnant native forest vegetation remaining. Similar to the other high islands in the Australs, Tubuai has intact native forest patches that occur below the grassy ridgetops at the summit, but only in the uppermost elevation gulches. Summit ridges on these islands are either periodically burned to allow islanders easy access to their stock, or are heavily grazed by livestock keeping the summit areas grassy. Tubuai appears to

have more intact native forested areas than Rurutu. On Rurutu only a very few gulches and *makatea* habitats contained any sizable amounts of native vegetation. The most extensive areas of native vegetation found on Rurutu appeared to be in regions at the tops *makatea* plateaus, likely because grazing animals find these areas harder to access.

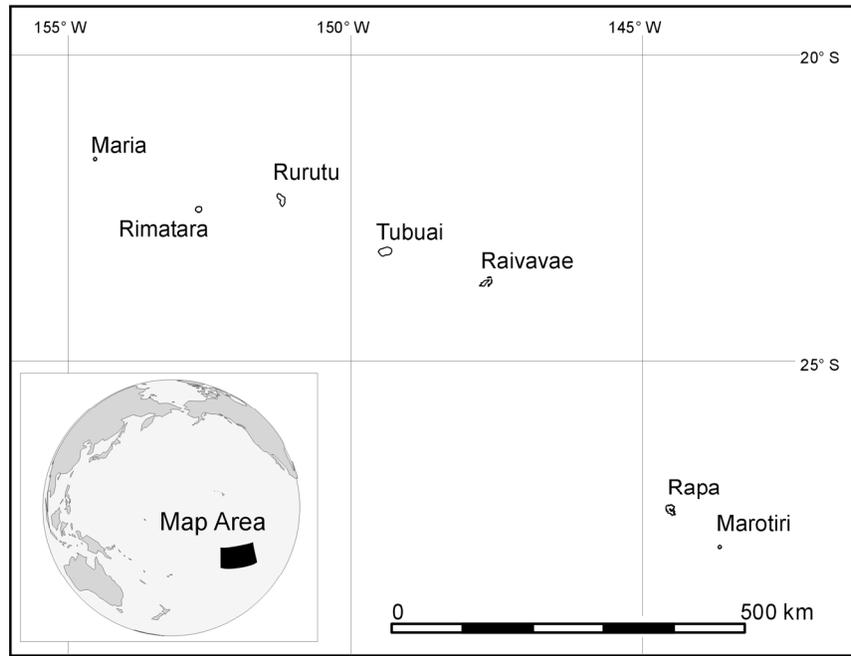


Figure 1. The Austral Island chain from Maria atoll to Marotiri.

Aquatic Habitats- Tubuai

The watersheds of Tubuai are relatively short and radiate out in a spoke-like arrangement from the central spine of the caldera. One of the most prominent features of Tubuai is the large wetland complex of Marais Matavahi and Marais Mihiura found on the western side of the island. These two wetlands are undoubtedly the largest in the Austral Island chain, and one of the larger wetland areas in all of French Polynesia. Small taro fields within the Marais Matavahi, near Piton Pahatu were sampled for aquatic insects, and the adjacent Marais was also briefly sampled.



Marais Mihiura, Tubuai

Sampling time was somewhat limited on Tubuai and the two major watershed areas sampled included Tamatoa Stream sampled on 13 Nov 2003, from 18-150 m elevation and an unnamed tributary at the

highest reaches of the Vaiapu watershed, below the summit of Mt. Panee. Tamatoa Stream was accessed near the Tamatoa Cemetery and the stream was surveyed by hiking upstream. The stream was covered with a thick growth of *Hibiscus tiliaceus* and *Pandanus tectorius* in the lowest reaches of this stream and had scattered cobbles and larger rocks, but mostly the stream flowed through soil and finer substrates. At 20 m elevation the stream channel started to pick up gradient and cobbles became more common, and small tributaries started to empty into Tamatoa Stream. Stream flow was somewhat high and the water was turbid from heavy rains the day before. At the end of the survey at around 150 m elevation a few 1-2 m high plunge pools were observed, and stream gradient began to pick up significantly.



Tamatoa Stream, Tubuai



Mt. Panee Cascade Tubuai

The other major aquatic system surveyed was the area below the Mt. Panee summit, and at 250 m elevation was the highest elevation at which flowing water was found on Tubuai. Water started flowing here from a perched spring in a mixed *Pandanus tectorius* and strawberry guava (*Psidium cattleianum*) forest and flowed downstream over the smooth rock face to a large pool estimated at 10 x 12 m in size around 170 m elevation. Because of time constraints only 10 minutes was spent at this pool area, though several samples were collected while climbing down the steep madicolous rock wall. As this is probably the largest permanently wetted rock face area on Tubuai the area was of great biological interest for aquatic insects, and should be sampled more thoroughly in the future as number of aquatic taxa

not collected during the brief sampling period on Tubuai could potentially be found here. This large wetted rock wall and downstream cascade chutes contradicts the observation by Craig (2003) that Tubuai lacks stream chute habitat. Stream sampling on Tubuai was hindered by poor water clarity resulting from very heavy rains during our collection period.

Aquatic Habitats- Rurutu

Aquatic wetland habitats are reduced in comparison to the vast wetlands found on Tubuai, but even so Rurutu contains small but significant stream systems with extensive aquatic habitats. Wetland areas, mainly taro fields were not uncommon, and those sampled included the Peva Iti marsh and wetland area that was

being used as pastureland and several large taro fields near Moerai Town, in Pupuhi Village and in the Plateau Paparai basin. Confirming observations by Craig (2003), streams in Rurutu flow over smooth chutes into shallow pools, indicating great geological age.

Puputa Stream, flowing behind the main village of Moerai was the largest stream on Rurutu and was diverted for domestic supplies, (as were all streams on Rurutu) at an elevation of 64 m. Water temperature above the captage (diversion) was recorded at a cool 20.5°C. The stream flowed for an estimated 400-500 m above the captage before the largest waterfall observed on Rurutu was encountered at 82 m elevation. The free-flowing Puputa Stream in this area was heavily shaded mainly by *Hibiscus tiliaceus* and *Pandanus tectorius* and was relatively high gradient with ample riffle habitats and excellent water clarity. Puputa Stream was sampled intensively for aquatic biota on 23 Nov and 27 Nov 2003. Other high quality stream habitats sampled on Rurutu included smaller Uatoa Stream that fed the taro fields of Pupuhi Village.



Puputa Cascade, Rurutu

Above the taro fields this beautiful stream flowed through a grove of Tahitian chestnut (*Inocarpus fagifer*) trees and has a series of clear pools with very little vegetation growing underneath these large trees.

Terrestrial Insect Habitats- Tubuai and Rurutu

Because most species of tropical phytophagous terrestrial insects are usually found on one or a narrow range of plant hosts, native forest habitats on Tubuai and Rurutu are closely correlated with native insect biodiversity. It is not within the scope of this report to provide a comprehensive vegetation analysis of these islands, rather, this can be found in Meyer et al. (in prep). However, vegetation patterns are critically important in influencing terrestrial insect distributions, and terrestrial insect sampling efforts were directed towards native plant communities found on both islands. Observations for new immigrant agricultural insect pests were also made during the expedition.

Similar to Raivavae and most of Rapa, the uppermost ridge and summit areas of Rurutu and Tubuai consisted primarily of short grass pastureland that appears to be regularly burned and grazed, and consequently was unsuitable to most native insects. On Rurutu, the major exception was the *makatea* plateau forest that contained the largest remaining areas of native plant species. Certain upper elevation *makatea* areas remained quite intact, likely resulting from the difficulty of grazing animals gaining access

2003 Trip Report: Expedition to Rurutu and Tubuai, Austral Islands, French Polynesia

Table 1. Sample localities, GPS coordinates (WGS 84), and host plant or habitat sampled on Tubuai, Austral Islands during terrestrial and aquatic surveys conducted during November 2003.

Locality	Date	Lat Long Coords	Host Plant/Habitat	Elev (m)
Vacant lot across road from ocean, nr. Sam and Yolande Pension	10-Nov-2003	23.35041°S 149.49858°W	Empty Field nr. circle island road	0
Beach at Mataura, nr. Sam and Yolande Pension	10-Nov 2003	23.34954°S 149.49620°W	Raised limestone shelf, wave splashed rocks	0
Mt. Tonarutu (1 st peak)	11 Nov 2003	23.38212°S 149.50760°W	<i>Hibiscus tiliaceus</i>	163
Mt. Tonarutu	11 Nov 2003	23.38298°S 149.50696°W	<i>Metrosideros collina</i> , <i>Dodonea viscosa</i>	236
Mt. Tonarutu	11 Nov 2003	23.38383°S 149.50754°W	Large patch of <i>Xylosma suaveolens</i> canopy fog	234
Mt. Tonarutu	11 Nov 2003	23.38424°S 149.50755°W	<i>Metrosideros collina</i> canopy fog/ <i>Pisonia amplifolia</i> general coll	293
Ridgeline btw. Mt. Tonarutu and Mt. Taevatu	11 Nov 2003	23.38536°S 149.50746°W	Ridgeline collection of dragonflies	282
Mt. Tavaetu	11 Nov 2003	23.38707°S 149.50775°W	<i>Metrosideros collina</i> canopy fog	270
Unnamed Stream nr. ocean road	11 Nov 2003	23.38242°S 149.52310°W	Stream nr. road	0
Piton Pahatu- very wet, poor collecting conditions	12 Nov 2003	23.37608°S 149.51451°W	<i>Metrosideros collina</i> general collection	79
Marais Matavahi	12 Nov 2003	23.37361°S 149.51089°W	Taro fields and associated wetlands	21
Tamatoa Stream	13 Nov 2003	23.37717°S 149.44763°W	Stream habitat- start of stream	8
Tamatoa Stream	13 Nov 2003	23.37716°S 149.45245°W	Stream habitat	19
Tamatoa Stream	13 Nov 2003	23.37326°S 149.45964°W	Stream habitat, upstream end of survey	47-150
Mt. Tamatoa area (Diana Percy collection)	13 Nov 2003	(UTM) 741354 x 248073	<i>Celtis pacifica</i> general collection	240
Tamatoa area	13 Nov 2003	23.38851°S 149.44681°W	Ditch by potato fields, observed/coll. dragonflies	0
Mt. Taitaa summit trail	14 Nov 2003	23.37019°S 149.46971°W	<i>Metrosideros collina</i> mossy log canopy fog; <i>Macropiper latifolium</i> / fern sweeping general collections	371
Mt. Panee summit cascade	14 Nov 2003	23.37121°S 149.47520°W	Main seep wall below summit, and upper stream	173-250
Motu #1 (unnamed)	15 Nov 2003	23.38095°S 149.42422°W	Rocky shoreline of tiny island	0
Motu Motiha	15 Nov 2003	23.37020°S 149.39604°W	<i>Pisonia grandis</i> / <i>Sophora tomentosa</i> / <i>Guettarda speciosa</i> / <i>Triumfetta procumbens</i> / <i>Calophyllum inophyllum</i>	0
Motu Rautaro	15 Nov 2003	23.34014°S 149.41966°W	<i>Triumfetta procumbens</i> / <i>Lepidium bidentatum</i>	0
Motu Mautaro and Tapaputauai Island	15 Nov 2003	23.34214°S 149.41508°W	<i>Pisonia grandis</i> , <i>Sophora tomentosa</i>	

Table 2. Sample localities, GPS coordinates (WGS 84), and host plant or habitat sampled on Rurutu, Austral Islands during terrestrial and aquatic surveys conducted during November 2003.

Locality	Date	Lat Long Coords	Host Plant/Habitat	Elev (m)
Pointe Arei	17 Nov 2003	22.45432°S 151.33058°W	<i>Chamaesyce fosbergii</i>	0
Pointe Arei area	17 Nov 2003	22.45555°S 151.32352°W	<i>Chamaesyce fosbergii</i> / <i>Canavalia sp.</i> / <i>Triumfetta procumbens</i>	0
Pointe Arei area	17 Nov 2003	22.46041°S 151.32213°W	<i>Ipomea pes caprae</i>	0
Peva Iti wetland	17 Nov 2003	22.46389°S 151.32359°W	Wetland/springs	1
Plateau Matu, makatea forest	17 Nov 2003	22.45952°S 151.32654°W	<i>Elaeocarpus floridanus</i> , <i>Dicranopteris linearis</i> , <i>Hibiscus tiliaceus</i>	101
Plateau Matu, trail	17 Nov 2003	22.45767°S 151.32852°W	<i>Amphineuron opulentum</i>	54
Mt. Taatioe slope/gulches	18 Nov 2003	22.46182°S 151.35930°W	<i>Metrosideros collina</i> , <i>Glychidium</i> , ferns, <i>Dodonea viscosa</i>	358
Mt. Taatioe slope/gulches (Avera side)	18 Nov 2003	22.46200°S 151.35854°W	<i>Metrosideros collina</i>	340
Mt. Taatioe slopes	18 Nov 2003	22.46292°S 151.35995°W	<i>Sophora tomentosa</i> (10-15 stunted, small trees)	390
Mt. Taatioe summit	18 Nov 2003	22.46302°S 151.36139°W	<i>Metrosideros collina</i> , ferns	388
Mt. Taatioe summit	18 Nov 2003	22.46360°S 151.36267°W	<i>Cyrtandra elizabethae</i>	301
Paparai Plateau, makatea forest	19 Nov 2003	22.49465°S 151.32445°W	<i>Cerbera manghas</i> , <i>Chamaesyce fosbergii</i>	137 m

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Locality	Date	Lat Long Coords	Host Plant/Habitat	Elev (m)
Paparai Plateau, makatea forest	19 Nov 2003	22.49347°S 151.32468°W	<i>Capparis cordifolia</i>	108 m
Paparai Plateau, makatea forest	19 Nov 2003	22.50002°S 151.32576°W	<i>Dodonea viscosa</i>	68
Beach nr. Pension Temarama, Pointe Teraipo	19 Nov 2003	22.43841°S 151.34906°W	<i>Canavalia sp.</i> , beach rocks	0
Road to Avera, in gully	20 Nov 2003	22.46687°S 151.36754°W	<i>Pipturus argenteus</i>	79
Avera Outlook	20 Nov 2003	22.46904°S 151.36533°W	<i>Pipturus argenteus</i> , spring and small stream area	117
Avera Town by ocean	20 Nov 2003	22.47528°S 151.35518°W	<i>Schleinitzia insularum</i>	0
Above village of Avera	20 Nov 2003	22.48606°S 151.34839°W	Small streamlet by road	74
Naairoa area	20 Nov 2003	22.51841°S 151.34094°W	Naairoa watershed, ephemeral puddles	40
Naairoa area, makatea forest	20 Nov 2003	22.51326°S 151.33511°W	<i>Pisonia sp.</i> and <i>Elaeocarpus floridanus</i> , ferns	83
Le Manôtel Pension (nr. Peva Iti)	20 Nov 2003	22.46307°S 151.32277°W	Lawn area	0
Moerai town	21 Nov 2003	22.45128°S 151.34099°W	Stream nr. quay, largest stream in town	0-1
Moerai town	21 Nov 2003	22.45437°S 151.33505°W	Small drainage/streamlet in town (Vaipurua Stream)	0
Te Oaa cascade (above Moerai town)	21 Nov 2003	22.45918°S 151.33696°W	Waterfall with smooth basalt substrate at Vaipurua Stream	24
Moerai town	21 Nov 2003	22.45721°S 151.33649°W	Taro fields above town	8
Plateau Paparai area	22 Nov 2003	22.50161°S 151.32758°W	Unusual stream/taro field areas flowing into makatea cliffs	8
Plateau Paparai, nr. Pointe Toarepe area, hiking up to plateau in makatea	22 Nov 2003	22.50322°S 151.32974°W	<i>Guettardia speciosa</i> , (<i>Ficus tinctoria</i>), <i>Morinda myrtifolia</i> , ferns	45
Plateau Paparai, nr. Pointe Toarepe area, on top of makatea plateau	22 Nov 2003	22.50338°S 151.33017°W	<i>Serianthes rurutensis</i> , <i>Tarenna sambucina</i>	60
Plateau Paparai, nr. Pointe Toarepe area, on top of makatea plateau	22 Nov 2003	22.50384°S 151.32962°W	<i>Dodonea viscosa</i> , ferns	85
Behind Moerai town, start near large watertanks	23 Nov 2003	22.45016°S 151.35100°W	Puputa Stream, starting at large diversion for town	64
Behind Moerai town, start near large watertanks	23 Nov 2003	22.45041°S 151.35210°W	Large cascade upstream in Puputa Stream	82
Moerai town, same stream by Dept. of Agriculture office at road crossing area	23 Nov 2003	22.44279°S 151.34631°W	Puputa Stream mouth at ocean	0
Mt. Teape Summit and gulches	24 Nov 2003	22.46310°S 151.36575°W	General collections: ferns, <i>Cyrtandra elisabethae</i> , <i>Homalium sp.</i> ; Canopy fog : mossy <i>Metrosideros collina</i> , <i>Angiopteris evecta</i>	187-213
Mt. Teape Summit and gulches	24 Nov 2003	22.46205°S 151.36633°W	<i>Cyclophyllum barbatum</i>	163
Teararoa sea cliff and cave area, plants sampled on sea cliffs; puddles formed by dripping stalactites	25 Nov 2003	22.51294°S 151.33090°W	<i>Pemphis acidula</i> , <i>Myoporium sp.</i> , <i>Heliotropium anomalum</i> , <i>Capparis cordifolia</i> , <i>Schleinitzia insularum</i> , <i>Hedyotis foetida</i> , algae	0-15
Pupuhi village	25 Nov 2003	22.51064°S 151.34766°W	Taro fields and associated stream, <i>Ludwigia</i>	11-25
Mt. Taatioe summit gulches	26 Nov 2003	22.46316°S 151.35962°W	<i>Xylosma suaveolens</i> canopy fog	315
Mt. Taatioe summit gulches	26 Nov 2003	22.46357°S 151.36273°W	Ferns, <i>Pipturus argenteus</i> , small seep, <i>Metrosideros collina</i> canopy/moss fog (good <i>Cyrtandra elisabethae</i> valley sampled also 18 Nov 2004)	251-271
Behind Moerai town, start near large watertanks	27 Nov 2003	22.45041°S 151.35210°W	Puputa Stream & cascade, same area sampled on 23 Nov 2004, yellow pan traps	82



Summit area of Mt. Tonarutu, Tubuai



Canopy fogging *Metrosideros* forest at Mt. Tavaetu, Tubuai

to these areas. On the other hand, steep-sloped gullies containing patches of remnant native upland forests were remarkably rare on Rurutu, while Tubuai was found to contain some surprisingly good patches of remnant *Metrosideros collina* forests in these gullies. Although sampling time was limited on Tubuai, the situation of significant native forest patches being found in the gullies was similar to that of Raivavae (Englund 2003) except that the island of Tubuai appears to have more native forest habitat remaining in the gulches than either Raivavae or Rurutu.

METHODS

Sampling concentrated in two major areas: freshwater habitats and remnant native forest habitats. Observations and collections of insects were conducted when native or introduced species of interest were encountered. Although these surveys were primarily concerned with the collection of terrestrial arthropods in remnant native forest areas and aquatic insects, representative vouchers of freshwater fish, crustaceans, and mollusks were collected on Tubuai and Rurutu. Identified specimens and newly described species from this biodiversity assessment will be returned to the insect collection at Paea (Laboratoire d'Entomologie médicale, Institut Louis Malardé) on Tahiti, with other specimens divided between the Bishop Museum in Honolulu, Hawaii, the Museum National d'Histoire Naturelle in Paris, and the Smithsonian Institution in Washington, D.C. as identification and description of new species permits.

Aquatic Insects

Aquatic insect sampling methodology followed Englund (2001) and Englund and Polhemus (2001). Yellow pan traps, aerial nets, dip nets, selective fogging of aquatic habitats with pyrethrins, and benthic kick samples were used to collect larval and mature stages of aquatic insects. Benthic sampling was conducted at aquatic sampling stations by holding an aquatic dip net while disturbing the rock substrate upstream of the net. Immature aquatic insects were also collected from rocks found in riffles by using a toothbrush and fine-point tweezers to extricate larvae from algae covering the rocks and into a yellow pan. Visual observations for aquatic insects, especially of larger taxa such as Odonata (dragonflies and damselflies) were also conducted during hiking along the streambed and in terrestrial habitats as well. Sampling effort was focused on habitat suitable for native aquatic insects such as splash zones around riffles and cascades, wet rock faces associated with springs and seeps, waterfalls, and also wetland areas near and along the stream corridor. General collecting was conducted in prime native aquatic insect habitats with numerous aerial net sweeps taken around riffle splash-zones, cascades, seeps, and waterfall areas.

The sampling of damselflies and dragonflies (Odonata) was emphasized as part of an assessment of the evolution and biogeography of Odonata in the Pacific Islands, and particularly to investigate similarities or differences between the faunas of Hawaii and French Polynesia. To preserve color patterns crucial in

identifying and describing new species of Odonata, photographs were taken of the endemic Odonata fauna found on each island. All insect specimens were stored in 95% ethanol and subsequently transported to the Bishop Museum collection for curation and identification. All insect voucher specimens are currently housed at the Bishop Museum; specimens are in the process of being sorted and loaned to taxonomic experts that will describe new species collected. Odonata from this survey, and previous surveys of the Marquesas and Society Islands (Polhemus et al. 1999) are in the process of being described by R. Englund, D. Polhemus of the Smithsonian Institution and S. Jordan, Bucknell University.

Terrestrial Insects

Canopy fogging using small, hand-held pyrethrin foggers was one of the most effective methods to capture insects. Fogging was especially effective for the rich and mostly undescribed insect fauna found deeply embedded in thick mossy tree habitats in upper elevation areas. Insects are killed or stunned on contact with the fog and fall into a white collecting sheet suspended beneath the tree. Attempts were made to fog in areas of native forest where wind disturbance was minimal, and individual trees were sampled randomly within the forest. Other methods used included hand collections, sweeping and beating vegetation with insect nets, and directly aspirating insects on vegetation into a collecting jar. Emphasis was also placed on sampling native insects associated with endemic and very rare native plants; host plant identifications are certain because these surveys were conducted in coordination with field botanical surveys.

Freshwater Fish, Crustaceans, and Mollusks

One of the primary objectives of this study was to assess whether aquatic organisms have been introduced into Tubuai and Rurutu. Thus, limited collections of freshwater fish, crustaceans, and mollusks undertaken. Collections of native freshwater fish were not the primary objective of this biodiversity assessment, but were conducted to assess the status of native and introduced species, and to provide voucher specimens for future researchers. Observations of alien fish species were made whenever possible, especially the widespread poeciliid and tilapia species that have caused so much damage in Hawaii (Englund 1999) and elsewhere. Aquatic dip nets and small hand-held seines were the primary collection methods of the aquatic macrofauna, and were effective in collecting most species with a few exceptions. Rotenone was not used for collecting fish on Tubuai or Rurutu.

RESULTS AND DISCUSSION

Significant findings of these surveys include a pristine native freshwater fauna lacking introductions of nonindigenous fish, amphibians, or aquatic reptiles on Rurutu, but two harmful invasive fish species were widespread on Tubuai which was similar to the findings of Keith et al. (2002). Collections on Tubuai were

also hindered by turbid waters resulting from heavy rains, thus few freshwater fish were collected here, but observations were made of introduced fish species whenever they could be found.

Numerous undescribed and several described aquatic insect species were found on both Rurutu and Tubuai, including new species and range extensions of Heteroptera (true bugs), Diptera (aquatic flies), and Odonata (dragonflies and damselflies), and Coleoptera (beetles). A rich terrestrial native insect fauna with numerous undescribed species of Coleoptera (beetles), Diptera (flies), and Heteroptera (true bugs), and was also found on Rurutu and Tubuai, although stands of native forest habitat for these insects were found to be severely reduced on both islands, and especially on Rurutu. Psylloidea, Hemiptera and their habitats are not discussed in this report as Diana Percy of the University of British Columbia collected and identified these species during this expedition.

The native species found on both islands are important on a worldwide basis, and preservation of this biodiversity is critical in preserving the rich Polynesian culture found on these islands. It is also necessary to preserve biodiversity to allow a greater understanding of the natural biological processes of dispersal and colonization of the fauna to these remote and isolated island areas. The following sections provide a summary of important findings of the terrestrial and freshwater surveys of Tubuai and Rurutu Islands, and should be considered preliminary as new species descriptions and identifications by taxonomic experts are currently ongoing.

Freshwater Findings–Tubuai

In areas of low elevation, Tubuai streams flowed over fine organic substrate in areas heavily shaded by *Hibiscus tiliaceus* and had small amounts of larger gravel or cobble substrate, and generally flowed through soil or masses of rootwads. Tubuai was apparently the only Austral Island currently having introduced freshwater fish species. Further sampling time is required on Tubuai to make any definitive conclusions on the impacts of these aliens. However, they were found in all aquatic habitats with only one exception, at the large cascade below the Mt. Panee summit containing the highest elevation area with flowing water (sampled 14 Nov 2003). This cascade flowed into a series of stair-step pools and chutes that were too steep and high gradient for introduced fish to access, and this area is a potential refuge area for native species that could be negatively impacted by introduced fish, such as endemic damselflies.

Freshwater species found on Tubuai during this expedition are shown in Table 3, and the presence of two nonindigenous fish species reflects the findings of Keith et al. (2002). Guppies (*Poecilia reticulata*) were widely distributed in apparently all lowland aquatic habitats and also were found in the two large Marais complexes on the western end of the island. Although not observed in the Marais because of time constraints, it is almost certain that tilapia inhabit open water sections of the marsh as they were common in

lower reaches where streams entered the ocean. Often promoted by international development agencies as an aquacultural food source, tilapia are one of the most harmful introduced fish species in the world. Tilapia have even become a pest in taro fields because they will eat the taro corms after they have consumed all the invertebrate and algal material in a taro field. Tilapia will also negatively impact the waterbirds such as the endangered Gray Duck or Canard à sourcils (*Anas superciliosa*) by reducing or entirely eliminating food required for these birds from taro wetland areas (Englund and Eldredge 2001). The further spread of noxious tilapia to other French Polynesian islands should be strongly discouraged.

Although generally uncommon and missing from many islands in French Polynesia, one species of aquatic Coleoptera (beetles), *Rhantus* new sp. near *scheneri* was found at Tamatoa Stream in the lower elevation still-water *Hibiscus* areas. Aquatic insects in the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) orders were not found on Tubuai or Rurutu. A meager benthic aquatic insect fauna was observed in what little substrate that was found on Tubuai streams. Most aquatic Diptera were collected on waterfall and seep habitats and water skating long-legged flies in Dolichopodidae family appeared to be absent from Tubuai aquatic habitats, though more collections in the upper elevation drainages are needed to verify this. Also missing from Tubuai and Rurutu were large freshwater neritid snails, although these taxa are found in the Societies, Marquesas, and Hawaii. Other aquatic findings of significant biogeographic interest on Tubuai were the collection and first record from the Austral Islands of two species of aquatic (non-biting) flies in the family Ephydriidae. These flies are of great interest as they are mainly marine species that have in some Pacific island areas penetrated into freshwater, and in Hawai'i they have undergone a tremendous radiation with 22 species found in a wide variety of freshwater habitats (Nishida 2002).

Aquatic Heteroptera. Aquatic and terrestrial Saldidae were not observed during the brief sampling time on Tubuai, but are common on a number of Polynesian islands such as Hawaii, the Marquesas, and the Society Islands of Tahiti, Moorea, and Raiatea. Permanent madicolous habitats (water flowing in a thin sheen over vertical water surfaces) and waterfall habitat appears to be relatively uncommon on Tubuai, but a small amount was found in the inner core island area as mentioned earlier. The only aquatic Heteroptera captured during this expedition was *Microvelia* nr. *prompta* which were common in still water taro wetland habitats. The Tubuai species appears to have a close affinity to the Society Islands *Microvelia prompta*, and further work is required to determine if this species and the Rurutu *Microvelia* are separate taxa.

Odonata (Dragonflies and Damselflies). There is no scientific literature available regarding the Odonata of Tubuai, and it appears they have never been sampled prior to this expedition. It is most unfortunate that Odonata were not sampled prior to the introduction of the invasive guppies and tilapia to Tubuai. Tubuai has the dubious distinction of being the only island with flowing water in French Polynesia sampled since 1999 to not have an endemic damselfly found in flowing stream areas. Further sampling is clearly warranted here and initial observations indicate that an endemic upland damselfly could potentially be

found in the Mt. Panee summit cascade area because this section of stream is lacking invasive fish species. It is quite possible that invasive fish species have eliminated the native damselfly from low-elevation stream areas as none were observed during sampling. In contrast, endemic native stream damselflies have recently been collected throughout areas of French Polynesia lacking these alien fish species in low elevations on Raivavae (3-4 m above sea level), and at elevations just above sea level in the Marquesas (Polhemus et al. 1999) and in Hawai'i (Englund and Arakaki 2003). Other Odonata that appear to be more resistant to alien fish species on Tubuai include widespread native species such as one common species of native damselfly, *Ischnura aurora*, found in taro patches and wetland areas, and five species of dragonflies (Table 3). The one dragonfly not collected but closely observed several times was a very large dark blue aeschnid seen flying along potato field ditches in the Tamatoa area. This species appears to be the same one recently collected from cattle ponds in Nuku Hiva, Marquesas (Englund unpub. data).



Rurutu: *Ischnura* new species adult (left) and larva (right), Puputa Stream



Tubuai: *Scatella* sp. 1, Tamatoa Stream



Rurutu: Tipulidae from Puputa Stream

Table 3. Preliminary results of Pacific Biological Survey, Bishop Museum aquatic surveys conducted in Tubuai in November 2003.

Taxon	Comments/Notes	Austral Island Status
Pisces (Fish)		
<i>Eleotris fusca</i>	Common	Indigenous
<i>Anguilla</i> spp.	Common	Indigenous
<i>Poecilia reticulata</i>	Common in Marais Mihiura, found in streams up to 150 m elev, common in taro fields	Introduced
<i>Oreochromis mossambicus</i>	Common in brackish-water lowland areas (identifications not yet complete)	Introduced
Crustacea		
<i>Atyoida pilipes</i>	Abundant at Mt. Panee summit cascade area	Indigenous
<i>Caridina</i> spp.	Common, Tamatoa Stream	
<i>Macrobrachium lar</i>	Common	Indigenous
<i>Macrobrachium</i> spp.	Common	Indigenous
Mollusca		
Thiaridae		
<i>Melanoides tuberculata</i>	Common in taro fields	Introduced
Hydrobiidae		
	Abundant at Mt. Panee summit cascade area	Indigenous
Lymnaeidae sp.		
	Tamatoa Stream	Indigenous?
Physidae		
<i>Physa acuta</i>	Common at Tamatoa Stream	Introduced
Insecta		
Zygotera (Dragonflies)		
Aeschnidae		
<i>Anaciaeschna jaspidea</i>	Large swarm of 50 observed nr. Pension	Indigenous
<i>Anax</i> prob. <i>guttatus</i>	Observed but not collected very large <i>Anax</i> at Tamatoa Stream	Indigenous
Libellulidae		
<i>Diplacodes bipunctata</i>	Common in taro fields	Indigenous
<i>Pantala flavescens</i>	Common in taro fields and ridge tops	Indigenous
<i>Tholymis tillarga</i>	Common in low elevation stream areas nr the ocean	Indigenous
Anisoptera (Damselflies)		
Coenagrionidae		
<i>Ichnura aurora</i>	Common in taro fields	Indigenous
Heteroptera (Bugs)		
Veliidae		
<i>Microvelia</i> sp.	Common in taro fields	Indigenous
Coleoptera (Beetles)		
<i>Rhantus</i> new sp. nr. <i>scheneri</i>	Tamatoa Stream, guppies here as well	Endemic
Diptera (Flies)		
Ephydriidae		
<i>Scatella</i> sp. 1	Abundant at Mt. Panee summit cascade area	Endemic
<i>Zeros</i> nr. <i>defectus</i>	Tamatoa Stream	Endemic

Freshwater Findings–Rurutu

Aquatic habitats sampled on Rurutu ranged from the Peva Iti wetland near the ocean, most of the major taro growing areas, to Puputa Stream above the diversion for the town of Moerai, which is the largest stream on the island. High elevation gulches up to 388 m were also sampled for terrestrial insects and observations were made for aquatic insects, and although these gulches were moist and contained some rainwater puddles these upper elevation gulches (e.g., Mt. Taatioe) were not found to contain permanent springs.

Because of their highly porous limestone nature, *makatea* areas did not contain areas of permanent water or even ephemeral rain puddles. As ample time was available on Rurutu sampling was thorough and especially prime habitats were sampled for aquatic biota at least two times. Aquatic biota collections in Rurutu somewhat contradicted findings by Craig (2003) that stated “The lowest diversity known for [French Polynesia] running water invertebrates is on Rurutu. Absolutely nothing other than nymphs of dragonflies, damselflies, and black fly larvae were collected there in 2000.” A preliminary examination of aquatic collections from Rurutu during this trip (Table 4) indicated several new native aquatic insect species were found, including at least three species non-biting freshwater ephydrid flies, two species of crane flies (Tipulidae), and two species of non-biting midges (Ceratopogonidae) and several species of native crustaceans. Further analysis of the extensive collections made in freshwater habitats will undoubtedly reveal more aquatic insect taxa than in the preliminary list shown in Table 4. Similar to the observations of Craig (2003) black fly larvae densely covered every leaf and rock face in cascade and other high-velocity stream areas in Rurutu, especially in areas above diversions.

Aquatic Heteroptera. It is apparent from extensive sampling of wetted rock surfaces, stream areas and forested areas of Rurutu that aquatic and terrestrial Saldidae were absent. It is probable that because aquatic saldids were not found that terrestrial species were also very likely absent as too little native forest likely remains to support terrestrial species even if they had been formerly present. Numerous cascades with madicolous flow and very large wetted rock faces were examined and fogged for saldids, and none were observed. One species of *Microvelia* was collected and was very common in taro patches and likely has affinities to the Tahiti and Tubuai members of this clade.

Odonata. With the exception of a description of damselfly species from Rapa by Lieftinck (1966), nothing has been published on the Odonata of the Austral Islands. One undescribed species of damselfly was moderately abundant and found above the diversion of Puputa Stream above the town of Moerai. This apparent *Ischnura* species was the third large endemic damselfly species found in the Austral Islands and indicates this genus has quite amazing dispersal abilities by finding even small, isolated islands such as Rurutu (32.3 km²) and Raivavae (16.7 km²).

Water temperature was measured at 20.5 °C in Puputa Stream, and the stream was moderately to heavily shaded with *Hibiscus tiliaceus*. While a few *Ischnura aurora* damselflies were observed along the margins of the small, open diversion pond area, none were observed above the diversion in the shaded and free-flowing stream area. However, the undescribed *Ischnura* damselfly species was found above the diversion, and females were observed ovipositing on a 2 m high sloping cascade in a sunny open area of the forest. Most males were collected midstream patrolling the stream corridor on or very near riffles. Not all

Table 4. Preliminary results of Pacific Biological Survey, Bishop Museum aquatic surveys conducted in Rurutu in November 2003.

Taxon	Comments	Austral Island Status
Pisces (Fish)		
<i>Anguilla marmota</i>	Common	Indigenous
<i>Awaous ocellaris</i>	Uncommon in Vaipurua stream above Moerai Town	Endemic
<i>Stenogobius randalli</i>	Uncommon, few individuals only at Moerai Town stream	Endemic
<i>Stiphodon elegans</i>	Common in lower reaches of Puputa and Vaipurua Stream	Endemic
<i>Sicyopterus lagocephalus</i>	Puputa Stream near ocean	Endemic
<i>Eleotris fusca</i>	Common	Indigenous
<i>Kuhlia marginata</i>	Common	Indigenous
<i>Mugil cephalus</i>	Common	Indigenous
Crustacea		
<i>Atyoida pilipes</i>	Common, Puputa Stream above the diversion	Indigenous
<i>Caridina</i> spp.	Common, Puputa Stream above the diversion	Indigenous
<i>Macrobrachium lar</i>	Common in Puputa Stream	Indigenous
<i>Macrobrachium</i> spp.	Common	Indigenous
Mollusca		
Ancylidae		
<i>Ferrissia sharpi</i>	Small streamlet above village of Avera, Puputa cascade	Introduced
Hydrobiidae		
	Puputa cascade	Endemic
Thiaridae		
<i>Melanoides tuberculata</i>	Common in taro fields	Introduced
Insecta		
Zygotera (Dragonflies)		
Aeschnidae		
<i>Anaciaeschna jaspidea</i>	Common at Le Manotel	Indigenous
Libellulidae		
<i>Diplacodes bipunctata</i>	Common in taro fields	Indigenous
<i>Pantala flavescens</i>	Common everywhere	Indigenous
<i>Tholymis tillarga</i>	Uncommon, Peva Iti wetland only	Indigenous
Anisoptera (Damselflies)		
Coenagrionidae		
<i>Ischnura aurora</i>	Common in taro fields	Indigenous
<i>Ischnura</i> new species	Moderately common at Puputa Stream, above the diversion	Endemic
Heteroptera (Bugs)		
Veliidae		
<i>Microvelia</i> sp.	Common in taro fields	Indigenous
Diptera (Flies)		
Ceratopogonidae		
<i>Dasyhelea</i> sp. 1	Small streamlet by road above Avera, 20 Nov 2003	Indigenous
<i>Dasyhelea</i> sp. 2	Small streamlet by road above Avera, 20 Nov 2003	Indigenous
Ephydriidae		
<i>Scatella</i> sp. A	Puputa Stream above the diversion	Endemic
<i>Scatella</i> nr. <i>sexpunctata</i>	Small streamlet by road above Avera, 20 Nov 2003	Endemic
<i>Zeros</i> sp. A	Peva Iti Wetland, 17 Nov 2003	Endemic
Simuliidae		
<i>Inselliellum rurutuense</i>	Dominant aquatic insect in flowing water	Endemic
Limoniidae		
Limoniidae sp. 1 (clear wing)	Common, Puputa Stream above the diversion	Endemic
Limoniidae sp. 2 (spotty wing)	Mt. Taatioe Summit gulch, near wet area, 26 Nov 2003	Endemic

males patrolled the stream corridor horizontally and many had the disconcerting habit, as do most endemic stream damselfly species in French Polynesia, of rising straight up into the thick *Hibiscus* and out of reach

to be collected. These damselflies were rarely observed in full sun in the open cascade area, but were instead captured near sunny spots adjacent to areas that were heavily shaded by *Hibiscus*. Several of these damselflies were captured adjacent to the shady base of the large and open Puputa cascade (20 m) where several series of smaller cascades flowed through the *Hibiscus*. However, at least 3-4 damselfly larvae were collected on the face of the Puputa cascade, and an additional 6 larvae were collected in fast-flowing, shaded riffle areas below this open cascade during benthic sampling. Larvae were collected in the fastest parts of riffles, however adults did not seem to favor areas of full sun and hence were difficult to capture in the shaded regions of the stream. Extensive research in Hawai'i has shown the devastating impacts of alien fish species on the native stream fauna (Englund 1999, Englund and Eldredge, 2001), particularly Odonata, and every effort should be made to avoid introductions of any non-native aquatic species to Rurutu.

Terrestrial Insect Sampling

Because botanists familiar with the local flora were on this expedition it was possible to obtain excellent plant-insect host association data. Rare plants such as *Cyrtandra elizabethae* and others such as *Homalium* sp. on Rurutu or *Dodonea viscosa* on Tubuai were sampled when possible for terrestrial insects, with often negative results, except in the spectacular case of *Cyrtandra* on Rurutu. The lack of insects on many rare plants is likely a result of there being too few individuals remaining on each island to support an associated endemic insect fauna. Insect collections made during this expedition in native forest areas will provide an important baseline for future researchers. While it will take many years to fully assess terrestrial insect collections made during this expedition, it is possible to summarize some of the exciting preliminary findings. Many new insect species and new island records were found during this expedition and these insects are either in the process of being sorted or have been sent to taxonomic various experts. Preliminary terrestrial insect findings are shown in Table 5.

Tubuai Terrestrial Insects. Although sampling time was limited, native forest areas of Tubuai were found to harbor a diverse terrestrial insect fauna, with some significant new and undescribed species being collected during this expedition. One of the most spectacular findings of this expedition was two new species of large emesine reduviids or assassin bugs (see Appendix for photos). These species appear to be able to tolerate quite small patches of native habitat as some were found in remnant patches of native *Metrosideros collina* forest, as small as 25 x 30 m. For example, both of these reduviids and numerous species of native beetles (i.e. Buprestidae, *Proterhinus*) were collected while fogging a 75 x 75 m patch of *Metrosideros* with *Xylosma* in the upper areas of Mt. Taitaa on 14 Nov 2003. The two new reduviid species were also collected while sweeping ferns and moss in this same patch. Strawberry guava is steadily encroaching into this small patch of native forest.

Other high elevation areas sampled with good results included the Mt. Tonarutu/Mt. Tavaetu summit area sampled on 11 Nov 2003. This area in southwestern Tubuai contained some excellent *Metrosideros* patches in gullies just below the summit. A new species of carabid beetle in the genus *Metacolpodes* was collected here (see Appendix for photo); these endemic beetles are top insect predators in a forest ecosystem and vulnerable to invasive ant species (Liebherr and Zimmerman 2000) and as such they are good indicator species of a healthy ecosystem. Two carabid species are native to Tahiti, and this species appears to have an affinity for the Tahiti species (J. Liebherr, pers. comm.). This is the first record of carabid beetles from the Austral Islands, and these individuals will be included in a comprehensive review of Pacific carabids currently being conducted at Cornell University by James Liebherr. Emesine reduviids were also collected in this same area, as was a new pentatomid species of *Catacanthus* that was a bright metallic-green and orange color (see Appendix for photo).

Several new species of Miridae or leaf bugs were also collected in the native forests of Tubuai with a diverse fauna found in *Metrosideros*, *Xylosma* and other native trees such as *Celtis pacifica*, and will be described by Dan Polhemus of the Smithsonian Institution. The motus (offshore islets) of Tubuai were sampled for one day, and a diverse native insect fauna was collected from the native vegetation here. Similar to sampling in Raivavae in 2002, native *Chamaesyce fosbergii* found on the motu contained several species of new bug species in the family Miridae. For some reason this plant contains an especially rich and striking insect community and higher densities of a wide variety of lygaeids, mirids, beetles and other insects were found on *Chamaesyce fosbergii* in comparison to other plants sampled on the motus. Additionally, *Lepidium bidentatum* which is another low-growing plant found in close proximity to *Chamaesyce* also had a diverse native insect community. Several species of native beetles were found on *Sophora tomentosa* in the motu areas (see photograph in Appendix), while large groves of *Pisonia* on the motus yielded few, if any, insects of note other than ants. The invasive tropiduchid *Kallitaxila sinica*, which is a small, green insect with clear wings was common both on vegetation in the offshore motus to areas of good *Metrosideros* habitat at the Tubuai summit and was also ubiquitous on Rurutu.

Rurutu Terrestrial Insects. While native upper elevation moist forest habitats are now extremely limited on Rurutu to several small gulches below a few summit areas such as Mt. Taatioe, a somewhat more extensive native *makatea* forest community remains. These forest patches continue to exist because they are in areas too steep for grazing cattle to access, and the gulches are apparently moist enough to protect them from the regular burning that occurs in the high pasturelands. The high quality upper elevation gulch native forest areas were estimated to comprise an area of less than 2-3 ha in size. However, invasive plant species threaten to overrun these few remaining patches of intact native forest. In contrast to the upper areas of Tubuai, which contain greater amounts of remnant native forest, little native vegetation and their concurrent native arthropod population remains in the gulches below the open pasture land of the highest areas of inner Rurutu. Nonetheless, what does remain still supports an important arthropod fauna such as a

new species of emesine reduviid found only during sampling of *Metrosideros* at the Mt. Teape/Rua o Hina summit area, making Rurutu the third Austral island with endemic reduviids.

Native plants containing notable native insect communities included a small stand of *Pipturus argenteus* found in a gully near the Avera outlook on 20 Nov 2003 that contained large numbers of 2 new species of seedbugs and mirids (leaf bugs), and in the *makatea* area *Serianthes rurutensis* was host to an endemic brightly colored yellowish green with red-eyed leaf bug. Several native species of planthoppers (see photos in Appendix) in the family Issidae were collected on a variety of host plants on Rurutu, with these species associated with plants such as *Cyrtandra elizabethae*, *Guetardia speciosa* and *Pemphis acidula*, and *Xylosma suaveolens*. The remnant native forests of Rurutu contain a remarkable diversity of insects, with three Miridae genera and two species of Lygaeidae found on single *Metrosideros* tree on Mt. Taatioe.

A bright green issid planthopper associated only with the endangered plant *Cyrtandra elizabethae* was one of the most impressive findings of this survey, and appears to be a key indicator species for native forests. This planthopper was restricted to *Cyrtandra* and was found only in one gully below the Mt. Taatioe summit between 250-301 m elevation at 22.46360° S, 151.36267° W. This habitat patch was relatively small and was called the “magic *Cyrtandra* valley” by expedition members, and started at a cliff face with a southwestern summit exposure. The estimated size of the best habitat was 100 x 25 m, but *Cyrtandra* was found from 250-300 m in elevation below the summit of Mt. Taatioe. The “magic *Cyrtandra* valley” had a slight trickle or spring flow with seeps in the streambed and *Pipturus argenteus* indicated that it was a relatively moist area, in contrast to the other nearby and drier valleys below the Mt. Taatioe summit.

Of interest is that other nearby gulches on the slopes of Mt. Taatioe summit area were sampled for the new green *Cyrtandra* issid planthopper without success. This included another valley just two gulches and only a few hundred meters away from the “magic *Cyrtandra* valley” (at 22.46316° S, 151.35962° W) where the green planthopper was not found on *Cyrtandra*. This small gulch area was estimated to be only 50 x 70 m and contained a small patch of *Xylosma suaveolens* and other native forest plants such as *Cyrtandra*, but appeared to be drier and smaller compared to the “magic *Cyrtandra* valley” containing the green planthopper. Another small valley below the summit of Mt. Teape/Rua o Hina on 24 Nov 2003 also contained *Cyrtandra*, but the green planthopper was not collected here perhaps because it was slightly drier or there were not enough *Cyrtandra* plants to support a planthopper population.

New Coleotichus species. One of the most important findings of the 2003 expedition was the collection of a new species of large native scutellerid *Coleotichus* bug from *Dodonea viscosa* in a *makatea* forest on Plateau Paparai. Other plant species mixed in with *Dodonea viscosa* on the summit of Plateau Paparai were strawberry guava, *Miscanthus* grass, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Serianthes rurutensis*, *Tarenna sambucina* and assorted ferns. Species in the genus *Coleotichus* are of great biogeographic interest because

of their excellent dispersal capabilities. Closely related species have been found on similar host plants in Fiji, Tahiti, the Marquesas, and Hawai'i. In Hawai'i this species is found both on *Dodonea viscosa* and *Acacia koa* and is known as the *koa* bug. This marks the only second record of this genus from the Austral Islands, with a single immature *Coleotichus* found on *Myoporum* in Raivavae in 2002 (Englund 2003). Perhaps the new Rurutu *Coleotichus* has a relatively robust population because large stands of *Dodonea viscosa* that exist on Rurutu are lacking from the other Austral Islands, as only very low numbers (one individual) of one other species have been found in this archipelago. On 22 Nov 2003 in *makatea* of Plateau Papanai the *Coleotichus* new sp. was collected mainly on the flowering/seed portion of *Dodonea* plant, but only after 30-45 minutes of sampling plants that were not in flower. Specimens were more easily collected from *Dodonea* plants in flower or that contained seed pods that were red and near maturity. Once the bugs preference for the seed pod area of the *Dodonea* plant was determined up to three mature adult bugs were collected with one net sweep.

Rurutu: *Coleotichus* new species from *Dodonea*



The *Coleotichus* new species was collected in a narrow elevational range of between 70-80 m, likely because feral ungulates are largely discouraged from gaining access to the upper plateau area by the sharp *makatea* limestone formation and the *Dodonea* maintained healthy stands in this area. The Plateau Papanai area contained one of the largest stands of *Dodonea* in the Austral Islands by far (J. Florence, pers. comm.), and also one of the most intact *Dodonea* shrublands in French Polynesia (J.Y. Meyer, pers. comm.). The size of the mixed *Dodonea* shrubland was estimated by J. Florence (pers. comm.) to range from 6-8 ha, with the larger and healthier fruiting plants found on the steep and shaded sides than at the dryer and flatter *makatea* plateau summit. Other much smaller patches such as the *Dodonea* plants sampled near the summit of Mt. Taatioe on 18 Nov 2003



Rurutu: *Oechalia* new species from *Amphineuron* fern,



Rurutu: Sampling *Cyrtandra elisabethae* for issid planthoppers



Rurutu: Plateau Papanai *makatea* area where large *Dodonea* stand was found

Table 5. Preliminary list of notable insect species collected during terrestrial sampling in Tubuai and Rurutu, Austral Islands, from November 2003.

Taxon	Comments/Notes	Austral Island Status
Coleoptera		
Aglycyderidae		
<i>Proterhinus fimbriatus</i>	Rurutu: 26 Nov 2003 Mt. Taatioe summit, <i>Metrosideros</i> fog, 271 m	Indigenous
<i>Proterhinus</i> new sp. 1	Tubuai: 14 Nov 2003, Mt. Taitaa, <i>Metrosideros</i> fog, 371 m	Endemic
Anobiidae		
Genus sp. 1	Rurutu: 26 Nov 2003, Mt. Taatioe, <i>Metrosideros</i> fog, 271 m	Endemic
Buprestidae		
<i>Agrilus</i> sp. 1	Tubuai: 14 Nov 2003, Mt. Taitaa, <i>Metrosideros</i> fog, 371 m	Endemic
Carabidae		
<i>Gnathaphanus</i> sp. 1	Tubuai, 10 Nov 2003, beach at Matura, (Australian origin)	Introduction
<i>Metacolpodes</i> new sp. 1	Tubuai, 11 Nov 2003, Mt. Tavaetu, <i>Metrosideros</i> fog, 270 m	Endemic
Cerambycidae		
Lamiinae sp. 1	Tubuai, 11 Nov 2003, Mt. Tonarutu, <i>Xylosma suaveolens</i> , 234 m	Endemic
Lamiinae sp. 2	Rurutu: 18 Nov 2003, Mt. Taatioe, <i>Metrosideros</i> fog, 388 m	Endemic
<i>Oopsis</i> sp. 1	Tubuai: 15 Nov 2003, Motu Tapapatauai, <i>Sophora tomentosa</i> , 0 m	Indigenous
Coccinellidae		
Genus sp. 1	Tubuai: 11 Nov 2003, Mt. Tavaetu, <i>Metrosideros</i> fog	Indigenous?
Curculionidae		
Genus sp. 1 (photo in appendix)	Tubuai: Motu Tapapatauai, <i>Sophora tomentosa</i> , 0 m	Indigenous
<i>Cranopeus</i> sp. 1	Rurutu: 26 Nov 2003, Mt. Taatioe, <i>Metrosideros</i> fog, 271 m	Endemic
<i>Miocalles</i> sp. 1	Tubuai: 11 Nov 2003, Mt. Tavaetu, <i>Metrosideros</i> fog	Endemic
<i>Platysimus insularis</i>	Rurutu: 17 Nov 2003, Pointe Arei, 0 m, <i>Ipomea pes caprae</i>	Introduced
<i>Rhyncogonus nodosus</i>	Tubuai, 13 Nov 2003, 240 m, Tamatoa Valley, ferns; 14 Nov 2003, Mt. Taitaa, <i>Metrosideros</i> fog, 371 m	Endemic
<i>Rhyncogonus longulus</i>	Tubuai, 13 Nov 2003, 240 m, Tamatoa Valley, ferns	Endemic
<i>Rhyncogonus debilis</i>	Rurutu: 18 Nov 2003, 388 m, Mt. Taatioe, <i>Metrosideros</i>	Endemic
<i>Rhyncogonus excavatus</i>	Rurutu: 26 Nov 2003, Mt. Taatioe, <i>Metrosideros</i> fog, 271 m; 18 Nov 2003, 388 m, Mt. Taatioe, <i>Metrosideros</i>	Endemic
<i>Rhyncogonus tenebrosus</i>	Rurutu: 20 Nov 2003, Naairoa makatea, ferns	Endemic
<i>Cylas formicarius</i> (sweet potato weevil)	Rurutu: 17 Nov 2003, Pointe Arei, 0 m, <i>Ipomea pes caprae</i>	Introduced Agricultural Pest
Scarabaeidae		
Ruteliinae sp. 1	Tubuai: 15 Nov 2003, Motu Rautaro, 0 m, <i>Triumfetta procumbens</i>	Indigenous
Hemiptera		
Issidae		
<i>Atylana</i> new sp. 1 (bright green)	Rurutu: 26 Nov 2003, Mt. Taatioe gulch, 271 m, on <i>Cyrtandra elisabethae</i>	Endemic (Endangered)
<i>Atylana</i> sp. 2 (brown)	Rurutu: 22 Nov 2003, Plateau Paparai, 45 m, on <i>Guettardia speciosa</i>	Endemic
<i>Atylana</i> sp. 3 (dark brown)	Rurutu: 25 Nov 2003, Te Araroa sea cliff area on <i>Pemphis</i>	Endemic
<i>Atylana</i> sp. 4 (brown)	Rurutu: 26 Nov 2003, Mt. Taatioe gulch, 315 m, <i>Xylosma</i> fog	Endemic
Tropiduchidae		
<i>Kallitaxila sinica</i> – this species was found on almost every plant species on both islands	Rurutu: 24 Nov 2003, Mt. Teape summit gulch, on <i>Cyclophyllum barbatum</i> Tubuai: 15 Nov 2003, Rautaro Motu, on <i>Lepidium</i>	Introduced- Agricultural Pest
Heteroptera		
Aradidae		
Genus sp. 1	Tubuai: 13 Nov 2004, Upper Tamatoa Valley, 240 m, on <i>Dicranopterus</i>	Introduced?
Lygaeidae		
Genus 1 sp. 1	Rurutu: 18 Nov 2003, Mt. Taatioe, 388 m, <i>Metrosideros</i> /ferns	Endemic
Genus 2 sp. 1	Rurutu: 18 Nov 2003, Mt. Taatioe, 388 m, <i>Metrosideros</i> /ferns	Endemic

Table 5 (continued) Preliminary list of notable insect species collected during terrestrial sampling in Tubuai and Rurutu, Austral Islands, from November 2003.

Taxon	Comments/Notes	Austral Island Status
Miridae		
Genus 1 sp. 1	Tubuai: 14 Nov 2003, Mt. Taitaa, <i>Metrosideros</i> fog, 371 m	Endemic
Genus 2 sp. 1	Tubuai: 13 Nov 2003, Mt. Tamatoa, <i>Celtis pacifica</i> , 240 m	Endemic
Genus 3 sp. 1	Tubuai: 13 Nov 2003, Mt. Tamatoa, <i>Celtis pacifica</i> , 240 m	Endemic
<i>Creontiades</i> sp. 1	Tubuai: 15 Nov 2003, Rautaro Motu, <i>Lepidium</i> , 0 m	Endemic
Mirinae Genus sp. 1	Tubuai 11 Nov 2003, Mt. Tonarutu, <i>Xylosma suaveolens</i> , 234 m	Endemic
<i>Campylomma</i> sp. 1	Rurutu: 20 Nov 2003, Road to Avera, <i>Pipturus</i> , 79 m	Endemic
<i>Taylorilygus</i> sp. 1	Rurutu: 20 Nov 2003, Road to Avera, <i>Pipturus</i> , 79 m	Endemic
Phylinae Genus sp. 1	Rurutu: 22 Nov 2003, Plateau Paparai, <i>Serianthes rurutensis</i> , 60 m	Endemic
Genus 1 nr. <i>Taylorilygus</i> sp.1	Rurutu: 22 Nov 2003, Plateau Paparai, <i>Dodonea</i> , 60 m	Endemic
Genus 2 nr. <i>Taylorilygus</i> sp.1	Rurutu: 22 Nov 2003, Plateau Paparai, <i>Dodonea</i> , 60 m	Endemic
Genus 1 sp. 1	Rurutu: 18 Nov 2003, Mt. Taatioe, 388 m, <i>Metrosideros</i> /ferns	Endemic
Genus 2 sp. 1	Rurutu: 18 Nov 2003, Mt. Taatioe, 388 m, <i>Metrosideros</i> /ferns	Endemic
Genus 3 sp. 1	Rurutu: 18 Nov 2003, Mt. Taatioe, 388 m, <i>Metrosideros</i> /ferns	Endemic
Hyalopepylini sp. 1	Rurutu: 24 Nov 2003, Mt. Teape, <i>Cyclophyllum barbatum</i> , 163 m	Endemic
Nabidae		
<i>Tropiconabis</i> sp. 1	Rurutu: 25 Nov 2003, <i>Ludwigia</i>	Introduced
Pentatomidae		
<i>Catacanthus</i> new sp.	Tubuai: 11 Nov 2003, Mt. Tonarutu, 234 m, on <i>Xylosma</i>	Endemic
<i>Oechalia</i> new sp.	Rurutu: 17 Nov 2003, Plateau Matu, 54 m, on <i>Amphineuron opulentum</i> , D. Percy collection	Endemic
<i>Nezara viridula</i> (southern green stinkbug)	Rurutu: nr. Avera outlook, 20 Nov 2003, 117 m, on ferns	Introduced Agricultural Pest
Reduviidae		
Emesinae new sp. 1	Tubuai: 14 Nov 2003, Mt. Taitaa, 371 m, <i>Metrosideros</i> fog bright yellow-stripe	Endemic
Emesinae new sp. 2	Tubuai: 14 Nov 2003, Mt. Taitaa, 371 m, <i>Metrosideros</i> fog alternating brown/white speckles	Endemic
Emesinae new sp. 3	Rurutu: Mt. Teape/Rua O Hina, 24 Nov 2003, <i>Metrosideros</i> fog, immature, 205 m	Endemic
Rhyparochromidae		
Genus sp. 1	Tubuai: 12 Nov 2003, Piton Pahatu, <i>Metrosideros</i> , 79 m	Endemic
Scutelleridae		
<i>Coleotichus</i> new sp.	Rurutu: Plateau Paparai, 22 Nov 2003, on <i>Dodonea</i>	Endemic
New species- Bright green/orange	Tubuai: 11 Nov 2003, Mt. Tonarutu, 234 m, on <i>Xylosma suaveolens</i>	Endemic
Homoptera		
Cicadellidae		
<i>Sophonia rufofascia</i> (Two-spotted leafhopper)	<u>Rurutu</u> : 18 Nov 2003, 271 m Mt. Taatioe summit, on <i>Metrosideros</i> /ferns, <i>Glychidium</i> , and <i>Dodonea</i> <u>Tubuai</u> : 11 Nov 2003, Mt. Tavaetu, <i>Metrosideros</i> , 270 m <u>Moorea</u> : Upper Oponohu Watershed (D. Percy collection)	Tubuai, Rurutu and Moorea Introduced Agricultural Pest
Phasmatodea		
Phasmatidae		
<i>Graeffea crouanii</i>	Rurutu: 23 Nov 2003, <i>Hibiscus</i> forest north of Avera, 10-20 m, B. Fontaine, coll. Tubuai: 11 Nov 2003, Mt. Tavaetu, 270 m, native forest	Introduced Agricultural Pest

did not yield any specimens of the *Coleotichus* new species. This is because this large bug likely requires an ample-sized stand of its preferred host plant. Thus, conserving this beneficial and attractive native insect will require relatively large patches of its native host plant, not just a remnant patch of a few scattered plants as were found on the slopes of Mt. Taatioe.

Two-Spotted Leafhopper and Southern Green Stinkbug. Collections of the two-spotted leafhopper (*Sophonia rufofascia*) were made on both Rurutu Island and on Moorea which was visited briefly on 9 Nov 2003. In Moorea the two-spotted leafhopper was collected by Diana Percy on *Syzygium malaccense* in the upper Oponohu Valley. This species was widespread on Rurutu, and also on Tubuai. On Rurutu, the two-spotted leafhopper was collected from remnant native forest areas such as the Mt. Taatioe summit area on *Metrosideros*, and was also common on ferns and other native vegetation, and was also found in the upper Mt. Tavaetu region. Originally from China, the two-spotted leafhopper (*Sophonia rufofascia*) is not native to Polynesia, and was first collected in Hawai'i in 1987 (Howarth et al. 2001) and the Society Islands in 1999 (Polhemus 2001). This species is about 4–5 mm long, thin and yellowish colored bug with distinctive eyespots on the tail end, and a long thin brown strip down the middle of the back. It is now found throughout French Polynesia, including the Marquesas, Society Islands, and the Australs from Raivavae to Rurutu. In Hawaii it has been found on all the Hawaiian Islands to 1220 m elevation and in association with more than 250 species of native and alien plants (Howarth et al. 2001). In the Society Islands it has been found on Tahiti to as high as 1280 m on Mt. Marau (Polhemus 2001). Problems caused in Hawai'i include yellowing, death, and dieback in many plants as the bugs suck the sap out of the plants and also transmitting plant diseases. In Hawai'i, two-spotted leafhoppers are a major agricultural pest damaging agricultural crops such as coffee, banana, taro, guava, mango, and macadamia nuts (Howarth et al. 2001). Two-spotted leafhoppers have also caused massive diebacks of the native *uluhe* (*Dicranopteris linearis*) fern in Hawai'i, and impact other native Hawaiian plants (Howarth et al. 2001).

The southern green stinkbug (*Nezara viridula*) was found on Rurutu and it is unknown how long this species has been present, but this is the first capture of this species during the present Austral Island surveys. This species is one of the most serious agricultural pests in Hawai'i, and is currently responsible for yield reductions averaging 10-20% in macadamia crops, and is responsible for US\$6 million dollars in yearly damages to crops in Hawai'i (Wright and Follet, in prep.). The southern green stinkbug is also a wide-ranging pest on other important vegetable and fruit crops. Strict quarantine laws would need to be actively enforced to prevent this highly injurious pest from spreading to other islands in French Polynesia.



Southern green stinkbug (*Nezara viridula*)
Photo by Jo Diez

CONSERVATION IMPLICATIONS

Biodiversity assessments of the Austral Islands, French Polynesia, began in 2002 on Raivavae and Rapa and have uncovered a wealth of insect species new to science, and this continued in 2003 on Tubuai and Rurutu as many new and unexpected insect species have been collected. Comparing insect communities on

the same or similar native plant communities from other islands in French Polynesia will provide further insights into biodiversity and conservation of fragile island ecosystems. The Austral Islands contain small but significant areas of native plant biodiversity, and still contain a diverse native forest insect community that was associated with these native forests. Because of their specialization on native plant species and low population sizes, none of the native endemic forest insects were considered harmful to humans or agricultural crops, and in fact are necessary for native forests to function in a variety of ways such as pollination and nutrient cycling.

To preserve a rich native biodiversity and Polynesian cultural heritage, it is imperative to protect the limited remaining native forests on Tubuai and Rurutu. Working with the inhabitants of each island, forest reserve areas should be set up to protect the most important and biologically diverse areas. The areas that should receive the highest priority for protection include the summit gulch areas of Mt. Taitaa, Mt. Tonarutu, and Mt. Tavaetu on Tubuai. These areas contain significant stands of *Metrosideros collina* and *Xylosoma suaveolens* and other native vegetation that was found to harbor numerous new species of undescribed endemic insects, despite some of these patches being as small as 25 x 25 m in the Mt. Tonarutu area. However, the small size and easy access to some of these areas along a major tourist hiking trail could perhaps allow supervised volunteer tourist hikers to cut down small sections of strawberry guava that would at least slow down the invasion process thereby preserving the patches of vegetation and native insects associated with this vegetation on Tubuai. Further conservation recommendations on Tubuai are at best preliminary because limited sampling time allowed for relatively few areas to be investigated. Little native forest is visible on Tubuai when arriving by plane, but in contrast to these initially low expectations relatively large patches of native forest were in fact found here, and the collection of indicator species such as undescribed carabid beetles, two species of assassin bugs, and other native insects provides evidence of a healthy native insect biodiversity.

Areas that should receive the highest conservation priority on Rurutu include the *makatea* forest at Plateau Paparai as this mixed *Dodonea viscosa* shrubland forest is the largest in size outside of the Marquesas, and harbors unique species of biogeographically important endemic insects. The “magic *Cyrtandra* gully” below the summit of Mt. Taatioe at 22.4630° S, 151.36267° W with the rare *Cyrtandra elisabethae* plants and new species of green planthopper is of world-wide conservation and biogeographic importance and contains the largest patches of remnant native upland forest on Rurutu. This area should be immediately fenced to keep grazing cattle out, and weeding could reduce encroaching invasive plant species. As this area is easily accessible, a community plan of using students to adopt this remnant forest would be feasible. School groups from a science class were observed on several occasions walking in the forest while we conducted biodiversity surveys on Rurutu. If local island science teachers were educated on the importance of these patches of native habitat and students encouraged to monitor the plant and insect species, then the native biodiversity that continues to exist in these extremely fragmented Rurutu habitats would persist. The

lack of action in protecting these forest patches from grazing cattle and other feral ungulates will certainly lead to the demise of native plants on Rurutu and the extinction of the unique insects associated with them.

Puputa Stream, located above the diversion for the town of Moeraï contained important habitats for a species of undescribed damselfly and several species of freshwater fish, crustaceans, snails, and other aquatic insects. Because the stream here is already fully diverted and not likely to be further diverted, it is now most threatened by alien fish introductions to Rurutu in areas upstream of the diversion. Another high quality watershed area that should be preserved by maintaining its status of lacking alien species was the Pupuhi village taro fields and stream that irrigates these taro fields. Alien fish were not found in streams, wetland, or taro field habitats on Rurutu and every effort should be made to educate agricultural inspectors and other government officials on the harm that introduced fish can cause not only to native species but also potentially to taro crops and water birds. A strict prohibition on the importation of any live alien freshwater species into Rurutu should be continued, and any accidental fish introductions should be immediately removed through chemical treatment of the waters.

REFERENCES

- Craig, D. A. 2003. Geomorphology, development of running water habitats, and evolution of black flies on Polynesian islands. *BioScience* 53: 1079-1093.
- Englund, R. A. 1999. The impacts of introduced poeciliid fish and Odonata on endemic Megalagrion (Odonata) damselflies on Oahu Island, Hawaii. *Journal of Insect Conservation* 3: 225-243.
- Englund, R. A. and K. Arakaki. 2003. Report on long-term aquatic insect monitoring by Hawaii Biological Survey, Bishop Museum in Pelekunu Valley, Molokai, Hawaii. Report prepared for TNCH Molokai Office. 10 pp.
- Keith, P., E. Vigneux, and G. Marquet. 2002. Atlas des poissons et des crustacés d'eau douce de Polynésie française. *Patrimoines Naturels* 55: 175 p.
- Lieftinck, M. A. 1966. Some Odonata of Rapa Island, with descriptions of three Polynesian species of Ischnura Charpentier. *Tijdschrift voor Entomologie* 109: 89-102.
- Meyer, J.-Y., Florence, J. and J.-F. Butaud. in prep. Rapport de mission de l'expédition scientifique à Rurutu et Tubuai (Australes) du 10 novembre au 28 novembre 2003. Délégation à la Recherche, Papeete.
- Nishida, G. M. 2002. Hawaiian terrestrial arthropod checklist, 4th Edition (World Wide Web version available at <http://hbs.bishopmuseum.org/hbsdb.html>). Hawaii Biological Survey. *Bishop Museum Technical Report* 22. 313 pp.
- Paulian, R. 1998. *Les insectes de Tahiti*. Paris, Boubée. 331 pp.
- Wright, M.G. and P.A. Follett. In Prep. Long-term patterns and feeding sites of southern green stink bug (*Nezara viridula*) in Hawai'i macadamia orchards.

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2003 Tubuai and Rurutu Expedition Participants, from left: the leg of J. Florence, B. Fontaine, D. Percy, O. Gargominy, J.F. Butaud, J.Y. Meyer, R. Englund

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APPENDIX I – PHOTOGRAPHS OF NATIVE TUBUAI AND RURUTU INSECTS



Tubuai: Emesinae new sp. 1 from *Metrosideros*, Mt. Taitaa



Tubuai: Emesinae new sp. 2 from *Metrosideros*, Mt. Taitaa



Tubuai: *Catacanthus* new sp. 1 from *Xylosma*, Mt. Tonarutu



Tubuai: Rhyparochromidae Gen sp. 1 from *Metrosideros*, Piton Pahatu



Tubuai: Miridae new sp. 1 from *Lepidium*, Motu Rautaro



Tubuai: *Rhyncogonus longulus* from ferns, upper Tamatoa Valley, 240 m



Tubuai: Curculionidae from *Sophora tomentosa*, Motu Tapapatauai



Tubuai: *Metacolpodes* new sp. Mt. Tavaetu, *Metrosideros*



Rurutu: Miridae new sp. from *Metrosideros*, Mt. Taatioe



Rurutu: Psylloidea, Hemiptera from *Serianthes rurutensis*



Rurutu: *Rhyncogonus debilis*



Rurutu: *Rhyncogonus excavatus*



Rurutu: *Atylana* new sp. 1 from *Cyrtandra elisabethae*, Mt. Taatioe



Rurutu: *Atylana* sp. 2 from *Guettardia speciosa*, Plateau Paparai



Rurutu: *Atylana* sp. 4 from *Xylosma suaveolens*, Mt. Taatioe



Rurutu: *Delphacidae* sp. 1 (immature) from *Pemphis*, Te Araroa sea cliffs



Rurutu: Miridae new sp. from *Serianthes rurutensis*



Rurutu: Miridae new sp. from *Pipturus argenteus*