

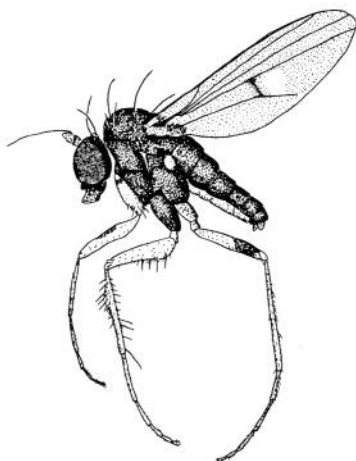
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RECORDS OF THE
HAWAII BIOLOGICAL SURVEY
FOR 1995
PART 1: ARTICLES

NEAL L. EVENHUIS
AND
SCOTT E. MILLER, EDITORS



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Cover illustration: *Campsicnemus halonae* Evenhuis, a new species of Dolichopodidae from the Waianae Range of Oahu, Hawaii.

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**RECORDS OF THE
HAWAII BIOLOGICAL SURVEY
FOR 1995
Part 1: Articles**

Editors' Preface

The Hawaii Biological Survey, established by the Hawaii State Legislature in 1992 as a program of the Bishop Museum, is an ongoing natural history inventory of the Hawaiian Archipelago. It was created to locate, identify, and evaluate all native and nonnative species of flora and fauna within the State and maintain the reference collections of that flora and fauna for a wide range of uses. In coordination with related activities in other federal, state, and private agencies, the Hawaii Biological Survey gathers, analyzes, and disseminates biological information necessary for the wise stewardship of Hawaii's biological resources.

This is the second annual compilation of *Records of the Hawaii Biological Survey* to be published within the *Bishop Museum Occasional Papers*. Each year, the Bishop Museum publishes the *Records of the Hawaii Biological Survey*, which provides a medium for dissemination of short notes and records of range extensions, first state or islands-records, or other pertinent information on the biota of the Hawaiian Islands. The *Records* provide a venue to collect and publish significant new data on Hawaiian organisms that might otherwise not be published in any standardized, retrievable and citable manner. In addition to these shorter notes, this first volume of the *Records* for 1995 includes some longer papers, which contain information essential to the Hawaii Biological Survey and substantially augment our current knowledge of the status of our State's biota.

Some of the highlights of *Records of the Hawaii Biological Survey for 1995* include: an essay by Edward O. Wilson on the importance of ants, all of which are nonindigenous, in Hawaiian ecosystems; an update to the numbers of species known from Hawaii, emphasizing parasitic protozoans and helminths; the historical distribution and status of the rare endemic orangeblack Hawaiian damselfly, *Megalagrion xanthomelas*; the first record of the endemic land snail subfamily Achatinellinae from Kauai; and many papers expanding knowledge of nonindigenous species. Through recent surveys and improved curation of older specimens, many new records of plants and invertebrates are presented for Kahoolawe, Lanai, and Molokai.

Many of the products of Hawaii Biological Survey, including many of the databases supporting papers published here, are now available on our Internet World Wide Web and gopher servers. Products currently available include specimen databases [type specimens in entomology, botany (including algae and fungi), and vertebrate zoology (over 40,000 specimens from around the world), as well as samples of Hawaiian non-type specimens of insects and fish], bibliographic databases (vascular plants and entomology), taxonom-

ic authority files (species checklists for terrestrial arthropods, flowering plants, and vertebrates), detailed information and images (featuring the endemic damselfly genus *Megalagrion*), and staff and publications lists. The Internet addresses are:

World Wide Web:

<http://www.bishop.hawaii.org/bishop/HBS/hbs1.html>

gopher:

<gopher.bishop.hawaii.org>: 70

The *Records of the Hawaii Biological Survey for 1995* were compiled with the assistance of Allen Allison (vertebrate zoology), Walter Appleby (botany), Robert Cowie (malacology), Lucius Eldredge (invertebrate zoology, marine zoology), and Gordon Nishida (entomology), who acted as editors for papers in their disciplines and was partially supported by a grant from the John D. and Catherine T. MacArthur Foundation. Some of the work reported here has also been supported by National Biological Service, National Science Foundation, U.S. Fish and Wildlife Service, U.S. Department of Defense, and Hawaii Department of Land and Natural Resources.

We encourage authors with new information concerning flora or fauna occurring in the Hawaiian Islands to submit their data to us for consideration of publication in the next *Records*. Information on submission of manuscripts and guidelines for contributors may be obtained from: Hawaii Biological Survey, Department of Natural Sciences, Bishop Museum, P.O. Box 19000, 1525 Bernice Street, Honolulu, Hawaii 96817-0916, USA; or by electronic mail: hbs@bishop.bishop.hawaii.org.

Hawaii: A World Without Social Insects

EDWARD O. WILSON

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Editors' note: This essay originally appeared as a chapter within E.O. Wilson's 1990 book *Success and dominance in ecosystems: The case of the social insects*, published by the Ecology Institute following the presentation of the *Ecology Institute Prize 1987 in Terrestrial Ecology* to Professor Wilson. Because of the importance of this essay, we reprint it here to make it more widely available in Hawaii and the Pacific. The essay provides many ideas that should stimulate research in ecology and conservation biology. Much remains to be learned about the pervasive ecological interactions of ants in Hawaii. Since this paper was written, several papers have appeared that complement this essay: Bach (1991), Cole *et al.* (1992), Gillespie and Reimer (1993), and Reimer (1994). We thank Professor Wilson and Professor Otto Kinne of the Ecology Institute, Oldendorf/Luhe, Germany, for their permission to reprint this essay.

In order to assess the impact of a dominant group of organisms, it would be extremely useful to have biotas free of the dominant group that can serve as evolutionary controls. This baseline is not easily found, because dominant groups are also as a rule very geographically widespread. The eusocial insects in particular have almost completely filled the terrestrial world. But there is one place to look. They did not, prior to the coming of man inhabit the easternmost archipelagoes of the Pacific. In particular, they did not reach Hawaii. This most isolated of all archipelagoes evolved a rich endemic fauna and flora in the absence of termites, ants, and eusocial bees and wasps (Zimmerman 1948, Wilson & Taylor 1967, Williamson 1981).

The massive weight of the social insects was therefore lifted from the plants and animals that departed from their midst and colonized Hawaii. Insects and other arthropods were freed from predation by ants and social wasps. Conversely, predators and scavengers did not have to compete with ants and social wasps; and invertebrate decomposers of wood did not have to contend with termites in the rotting logs and stumps. On the negative side, plants were deprived of the protection of ants and the pollination services of social bees.

How did the Hawaiian biota respond to this release? Unfortunately, we cannot directly read off the results, because there is an additional force working in Hawaii that is easily conflated with the absence of social insects: the disharmonic nature of the biota as a whole. The Hawaiian biota, as expected from its extreme remoteness, has evolved from a limited number of stocks, which have radiated extensively thereafter. By 1980, 6500 endemic insect species had been described, and these are believed to have evolved from about 250 original immigrant species (Williamson 1981). A typical case is the oecanthine tree crickets, comprising 3 genera and 54 species, or 43% of the entire known oecanthine fauna of the world, all derived from a single species that colonized the islands no more than 2.5 million years ago (Otte 1989). Disharmony of this kind means that not just social insects but many other major stocks of invertebrates are absent in the native fauna. Their absence as predators, herbivores, and decomposers must also be taken into account when assessing the histories of the sweepstakes winners.

The problem, while not readily soluble, is nevertheless tractable. Given the great ecological importance of social insects and the general significance of dominance in community evolution, the Hawaiian biota deserves a new look with social insects in mind. It is entirely possible that certain traits of the Hawaiian fauna usually ascribed to disharmony and reduced dispersal opportunity, such as extreme local abundance and flightlessness, are due at least in part to the lack of pressure from social insects, especially ants. What I offer now as a first analysis is a set of properties of biotas expected from the absence of social insects, without the attempt (or even the capacity, given the present scarcity of ecological knowledge) of disentangling the effects from those due to the absence of other, ecologically equivalent invertebrate groups as a reflection of disharmony in the fauna.

Scale insects and other honeydew producing insects protected by ants elsewhere will be scarcer relative to related groups. This prediction is confirmed but vitiated by the disharmonic nature of the fauna. There are no native coccids, fulgorids, or aphids, among the groups most avidly attended by ants elsewhere. Their absence could be ascribed either to the absence of ant protectors or bad luck in the dispersal sweepstakes. The latter hypothesis seems somewhat less likely in view of the fact that aphids are excellent dispersers. There is only one butterfly species belonging to the Lycaenidae, a family whose caterpillars are heavily attended by ants, but the native butterfly fauna of Hawaii is, inexplicably, very small overall. Mealybugs (Pseudococcidae), also much favored by ants, are represented by 3 endemic genera and 14 species, but are heavily outweighed in diversity by the homopterous families Cixiidae, Delphacidae, and Psyllidae, which are not attended by ants (Zimmerman 1948).

Both herbivores and predaceous insects will occur in denser, less protected populations. This prediction is dramatically confirmed. A very high percentage of the endemic insect species are flightless, and also generally "sluggish," to use Perkins' (1913) term, with populations persisting on the same tree or bush for years. Otte (personal communication) has referred to the conspicuous abundance of endemic crickets and their "lackadaisical" behavior. Many of the species walk about in the open where they can be easily picked up with the fingers, in sharp contrast to the cryptic, fast-moving species that occur in other faunas. Caterpillars such as those of the pyraustid moth genera *Margaronia* [now *Glyphodes* and *Stemorrhages*] and *Omiodes*, the extremely diverse drosophilid flies, and a few other dominant groups are comparably abundant and accessible, or at least were so in the last century in the less disturbed habitats. These are the kinds of insects most vulnerable to ant predation. No fewer than 36 ant species have been introduced by man, including the notorious omnivore and pest species *Pheidole megacephala*. The widespread destruction of native Hawaiian insects by ants is well known. Zimmerman (1948) states that "the introduction of a single species of ant, the voracious *Pheidole megacephala*, alone has accounted for untold slaughter. One can find few endemic insects within that scourge of native insect life. It is almost ubiquitous from the seashore to the beginnings of damp forest." Otte has observed the same displacement in the case of native crickets on Hawaii and the Society Islands, which also lacked ants before they were introduced by human commerce. There are other major causes of extinction of Hawaiian native insects, including habitat destruction and the incursion of alien parasites and diseases. But the important point with reference to the question of social insect dominance is the documented extreme vulnerability of the native insects to introduced ants in both disturbed and undisturbed habitats, which is consistent with observations in other parts of the world

where ants are native. (Ants may also have played a key role in the retreat of the rich and abundant Hawaiian land snail fauna, comprising over a thousand species, although I am not aware of studies addressing this possibility.) The converse conclusion is equally important: the local abundance of behaviorally vulnerable, epigeic insects is consistent with the absence of native ants, whether or not it explains the phenomenon entirely.

The non-formicid predators in the mesofauna (0.2 to 2.0 mm body length range), especially carabid beetles and spiders, should be more diverse and abundant. Also, predators should have evolved in mesofaunal arthropod groups that are not predaceous in other parts of the world. I call attention here especially to carabid beetles and spiders, because it is my experience in many other parts of the world that large numbers of species belonging to these two predatory groups have similar microhabitat preferences to ants. They occur abundantly in the litter and soil and especially under rocks not yet colonized by ants. In the summit forest of Mt. Mitchell in North Carolina, USA, where ants are very scarce, I found carabids and spiders to be more abundant, or at least more conspicuous, than at lower elevations. Darlington (1971) and Cherix (1980) present evidence that ants generally reduce the abundance of ground-dwelling carabids and spiders in both the tropics and temperate zones, especially those species specialized to live in soil and rotting vegetation. And as expected, carabids and spiders are both very diverse and abundant in the native forests of Hawaii. Other mesofaunal predatory groups that have radiated include the nabid bugs, staphylinid beetles, dolichopodid flies, and muscid flies of the genus *Lispocephala*. Groups that have moved into the ant predator zone include the geometrid moth *Eupithecia*, whose caterpillars ambush insects like praying mantises, and the damselfly *Megalagrion*, whose predator nymphs have left the aquatic environment entirely to hunt on the ground, especially under clumps of ferns. As I have stressed, these adaptive radiations and major ecological shifts may have been favored by the absence of competing predators in addition to ants, due to the general disharmonic nature of the fauna. Yet it is hard to imagine their occurring at all if a well-developed ant fauna had been present.

Non-formicid scavengers should be diverse and prominent relative to those in ecologically otherwise comparable faunas. Ants are strongly dominant as the scavengers of small arthropod corpses in most parts of the world. It is to be expected that this largely empty niche was filled by other groups on Hawaii, perhaps (at a guess) staphylinid and histrid beetles, but I know of no studies addressing the matter. Wood borers other than termites should be very prominent. In the absence of termites, we should expect to find a greater diversity and abundance of insects that bore through dead wood, especially the softer, rotting "wet" wood favored by so many termite species elsewhere in the world. Again, studies appear not to have been directed specifically to this hypothesis. Candidate groups include beetles of the families Anobiidae, Cerambycidae, Curculionidae, Elateridae, and Eucnemidae, which have in fact radiated extensively on Hawaii.

Solitary wasps and bees should be relatively diverse and very abundant. The solitary eumenid wasp genus *Odynerus* is represented by over 100 endemic species on Hawaii and, until the last century at least, was extremely abundant. The solitary hylaeid bee genus *Hylaeus* contains at least 50 endemic species, all derived from a single ancestor. The relation of these minor evolutionary explosions to the absence of social wasps and bees is an intriguing possibility but has not yet been explored.

Extrafloral nectaries and elaiosomes will be reduced or absent in the native flora. In general, extrafloral nectaries serve to attract ants, which in turn protect the plants from

herbivores. Extrafloral nectaries are substantially scarcer in the Hawaiian flora than elsewhere, in agreement with the prediction (Keeler 1985). Eleven endemic species and 6 indigenous species do have the nectaries, which may be attended by protector arthropods other than ants or simply reflect phylogenetic inertia. Significantly, three other indigenous (but not endemic) species having extrafloral nectaries elsewhere lack them on Hawaii, again supporting the prediction. Elaiosomes are seed appendages attractive to ants that induce the ants to disperse the seeds. No study has been made to my knowledge of their relative abundance on Hawaii.

To conclude, Hawaii has long fascinated biologists for its superb adaptive radiations, and depressed conservationists for the continuing destruction of those same evolutionary wonders. I suggest that the value of the biota is enhanced still further by the realization that it is a natural laboratory, the unique site of an experimental control, for the assessment of the impact of social insects on the environment. These insects are so dominant in almost all other parts of the world that their absence in the original, native Hawaiian fauna and flora provides an exceptional opportunity to study the effects of ecological release on the part of taxa that would otherwise have interacted with them most strongly. At the very least, the absence of social insects should be taken into more explicit consideration in future studies of the biota. What is clearly needed are deeper studies of the life cycles of native Hawaiian taxa in comparison with sister taxa elsewhere, and especially on other islands with and without key elements such as social insects.

Hawaii, the most remote archipelago in the world and home of a rich endemic fauna and flora, was evidently never colonized by social insects before the coming of man. The absence of these dominant elements means that the Hawaiian native biota is a controlled experiment in which we can observe the effects of freedom from social insects, especially ants and termites. It seems probable that the circumstance was a major contributor to some of the tendencies characterizing the Hawaiian biota as a whole, including flightlessness, lack of evasive behavior, increased abundance and diversity of carabid beetles and spiders, adaptive shift to predation in some terrestrial insect groups, and the loss of extrafloral nectaries in flowering plants.

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Numbers of Hawaiian Species: Supplement 1¹

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This is a supplement to our earlier tabulation of species known from Hawaii (Eldredge & Miller 1995; see also Mlot 1995). The Hawaii Biological Survey is currently working on species checklists and bibliographies for many of these taxa, so this should be viewed as an interim report subject to further change. See Eldredge & Miller (1995) for definitions and scope. We have not included bacteria and viruses, but have now included human parasitic protists and helminths. Allison *et al.* (1995, table 21.3) summarized the numbers of marine species based on Eldredge & Miller (1995).

From literature and unpublished sources, approximately 22,056 species have been recorded from the Hawaiian Islands and surrounding waters. Of these, 8,850 are endemic to the Hawaiian Islands, and 4,465 are nonindigenous species of protists, fungi, plants and animals. These numbers include significant refinements from the previous compilation by Eldredge & Miller (1995), based on continued literature survey and review by specialists, especially among the parasitic Protozoa and helminths. Many gaps in knowledge of Hawaii's biota remain and many species of protists, algae, fungi, worms and arthropods remain to be described.

Table 1. Estimates of numbers of species of the Hawaiian biota (based on Eldredge & Miller 1995, as updated by this paper and other papers in this issue of *Records of the Hawaii Biological Survey*).

Taxon	Total	Endemic	NIS
Algae and other protists	2228	4	5?
Fungi and lichens	2023	240	0?
Flowering plants	1910	850	877
Other plants	703	243	50
Mollusks	1656	956	75+
Insects	7862	5237	2527
Other arthropods	1795	335	519
Other invertebrates	2338	785	250
Fish	1195	139	73
Amphibians	4	0	4
Reptiles	24	0	20
Birds	274	60	46
Mammals	44	1	19
Total	22056	8850	4465

Endemic species are restricted to Hawaii; nonindigenous (= alien, = exotic, includes introduced) species do not naturally occur in Hawaii; indigenous species occur naturally in Hawaii but are not endemic. See Eldredge & Miller 1995 for additional definitions and qualifications.

1. Contribution No. 1996-001 to the Hawaii Biological Survey.

2. Executive Secretary, Pacific Science Association, P.O. Box 17801, Honolulu, Hawaii, 96817, USA.

Freshwater and terrestrial Cyanophyta (blue-green algae)

We have not yet reconciled the many old records (e.g., MacCaughey 1918, Tilden 1901, 1910) with current nomenclature. Some recent records include Doty & Watson 1981, MacEntee & Bold 1978, and Zimmerman & Bergman 1990. Patterson *et al.* (1991 and included references) included many Hawaiian species in a phytochemical screening program. The recorded flora of freshwater and terrestrial forms likely approaches 100 species.

Freshwater and terrestrial algae

We have not yet reconciled the many old records (e.g., MacCaughey 1918, Tilden 1901) with current nomenclature, but our original estimate of over 120 species was too low. Recent authoritative records include over 172 diatoms (Fungladda *et al.* 1983), 26 desmids (Prescott *et al.* 1975–1983), and 34 macroalgae in streams (Vis *et al.* 1994). The total likely exceeds 250 species.

Protozoa

The protists of the Hawaiian islands have never been systematically surveyed, but we have accumulated records of 207 species (excluding Foraminifera) from a variety of sources. Only authoritative identifications have been included. We expect that the ultimate number of species will be vastly greater.

Free-living marine protozoa: 39 species (Phillips 1977, Larsen & Patterson 1990), in addition to over 1000 species of Foraminifera (Chave 1987).

Free-living freshwater protozoa: 61 species, including 59 testaceous rhizopods (Van Winkle 1927), *Paramecium primaurelia* Sonneborn 1975, and *Tetrahymena tropicalis* Nanney & McCoy 1976 (= *T. pyriformis* variety 9 of Elliott *et al.* 1964).

Free-living soil protozoa: At least 31 ciliates, 9 flagellates, 6 Sarcodina, and 10 Testacea recorded from various habitats on Hawaii Island (Bamforth & Egglar 1973, Foissner 1993, 1994).

Parasitic protozoa of terrestrial vertebrates including humans: 60 species. Alicata (1969) detailed the species known from humans and domestic animals. Other key references include: Colgrove (1976 — dog), Metcalf (1923 — amphibian), Upton *et al.* (1994 — reptiles), Wallace & Frenkel (1975 — cat), Van Hoven *et al.* (1992 — deer), and Van Riper (1991 — birds).

Parasitic protozoa of invertebrates: 11 species symbionts in 3 species of termites (Kirby 1941–1946, Lai *et al.* 1983), at least 9 species from insects (Fujii & Tamashiro 1967, Tamashiro 1968, Tanabe & Tamashiro 1967, Tanada 1957), 2 species from marine crabs (Ball 1963).

Parasitic protozoa of marine fishes: 8 species (Basson *et al.* 1990, Lom 1970, Moser & Noble 1977a, b).

Fungi

We have not yet tabulated the number of fungi beyond our original estimates, but it is worth pointing to the recent work on yeasts associated with flowering plants (Starmer 1981), especially *Opuntia* cactus (Starmer *et al.* 1990); the recent reviews of rust fungi (over 74 species — Gardner & Hodges 1989, Gardner 1994); and Agaricales (101 taxa — Desjardin *et al.* 1992).

Platyhelminthes (zooparasitic)

Of 583 species, 56 are cestodes (tapeworms) including 20 from marine fishes (Cornford 1974, Carvajal *et al.* 1976, Beveridge & Campbell 1993, Brill *et al.* 1987, Deardoff *et al.* 1984, Gulyaev & Korotaeva 1989, Yamaguti 1968a), 1 from freshwater fishes (Font & Tate 1994), 21 from terrestrial vertebrates (including human) (Alicata 1969, Olsen & Haas 1976, Lewis & Holmes 1971), of 2 species from intermingling mammals 1 is new record (McKenzie & Davidson), 7 from green turtles (Dailey *et al.* 1992), 1 from porpoise (Testa & Dailey 1977), 4 from Hawaiian monk seal (Anderson 1987), and 1 from "megamouth" shark (Dailey & Vogelhein 1982); the remaining 527 species are trematodes (flukes), 507 from marine fishes (Lebedev 1984, Mamaev 1989, Oliver 1983, Yamaguti 1965, 1968b, 1970), 16 from terrestrial vertebrates (including human) (Alicata 1969, O'Leary *et al.* 1985), 1 unidentified species (larva) from freshwater fish (Font & Tate 1994), 1 from nonindigenous, marine, cage-cultured tilapia (Kaneko *et al.* 1988), 1 species from the cane toad (Speare 1990), 1 species with secondary intermediate stage in coral *Porites compressa* (Aeby 1991).

Acanthocephala

Three species not reported in 1995: *Moniliformis moniliformis* from rats (Alicata 1969) and cockroach (Schaefer 1970); *Corynosoma rauschi* from Hawaiian monk seal (Dailey *et al.* 1988); and *Mediorhynchus orientalis* from birds (Schmidt & Kuntz 1977); also unidentified species from freshwater fish (Font & Tate 1994).

Nematoda (zooparasitic)

Of 131 zooparasitic species, 93 reported from terrestrial vertebrates (including man) (Alicata 1969), of 22 species reported from intermingling mammals 12 are new records (McKenzie & Davidson 1989), 1 species from Hawaiian monk seal (Dailey 1988), 1 from albatross (Langston & Hillgarth 1995), 3 from endemic birds (Cid del Prado *et al.* 1985), 3 from gamebirds (Lewin & Holmes 1971, Smith 1973), 18 from marine fishes (Bruce *et al.* 1994, Deardoff & Overstreet 1982, Deardoff *et al.* 1982, 1983, Deardoff 1987, Noble 1966, Solovjeva & Pozdnyakov 1984), and 1 from freshwater fish (Font & Tate 1994).

Tardigrada

Pollock (1995) published the first record of 2 species of marine tardigrades—*Dipodarctus borrori* and *D. anaholiensis*—from Anahola Bay, Kauai.

Bryozoa

Two Hawaiian freshwater bryozoan species were overlooked in our earlier report (Bailey-Brock & Hayward 1984); one new deepwater, marine species described (Chimonides & Cook 1994).

Mollusca

Cowie *et al.* (1995) previously cited as "in press" has been published; the 75 non-indigenous species in the table represents non-marine mollusks only— numbers of non-indigenous marine mollusks have not yet been ascertained (R.H. Cowie, pers. comm.).

Annelida: Hirudinea

Two leeches collected in association with freshwater fishes to be added to species list: *Myzobdella lugubris* and *Cystobranchnus* sp. (Font & Tate 1994).

Arthropoda: Crustacea

Recent additions to the crustacean fauna of the Hawaiian Islands include: cyclopoid copepod *Haplostomides hawaiiensis* [n.sp.](Ooishi 1994); harpacticoid copepod *Psammopsyllus stri* (Kunz 1993); ascothoracid cirriped *Laura bicornuta* [n.sp.] and *Zoanthoecus cerebroides* [n.sp.](Grygier 1985); mysids *Anisomysis hawaiiensis* [n.sp.], *A. extranea* [n.sp.], *A. xenops* (Murano 1995), *Holmesimysis costata* (Holmquist 1979), and *Gnathophausia longispina* (Wilson & Boehlert 1993); marine isopods *Neonaesa rugosa* and *Cymodocella hawaiiensis* [n.sp.](Bruce 1994); deep-water caridean shrimp *Opaepele loihi* [n.gen. & n.sp.](Williams & Dobbs 1995).

Terrestrial and freshwater Arthropoda

The numbers for some groups have changed because of continued refinement of synonymies and distribution status in the database (G.M. Nishida, pers. comm.), as well as recent publications (Gillespie 1994—3 new endemic spiders; Asquith 1994—39 new endemic bugs). Many additional endemic species of arthropods remain to be described (e.g. Howarth 1990). Also, for the original figure for nonindigenous species of the insect order Diptera, there was a typographical error in the table. The number for NIS should read 361 rather than 631 (this did not impact the total numbers).

Insecta: 7862 total species, including 5237 endemic and 2527 nonindigenous;

Araneae: 200 total species, including 126 endemic and 70 nonindigenous;

Acari: 529 total species, including 103 endemic and 365 nonindigenous.

Symphyla: Has 5 nonindigenous species (Nishida 1994). It was overlooked in the original list.

Chordata: Reptilia

Our original list omitted 3 indigenous species of sea turtles and 3 nonindigenous species of freshwater turtles (C. Kishinami, pers. comm.).

Acknowledgements

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New Records and Synonymies of Hawaiian Bivalves (Mollusca)¹

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Our present understanding of the Hawaiian bivalve fauna stems from Dall, Bartsch & Rehder's (1938; hereinafter DBR) exhaustive survey and Kay's (1979) reanalysis of the fauna. Although previous studies (notably Conrad 1837 and Pilsbry 1917–1921) described several species, DBR were the first to comprehensively treat the fauna, recognizing 190 Recent and fossil species, of which they described 137 as new. Their survey was also noteworthy in that it considered the vast majority of the species encountered to be endemic to Hawaii. They named every Hawaiian species known in the fauna that was not already described from a collection made in Hawaii, with 3 exceptions: *Navicula* [= *Arca*] *ventricosa* (Lamarck, 1819), *Quidnipagus palatam* Iredale, 1929 and the introduced *Venerupis* (*Ruditapes*) *philippinarum* (Adams & Reeve, 1850). Kay (1979) published the first and only major overhaul, synonymizing many putative endemics with species described from other localities and even each other, and adding 16 species not included in DBR. Ongoing studies indicate that the majority of DBR's species are not endemic to Hawaii: many are junior synonyms of widespread Indo-West Pacific taxa (and often of each other), others, although validly named, also occur elsewhere. As with opisthobranchs (Gosliner & Darheim in review), the history of the Hawaiian bivalve fauna will be one of decreasing endemicity as the fauna receives more study. The anomalously high endemicity of Hawaiian bivalves (Kay & Palumbi 1987) is simply a taxonomic artifact.

The present paper is the first in what is planned to be a series of studies revising the Hawaiian bivalve fauna. Here I bring together 27 recent records, synonymies and generic reassignments encountered in the literature, using Kay's (1979) fauna as a starting point². I also add 6 new records, provide documentation for 3 new synonymies needed for other studies, and remove one species from the fauna. The distribution of all species treated is noted. All new records here reported are of adventive species, and although their USNM labels are varied, all appear to be based on surveys by Lt. Cdr. Henry Ryder of ship bottoms in Pearl Harbor between 1950–1951, deposited at the USNM ex the A.E. Mehring collection. Abbreviations: USNM: United States National Museum of Natural History; DMNH: Delaware Museum of Natural History; MCZ: Museum of Comparative Zoology, Harvard Univ.; BMNH: The Natural History Museum, London (formerly British Museum (Natural History)); ZMC: Zoological Museum, Copenhagen; UGI: University of Guam Invertebrate Collection.

Summary of status changes discussed in this paper

Previously published generic reassignments:

Present combination	From
<i>Adipicola pacifica</i> (DBR, 1938)	<i>Terua</i>
<i>Adipicola crypta</i> (DBR, 1938)	<i>Terua</i>
<i>Cosa waikikia</i> (DBR, 1938)	<i>Limopsis</i>
<i>Laevichlamys irregularis</i> (Sowerby, 1842)	<i>Chlamys</i> originally from <i>Pecten</i>
<i>Globivenus toreuma</i> (Gould, 1850)	<i>Venus</i>

1. Contribution No. 1996-002 to the Hawaii Biological Survey.

2. New records documented in Burch (1995) and Burch & Burch (1995) in the *Records of the Hawaii Biological Survey* for 1994 are not included below. Moretzsohn & Kay (1995) provide an updated checklist, but only add 2 new records and note 2 nomenclatural changes for bivalves. As some of these changes are problematic, they are all reviewed below.

*Previously published synonymies:***Senior synonym**

Botula fusca (Gmelin, 1791)
Botula fusca (Gmelin, 1791)
Lithophaga (*Leiosolenus*) *obesa*
 (Philippi, 1847)
Cryptopecten bullatus
 (Dautzenberg & Bavay, 1912)
Spondylus nicobaricus Schreibers, 1793
Spondylus violacescens Lamarck, 1819
Parahyotissa numisma (Lamarck, 1819)
Gari (*Gari*) *pennata* (Deshayes, 1855)
Gari (*Dysmea*) *occidens* (Gmelin, 1791)
Tellina (*Tellinides*) *ovalis* Sowerby, 1825
Tellina (*Scutarcopagia*) *scobinata* Linné, 1758
Venerupis (*Ruditapes*) *philippinarum*
 (Adams & Reeve, 1850)
Gastrochaena gigantea (Deshayes, 1830)
Gastrochaena inaequistriata Jousseume, 1923

*New synonymies:***Senior synonym**

Septifer (*Septifer*) *excisus* (Wiegmann, 1837)
Barbatia foliata (Forsskål, 1775)

Neopycnodonte cochlear (Poli, 1795)

Removed from fauna:

Spondylus cuneatus Reeve, 1856

Previously published reinstatement:

"*Chlamys*" *russata* (Reeve, 1853)
Pinna exquisita DBR, 1938

Previously published "new" records:

Lithophaga (*Leiosolenus*) *nasuta* (Philippi, 1846)
Neoaviculovulsa coralicola Okutani & Kusakari, 1987
Nanostrea exigua Harry, 1985
Pectinella aequoris Dijkstra, 1991
Fulvia (*Laevifulvia*) *ballieni* Vidal, 1994
Lyonsiella formosa (Jeffreys, 1881)

New records:

Septifer (*Septifer*) *bilocularis* (Linné, 1758)
Lopha cristagalli (Linné, 1758)
Hyotissa hyotis (Linné, 1758)
Chama lazarus Linné, 1758
Chama pacifica Broderip, 1835
Chama brassica Reeve, 1847

Junior synonym

Botula hawaiiensis DBR, 1938
Botula laysana DBR, 1938
Lithophaga hawaia DBR, 1938

Cryptopecten dalli DBR, 1938

Spondylus hystrix Röding, 1798
Spondylus tenebrosus Reeve, 1856
Ostrea thaanumi DBR, 1938
Heteroglypta kanaka Pilsbry, 1921
Dysmea vitrea DBR, 1938
Angulus hawaiiensis DBR, 1938
Tellina elizabethae Pilsbry, 1918
Tapes japonica Deshayes, 1853

Rocellaria hawaiiensis DBR, 1938
Rocellaria oahuana DBR, 1938

Junior synonym

Septifer vaughani DBR, 1938
Barbatia (*Abarbatia*) *hendersoni* DBR,
 1938
Ostrea laysana DBR, 1938

Systematic Treatment

Mytiloida: Mytilidae

Adipicola pacifica (DBR, 1938)

Terua pacifica DBR, 1938

Dell (1987) examined Habe's (1977a) record of this species and concurred that they are conspecific with the Hawaiian type, indicating that the species also occurs in Japan. Dell (1987) showed that *Terua* DBR, 1938 is a subjective junior synonym of *Adipicola* Dautzenberg, 1927.

Adipicola crypta (DBR, 1938)

Terua crypta DBR, 1938

Habe (1977a) recorded this species from Japan, but his record was based on adults compared with a juvenile representing the unique Hawaiian type. Thus Dell (1987) notes that the conspecificity of the 2 collections must await better material from Hawaii, as there are slight morphological differences between them. Generic reassignment by Dell (1987).

Botula fusca (Gmelin, 1791)

Botula hawaiiensis DBR, 1938

Botula laysana DBR, 1938

Wilson & Tait (1984) recognize but *Botula fusca* in their revision of the genus, and synonymize both Hawaiian nomina under this name.

Distribution: Red Sea and E Africa to Pitcairn, Hawaii, and W America, also W Atlantic (Wilson & Tait 1984).

Lithophaga (Leiosolenus) obesa (Philippi, 1847)

Lithophaga hawaia DBR, 1938

This large date mussel was described from Holocene or Pleistocene shells on Oahu, and has not been collected alive in Hawaii (Kay 1979). It was synonymized with the widespread *L. obesa* by Kleemann (1984).

Distribution: Red Sea and E Africa to the Society Is. and Hawaii (fossil) (Kleemann 1984).

Lithophaga (Leiosolenus) nasuta (Philippi 1846)

Lithophaga hawaia DBR, 1938, in part

Kleemann (1984: Fig. 19) records this species from Oahu on the basis of a single specimen found within one of the original lots (USNM 337461) of *Lithophaga hawaia* (see above).

Distribution: E Africa to the Line Is. and Hawaii (fossil) (Kleemann 1984).

Septifer (Septifer) bilocularis (Linné, 1758) **New state record**

This species is recorded from Pearl Harbor on ship bottom; whether it is established in Hawaii at present is not known.

Distribution: E Africa to the Mariana and Caroline Islands and Niue outside Hawaii (USNM and G. Paulay collection). Literature records from further east require verification, as juveniles of the species are easily confused with the more widespread and simi-

larly shaped and colored, but much smaller *Septifer cumingi* Récluz, 1849.

Material examined: USNM 699564 - mixed lot of 5 conjoined valves from two collections: 20 Jan. 1950 "boat bottom at Pearl Harbor" and 31 May 1950 "So. Pac. ship bottom at Pearl Harbor", respectively; both coll. Lt. Com. Henry Ryder. Note with specimens reads "Introduced? Palau" in H.A. Rehder's hand (A.R. Kabat, pers. comm.); basis for statement unknown.

***Septifer (Septifer) excisus* (Wiegmann, 1837)**

Tichogonia excisa Wiegmann, 1837

Septifer vaughani DBR, 1938; **new synonymy**

Septifer excisus can be immediately distinguished from other members of the genus by the notch in its septal shelf, from which its name presumably derives. It can be further distinguished from other Indo-West Pacific members of its subgenus by the strong beading on the ribs and the frequently raised posterior adductor scar. I have not seen the type(s) of *S. excisus*, but the interpretation here presented corresponds to the concept of other authors, starting with the first illustration of the species by Reeve (1857: pl. IV, Fig. 13) and Lamy's (1937) concept in the last revision of the group. This species is well represented in Pleistocene deposits on Oahu (Kosuge 1969). These fossils were initially identified as *Septifer kraussii* Küster by Ostergaard (1928), but differ from that species (which is closely related to, or is a variety of *S. bilocularis*, (Lamy 1937), by the above mentioned characters.

Distribution: Red Sea and E Africa to the Mariana Islands, fossils from Mangaia (Cook Is.); Henderson (Pitcairn Is.); Oahu (Hawaiian Is.)(Paulay in review).

Material examined: Recent: Marianas: USNM 595515 - Lagoon W of Saipan; USNM 595424 - Lagoon W of Saipan, ; USNM 617675 - Pagan I., 2000 yds S of B.M. on point forming Shomushon Harbor; USNM 620116 - Rota I.; USNM 248787 - Ladrone Is. (=Guam); USNM 487080 - Guam, Oca Pt.; USNM 487060 - Guam, Ritidian Pt.; USNM 248741 - Guam, Apra Bay; USNM 248743 - Guam, Apra Bay; USNM 248744 - Guam Apra Bay; USNM 853050 - Pago Bay, intertidal shallow grass beds behind reef crest; *Japan:* MCZ 44704 (mixed w/ *S. bilocularis*) - Tosa, Japan; MCZ 143226 - Oshima, Japan; MCZ 110602 (mixed w/ *S. bilocularis*) - Kashiwajima, Japan; USNM 344639 - Tosa, Japan; USNM 304298 - Kashiwajima, Japa, Japan; DMNH 20562 - exANSP 86291 - Kashiwajima, Tosa; *Philippines:* MCZ 22684 - Ulugau, Palawan; *Indonesia:* USNM 261289 - Java, Bantam, Keledjitan; *SE Asia:* USNM 762857 - Viet Nam, Chu Lai Bay, USA beach, Chu Lai; MCZ 238435 - Thailand, Rawai Beach, Phuket, 7°45'N; 98°19'E; *Indian Ocean:* USNM 836520 - Ile Picard, Passe Dubois, Aldabra, Seychelles, coral rock at sides of channel, 1-3ft; MCZ 188148 - Reunion Id.; AMNH 51636 - Mauritius. *Fossil:* USNM 495045 (holotype of *Septifer vaughani*), Wailupe Quarry, Oahu, Hawaiian Islands; USNM Invert. Paleo. no reg. #: Pitcairn Group: Henderson I., Paulay Sta. FHEN-13: ca. 1.3 km inland of N Beach, in fossil lagoon, Pleistocene; USNM Invert. Paleo. no reg. #: Cook Ids., Mangaia I., Paulay & Kohn Sta. G-11: ca. 1 km W of airfield, coastal terrace, ocean side of road, Pleistocene. USNM Invert. Paleo. no reg. #: Cook Ids., Mangaia I., Paulay & Kohn Sta. G-14: ca. 0.75 km W of airfield, coastal terrace, inland side of road, Pleistocene.

Arcoida: Arcidae

***Barbatia foliata* (Forsskål, 1775)**

Arca foliata Forsskål, 1775

Barbatia (Abarbatia) hendersoni DBR, 1938; **new synonymy**

Barbatia hendersoni was described from emergent sediments on Pearl Harbor grounds; additional apparently subfossil material was dredged from Pearl Harbor. These are probably of Pleistocene or Holocene in age, and the species is not known to live in the Hawaiian Islands today (Kay 1979). The holotype perfectly matches specimens of

Barbatia foliata (lectotype at ZMC; designated by Kilburn & Rippey 1982: 215–16, figured p. 216). There has been some confusion in the literature between this species and the similar *Barbatia decussata* (Sowerby, 1833) (see Oliver 1992); *B. foliata* can be distinguished by its larger size, dorsoventrally narrowed anterior, alternating large and small ribs, and distinct habitat. While *B. foliata* tends to nestle among corals and often lives conspicuously exposed on the reef, *B. decussata* lives cryptically: attached to the undersides of rocks. The nestling habit of *B. foliata* typically leads to a wide, central, abraded area, a feature clearly visible on the holotype of *B. hendersoni* and implying a similar habit. *Barbatia decussata* ranges from the Red Sea and E Africa to the Tuamotus; it is not known in Hawaii (Kay's (1979) synonymy of *B. oahua* DBR under *decussata* is in error).

Distribution: E Africa and Red Sea to Tuamotus and Line Is, Hawaii (fossil) (USNM).

Material examined: USNM 427768 (holotype of *B. hendersoni*) - "Owan [?] outcrop in the road that leads from the main route into Pearl Harbor Grounds", Bartsch & Henderson!; USNM 48450 - Pearl Harbor, dredgings; USNM 341286 - Pearl Harbor; USNM 484274 - Pearl Harbor dredgings. The last 3 lots were studied in 1990 and could not be relocated in 1995.

Arcoida: Philobryidae

Cosa waikikia (DBR, 1938)

Limopsis waikikia DBR, 1938

As pointed out by Hayami & Kase (1993), DBR's species belongs to the philobryid genus *Cosa*, not in the Limopsidae. *Cosa waikikia* is a characteristic inhabitant of the bizarre minute bivalve fauna of reef caves and crevices.

Distribution: Indonesia, S Japan, Ryukyus, Bonin, Palau, ?Samoa, Marshalls, Hawaii (Hayami & Kase 1993, in press, G. Paulay collection).

Pterioida: Pinnidae

Pinna exquisita DBR, 1938

This species was reinstated by Rosewater (1982) after the discovery of additional specimens. Rosewater (1961) had synonymized it under *Pinna muricata*, and it was not recognized since.

Distribution: Hawaii (Rosewater 1982).

Pterioida: Malleidae

Neoaviculovulsa coralicola Okutani & Kusakari, 1987

As noted in Moretzsohn & Kay (1995) this species was recently described from deep water off Midway Is.

Ostreoida: Entoliidae

Pectinella aequoris Dijkstra, 1991

Described from Indonesia, Fiji, and Hawaii (Dijkstra 1991).

Ostreoida: Pectinidae

Laevichlamys irregularis (Sowerby, 1842)

Chlamys irregularis (Sowerby, 1842)

Waller (1993) recently erected *Laevichlamys* for 8 extant and 2 extinct pectinids from the Indo-West Pacific and West Atlantic.

Distribution: Seychelles to Tuamotus and Hawaii (T.R. Waller, pers. comm. 1987; Paulay 1988).

“*Chlamys*” *russata* (Reeve, 1853)

This species was reinstated into the fauna by Dijkstra (1987a) on the basis of specimens dredged by W.M. Thorsson; it is known only from the Hawaiian Islands.

Cryptopecten bullatus (Dautzenberg & Bavay, 1912)

Cryptopecten dalli DBR, 1938

Hayami (1984) in his revision of *Cryptopecten* DBR, 1938 showed that the type species of the genus, *C. dalli*, is synonymous with *Pecten (Chlamys) bullatus* Dautzenberg & Bavay 1912; Dijkstra (1987b) also concurred.

Distribution: Japan, Philippines, and Hawaii, with a doubtful record from the Nazca Ridge (E Pacific) (Hayami 1984).

Ostreoida: Spondylidae

Spondylus nicobaricus Schreibers, 1793

Spondylus hystrix Röding, 1798

As noted by both Lamy (1938) and Lamprell (1987), the senior synonym for the Hawaiian shell previously known as *S. hystrix* Röding is *S. nicobaricus*. Moretzsohn & Kay (1995) created some confusion in their updated checklist of Hawaiian mollusk, in noting *S. nicobaricus* as a new record for Hawaii (based on Lamprell, 1986 [sic, = 1987]), and in recording *S. cuneatus* Reeve, 1856 from Hawaii based on its synonymy with *S. hystrix* Reeve, 1856. The latter species is a junior homonym of *S. hystrix* Röding, and, according to Lamprell, synonymous with *S. cuneatus*. As noted by Kay (1979), however, the Hawaiian shells are of *S. hystrix* Röding, not Reeve, an identification with which I concur. Thus the record of *Spondylus cuneatus* in Hawaii is an error.

Distribution: Madagascar to Pitcairn Group and Hawaii (Lamprell 1987, Paulay 1989).

[*Spondylus cuneatus* Reeve, 1856]

Removed from fauna, see discussion above under *Spondylus nicobaricus*.

Spondylus violacescens Lamarck, 1819

Spondylus tenebrosus Reeve, 1856

As noted by Lamy (1938), *S. violacescens* is the senior synonym of *S. tenebrosus*, under which name this bivalve was previously known in Hawaii. Moretzsohn & Kay (1995) noted this synonymy as *S. violascens* Lamarck, a misspelling originating from Lamprell (1987).

Distribution: Indonesia to Pitcairn Group and Hawaii (USNM).

Ostreoida: Gryphaeidae

The following oysters described from the Hawaiian Islands are referable to this family rather than the Ostreidae: *Ostrea hanleyana* Sowerby, 1871, *Ostrea thaenumi* DBR, 1938, *Ostrea laysana* DBR, 1938, *Ostrea kauaia* DBR, 1938, *Ostrea kamehameha* Pilsbry, 1936.

Hyotissa hyotis* (Linné, 1758)*New state record**

Hyotissa hyotis is the largest extant species of Gryphaeidae. "This species does not seem to live in Hawaii now, but is fossil there, ± frequently reintroduced ... but does not become established" (H. A. Harry, *in litt.* with USNM 700474, June 1979). Harry's comments accompany two lots from Pearl Harbor ship bottoms at the USNM; his reference to Hawaiian fossils are certainly to *Ostrea kamehameha* Pilsbry 1936, a likely synonym. Whether the species has become established in Pearl Harbor or elsewhere in Hawaii, is not known.

Distribution: Red Sea and Madagascar to the Tuamotus, Galapagos and W America outside Hawaii (USNM).

Material examined: USNM 699996 - bottom of ship from So Pacific at Pearl Harbor, Henry, ex A.E. Mehring collection; USNM 700474 - Ship bottom, Pearl Harbor, Cdr. Henry Ryder!; ex A.E. Mehring collection.

***Neopycnodonte cochlear* (Poli, 1795)**

Ostrea cochlear Poli, 1795

Ostrea laysana DBR, 1938; **new synonymy**

Neopycnodonte cochlear was first recorded from the Hawaiian Islands under this name by Harry (1985: 133), although Burch & Burch (1995) also listed it as a "new state record". DBR's *O. laysana* also represents this species, a synonymy pointed out by the late H. A. Harry in the USNM collections, with which I concur.

Distribution: moderately deep water (27–2100m; Harry 1985); Red Sea and Madagascar to Hawaii, also E Atlantic (USNM).

Material examined: USNM484157 (Syntypes of *O. laysana*: 4 valves attached to each other) - Laysan Id. US Fish Comm. Sta, 3857, 30–20 fms, 73°; USNM 758163 - Kealakekua Bay, W coast, Hawaii, USFC Albatross, (1902) 14fms+, on spines of *Chondrocidarus gigantea* (#27309); USNM 335596 - Laysan, 20–30 fms; USNM 76277 - ca. Lahaina, Maui, channel btwn Maui and Lanai, 200ft; USNM 622172 - Mala Maui; USNM 337497 - off Waikiki, 2–300 ft.

***Parahyotissa numisma* (Lamarck, 1819)**

Ostrea thaanumi DBR, 1938

Synonymy by Harry (1985); this species is common on shallow fore reefs on most central Pacific islands (Paulay 1990) and Hawaiian shells do not appear distinct. Kay (1979) synonymized *Ostrea thaanumi* under *Ostrea hanleyana* Sowerby, 1871, which was also described from the Hawaiian Islands, and may thus also be a synonym of *numisma*.

Distribution: E Africa to Tuamotus and Hawaii (Harry 1985).

Ostreoida: Ostreidae***Nanostrea exigua* Harry, 1985**

Harry (1985) records this species from Hawaii, presumably on the basis of USNM 337556 (Hawaii Pearl Harbor, 35–40 ft, Thaanum Collection 7694d).

Distribution: Red Sea to Marshalls, Marquesas and Hawaii (Harry 1985, USNM).

***Lopha cristagalli* (Linné, 1758)**

Lopha cristagalli is commonly confused with some ecomorphs of *Dendrostrea folium*, from which it can be readily distinguished, however, by its densely pustulose exterior. A single lot indicates that the species has been transported to Pearl Harbor; its present status in the Hawaiian Islands is unknown.

Distribution: Red Sea to Marianas, Carolines, Marshalls, and Samoa outside Hawaii (USNM collections).

Material examined: USNM 699998 - Hawaii, Pearl Harbor, A.E. Mehring, ship bottom, 3/20/51. A label by H.A. Harry (dated June 79) in the lot notes: "Is true *Lopha cristagalli* but from a ship bottom - it may be imported from elsewhere".

Veneroida: Chamidae

Chama lazarus Linné, 1758

New state record

This species has been collected on ship bottoms in Pearl Harbor; its present status in the state is unknown.

Distribution: E Africa and the Red Sea to Marshalls, Tungaru (Kiribati) and Tonga outside Hawaii (USNM, DMNH, G. Paulay collection).

Material examined: USNM 699558 - Hawaii, Pearl Hbr., boat bottom, 1/20/50, A.E. Mehring [collection], Lt.Comm.Henry, with *Chama pacifica* attached to shell. Additional material seen but not recorded at BPBM.

Chama pacifica Broderip, 1835

New state record

Chama pacifica was at least at one time fairly common on ship bottoms in Pearl Harbor; its present status in Hawaii is not known.

Distribution: Similan Islands (Thailand, Andaman Sea) to Tuamotus and Line Is outside Hawaii (USNM, DMNH).

Material examined: BMNH 1950.11.1.54 (figured syntype); USNM 699565 - Hawaii, Pearl Hbr., boat bottom, 7/23/51, A.E. Mehring (Henry); USNM 699561 - Hawaii, Pearl Hbr., boat bottom, 5/31/50, A. E. Mehring (Henry); USNM 699563 - Hawaii, Pearl Hbr., boat bottom, 1/20/50, A.E. Mehring (Henry); USNM 699558 - Hawaii, Pearl Hbr., boat bottom, 1/20/50, A. E. Mehring ("Lt. Comm. Henry"), 2 valves attached to *Chama lazarus*, under which name it is filed at USNM. Additional material seen but not recorded at Bishop Museum.

Chama brassica Reeve, 1847

New state record

Chama brassica has been found on ship bottoms in Pearl Harbor; its present status in the Hawaiian Islands is unknown.

Distribution: E Africa and Red Sea to Marshalls, Samoa and Tonga outside Hawaii (USNM, DMNH).

Material examined: BMNH no reg. # (3 syntypes); USNM 700006 - Oahu, Pearl Harbor, Ship bottom, 3/20/50, A.E. Mehring

Veneroida: Cardiidae

Fulvia (Laevifulvia) ballieni Vidal, 1994

This recently described species was based on a single specimen labeled "Sandwich Islands, Mr Ballien, 1876" in the Muséum National d'Histoire Naturelle, Paris. According to Vidal (1994), Ballien sent numerous shells from Honolulu to Paris between 1872 and 1878, and as he notes, "be it Hawaiian or not, [it] must be a rare species, as evidenced by the fact that no other specimen has shown up since Ballien's collect [sic] in 1876."

Veneroida: Tellinidae

Tellina (Tellinides) ovalis Sowerby, 1825

Angulus hawaiiensis DBR, 1938

Listed in synonymy by Lamprell & Whitehead (1992). Having studied DBR's type,

I agree with their decision.

Distribution: Queensland, through Indonesia, to Japan, and east to Fiji, Marianas and Hawaii (USNM, UGI, G. Paulay collection).

Tellina (Scutarcopagia) scobinata Linné, 1758

Tellina elizabethae Pilsbry, 1918

Listed in synonymy by Lamprell & Whitehead (1992). Hawaiian shells were separated by Pilsbry in large part because they have finer scale-like sculpture than shells seen by Pilsbry from elsewhere in the Pacific. However although the Hawaiian population is relatively homogeneous in this regard, the range of variation in scale size is great at other locations and includes Hawaiian-type forms also; thus Lamprell & Whitehead's (1992) synonymy of the 2 may be justified.

Distribution: E Africa to Line and Pitcairn Is, Hawaii; common throughout the central Pacific (Paulay 1987, USNM).

Veneroida: Psammobiidae

Gari (Gari) pennata (Deshayes, 1855)

Heteroglypta kanaka Pilsbry, 1921

Synonymized in revisionary context by Willan (1993).

Distribution: E Africa and Red Sea to Societies and Hawaii (Paulay 1990, Willan 1993).

Gari (Dysmea) occidens (Gmelin, 1791)

Dysmea vitrea DBR, 1938

Synonymized in revisionary context by Willan (1993).

Distribution: Red Sea to New Caledonia and Hawaii (Willan 1993).

Veneroida: Veneridae

Globivenus toreuma (Gould, 1850)

Venus toreuma Gould, 1850

Generic reassignment by Paulay (1990).

Distribution: E Africa to Australs, Pitcairn Group, Hawaii (USNM).

Venerupis (Ruditapes) philippinarum (Adams & Reeve, 1850)

Tapes japonica Deshayes, 1853; Kay (1979)

As pointed out by Fischer-Piette & Métivier (1971) and Habe (1977b), the senior synonym of *Tapes japonica*, as well as the identity of the species introduced to Hawaii, is *Venerupis (Ruditapes) philippinarum*, under which name this species was originally recorded by DBR. The relationships of the closely related generic taxa *Venerupis* Lamarck, 1818 and *Ruditapes* Chiamenti, 1900 are poorly resolved; DBR and Coan *et al.*'s (1996) useage of *Ruditapes* as a subgenus of *Venerupis* is a reasonable approach for now.

Distribution: Pakistan to Philippines and Japan, and north to Kuril Is; introduced into Hawaii and W America (Fischer-Piette & Métivier 1971).

Myoida: Gastrochaenidae

Gastrochaena gigantea (Deshayes, 1830)

Rocellaria hawaiiensis DBR, 1938

Nielsen (1986) established the above synonymy and also noted that this species does not match the types (at ZMC) of *Gastrochaena cuneiformis* Spengler 1793, under which Kay (1979) synonymized DBR's species previously.

Distribution: Gulf of Aden to New Caledonia and Hawaii (Nielsen 1986).

Gastrochaena inaequistriata Jousseaume in Lamy, 1923

Rocellaria oahuana DBR, 1938

Synonymy was established by Nielsen (1986).

Distribution: known from the Gulf of Aden, Thailand, and Hawaii (Nielsen 1986).

Myoida: Teredinidae

Roch (1976) provides a review of Polynesian teredinids, in which he presents alternative species interpretations for many Hawaiian species to that given in Turner's (1966) revision and adopted by Kay (1979). As his paper is not revisionary in context (and does not even cite Turner (1966)!) and includes several nomenclatural errors, it appears to be less solidly founded than Turner's study. Thus it may be best to follow Turner's classification for the present.

Pholadomyoida: Verticordiidae

Lyonsiella formosa (Jeffreys, 1881)

Recorded from 460 m depth on Oahu (BPBM 207491) (Morton 1984, see also Burch 1987). The species was previously known only from the Atlantic: from the Gulf of Mexico to the Bay of Biscay at 366–3783 m depths (Morton 1984).

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The Orangeblack Hawaiian Damselfly, *Megalagrion xanthomelas* (Odonata: Coenagrionidae): Clarifying the Current Range of a Threatened Species¹

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Introduction

The Orangeblack Hawaiian Damselfly, *Megalagrion xanthomelas* Selys-Longchamps, formerly occurred in lowland aquatic habitats throughout all the high Hawaiian Islands. Although common at the turn of the century, the species began to experience a progressive decline after World War II, and by the early 1990s had not been seen on Oahu for over 20 years. This fact, coupled with the extensive alteration of lowland habitats in which the species formerly bred, led Polhemus (1993) to conclude that the species was probably extirpated on Oahu when he reviewed the conservation status of *Megalagrion* species for the U. S. Fish and Wildlife Service (USFWS). Based on this assessment, plus the apparent extirpation of the species on Kauai and Maui as well, USFWS (1994) proposed that *M. xanthomelas* be listed as a Threatened species and given protection under the Endangered Species Act.

Given this, it was of great interest when a remnant population of *M. xanthomelas* was discovered in the course of an environmental survey conducted by personnel from the Hawaii Biological Survey in March 1994 at the Tripler Army Medical Center (TAMC), on the outskirts of Honolulu. This population, so far as is known, is the last remaining colony of *M. xanthomelas* on Oahu, and thus a priority target for conservation efforts. The existence of the population was noted in a report to the R.W. Towill Corporation of Honolulu (Evenhuis & Cowie 1994); this report also concluded that the insects were confined to a small gully near the greenhouse at the lower end of the TAMC site, in an area that had the potential for being impacted by proposed construction activities further upslope. It was recommended that in order to ensure the continued survival of the TAMC *M. xanthomelas* colony the population should be relocated to a nearby site that would not be subject to construction impacts or other activities taking place on the TAMC grounds, a task that has recently been accomplished through the construction of an artificial refugium.

In order to properly design the refugium for the TAMC population, it was necessary to conduct a detailed investigation of the biology of *M. xanthomelas*, which was poorly known at the time. This involved both detailed studies at TAMC (to be reported in a separate publication), and investigations at sites on other islands where populations of *M. xanthomelas* were still known to persist. This report details the results of those surveys, providing a statewide conservation assessment of this increasingly rare species.

Taxonomy and Historic Distribution of *Megalagrion xanthomelas*

Megalagrion xanthomelas was described by Selys-Longchamps (1876) based on specimens collected by G.F. Matthew of the Royal Navy, and labelled "Sandwich Islands", with no specific island within the group noted on the labels. The location of Selys-Longchamps' types is not currently known, although they may be in the Koninklijk

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Belgisch Instituut voor Natuurwetenschappen, in Brussels. The species has not been confused with others since its original description, thus its taxonomic history is relatively simple and devoid of synonyms.

The original distribution of *M. xanthomelas* within the Hawaiian Islands is a matter of some speculation. It seems unlikely that the species ever inhabited the small, dry island of Kahoolawe, and its presence on Kauai is open to question, although a single specimen is present from nearby Niihau (see below). Perkins (1899) stated that *M. xanthomelas* "Probably occurs all over the islands", despite the fact that he lacked any collections from Kauai and Lanai. Kennedy (1917), probably following Perkins' statement, listed *M. xanthomelas* from Oahu, Molokai, Maui, Hawaii, Kauai and Lanai, even though once again there were apparently no specimens at hand supporting the latter 2 records. It was only in 1993 that specimens were finally captured on Lanai (Polhemus 1993); and to date the species has never been taken on Kauai.

The ecology of *M. xanthomelas* was discussed anecdotally by Williams (1936), who also illustrated the immatures. They appear to have formerly bred in impounded sections of lowland streams, and in both natural and artificial ponds. The ability of this species to exploit artificial habitats was noted by Perkins (1913), who observed that *M. xanthomelas* was:

"a common insect in Honolulu gardens and in lowland districts generally, not usually partial to the mountains, though in the Kona district of Hawaii it is common about stagnant pools up to an elevation of about 3000 feet. It is very numerous under conditions changed from the natural; perhaps it now finds more numerous breeding places, and a more abundant prey in the numerous insects that have been introduced by man in the region it frequents."

Williams (1936) also noted that *xanthomelas* bred abundantly in sugar plantation reservoirs at Waianae. Zimmerman (1948), by contrast, remarked that the introduction of *Gambusia* topminnows "has changed the lowland situation considerably in recent years, however, and the species is much less abundant than formerly."

The decline in populations of *M. xanthomelas* noted by Zimmerman in the years after World War II has continued to the present day. The species is now apparently extirpated on Maui, with no records from that island for the last hundred years, and reduced to single known population on Oahu (at TAMC). Molokai is known to support 4 populations, and the species is abundant in artificial golf course ponds on Lanai, although elsewhere on that island it retains only a tenuous foothold in small remnants of its former natural habitat. Only on Hawaii Island is the species still truly widespread, being commonly found in the coastal wetlands of the Puna, Kau and Kona districts.

In the sections below, the current distribution of *M. xanthomelas* is discussed on an island by island basis. The terminology used to describe aquatic ecosystems follows Polhemus *et al.* (1992).

Niihau

A single specimen of *M. xanthomelas* is in the Bishop Museum (BPBM) bearing a Niihau label, collected by L.D. Tuthill on 16 August 1947. No specific locality is given, but the specimen was probably collected along the margin of Halulu Lake, a permanent mixohaline pond fed by basal spring outflows, or from one of the perched springs that occur at Kaali and in Waiokanaio Gulch.

Kauai

Although *M. xanthomelas* was listed as occurring on Kauai by Kennedy (1917), there are no extant specimens from this island. The presence of the species on Niihau and Oahu, however, makes it virtually certain that it once occurred on intervening Kauai as well, even during historic times. The extensive alteration of basal spring wetlands on this island, particularly those formerly existing on the Mana plain near the present town of Kekaha (which were filled and converted to sugarcane cultivation beginning in the 1920s), appears to have led to the local extirpation of *M. xanthomelas* on Kauai. An extensive search by John Maciolek of the USFWS in the late 1970s failed to uncover any evidence of this species, and subsequent damselfly surveys on the island have been similarly unsuccessful in locating any populations.

Oahu

Tripler Army Medical Center

The present and historic distribution of *M. xanthomelas* on Oahu is summarized in Figure 1. As noted in the introduction, only a single population of this species is known to remain on the island, at the Tripler Army Medical Center (TAMC) on the outskirts of Honolulu. This population occupies a small gully shaded by koa haole (*Leucaena leucocephala*), with a bedrock channel that in this reach forces the base flow to the surface, creating a series of small pools connected by short, shallow runs. The flow into this reach originates from a 48-inch concrete pipe that drains the area around the main hospital buildings upslope, and disappears downslope into a similar culvert, making the Tripler habitat a small island of relatively natural stream channel within a sea of surrounding development. The survival of *M. xanthomelas* at this site appears to have been paradoxically favored due to the presence of the culverts, which have acted as filters to the introduced fishes that are abundant in the lower section of Moanalua Stream into which the Tripler gully eventually drains.

The *M. xanthomelas* population at TAMC appears to be a remnant of much larger and more continuous populations that formerly occupied the wetlands along the inner margin of Pearl Harbor. Five large basal springs previously emerged from the Koolau Aquifer in this area, these being from east to west the Kalauao, Waiau, Waimano, Waiawa and Waikele springs. The combined discharge of these springs in 1932 was over 80 million gallons a day (Stearns & Vaksvik, 1935), and their outflows formed extensive limnetic and mixohaline wetlands. The above authors noted that these springs issued forth in low, swampy areas along the margin of Pearl Harbor and were affected by tides. Similar types of habitats on Hawaii island currently support large populations of *M. xanthomelas*, and the former presence of this species in the Pearl Harbor area is confirmed by specimens in BPBM and the University of Hawaii.

A search was made of these Pearl Harbor springs for *M. xanthomelas* during damselfly conservation status surveys funded by USFWS, and the results are germane to the present study, since they indicate the absence of other *M. xanthomelas* populations in proximity to TAMC. The closest of the springs to TAMC is the Kalauao Spring, which now forms a watercress farm lying between the Kamehameha Highway and the Pearlridge shopping mall. This spring has been extensively modified by watercress cultivation, and contains large numbers of introduced fish and prawns. A search for *M. xanthomelas* here on several occasions during 1994 and 1995 proved fruitless. The Waiau Spring lies imme-

diately upslope of the Kamehameha Highway and behind a Zippy's restaurant. It is also given over to watercress cultivation, and contains numerous introduced fish species. The Waimano Spring formerly emerged at the site now occupied by the Waiawa electrical generating station, built in 1945, which exploits the spring's water for cooling. The Waiawa Spring lies below a bluff occupied by the Leeward Community College, in a degraded area containing the Pearl City Peninsula landfill, a highly contaminated EPA Superfund site; it too supports watercress production, and forms an extensive wetland on its seaward side that has yet to be completely surveyed. The Waikele Springs emerge from the east bank of Waikele Stream upstream from the H-1 freeway bridge; these springs are partially diverted by the Oahu Sugar Company, although significant outflows still emerge, providing the majority of base flow in the terminal reach of Waikele Stream. This area was intensively surveyed by Englund (1993), who found high densities of tilapia, *Rana cateseiana*, and other introduced aquatic vertebrates, but no indication of *M. xanthomelas*. Based on current knowledge, it thus appears that all the basal spring wetlands in the Pearl Harbor area that formerly could have supported *M. xanthomelas* are now physically altered or biologically degraded to the point that they no longer harbor this species. Examination of *M. xanthomelas* specimens in BPBM shows that the last date of collection for this species at Waipahu was in 1925, although a specimen was taken at Pearl City as late as 1977.

Basal spring wetlands similar to those that occurring at Pearl Harbor are also present on the north shore of Oahu to the east of Haleiwa, near the mouth of the Anahulu River. One of these wetlands, surrounding Emerson Spring, is still relatively intact, although it is now traversed by the recently constructed Haleiwa Bypass highway project. An investigation of these wetland systems by Adam Asquith of the USFWS in early 1995 found them to be dominated by alien aquatic species, and to lack populations of *M. xanthomelas*, although specimens taken at Waialua in 1892 are present in BPBM.

Recent surveys thus indicate that *M. xanthomelas* has been extirpated from suitable lowland habitats throughout Oahu, and reinforce the view of the Tripler population as an isolated remnant that has survived through fortuitous circumstances. Since some of the basal spring wetlands formerly occupied by this species still exist, it might be possible in the future to reintroduce this species to suitably managed sites in the Pearl Harbor and North Shore areas, provided that the Tripler population can be maintained in the interim.

Molokai

Pelekunu Valley

Pelekunu Stream is a swift, rocky, perennial stream that begins as a set of plunging streamlets at elevations near 120 m on the sheer northern face of the Molokai Crest. The catchment takes the form of a giant bowl, ringed by peaks including Kaunuohua, Olokui and Kamakou, the latter at 1515 m being the highest point on Molokai. The headwater reaches are nearly vertical, with the stream profile making an abrupt transition to a more moderate gradient at ca. 915 m elevation, which is interpreted as the head of the midreach. From this elevation downstream to the mouth the channel exhibits a moderate but continuous gradient, with numerous riffles and small cascades, and thus retains a midreach character completely to its seaward terminus.

The extreme lower section of Pelekunu Valley consists of a vegetated debris fan, laced by various stream channels that are continually cut off and reoccupied. These aban-

doned channels in many cases contain pools with weak flow that are fed by seepage through the pore spaces in the coarse surrounding alluvium. At the mouth of the stream the debris fan forms a transverse barrier of water-rounded rocks and cobbles, behind which the stream pools to form a small pond before entering the sea via a small rapid. The size of the terminal pond varies according to spates and other stream fluctuations, and at certain times of year a black sand beach is also exposed seaward of the cobble bar that impounds it.

Further upstream at the head of the debris fan the bed narrows and vertical walls of coarse volcanic conglomerate occasionally confine the channel. The basic channel substrate throughout this terminal section consists of rounded cobbles averaging 20–40 cm diameter, alternating with beds of coarse gravel. Except for the large pool at the mouth, the stream profile is composed primarily of erosional zones formed by rapids and riffles. In the first kilometer upstream from the mouth numerous streamlets and rheocrenes enter from the east bank off the steep flanking wall of the Olokui massif, forming swampy areas at the base of the eastern valley wall. To the west of the stream mouth is an extensive complex of abandoned taro fields, now dry and heavily overgrown by introduced grasses.

During an initial visit to lower Pelekunu Valley in 1991, the author captured individuals of *M. xanthomelas* along the margins of the terminal pond formed behind the cobble bar at the stream terminus (Polhemus 1991). This bar was high enough and steep enough that the waves did not overtop it, and thus retained a limentic character despite its proximity to the sea. The adults observed here did not range far from the pond, flying low and perching amid vegetation on the stream margins which offered protection from the sea breeze, and since the species was not encountered elsewhere in the lower valley it was assumed that this terminal pond was the breeding site.

This area was revisited in late August of 1995 and showed a number of changes from its aspect in 1991. The alluvial delta bordering the terminal pond was now heavily overgrown with tall stands of Job's tears (*Coix lachryma-jobi*), and the riparian vegetation further up the valley was also much denser. This revegetation appears to indicate recovery from a major flood that took place immediately prior to the initial 1991 survey. The stream channel itself also exhibited a different configuration, splitting into a D-shaped loop just before its seaward terminus. The previously ponded section now occupied a small area along the outside curve of the D near the point where this side branch rejoined the main channel. The pond, which in its present configuration could more properly be considered a deep, flowing pool, was bordered along its seaward side by the terminal cobble bar covered with *honohono* (*Commelina diffusa*), along its eastern side by a steep bedrock face, and along its remaining margins by cobble bars overgrown with Job's tears and Guinea grass (*Panicum maximum*). The pond was measured and found to be 11 m in length and 9.5 m in width, with an inflow width of 5.3 m. The maximum depth of the pond was 1.4 m, and the depth at the inflow was 0.5 m. The substrate of the pond consisted of stream-rounded rocks and cobbles sitting on coarse, dark gravel. The water chemistry of this site is summarized in Table 1.

Megalagrion xanthomelas was found once again at the mouth of Pelekunu Valley during the 1995 survey, but only in a small area along the seaward margin of the reduced terminal pond. At least 4 males were observed perching amid marginal vegetation and making short forays over the open water; no females were seen. A detailed search was made of the leaves of the *honohono* that bordered the pond but no oviposition scars were

found, although tissues of this plant are known to be a favored oviposition sites for *M. xanthomelas* at TAMC. Other Odonata co-occurring with *M. xanthomelas* at the terminal pond included the introduced damselfly *Ischnura ramburii* (Selys-Longchamps), which was not seen during the 1991 surveys and may be a recent invader in the valley, and the indigenous dragonflies *Anax junius* (Drury) and *Pantala flavescens* (Fabricius).

Of particular note at Pelekunu was the short time duration of *M. xanthomelas* activity during the day. When the survey team arrived at 0900, the weather was clearing after a brief rain shower and the sun was just rising above the rim of the Olokui massif. Although fair and sunny conditions prevailed for the next several hours after this, no *M. xanthomelas* were observed. In the absence of any activity, surveys were made a short distance up the main stream to see if populations might be present there, but none were found, although 3 other *Megalagrion* species, *M. pacificum* McLachlan, *M. blackburni* McLachlan and *M. hawaiiense* (McLachlan), were observed. The survey party returned to the pond area at ca. 1130 and at this point found adult *M. xanthomelas* to be active, allowing the capture of several specimens. By 1230, a brief shower passed over and activity ceased. Although the remainder of the day was characterized by alternating periods of sun and light showers, no additional *M. xanthomelas* were observed. At this site the total duration activity on the day that surveys were made thus appeared to be ca. 1 h during midday when the valley received its most direct sunlight. This preference for high light conditions corresponds to similar observations made at the Koele Lodge on Lanai (see following section).

Waikolu Stream

Waikolu Stream is a swift, rocky perennial stream occupying an elongate, sheer-sided valley on the northern, or windward, side of eastern Molokai. As in nearby Pelekunu Valley, the Waikolu drainage begins with a steep headwall section dropping rapidly from an encircling rim at ca. 1067 m elevation to the beginning of the midreach at ca. 305 m elevation. This midreach section continues for several km to the stream mouth, following a moderate gradient with numerous small waterfalls and rapids, with the stream entering the sea across a steeply sloping cobble bar. The stream profile throughout the midreach is thus composed primarily of erosional zones, along with a few deep pools found primarily below old water diversion structures, and in the area immediately behind the cobble bar at the stream terminus. The basic channel substrate throughout the mid- and terminal reaches consists of large stream-rounded boulders averaging 1–2 m in diameter, alternating with beds of cobbles and coarse gravel. The stream is shaded in its upper reaches by a closed canopy forest of kukui and guava, but becomes progressively more open as one proceeds downstream. Numerous small tributary rivulets and rheocrenes enter along the midreach, particularly in the area immediately below the pumping station. These spring fed ecosystems provide stable aquatic habitats that are not subject to the sudden and unpredictable variations in discharge rate that characterize the main stream, and thus support diverse aquatic insect communities including some taxa not commonly seen along the main channel. Water temperatures in along the main channel sampled range from 18 °C at 180 m to 21 °C at 80 m, while the water temperature in the spring fed tributaries is 19 °C (Polhemus 1992).

Individuals of *M. xanthomelas* were observed by Adam Asquith along the terminal reach of Waikolu Stream at midday on 19 July 1995. The insects were not abundant, and

flew along the margins of five slow, shallow stream pools lying behind the terminal bar. In general aspect this habitat is thus very similar to Pelekunu.

Palaau Wetland

An extensive basal spring wetland is present at Palaau, 3 km east of Kaunakakai on the southern coast of central Molokai (Fig. 2). At least 6 individual spring outflows of varying sizes are present in this area, many being marked by stands of bulrushes (*Schoenoplectus* sp.), bordered peripherally by expanses of pickleweed (*Batis maritima*), and others emerging along the margins of shallow coastal basins to form large, horizontally stratified mixohaline ponds, most notably the Kaluaapuhi Pond. Most of the larger springs that emerge above sea level have been boxed, although their outflows still reach the ponds, and water from others is being used to supply an expanding series of aquaculture projects, and for cooling and steam generation at the local power plant. The vegetation of the area is highly altered from its original state, being a kiawe (*Prosopis pallida*) savannah along the inland margins, and bearing a thick band of mangroves seaward, the latter having become established after World War II. A more complete vegetative description of this ecosystem type may be found in Wagner *et al.* (1990). Although the Palaau wetland is still partially intact, the continued spread of aquaculture facilities, which are being actively promoted and funded by the County of Maui, will likely alter this area in the near future, both by reconfiguring the mixohaline pools and marshes, and by diverting the spring waters upon which these systems depend.

Megalagrion xanthomelas was present here along the along the inland margins of the wetland, in company with 2 introduced damselfly species, *Ischnura ramburi* and *Ischnura posita*, and 2 larger dragonfly species, *Anax junius* and *Orthemis ferruginea*. Individuals of *M. xanthomelas* were observed along the back edge of Kaluaapuhi Pond, in the nearby mangroves along a flooded trail, and emerging as teneral from small water pockets at the base of an isolated *Schoenoplectus* clump. Measured salinities in Kaluaapuhi Pond varied from 2 ppt at a small spring inflow to 3 ppt in middle of the pond away from this inlet. Stearns & Macdonald (1947) noted that the entire basal lens underlying west and central Molokai is brackish, thus all basal springs in this area are saline to some degree. The fact that *M. xanthomelas* is breeding in the Palaau wetland, which is supplied by such brackish springs, clearly indicates that the species can tolerate salt concentrations of at least 2 ppt.

This conclusion was reinforced by the discovery of *M. xanthomelas* at a small pond adjacent to the Molokai Sea Farms aquaculture facility at western end of the Palaau wetland complex. This pond occupied an elongate, steep sided basin bordered by pickleweed (*Batis maritima*) and other introduced weeds. The waters of the pond were heavily covered with a layer of duckweed (*Lemna aequinoctialis*), which was maintained by the aquaculture farm as a means of deterring algal growth. The steep sides and elongate form of the basin suggest that it is an artificial modification of a former spring outflow.

Megalagrion xanthomelas was present at this small pond, in association with the same damselfly and dragonfly species seen at Kaluaapuhi pond, but did not occur at the adjacent aquaculture ponds, which lacked floating or marginal vegetation. Individual males were seen perching on sticks and weeds that projected over the water, and a tandem pair was observed ovipositing on the thick duckweed mat. The salinity of the water in this pond was taken and found to be 2 ppt, the same as that of the springs at Kaluaapuhi Pond

(the water chemistry of these sites is summarized in Table 1). This once again clearly demonstrates that *M. xanthomelas* can breed in mildly saline waters.

Kauhako Lake

A single immature specimen of *M. xanthomelas* (which was reared to adulthood at BPBM to confirm its identity) was taken by Dr. Robert Kinzie of the University of Hawaii in late March 1995 along the margins of Kauhako Lake, lying in Puu Uao crater on the Kalaupapa Peninsula of northern Molokai. The salinity of the lake is 15 ppt (R. Kinzie, pers. comm.), although freshwater inflows presumably enter at certain points due to percolation through the volcanic cone, creating a system reminiscent of a very large anchialine pool. The lake is over 250 m deep (Maciolek 1982), and its steep, rocky margins lack emergent aquatic vegetation, although they are heavily shaded in some areas by overhanging tree limbs. No adults were seen at the time the immature was collected.

Table 1: Summary of water chemistry and other physical data for sampling sites on Molokai

Site	Soil pH (2/site)	Water pH (2/site)	Air Temp. (°C)	Soil Temp. (°C)	Water Temp. (°C)	Salinity (ppt)
Palaau:						
Kaluaapuhi	— —	7.2 ¹ 7.2 ¹	—	—	24.5	2.0 ¹
		7.1 ² 7.1 ²				3.0 ²
Palaau:						
Molokai Sea Farms Pond	— —	6.6 6.6	—	—	31.0	2.0
Pelekunu Val. breeding site	— —	8.2 8.3	—	—	23.0	0.0

¹ inlet; ² boat

The distributions of the Molokai populations discussed above are summarized in Figure 2.

Lanai

Koele Lodge

One of the largest populations of *Megalagrion xanthomelas* outside of Hawaii island occurs in a set of ornamental streams and pools at the Koele Lodge on upland Lanai. These habitats, lying at 580 m above sea level, are also the highest elevations from which the species has been recorded in this century. The existence of this population remained undetected until 1993, although the species presumably occupied the ranch pond that was constructed at this site in the late 1800s. The fact that *M. xanthomelas* has been able to colonize an artificial habitat that was constructed within the last 5 years with no consideration to damselflies whatsoever had an important bearing on the situation at TAMC, since it indicated that construction of similar habitats at TAMC might be sufficient to mit-

igate the present threats to the species at this latter site.

The resort complex at Koele, consisting of The Lodge at Koele and The Experience at Koele golf course (referred to subsequently as the Koele Lodge) was constructed in 1990 on the site on the former Koele ranch, at an elevation of 580 m. The development includes ten separate aquatic features, including a large reflecting pool and ornamental stream complex behind the lodge building itself, a putting course nearby with several small ornamental streams, and 8 large ponds scattered around the golf course to serve as water hazards. All of these individual habitats were surveyed, and their water chemistries are summarized in Table 2. For purposes of this study the reflecting pool and inflow stream behind the lodge building were treated as a single aquatic feature, as were the two large ponds at Holes 8 and 9 that are connected by a cascading ornamental stream. Several of these water features are also fed by shared recirculating water systems. Most notable among these are the ponds at Holes 4 and 18, which are widely separated topographically and elevationally (Hole 4 lies at 610 m, Hole 18 at 580 m), but connected hydraulically. Such connections would allow potential transfer of *M. xanthomelas* eggs and immatures from one site to the other. All the water features on the golf course are internally recirculating with the exception of the pond at Hole 17. The pond and streams behind the lodge, Holes 4, 8–9, and 18, and the putting green streams occupy sheltered locations at the base of Lanaihale mountain and are surrounded by tall stands of *Araucaria* and other introduced trees. By contrast, the ponds at Holes 12, 15, 16 and 17 are more exposed to the wind and lack shelter from either topography or trees.

The large pond and its associated inflow streams behind the lodge building, referred to subsequently as the Lodge Pond, has a capacity of 3.5 million gallons, and is not currently subjected to any water treatment protocol. The pond is equipped with a downflow biofilter system, but this has never been used in the 6 years since its emplacement due to technical problems. A high rate sand filter is also installed, but like the biofilter is not currently in use. Instead, occasional treatments of potassium permanganate at 5 ppm concentrations are applied to retard the growth of algae. The pond occupies the site of a previous storage reservoir used by the former Koele Ranch to water cattle, indicating that an artificial aquatic feature has been continuously present at this site for over a century.

The recirculating inflow stream feeding the Lodge Pond originates in a small lily pond upslope from the lodge. This pond occupies a roughly circular basin approximately 4.5 m in diameter and 1 m deep. The surface is covered with numerous floating lily pads, and the western margins are composed of set rock walls bearing a growth of ferns, whose roots hang into the water. This pond previously received applications of Aqua Shade to retard algal growth, but this practice has been discontinued for the last 2.5 years.

The several small streams present on the putting green, immediately east of the lodge building, are swift and unshaded, originating in small ponds lined with ornamental rock walls. They are lined by plantings of exotic flowering plants, and receive an application of Aqua Shade once a month to eliminate algae.

None of the other water features on the golf course are currently subjected to filtration or chemical treatments. Carp were present in the Lodge Pond and at Hole 12, guppies were seen at Holes 12 and 15, and apple snails were present at Hole 15. Apart from this, and the exotic Odonata noted in Table 3, the water features at Koele Lodge seem to be relatively free of introduced aquatic biota.

Table 2. Summary of water chemistry and other physical data for sampling sites on Lanai.

Site	Soil pH (2/site)		Water pH (2/site)		Air Temp. (°C)	Soil Temp. (°C)	Water Temp. (°C)	Salinity (ppt)
Lodge pond	—	—	8.6	8.6	19.1	19.0	21.6	0
Lodge pond	—	—	9.3	9.4	20.3	19.5	20.7	0
Putting course	—	—	9.1	9.1	20.9	19.0	21.9	0
Hole 12			8.8	8.9	18.5	19.0	20.1	0
Hole 15			9.8	9.9	18.7	20.0	20.3	0
Hole 16			9.0	9.1	18.1	19.0	20.0	0
Hole 17			9.1	9.2	17.4	19.5	20.4	0
Maunalei Gulch			8.0	8.1	22.5	21.0	24.5	0

Table 3. Distribution of Odonata at sampling sites on Lanai.

Taxon	Locality									
	LG	PC	4	8-9	12	15	16	17	18	WW
<i>M. xantho</i>	x	x	x	x	-	-	-	x	x	-
<i>E. civile</i>	x	x	x	x	x	x	x	x	x	x
<i>I. ramburii</i>	-	-	-	-	x	-	-	x	-	x
<i>A. junius</i>	x	x	-	-	x	x	x	x	x	x
<i>O. ferru</i>	x	-	x	x	x	-	-	x	-	-
<i>P. flaves</i>	x	-	x	x	x	x	x	x	-	-

Explanation of locality codes:

LG = Lodge reflecting pond; PC = putting course, 4 = 4th hole, 8-9 = 8th and 9th holes; 12 = 12th hole; 15 = 15th hole; 16 = 16th hole; 17 = 17th hole; 18 = 18th hole; WW = wastewater treatment plant.

Explanation of taxon codes:

M. xantho = *Megalagrion xanthomelas*; *E. civile* = *Enallagma civile*; *I. ramburii* = *Ischnura ramburii*; *A. junius* = *Anax junius*; *O. ferru* = *Orthemis ferruginea*; *P. flaves* = *Pantala flavescens*

Populations of *M. xanthomelas* were found at the Lodge Pond and its inflow streams, Holes 4, 8, 9, 17, and 18, and at the small streams on the putting course, but the species was absent at the ponds adjoining Holes 12, 15, and 16 (see Table 3). It was evident that the insects preferred the more sheltered sites, an observation congruent with that made at Ninole Springs in Kau (see following section). Numerous other Odonata were also found in these artificial systems, including the introduced damselflies *Enallagma civile* and *Ischnura ramburii*, and the dragonflies *Anax junius*, *Pantala flavescens* and *Orthemis ferruginea*. No clear correlation was evident between the presence of any of these other species at a site and the absence of *M. xanthomelas*, indicating that competitive interactions are not structuring the Odonata guilds in this system.

Detailed observations were made regarding *M. xanthomelas* behavior at several of the Koele sites. The most robust population appeared to be in the lily pond at the source of the ornamental stream feeding the Lodge Pond. Females were seen ovipositing here on floating lily pads, which exhibited numerous brown oviposition scars, and immatures were taken from the submerged roots of ferns that grew on the rock wall bordering the pool. Adults were also observed emerging from their immature casings at this site. Emergence took 30–60 min, after which the insects flew away from the water to perch in sheltered spots amid vegetation, presumably to allow their cuticle to harden. By contrast, adults in later stages of maturity were active around and above the pond, with males aggressively defending territories ca. 2 m in diameter. These adults quickly ceased activity if the sunlight was interrupted by passing clouds, indicating that *M. xanthomelas*, at least at this elevation, is very photosensitive.

At the Hole 8–9 complex, tandem pairs of *M. xanthomelas* were observed ovipositing in collapsed lily stems that hung into the water, while at Hole 4 a female was observed ovipositing on algal mats in the lowermost of three inflow basins below an ornamental waterfall. The pond at this latter site had relatively open, grass-lined banks, and in this area adults were observed only in areas where small irregularities in the shore line, such as coves formed by large rocks, provided some form of shelter.

Maunalei Gulch

The population of *M. xanthomelas* currently extant at the Koele Lodge occupies artificial habitats that did not exist prior to the early 1990s. The source of the *M. xanthomelas* population that colonized this site must thus lie elsewhere. It is possible that the insects colonized the former Koele Ranch cattle pond from populations inhabiting small springs emerging at the base of Lanaihale mountain, but no such outflows are mentioned by Stearns (1940). Instead, the most logical source from which the colonists could have come is Maunalei Gulch, a deep canyon on the northern side of Lanai that previously contained the only perennial stream on the island. A survey of the upper reaches of this gulch by the author in 1993 revealed that three species of *Megalagrion* damselflies, *M. hawaiiense* (McLachlan), *M. blackburni* McLachlan and *M. calliphya* (McLachlan) still persisted in this catchment, but *M. xanthomelas* was not seen. In 1994, however, a specimen of *M. xanthomelas* was taken in dry forest near the mouth of Maunalei Gulch by Dr. Richard Baumann, a visiting entomologist from Brigham Young University. This discovery indicated that a colony of *M. xanthomelas* did indeed persist somewhere in the lower Maunalei system, and an attempt was thus made to locate it during the current investigations on Lanai.

An initial reconnaissance of the coast revealed no wetlands that might support the species. A foray was then made up the lower reaches of Maunalei Gulch, which is at this point a dry bed shaded by kiawe forest. A leak was eventually discovered in a small water pipeline at ca. 120 m above sea level, which created a limited outflow on a bench above and to the south of the gulch bed. *M. xanthomelas* was relatively abundant along this seepage, with many mating pairs present. The water at this site was found to have the following characteristics: temperature, 24.5 °C; salinity, 0.0 ppt; pH, 8.0. This habitat is extremely limited, and could easily be eliminated by repair or replacement of the currently leaking pipeline.

Lopa Fishpond

A good series of *M. xanthomelas* was taken from this remote fishpond near the eastern tip of Lanai by Steve Montgomery of the Bishop Museum in August 1994. Montgomery (pers. comm.) reports that the fishpond was filled with mangroves, and that the damselflies were taken along its inland margin in an area where deer were coming down to water. These observations, coupled with the presence of *M. xanthomelas*, indicate that a permanent mixohaline aquatic habitat exists at this site, probably due to weak basal spring percolation into the fishpond basin.

Keomoku

A tandem pair of *M. xanthomelas* was taken by Montgomery at this site on the same day as the specimens from Lopa were captured. The distance between these localities is over three miles, indicating the presence of two separate populations. The only water source at Keomoku is a covered well (Montgomery, pers. comm.), which seems an unlikely breeding habitat for *M. xanthomelas*, although its plumbing system may be providing artificial habitat in a manner similar to the leaking pipeline in Maunalei Gulch. It seems more likely, however, that the species is breeding in small pockets of fresh or brackish water present somewhere in the general area surrounding Keomoku. The water table along the section of the coast between Lopa and the mouth of Maunalei Gulch lies only a few meters above sea level, and in certain areas fresh water can be seen running into the sea at low tide (Stearns, 1940). Some of this water may be collecting in small natural depressions, or in the remnants of trench wells dug by settlers, and thus providing habitat for *M. xanthomelas*.

The distributions of the Lanai populations discussed above are summarized in Fig. 3.

Maui

The only specimens of *M. xanthomelas* known from Maui are four individuals in the BPBM by R.C.L. Perkins from the "West Maui Mountains" in 1894 and 1895. Perkins gave no further locality data, and one can only speculate as to the precise areas he sampled. Since Perkins' collections on West Maui during May 1894 were made entirely in the vicinity of Iao Valley, it seems likely that his specimens of *M. xanthomelas* taken in this year came from the wetlands and sand hills of the Wailuku Plain at the valley mouth, which prior to urban development in this century supported some of the most extensive sets of taro fields in Hawaii.

Another area that appears to have been capable of supporting *M. xanthomelas* was the Loko o Mokuhinia marsh at Lahaina, a basal spring wetland that was filled in for development in 1913. Pictures of Loko o Mokuhinia taken in the mid-1890's (the period when Perkins' collections were made) show a pond with floating vegetation and emergent bulrushes, similar to coastal habitats on Hawaii island in which *M. xanthomelas* breeds at the present time (Klieger *et al.*, 1995).

Recent surveys on Maui have found no evidence of *M. xanthomelas* populations, even at potentially suitable sites such as the coastal Kealia and Kenaha ponds. A complete circuit of the West Maui coastal lowlands was conducted in mid-1995, but failed to uncover any remaining populations, although potential habitat was available at the mouths of Makamakaole, Kahakuloa and Honokohau streams. Surveys of coastal wetlands on leeward Haleakala and at various stream mouths along the Hana Coast have been similarly

unsuccessful. Based on these results, it seems possible that *M. xanthomelas* may have been locally extirpated on Maui.

Hawaii (Big Island)

Ninole Springs

Scattered populations of *M. xanthomelas* are known from coastal wetlands in Puna, Kau and North Kona on Big Island, where limnetic groundwater percolates seaward and mixes with the inland percolating marine water table to form horizontally stratified mixohaline systems. The largest of these coastal *M. xanthomelas* populations is found in a set of limnocrenes, rheocrenes, and mixohaline marshes located at Ninole, Kau, where downslope subsurface percolation from the Ninole Hill drainages emerges just above sea level at the mouth of Ninole Stream. This is the second largest basal spring complex on the island of Hawaii (the largest being Waiakea Pond at Hilo), discharging over 20 million gallons per day in 1946 (Stearns & Macdonald, 1946), although this flow may have been subsequently modified by withdrawals from wells to irrigate sugar cane fields upslope. The water originates from lava tubes in the Kau volcanic series, and represents the subterranean outflow from ancient valleys in the nearby Ninole Hills that were filled by subsequent eruptions from Mauna Loa. Due to its origination in catchments upslope the water is quite cold, with an emergent temperature of 19 °C. This groundwater surfaces along the inland sides of coastal lava basins that have some degree of connection to the sea, creating horizontally stratified mixohaline systems with a zone of freshwater marsh along their inner margins. Similar basal spring wetlands are found at several other points along the Kau coast, including Punaluu, the mouth of Hilea Stream at Hawa Bay, Hawa Springs, and Whittington Beach Park.

The Ninole Spring wetland complex contains an extensive set of limnetic to mixohaline marshes, ponds and creeks lying at the stream mouth and in the area directly to the east, between the Sea Mountain golf course parking lot and the lava coastline. Numerous cold freshwater springs emerge just inland of the coast at the base of an a'a flow, some flowing directly into tidepools, others feeding large ponds and sloughs. One large pond with thick beds of watercress along its margins occupies a lava basin immediately east of the stream mouth, and is separated from the sea by a wall of lava ca. 3 m high, which large waves occasionally overtop. A second, even larger pond lies further to the east, in a basin just above sea level, and enters the ocean via a swift freshwater creek ca. 1 m wide and 15 cm deep. The inland margins of both these ponds grade into marshes dominated by bulrushes (*Schoenoplectus* sp.) and *honohono*; similar marshes are also present in the area between the ponds, in association with smaller spring outflows. The eastern pond also contains water hyacinth (*Eichornia crassipes*) along its inland margin.

Surveys undertaken during early May 1994 found *Megalagrion xanthomelas* to be abundant at Ninole Springs, breeding in all suitable habitats. Numerous mating pairs were observed, and many newly emerged adults were seen along the margins of the westernmost pond. A mating pair was also captured above the standing pool formed behind the cobble bar at the mouth of the stream itself. In addition, the introduced damselflies *Enallagma civile* and *Ichnura ramburi* were present along the margins of the eastern pond, especially in seaward areas exposed to the wind, but *M. xanthomelas* was clearly the dominant damselfly species across the entire Ninole system. In general the introduced damselflies seemed more abundant in open areas, while *M. xanthomelas* flew amid the

shelter of vegetation along the slough channels, which were difficult to investigate, being heavily vegetated and often over 1 m in depth. The large dragonflies *Anax junius* and *Pantala flavescens* were also seen throughout the Ninole area.

The salinity of the aquatic features at Ninole Springs varied from limnetic (less than 0.7 ppt) at the outflows to fully euhaline (at least 30 ppt) at the shore, with all degrees of intermediate salinity encountered throughout the ponds and marshes. It is clear from other investigations on Molokai (see previous section) that *M. xanthomelas* can tolerate salinities of at least 2 ppt, thus it is able to breed along much of the inland margin of the Ninole wetland system.

The estuarine marshes and limnocrenes at Ninole Springs and other coastal wetlands in Kau provide extensive breeding habitats for *M. xanthomelas* that are not currently duplicated on the other high islands, although similar systems may once have existed at Pearl Harbor on Oahu prior to its urban development. Throughout such coastal situations, both here and in North Kona, *M. xanthomelas* is typically found in company with the alien *Ischnura ramburi* and *Enallagma civile*, but the competitive interactions among these species, if any, do not seem to preclude the continued presence of *M. xanthomelas* at these sites.

Hilea

A coastal wetland similar in form and origin to that seen at Ninole but of smaller extent occurs at the mouth of Hilea Stream, approximately one mile to the southwest on the opposite (western) side of an intervening lava flow. The habitat consists of several elements, beginning with a long, deep mixohaline pool at the mouth of the stream channel, which runs parallel to the base of the lava flow. This pool is separated from the sea by a cobble bar that is occasionally overtopped by high swells, and experiences a weak tidal flux. No damselflies were seen along this pool. West of the stream mouth are several small limnetic ponds bordered with sedges, grasses, and *honohono*; these ponds supported *Megalagrion xanthomelas*, *Enallagma civile*, *Ischnura ramburi*, *Anax junius*, *Pantala flavescens*, and *Tramea lacerata*. Even further to the west is a large basin, connecting directly to the sea via a narrow mouth, but with a zone of bulrushes at the back, bordered even further inland by an extensive, apparently limnetic marsh thickly overgrown with tall grasses. No damselflies were seen at this latter basin, but it seems likely that *M. xanthomelas* may occur in the marsh.

When this site was visited on 4 June 1994, water was being pumped from the western marsh by squatters, who were using it to irrigate small taro fields. One of these squatters claimed that the mouth of Hilea Gulch previously consisted of a large, swampy estuary, but that a major flood 4 or 5 years earlier had washed in a large amount of sediment, producing the current configuration.

Hawa Springs

This habitat consists of a small limnetic spring outflow emerging at the base of an eroded lava flow, and flowing into a linked series of progressively more saline ponds scattered along a sinuate depression behind the shoreline. The overall impression is one of an interrupted tidal creek, bordered by grasses and sedges. During a survey on 4 June 1994 the limnetic pools near the head of this system supported populations of *Megalagrion xanthomelas* and *Anax junius*; no introduced damselflies were seen. The area appears to be in a relatively natural condition, and does not appear to be frequently visited.

Whittington Beach Park

A single large pond behind the shoreline at Whittington Beach Park receives limnetic inflow along its inland margin, while connecting to the sea via a narrow mouth along the ocean side. A mixohaline gradient appears to exist across the width of this pond, with the seaward portion being essentially euhaline, but changing to mixohaline as one progresses inland. The basin here is similar in extent to the large eastern pond at Ninole, but is not raised above sea level as in the former case. The back margin of the Whittington pond is bordered with low grasses and bulrushes, indicating that a narrow freshwater zone exists as a result of limnetic downslope percolation into the basin. *Megalagrion xanthomelas* was found here on 4 June 1994, with adults flying low amid the shelter of the vegetation along the back edge of the pond. No individuals were seen along the front edge of the pond nearer to the sea. Cattle have disturbed this system, but do not appear to pose a threat to the long term stability of the marsh.

Kaloko Fishpond

A large fishpond and many other smaller anchialine pools are found in this area. David Foote of the National Biological Service, Hawaii Volcanoes National Park, has taken numerous specimens of *M. xanthomelas* from this site and documented their occurrence in the various habitats present.

Kiholo Bay

A complex of wetlands containing numerous anchialine ponds and pools occurs along the margins of Kiholo Bay. Access is difficult due to private ownership, and the area remains poorly surveyed. During the present study it was possible to walk down the shore along the northern end of the bay and sample a large, apparently mixohaline pond that lay immediately behind the beach ridge. One specimen of *Megalagrion xanthomelas* was taken here, in company with *Ischnura ramburii*, which was abundant.

Anaehoomalu Bay

One of the most extensive sets of anchialine pools known on the North Kona coast formerly occurred along the northern margin of Anaehoomalu Bay, at a site now occupied by the Waikoloa resort. These pools were bulldozed in the course of resort development, but similar systems, though smaller in extent, still exist along the southern margin of the bay, in a complex owned by Parker Ranch and known as the "Parker Ponds". In this area the shore forms a high dune ridge, behind which lie a series of depressions, marked by palms, containing mixohaline marshes and bordered by low, halophytic vegetation, predominantly pickleweed (*Batis maritima*). A specimen of *M. xanthomelas* was taken along the margin of one of these basins on 7 June 1994, in company with the introduced *Ischnura ramburi*, which was abundant. Although the salinity of these marshes was not ascertained, females of *Anax junius* were seen ovipositing in them, indicating that in at least some sections it must be quite low.

Beyond the marshy basins to the southwest lies a set of rock rimmed anchialine pools, some forming large ponds with bulrushes along their margins. No damselflies were seen in this area, but two dragonfly species, *Anax junius* and *Tramea lacerata*, were observed. The overall Parker Pond system is relatively undisturbed, and further surveys in the area would be useful in order to localize the sources of limnetic inflow, around which

M. xanthomelas would be likely to congregate. The area has recently been sold by the Parker Ranch, but alteration of the pools and marshes should be discouraged if possible, since they represent the last remaining undisturbed portion of the formerly extensive Anaehoomalu anchialine pool complex, which was described in detail by Maciolek & Brock (1974).

The large Kuualii and Kahapapa fishponds at the Waikoloa resort were also surveyed, along with a complex of smaller adjacent anchialine pools containing red shrimps. All these habitats proved either too saline or too ecologically altered to support damselfly populations, and a search for further, more limnetic habitats in the general area was unsuccessful. A few *Anax junius* and *Pantala flavescens* were observed, but these may have been strays from populations breeding in nearby golf course ponds. An extensive set of anchialine pools formerly occurred to the north of this site, near Waiulua Bay (Maciolek and Brock, 1974), but these were destroyed in the course of resort development and no longer exist.

Leleiwī Point

A population of *M. xanthomelas* was found breeding in an anchialine pool system at Leleiwī Point by David Foote when he surveyed the area on 20 March 1995. Foote reports that the site consists of a large anchialine pond with a lava rubble and coral sand bottom. The submerged rocks are covered by a layer of light brown algal growth, and the pond margins are set with a dense growth of California grass (*Bracharia mutica*) that form floating mats in several places. A small patch of *Wedelia trilobata* also occurs along the shore in an area shaded by hau (*Hibiscus tiliaceus*). Water conductivity ranged from 4.86–6.52 mS, and the water temperature averaged 19 °C, indicating the pond is fed by a basal spring. Males of *M. xanthomelas* were observed along the pond margins, along with 1 tandem pair. Other Odonata at this site included the introduced damselflies *Enallagma civile* and *Ischnura ramburii*, and the dragonfly *Anax junius*.

The pond at Leleiwī is part of a very large system of anchialine pools and estuarine limnocrenes that extends from this point westward along the coast to Hilo, and includes Waiakea Pond, the largest basal spring in Hawaii. Individuals of *M. xanthomelas* were observed at Liliuokalani Park within Hilo itself in October 1995, and historical collections are present from Coconut Island immediately offshore, suggesting a long-standing population of *M. xanthomelas* in this area.

Onomea Stream

This is a relatively short catchment heading at approximately 275 m elevation and flowing for 3 km to a seaward terminus in Onomea Bay, north of Hilo. The stream exhibits a steep profile typical of drainages on the Hamakua Coast, descending stair-step fashion via waterfalls in a bed of hard basalt. The seaward terminus, lying within the Hawaii Botanical Garden, consists of a long, flowing freshwater pool impounded behind a cinder beach, with a waterfall at its head. Progressing upstream one encounters a series of falls and plunge pools heavily shaded by introduced figs, palms and bamboo, until the bridge on the Pepeekeo Scenic Drive is reached. Immediately above this road crossing the stream is less confined, and forms long, partially shaded flowing pools, which continue to the base of another high waterfall.

The terminal reach and lower midreach of this system both up and downstream of

the Pepeekeo Scenic Drive were surveyed on 8 June 1995. *Megalagrion xanthomelas* and *M. hawaiiense* were found along the pooled midreach section of the stream at 55 m elevation, just upstream from the road, but no damselflies were seen along the terminal reach in the botanical garden. Individuals of *M. xanthomelas* were observed perching on low ferns, dead palm fronds, and bare rocks along the channel margins. Immatures were not found, but are likely to inhabit the trailing submerged root mats that are well developed here.

Alakahi Stream

This is a short, steep catchment approximately 2 km long, heading at about 230 m elevation and terminating in Onomea Bay adjacent to Onomea Stream. The stream presents a steep profile, descending through a bed of mossy boulders, heavily shaded by a forest of introduced trees. The terminal reach and lower midreach of this system upstream of the Pepeekeo Scenic Drive were surveyed on 8 June 1995. *Megalagrion xanthomelas* and *M. blackburni* were found between 55 and 75 m elevation, up to a point where hau (*Hibiscus tiliaceus*) begins to heavily overtop the stream; the former species was found even in areas of dense shade, an unusual habitat preference (see comments under sections on Lanai and Molokai). No damselflies were seen along the lower section of the stream below the road, in the area where it passes through the Hawaii Botanic Garden, despite the presence of suitable habitat, including a large ornamental pond adjacent to the stream itself.

Kawainui Stream

This is a large volume catchment that flows through a steeply dropping basalt bed and reaches the sea in an incised fjord south of Pepeekeo. At 60 m elevation the stream flows through a natural archway formed by an old lava tube. The lower midreach of this system immediately downstream of the Pepeekeo Scenic Drive was surveyed on 8 June 1995. *Megalagrion xanthomelas* adults and immatures were taken at small side pools in bedrock adjacent to the main channel, and bordered by clumps of yellow flowering *Wedelia trilobata*. Other adults were taken next to seepage fed pools on bedrock shelves along the south bank of the stream immediately across from these side pools. Heavy rains several days later caused the stream to rise appreciably, completely covering the side pool habitats with swiftly flowing water (although the seeps were not affected). It thus appears that at this site *M. xanthomelas* is exploiting temporary habitats on an opportunistic basis.

This and other *M. xanthomelas* populations found along drainages entering Onomea Bay probably represent a northward extension of the populations centered around the estuarine limnocrenes at Hilo. To date *M. xanthomelas* has not been found to the north along the Hamakua Coast past Pepeekeo Point, despite surveys at suitable stream mouths between there and Honokaa. Most of the streams in the Hamakua area end in terminal falls, and of those few that do not the following have been surveyed: Kolekole, Hakalau, Honolii, and Laupahoehoe. Several others, such as Maulua and Nanue, still await surveys, but it is considered unlikely that they harbor *M. xanthomelas* populations based on current findings.

Kapoho

An extensive series of anchialine and mixohaline wetlands fed by basal springs is found along the shoreline to the east of Kapoho Crater, in Puna, developed amid a series of recent lava flows that have been subject to coastal subsidence. Searches were made along the seaward edge of this system between 8 and 9 June 1995, both north and south of Kapoho Point. *Megalagrion xanthomelas* was found in the former area, which is being developed into residential subdivisions, with adults patrolling along the margins of moderately saline (8.0–8.5 ppt) pools. Current USGS maps do not correctly reflect the coastline profile and adjacent wetlands in this area, since extensive subsidence took place after their last update in 1981.

The interior of nearby Kapoho Crater contains a water filled basin known as Green Lake, which has no outlet and appears to be fed by seepage from the surrounding crater walls. This lake, which is essentially circular and ca. 100 m across, has silty, greenish waters with a temperature of 27 °C, and supports an overwhelmingly alien aquatic biota including frogs, topminnows, and numerous introduced aquatic plants. The shores are thickly lined with bamboo, kukui, breadfruit, mango and other exotic vegetation. Two males of *M. xanthomelas* from this locality, taken by F.X. Williams in 1936, are present in the collection of the Hawaii State Department of Agriculture. A survey of the lake and its surroundings in good weather failed to detect any sign of this species, although the introduced damselflies *Ischnura ramburii* and *Enallagma civile* were abundant, in company with the dragonflies *Anax junius* and *Pantala flavescens*. It is assumed that the introduction of alien fishes and frogs at Green Lake has led to the extirpation of this population of *M. xanthomelas*.

The distributions of the Hawaii populations discussed above are summarized in Figure 4.

Summary

The present surveys of *M. xanthomelas* demonstrate that the species occupies a wide range of habitats and has broad ecological tolerances. The most common habitats in which this species occurs are coastal wetlands fed by basal springs, as seen in the Puna, Kau and North Kona districts of Hawaii, at Palaau on Molokai, and formerly at Pearl Harbor on Oahu. This species also occasionally breeds along the terminal and lower midreaches of perennial streams, as illustrated by the populations at Pelekunu and Waikolu streams on Molokai, and at Onomea Bay on Hawaii island. Given the absence of introduced aquatic biota, *M. xanthomelas* can also breed in reservoirs and ornamental ponds, as recorded previously by Williams (1936), and currently documented at the Koele Lodge on Lanai. The species will also opportunistically exploit temporary habitats, as shown by its occupation of ephemeral side pools bordering flashy streams on Hawaii island, and pipeline seepages on Lanai.

Although *M. xanthomelas* has a recorded elevational range of 0–1000 m above sea level (Perkins, 1899), it is generally a lowland species, with most of the known populations now occurring below 60 m, and the highest recent records coming from 610 m, in artificial settings on Lanai. Results from salinity readings taken at Palaau, Molokai demonstrate that the species can tolerate salt concentrations of at least 2 ppt, and circumstantial evidence from habitats in Puna and North Kona indicates that the tolerance may be as high as 8 ppt. Based on results from Lanai the species also does not seem to be

adversely affected by commercial anti-algal treatments such as AquaShade and copper sulphate, which are commonly used in hotel and golf course water features. The species was found breeding in habitats with water temperatures ranging from 20–31 °C, and with pHs ranging from 6.6–9.2.

In terms of interactions with alien aquatic species, *M. xanthomelas* seems to be able to tolerate the presence of carp and apple snails, but does not do well in habitats containing guppies or top minnows. There is no indication of adverse competitive interactions between *M. xanthomelas* and the widespread introduced damselflies *Ischnura ramburii*, *Ischnura posita*, and *Enallagma civile*, with which it frequently co-occurs.

Despite its broad range of ecological tolerances, *M. xanthomelas* is becoming increasingly rare in Hawaii, having apparently been extirpated from two islands, Kauai and Maui, on which it previously occurred, while being perilously close to extirpation on Oahu. Based on our current understanding of the species' biology, this loss of *M. xanthomelas* populations is linked more to the introduction of alien aquatic biota than to outright habitat alteration or destruction. On one hand this is a source of optimism, since this pattern of decline can perhaps be stabilized through protection of remaining natural habitats or construction of suitable refugia. On the other hand, it is also a source of pessimism, since the continuing onslaught of alien aquatic species in Hawaii shows no signs of abatement (Eldredge 1994).

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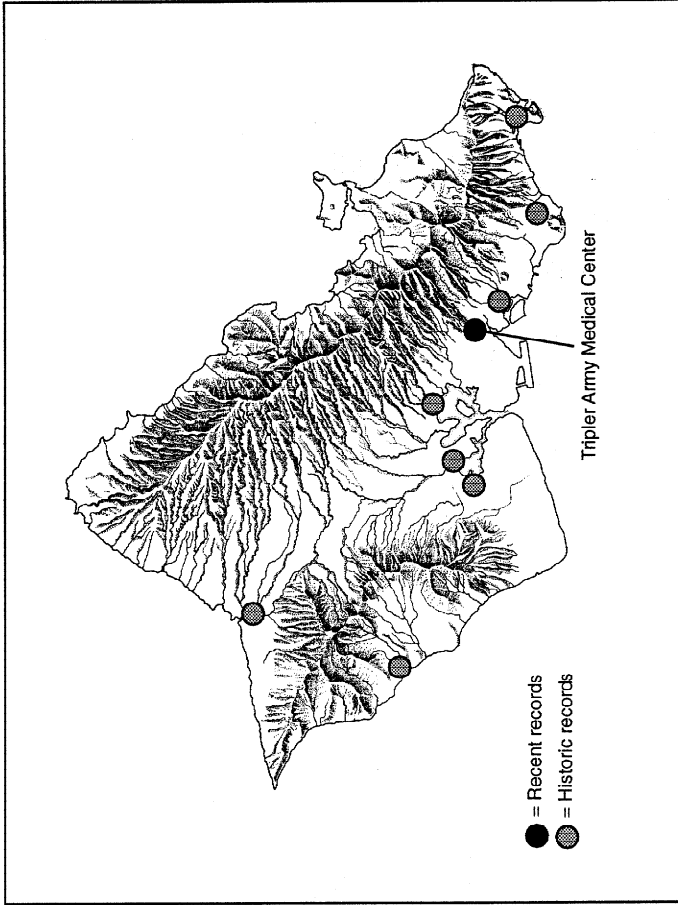


Fig. 1. Map of Oahu, showing locations of current and historic records for *Megalagrion xanthomelas*.

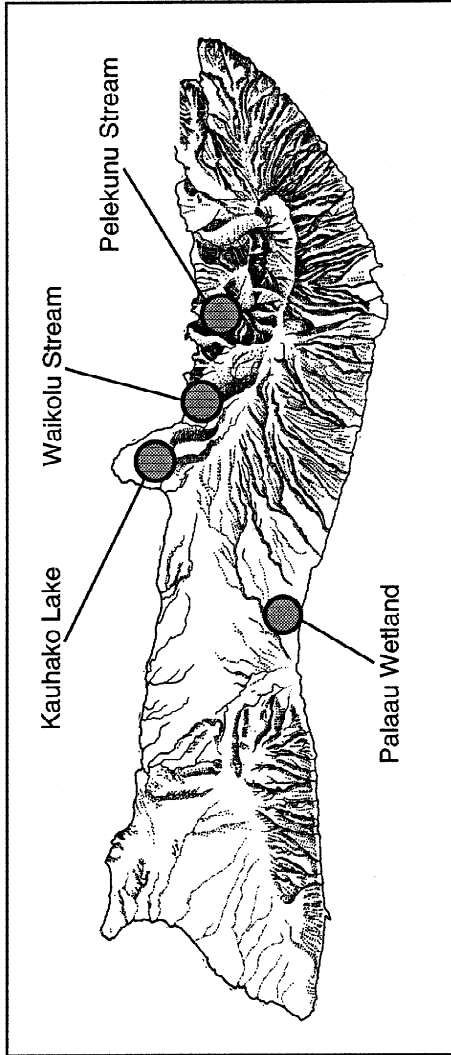


Fig. 2. Map of Molokai, showing currently known populations of *Megalagrion xanthomelas*.

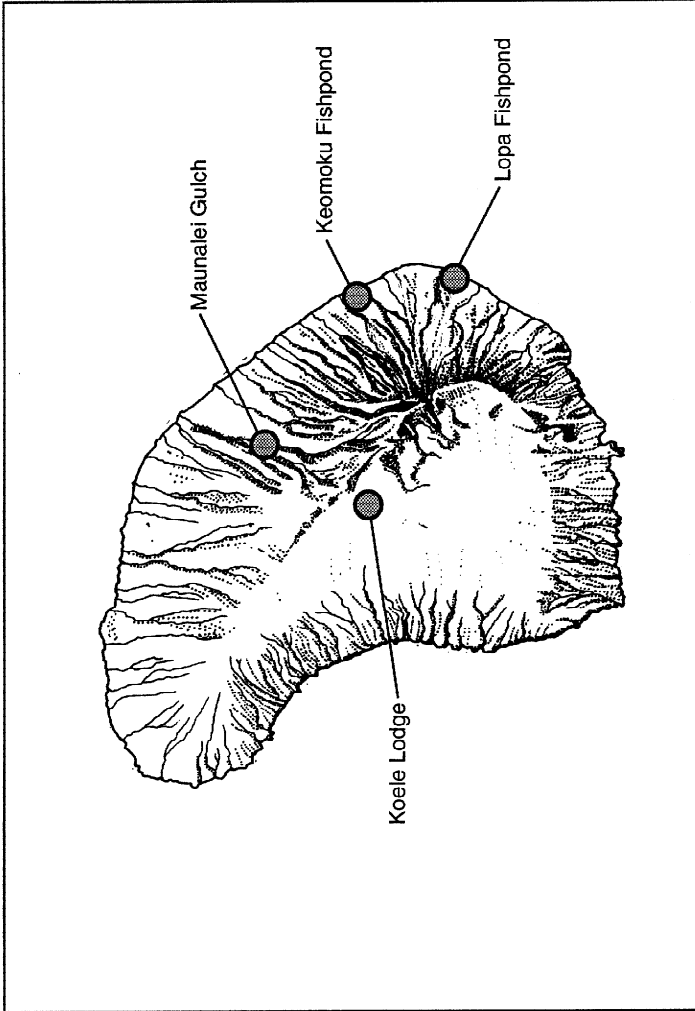


Fig. 3. Map of Lanai, showing locations of current and historic records for *Megalagrion xanthomelas*.

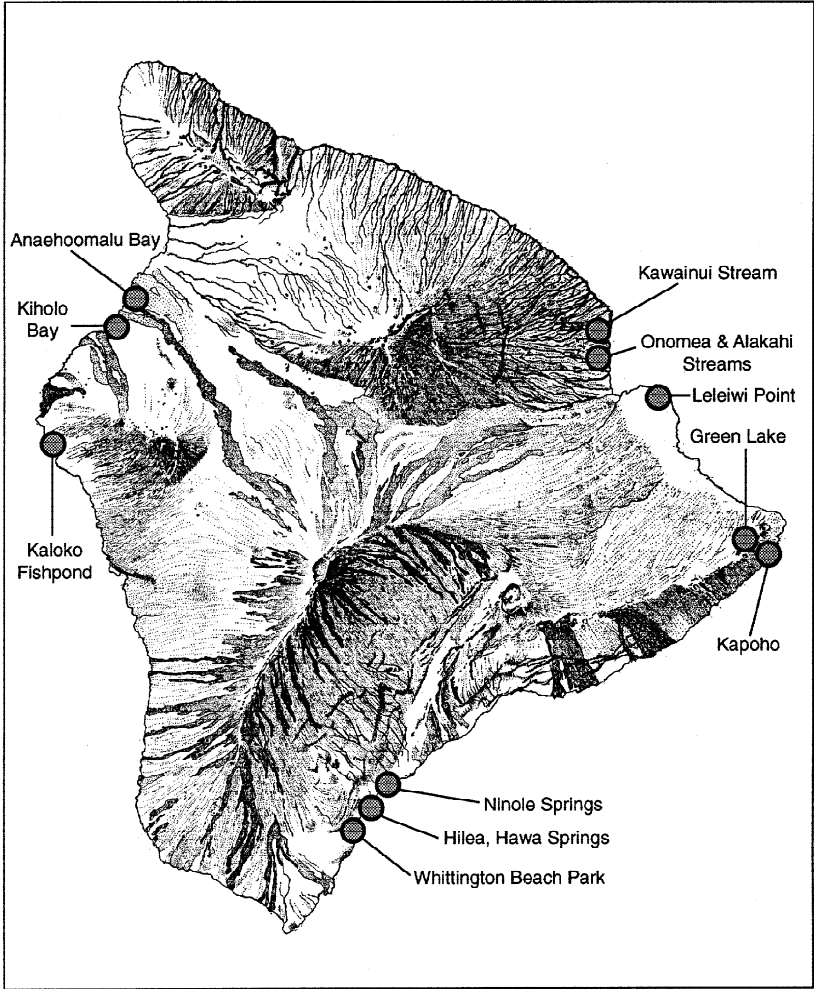


Fig. 4. Map of Hawaii Island (Big Island), showing known populations of *Megalagrion xanthomelas*.

New species of *Campsicnemus* from the Waianae Range of Oahu, Hawaii (Diptera: Dolichopodidae)¹

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Collections by the Hawaii Biological Survey in the Waianae mountain range of Oahu, Hawaii in the last few years resulted in the discovery of 2 new species of *Campsicnemus* Haliday. Their description is given here to aid in their identification and to allow names to be used in future studies.

Materials and Methods

Diagnosis of and key characters in *Campsicnemus* are based almost entirely on the male. Females are, for the most part, fairly indistinguishable from each other and can only be accurately assigned to species on the basis of association with males.

Descriptive morphological terminology and associated abbreviations used here follow Bickel (1991) and McAlpine (1981).

Specimens examined are deposited in the Bishop Museum (BPBM).

Abbreviations used: I, II, III = fore, mid, and hind leg; C = coxa; F = femur; T = tibia; MSSC = male secondary sexual characters; *ac* = acrostichal setae; *dc* = dorsocentral setae; *hm* = postpronotal setae; *np* = notopleural setae; *oc* = ocellar setae; *pa* = post alar setae; *ph* = posthumeral setae; *sc* = scutellar setae; t = tarsus; t1–5 = tarsomeres 1 to 5; *vt* = vertical setae.

Systematics

Campsicnemus charliechaplini Evenhuis, new species

Fig. 1

Diagnosis. Keys to couplet 6 using the key to species in Tenorio (1969), but is stymied there not fitting either *C. williamsi* Van Duzee or *C. invaginatus* Tenorio. The striking FII modification is somewhat similar to that found in its Koolau mountain counterpart, *C. brevipes* Van Duzee, but *C. charliechaplini*, n. sp. can be easily separated from it by the much more modified ventral swelling, the presence of a peg-like protuberance, and the prominent silvery white tuft of setae subbasally on that femur, by the longer II t1, and by lack of greenish hues in the body color.

Male. Body length: 2.04–2.48 mm. Wing length: 2.80–2.92 mm. *Head.* Face and clypeus brown, front and vertex brown pollinose, subshining in some portions; *oc* and *vt* black, about one-half length of antennal arista; clypeus slightly yellowish pollinose; face only slightly constricted at middle, eyes dichoptic below antennae; palp small, brown; proboscis brown to yellowish-brown, extending below eye in lateral view; antennal scape and pedicel yellowish brown, flagellomere brown; arista subequal to head height.

Thorax. Brown throughout, darker brown on dorsum of mesoscutum and scutellum, brownish pollinose admedially; thoracic setae (except *ac*) black: 4 *dc*; 2 + 1 *np*; 1 + 1 *ph*; 1 *pa*; 1 *sc*; 5–6 pale *ac*.

Legs. Fore coxae yellowish, remainder of legs brown. Leg I unmodified, without MSSC. FII (Fig. 1) with prominent subtriangular swelling ventrally, small peg-like protuberance basally, and small, flange-like flap apically, peg-like protuberance with small, fine hairs, large, dense silvery white tuft of hairs basal to triangular swelling, small, dense tuft of dark setae distal of triangular

1. Contribution No. 1996-004 to the Hawaii Biological Survey.

swelling, strong, black setae ventrally from swelling to dense patch of small dark setae (all MSSC); TII (Fig. 14) slightly wider apically than basally, with long patch of fine setae subapically; patch of strong black setae along apical one-fifth (MSSC); IIt1 (Fig. 14) subequal in length to IIt2, with minute black spatulate apical spur (MSSC); IIt2–5 unmodified. FIII with 3 black setae apicoventrally, remainder of leg III unmodified, without MSSC.

I—6.5/4.5/3.5;2.2;2.0;1.5;1.5

II—8.5/10.0/3.2;3.0;2.0;1.2;1.2

III—9.5/10.8/3.0;3.0;2.0;1.0;1.0

Wing subhyaline; halter and knob brown.

Abdomen. Dark brown with short black hairs dorsally on each tergite, a few longer hairs laterally. Hypopygium brown, not dissected.

Female. As in male except for lack of MSSC; legs normal, without modifications; antennal flagellomere slightly longer than in male.

Types. Holotype male (BPBM 15,716), from Hawaiian Islands: **Oahu:** Waianae Mts., Mt. Kaala: Upper Halenau Gulch near summit bog, 3800 ft [1190 m], 14.i.1992, N.L. Evenhuis & J.M. Cumming, taken by hand from small pool. *Paratypes:* 54, topotypic, 22.iv.1991 (D.A. Polhemus), 4.viii.1991 (D.A. Polhemus), 20.i.1992 (D.A. Polhemus), 20.ii.1993 (N.L. Evenhuis, D.A. Polhemus) (all in BPBM).

Discussion. This species is a water skater found only on the upper reaches of Halenau stream near the summit of Mt. Kaala. It is restricted to the small quiet pools along the edges of the stream away from the current. It has been observed crossing moss covered soil and rocks to move from one pool to another, but prefers to remain on the water unless disturbed. It feeds on small invertebrates in the water or that fall upon the water surface including carcasses of other *C. charliechaplini* and has even been observed at times attempting to capture other individuals of this species from behind.

Etymology: This species is named in honor of the great silent movie comedian, Charlie Chaplin, because of the curious tendency of this fly to die with its midlegs in a bandy-legged position.

***Campsicnemus halonae* Evenhuis, new species**

Figs. 2–3

Diagnosis. Keys to couplet 12 using the key to species in Tenorio (1969), but is stymied there. It is most similar to the Hawaii Island species, *C. grimshawi* Van Duzee, but is separated from it by the setation on the subbasal projection on TIII (such setation lacking *grimshawi*), the darker lower pleura (yellowish in *grimshawi*), and by the yellowish antennal segments (brown in *grimshawi*). The striking infumate spot on the wing is found elsewhere in Hawaiian species only in *fumpipennis* Parent, which has additional strong infumation along other veins and crossveins. Moreover, *C. halonae* is half the size of *C. fumpipennis* and is a dark-colored species, whereas *C. fumpipennis* is large and yellowish with brownish abdominal markings.

Male (Fig. 3). Body length: 1.68–1.76 mm. Wing length: 1.84–2.0 mm. *Head.* Black, face gray pollinose, subshining in some portions; *oc* and *vr* black, about one-half length of antennal arista; face constricted at middle, almost holoptic, eyes separated below antennae by width of 1–2 ommatidia; palp small, brown; proboscis brown, extending below eye in lateral view; antennal segments yellow; arista subequal to head height.

Thorax. Mesoscutum, scutellum, and pleura dark brown throughout; thoracic setae black: 3 + 1 *dc*; 2 *np*; 2 *ph*; 1 *pa*; 1 *sc*; *ac* absent.

Legs. CI white, smoky brownish black on basal 1/5; CII brown, slightly paler than surrounding pleura; CIII yellowish; F and Ti yellowish except as noted, remainder of legs brownish; FI with small brownish patch of color dorsally in middle; FIII with dark brown band subapically. foreleg without

MSSC; FII with long black seta on apical 1/3, 4–5 smaller black setae apically (MSSC); FIII with single strong black seta subapically; TiII (Fig. 2) with small rounded projection subbasally bearing 4–5 strong black apically curved setae (MSSC), smaller black setae and hairs along entire length, 2 strong black setae near middle and single apical black seta; remainder of mid and hind legs normal, without MSSC.

I—5.5;4.5;2.5/1.7/1.0/0.5/0.5

II—6.2;6.5;3.0/1.8/1.2/0.8/0.5

III—8.2;8.0;2.5/3.0/1.7/1.0/0.7

Wing (Fig. 3) subhyaline to pale smoky; spot of smoky black color on posterior crossvein; clear area just distal to posterior crossvein.

Abdomen. Dark brown with short black hairs dorsally on each tergite, a few longer hairs laterally; tergal interstices white. Hypopygium brown with paler brown cerci, not dissected.

Female. As in male except for lack of MSSC; legs normal, without modifications.

Types. Holotype male (BPBM 15,717) from Hawaiian Islands: **Oahu:** Waianae Mts., Lualualei Naval Magazine, Halona Valley, 450 m, 22.xi.1995, N.L. Evenhuis, yellow pans. *Paratypes:* 10 = ×, same data except, 9.v.1994 (F.G. Howarth), at light; 10, 23.v.1994 (G.M. Nishida); 1 =, 7.xii.1995 (D.J. Preston); 2 =, 3.i.1996 (D.J. Preston & G.M. Nishida), Malaise trap; 4 = ×, 1420 ft [432 m], 18–19.i.1996 (D.J. Preston & G.M. Nishida), yellow pans; 1 =, 1620 ft [493 m], 18–19.i.1996 (D.J. Preston & G.M. Nishida); 15 = ×, Palikea Peak, 3100 ft [945 m], 3.v.1995 (D.A. Polhemus), running on leaves; 8 = ×, Puu Kaua summit, 3100 ft [945 m], 4.v.1995 (D.A. Polhemus), sweeping understory (all in BPBM).

Discussion. This species has been observed running on leaves on low-growing vegetation and on leaf litter on open ground.

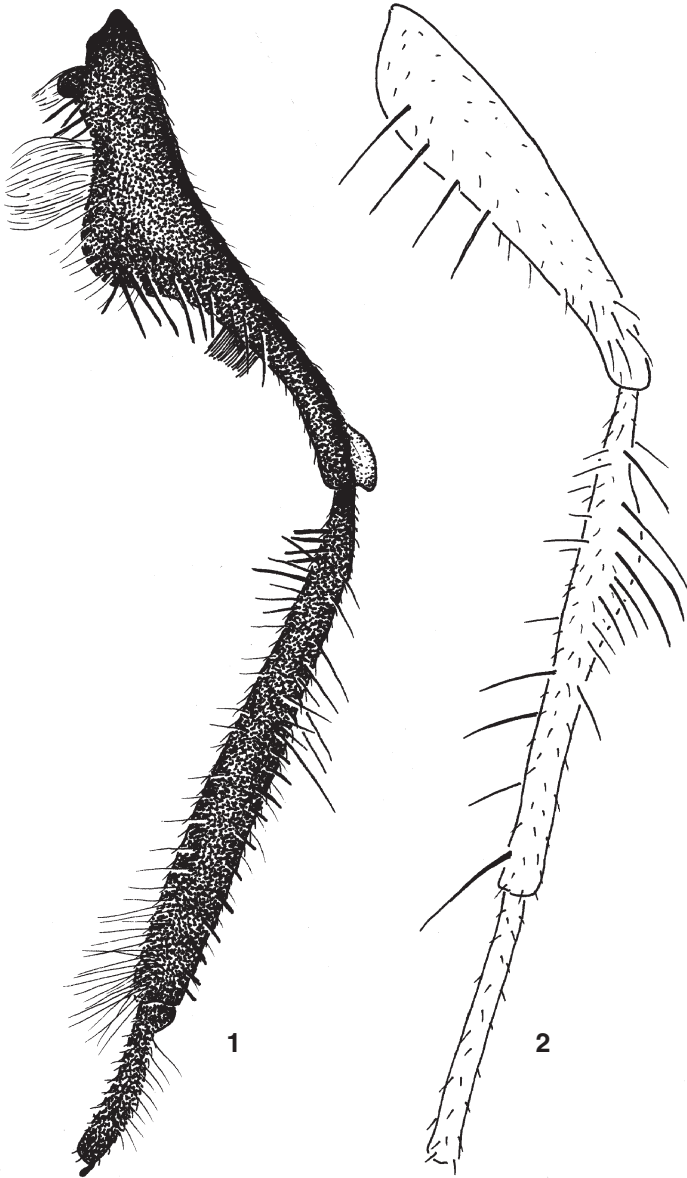
Etymology: This species is named for the Waianae Mts valley to which it is apparently endemic.

Acknowledgments

I thank the collectors listed above for making the material available for study. A portion of this work was made possible by a contract from the U.S. Navy (N00025-95-2-NP0001) to the author. The State of Hawaii Department of Land and Natural Resources, Natural Area Reserve Division, allowed access to the Mt. Kaala NAR, adjacent to which collections of *C. charliechaplini* were made. Norm Glenn and Dan Moriarty were instrumental in helping arrange permissions and access to Lualualei Naval Magazine. The Nature Conservancy of Hawaii is thanked for access to the area around Puu Kaua and Palikea Peak.

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Figs. 1-2. *Campsicnemus* male mid femur, tibia, and basitarsus. 1, *C. charliechaplini*, n. sp.; 2, *C. halonae*, n. sp.

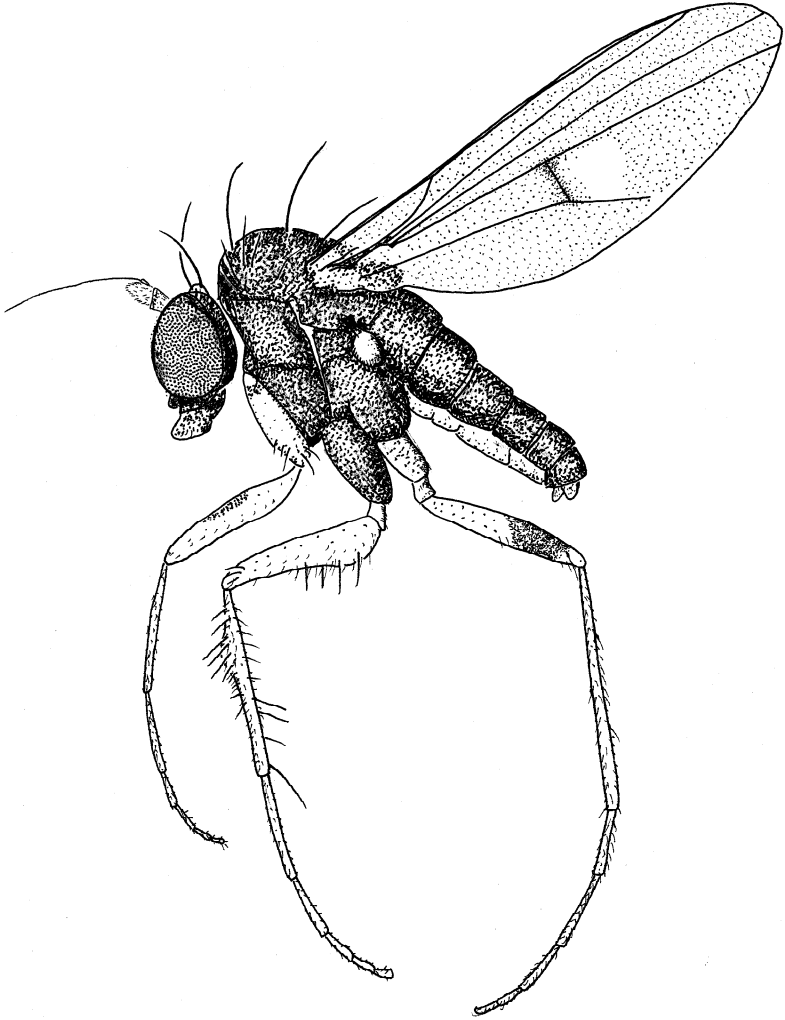


Fig. 3. *Campsicnemus halonae*, n.sp., male habitus.

Terrestrial Isopods from the Hawaiian Islands (Isopoda: Oniscidea)¹

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The following are notable new distribution records for terrestrial isopods in Hawaii. Four species are newly recorded from the state, and many new island records are given for other species, especially for the Northwestern Hawaiian Islands, where only one species (*Porcellionides pruinosus* [Brandt]) was previously known. All included records are based on specimens deposited in Bishop Museum. Taiti & Ferrara (1991) presented new distribution records and taxonomic information on 27 species and provided an overview of the terrestrial isopod fauna of the Hawaiian Islands, and Nishida (1994) listed all species recorded from the islands together with the island distributions of each.

We call special attention to the several endemic armadillid pillbugs that have not been recollected in more than 60 years. These are *Hawaiodillo danae* (Dollfus) and *H. sharpi* (Dollfus) from Kauai, *H. perkinsi* (Dollfus) from Maui, *Spherillo albospinosus* (Dollfus) from Oahu, and *S. carinulatus* Budde-Lund from Kauai. In addition, *S. hawaiiensis* Dana, previously recorded from Kauai, Oahu, Molokai, and Lanai was last collected on the main islands in 1933 on Oahu although it appears to be still common on Nihoa. We fear some species in this complex may be extinct and encourage field biologists to watch for them in potential refugia.

For economy of space, the following abbreviations are used for collectors listed below: DJP = David J. Preston; DMA = D.M. Allread; ECZ = E.C. Zimmerman; EHB = E.H. Bryan, Jr.; ELB = E.L. Bousfield; FGH = Francis G. Howarth; GAS = G. Allan Samuelson; JWB = John W. Beardsley; NLE = Neal L. Evenhuis; NLHK = N.L.H. Krauss; SLM = Steven L. Montgomery; SFS = S.F. Swift; TWS = T.W. Suman; WAS = W.A. Steffan; WCG = Wayne G. Gagné.

Ligiidae

Ligia hawaiiensis Dana, 1853

New island records

This is a littoral species endemic to the Hawaiian Islands. Previous records from Fiji and Lombok, Indonesia are misidentifications.

FRENCH FRIGATE SHOALS: **New island record:** La Perouse Pinnacle, 27.vi.1923 (EHB), 1 specimen.

NECKER: **New island record:** 10.vi.1923 (C. Grant), 2 specimens. 21.vi.1923 (EHB), 1 specimen. 26.ix.1964 (JWB), 1 specimen.

NIHOA: **New island record:** Miller Valley, 24-27.iv.1983, intertidal zone (WCG), 3 specimens.

OAHU: W. Loch, Pearl Harbor, Honouliuli, 2.ii.1974, sea level on beach (FGH, WCG & F.D. Stone), 1 specimen. Waikane Trail, 22.x.1947 (H.S. Dybas), 1 specimen. Manana Islet, on sea cliff, 11.v.1975 (FGH), 1 specimen.

MAUI: **New island record:** Makena, vii.1931 (Edmondson), 1 specimen. Kipahulu Valley, Puaaluu Gulch, Ka'u Bay, 6.vii.1980 (NLE & GAS), 1 specimen.

Ligia perkinsi Dollfus, 1900

New island record

This is a montane species living on wet vertical surfaces, including rheocrenes,

1. Contribution No. 1996-005 to the Hawaii Biological Survey.

stream margins, and wet mossy tree trunks. This species is endemic to the Hawaiian islands. Previous records from Samoa (Jackson, 1927a, b) refer to *Ligia vitiensis*. The Oahu record in Nishida (1994) was based on a misidentification; thus, this is the first true record of this species from Oahu.

KAUAI: Hoary Head, Mt Haupu, 670 m, 30.viii.1970, on *Tetraplasandra* (WCG), 2 specimens. Lihue: Koloa Forest Reserve, Wahiawa Stream N Kanaele Bog, 630 m, 30.viii.1982, on rotting *Tetraplasandra* trunk (WCG), 2 specimens. Mt. Kahili, 940 m, 15.iii.1974, in liverworts on trees (FGH), 6 specimens. Near Alakai Swamp, 8.vii.1937 (ECZ), 1 specimen. Kaunuu Hua Ridge, 22.vii.1937 (ECZ), 1 specimen.

OAHU: **New island record**: Koolau Mtns, Nuuanu Pali, 300 m, 26.xi.1980 & 16.viii.1985, on wet rock wall (FGH), 4 specimens.

Styloniscidae

Styloniscus mauritiensis

New island record

(Barnard, 1936)

Commonly found under bark and in moss on trees. Besides Hawaii, it is also known from Mauritius and hothouses in Scotland.

OAHU: Mt. Kaala, 1220 m, 19.iv.1966, in moss on tree (C.M. Yoshimoto), many specimens.

LANAI: **New island record**: Summit Lanai Hale, 900 m, 17.i.1974, leaf litter under ohia and *Dicranopteris* (ELB), 4 specimens.

MAUI: **New island record**: W Maui, Puu Kukui Trail, 900 m, near Haelaau Cabin, beating *Dicranopteris*, 19.i.1974 (ELB & FGH), 3 specimens.

HAWAII: Hawaii Volcanoes Natl Park, Olaa Tract, 1170 m, 5.viii.1982 (F.D. Stone), 4 specimens.

Styloniscus spinosus (Patience, 1907)

New island record

This species occurs in leaf litter and moss. It is also known from Mauritius, Madagascar, and Reunion.

KAUAI: **New island record**: Alakai Swamp, 1220 m, 22.vii.1964 (TWS), many specimens. Same except near Alakai Swamp, 1125 m, 5 specimens. "Kokee State Park, Kawaikoi Stream Trail, 1060 m, 27.v.1989, moss on ohia, grass litter, and soil (SFS)", 7 specimens. Kokee State Park, Pihea Trail, 1300 m, 27.v.1989, ohia litter (SFS), many specimens. Kalalau Trail, East fork of Hoolulu Stream, 95 m, 19.i.1973, leaf litter in *Pandanus* forest moss (WCG & D. Herbst), 1 specimen. Mt. Kahili, 900 m, 15.iii.1974, on wet cliff face & beating *Dicranopteris* (FGH), 2 specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Hibiscus tiliaceus* litter, 2 specimens. Kokee, Hwy 55, 19 mi [30 km] from jct Hwy 50, 13.v.1969 (DMA), *Cupressus* humus. Waimea Canyon St Park, Hwy 55, 9.9 mi [16 km] from jct Hwy 50, 14.v.1969 (DMA), *Eucalyptus* litter.

OAHU: Lanihuli at Nuuanu & Kalihi, 23.ii.1936 (R.L. Usinger), 6 specimens. Honolulu, Kalihi Valley, 27.iv.1966, in debris (W. Voss), 2 specimens. Tantalus, 300-500 m, 24.viii.1963, bamboo leaves (D.M. Tsuda), many specimens. Koolau Range, Kaumuhonu Peak, slopes, 525 m, ca. 2 km NE Mt Tantalus, 19.v.1982, on moss soil under koa (GAS), 2 specimens. Aiea, Keiawa Heiau Campsite, 5.vii.1981, leaf litter (SFS), many specimens. Koolau Mtns, Poamoho Trail, 650 m, 23.xii.1972, sifting leaf litter in native rainforest (WCG & J. Jacobi), 3 specimens. N end Koolau Mtns, 9.v.1964 (TWS), many specimens. Koolau Mtns, Laie Trail, 550 m, 29.xi.1974, sifting litter (FGH), 1 specimen. Kawaiolo Forest Reserve, 750 m, 25.viii.1973, sifting moss leaf litter (WCG), 1 specimen. Mt Kaala, 1225 m, 27.iii.1987, leaf litter (P. Swift), 9 specimens.

LANAI: **New island record**: Summit Lanaihale, 900 m, 17.i.1974, leaf litter under ohia & *Dicranopteris* (ELB), 1 specimen. Road to summit near pipeline tunnel, 600 m, 17.i.1974, in *Eucalyptus* litter (FGH & ELB), 1 specimen

MAUI: **New island record**: W. Maui, Puu Kukui Trail, 1220 m, in *Cibotium*, 18.i.1974 (ELB & FGH), 3 specimens. Same except 900 m, near Haelaau Cabin, 2 specimens. E. Maui, Koolau Forest

Reserve, 1300 m, 23.i.1973, tree fern and moss litter (FGH & ELB), 1 specimen. Koolau Forest Reserve, Hanawi Stream, 1525 m, 9.viii.1973, under rotting *Tetraplasandra dipyrena* bark (WCG), 4 specimens. Waikamoi Forest Reserve, 1219 m, 3.i.1986, litter (W.D. Perriera), many specimens. Haleakala Natl Park, Kipahulu Valley, 400 m, 24.vii.1980, moss on rock (no coll.), many specimens. Same except Puu Ahuula, leaf litter (WAS), many specimens. Same except Palikea Stream, 500 m, 7.vii.1980, moss on log (NLE, WCG & GAS), many specimens. Same except Puaaluu Stream, 0-300 m, 22.vii.1980 (D. Bishop), 10 specimens.

HAWAII: Hamakua Forest Reserve, 2 mi SSW of Paauito, 700 m, 18.xii.1960, leaf litter (G.E. Haas), 12 specimens. Kohala Mtns, East Ridge Puu Pili, 1370 m, 6.vii.1964, leaf litter (B. Haas), many specimens. Kohala Mtns, 1050 m, 29.vii.1966, moss under trees (JWB, TWS, P. Ashlock, & C. Yoshimoto), many specimens.

Trichoniscidae

Haplophthalmus danicus

New state record

Budde-Lund, 1885

This is a widespread species known from Europe, North Africa, Asia Minor, several Atlantic islands, North America, and Japan.

MAUI: 2.5 mi S Kahakuloa, 21.i.1973, sifting litter (FGH & ELB), 2 specimens.

Scyphacidae

Alloniscus oahuensis Budde-Lund, 1885

This is a strictly littoral species that occurs under logs, or litter in the upper part of sandy shores. It is widely distributed in the Indian and Pacific Oceans.

OAHU: Kaneohe Bay, near Kahaluu mud flats above high water, 14.i.1973 (ELB & FGH), many specimens. Kaiwainui Marsh, sealevel, 15.xi.1980, litter adjacent to marsh (WCG), 3 specimens. Popoia Islet, 27.x.1973, debris (FGH), 1 specimen.

MOLOKAI: 1 mi west Kamehameha, Coconut Grove, 1st stop near mauka edge of mangrove, 16.i.1974 (ELB & FGH), 1 specimen.

Philosciidae

Anchiphiloscia pilosa

New island records

(Budde-Lund, 1913)

This species has a wide distribution in the lands around the Indian and Pacific Oceans where it occurs in leaf litter and along low altitude streams.

KAUAI: **New island record:** Haena, Hwy 56, 13.v.1969 (DMA), mango leaf litter, 2 specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Hibiscus tiliaceus* litter, 2 specimens.

OAHU: Lanihuli at Nuuanu & Kalihi, 23.ii.1936 (R.L. Usinger), 4 specimens. Kaneohe Bay, 14.i.1973, mangrove litter (ELB & FGH), 2 specimens. Honolulu, Salt Lake, 8.i.1978 (J. Nishioka), 2 specimens.

MAUI: **New island record:** Hana, 5 mi W junction Highway 360 & Airport Road, 24.i.1973, sifting leaf litter & rotting logs (FGH & ELB), 2 specimens.

Australophiloscia societatis

New island records

(Maccagno, 1932)

A very common species throughout Polynesia. It lives in leaf litter, moss and under tree bark.

PEARL AND HERMES ATOLL: **New island record:** Southeast I, 28.v.1969, Burrow of wedgetailed shearwater (DMA), 1 specimen.

KAUAI: **New island record:** Kalalau Trail, E fork Hoolulu Stream, 95 m, 19.i.1973, leaf litter

in *Pandanus* forest moss (WCG & D. Herbst), many specimens. Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 7 specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Casuarina* humus, many specimens; same data except *Psidium* litter, many specimens. Haena, Hwy 56, 13.v.1969 (DMA), mango leaf litter, 8 specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Hibiscus tiliaceus* litter, many specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Eugenia* litter, many specimens. Wailua, 0.5 mi [0.8 km], NW Coco Palms Hotel, 13.v.1969 (DMA), Eucalyptus litter, many specimens. Waimea Canyon Rd, 1–200 m, 14.v.1969 (DMA), *Acacia decurrens* humus, 15 specimens.

OAHU: Manoa, 4.vii.1928, under bark *Acacia koa* (no coll.), 1 specimen. Pupukea, 6.v.1932, *Broussaisia arguta* (O. Bryant), 2 specimens. Kamokunui Valley, 1.x.1933 (NLHK), 2 specimens. Kipapa, 18.ix.1934 (EHB), 1 specimen. Lanihuli at Nuuanu & Kahili, 23.ii.1936 (R.L. Usinger), 5 specimens. Castle Trail, 27.ix.1938 (EHB), 6 specimens. Waimano Trail, 27.iii.1941, mossy bark (EHB), 2 specimens. Kalihi Valley, 60 m, 4.iii.1961 (Y. Miyataki), many specimens. Manoa Valley, 29.iv.1961 (Y. Miyatake), many specimens. Tantalus, 300–500 m, 24.viii.1963, bamboo (D.M. Tsuda), 5 specimens. Aiea, Keaiwa Heiau State Park, 26.vii.1964, in shaded ravine (TWS), 13 specimens. N end Koolau Mtns, 9.v.1964 (TWS), 8 specimens. Kailua, Ulumawao, E slope, 45 m, 19.vii.1966 (T.Suman), many specimens. Honolulu, Kalihi Valley, 27.iv.1966, in debris (W.Voss), 12 specimens. Koolau Mtns, Waikane Trail, 650 m, 20.x.1974, ex. *Cladium* clumps (WCG), 2 specimens. Koolau Mtns, Laie Trail, 550 m, 29.xi.1974, sifting litter (FGH), 7 specimens. Koolau Mtns, Poamoho Trail, 2.vi.1977, leaf litter near summit (FGH), 2 specimens. Same data except 790 m, 1.xii.1974, on mossy tree trunk, 3 specimens. Koolau Range, Kaumuhonu Peak, slopes 525 m, ca. 2 km NE Mt Tantalus, 19.v.1982, on moss soil under koa (GAS), 1 specimen. Halawa Valley, 300 m, 8.vii.1992, ex malaise trap (DJP), 1 specimen. Same data except 19.x.1995, beating ieie, 15 specimens. Same data except 250 m, beating *Sadleria* (DJP), 8 specimens. Same data except 350–375 m, 10.i.1994, on *Pritchardia* (FGH & DJP), 16 specimens. Waianae Mtns, Nanihuli, 6.v.1923 (O. Oswald), 9 specimens. Makaleha Valley, 13.i.1929 (no coll.), 11 specimens. Head of Makua Valley, 450 m, 6.viii.1965 (WAS & C. Phillips), many specimens. Honouliuli Forest Reserve, Kaluaa Gulch, 730 m, 10.x.1976, ieie axils., (FGH), 1 specimen. Mt Kaala, 800 m, FAA Road, 18.i.1983, sweeping *Dicranopteris* (FGH & SLM), 1 specimen. Lualualei, Halona Valley, 500 m, 9.v.1994, under talus in *Sapindus* & general collecting (FGH), 15 specimens.

MOLOKAI: **New island record:** McVeigh's, 28.vii.1925 (A.F. Judd), 2 specimens. Kainalu, 22.vii.1927 (EHB), 4 specimens. Kaulolo, 8.vii.1968, under moist leaves at roadside (DMA), 1 specimen. Pukoo, 730 m, 27.i.1973, sifting moss base of trees (WCG), 3 specimens. Molokai Forest Reserve, Kolekole Cabin Trail, 1020 m, 14.i.1974, *Sadleria* crowns & rotten stumps (ELB & FGH), 1 specimen.

MAUI: **New island record:** Nahiku, 30.xii.1931 (NLHK), 2 specimens. 2.5 mi S Kahakuloa, 21.i.1973, sifting litter (FGH & ELB), many specimens. Haleakala Natl Park, Kipahulu Valley, 400 m, 24.vii.1980, moss on rock (no coll.), many specimens. Same data except 500 m, 5.vii.1980, *Pandanus* leafaxils (GAS), many specimens. Kipahulu Valley, gauging station, 475 m, 5.vii.1980 (WCG & NLE), 10 specimens. Same data except Puaaluu Stream, 300–500 m, 21–22.vii.1980 (D. Bishop & G.M. Nishida), 10 specimens. Same data except 100 m, 6.vii.1980, under *Eugenia jambos* bark (WCG), 1 specimen. Same data except 0–300 m, 22.vii.1980, 9 specimens. Same data except 425 m, moss on *Metrosideros* (G. Young), 1 specimen. Same data except 300 m, 22.vi.1980, riparian, 2 specimens. Same data except Puu Ahuula, 400 m, 24.vii.1980, leaf litter (WAS), 9 specimens. Same data except Koukouai Stream, 4 specimens. Same data except Puu Ahuula to Palikea, 400–600 m, 23.vii.1980, 1 specimen. W Maui, Iao Valley, at overlook, 21.i.1973, sifting leaf litter near stream (FGH & ELB), 7 specimens. Puu Kukui Trail, 900 m, near Haelaau Cabin, 19.i.1974, beating *Dicranopteris* & in *Cibotium* (ELB & FGH), 5 specimens.

HAWAII: Kohala Mtns, Honopue Valley, 600 m, 9–13.vi.1970 (WCG), 1 specimen.

Burmoniscus mauritiensis

(Taiti & Ferrara, 1983)

New island record

Occurs in disturbed habitats at low altitudes. It has a wide distribution from Maur-

itius to Hawaii.

OAHU: **New island record:** Manoa Valley, 29.iv.1961 (Y. Miyatake), many specimens. Honolulu, Kahili Valley, 27.iv.1966, in debris (W. Voss), many specimens. Kaneohe Bay, 14.i.1973, mangrove litter (ELB & FGH), 5 specimens. Same data except 25.iii.1973 (FGH), 1 specimen. Koolau Mtns, Tantalus, 30.ix.1976, taro axils (FGH), 3 specimens.

Burmoniscus meeusei (Holthuis, 1947)

New island record

Common in leaf litter on and near beaches, and along streams. Originally described from greenhouses at Kew, UK, it appears to have a very wide distribution in the tropics, including Brazil, Taiwan, and the Hawaiian Islands.

KAUAI: **New island record:** Kapaa, Hwy 580, 6 mi [9.5 km] above Opaekaa Falls, 13.v.1969 (DMA), *Albizia* litter, 1 specimen. Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen.

MOLOKAI: **New island record:** Kalawao Crater Lake, 0 m, 14.viii.1973, leaf litter (WCG & FGH), 5 specimens.

MAUI: **New island record:** 2.5 mi S Kahakuloa, 21.i.1973, sifting litter (FGH & ELB), 1 specimen. Hana Beach, 24.i.1973, in false kamani litter on beach (FGH & ELB), 1 specimen. Kipahulu Valley, Puaaluu Stream, 100 m, 6.vii.1980, under *Eugenia jambos* bark (WCG), 2 specimens.

Burmoniscus okinawaensis

New island record

(Nunomura, 1986)

A eurytopic species particularly common in disturbed habitats. Recorded from China, Japan, Taiwan, and Hawaii.

OAHU: Kaneohe Bay, 25.iii.1973, mangrove leaf litter (FGH), 1 specimen. Kawailoa Forest Reserve, 750 m, 25.viii.1973, sifting moss leaf litter (WCG), 3 specimens. North Halawa Valley, 350 m, 10.i.1994, *Prichardia* (FGH & DJP), 2 specimens. Mt Kaala, 800 m, 18.i.1983, sweeping *Dicranopteris* (FGH & SLM), 2 specimens. Lualualei, Halona Valley, 500 m, 9.v.1994 (FGH), 2 specimens.

MAUI: **New island record:** Hana, 5 mi [8 km] W jct Highway 360 & Airport Road, 24.i.1973, sifting leaf litter & rotting logs (FGH & ELB), 1 specimen. Kipahulu Valley, Puaaluu Stream, 100 m, 6.vii.1980, under *Eugenia jambos* bark (WCG), 4 specimens.

Littorophiloscia culebrae

New island record

(Moore, 1901)

A strictly halophilic littoral species found under debris, logs, and stones on both rocky and sandy shores. It is widely distributed in the tropics; currently known from Florida, Puerto Rico, Cuba, Virgin Islands, Angola, Madagascar, and Hawaii.

PEARL AND HERMES ATOLL: **New island record:** Southeast I, 20.vii.1983 (WCG), 15 specimens.

LISIANSKI: **New island record:** 7.viii.1983, under rocks on beach (WCG), 14 specimens.

Littorophiloscia hawaiiensis

New island record

Taiti & Ferrara, 1986

This littoral species occurs from the shoreline to a few hundred meters inland. It appears to be endemic to the Hawaiian Islands.

LAYSAN: **New island record:** iv.1923, under rocks of guano (S.C. Ball), 1 specimen.

Tropicana minuta

New island records

Manicasteri & Taiti, 1987

This species has a wide distribution in the tropics where it occurs in leaf litter, moss,

and under tree bark from sea level to ca. 900 m elevation. It has been recorded from Cameroon, Comoros Islands, Sri Lanka, and Hawaii.

KAUAI: **New island record:** Haena, Hwy 56, 13.v.1969 (DMA), *Casuarina* humus, many specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Hibiscus tiliaceus* litter, 1 specimen. Kapaa, Hwy 580, 6 mi [9.5 km] above Opaekaa Falls, 13.v.1969 (DMA), *Albizzia* litter, 1 specimen. Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen. Mt. Kahili, 900 m, 15.iii.1974, on wet cliff face & beating *Dicranopteris* (FGH), 1 specimen.

OAHU: Manoa Valley, 29.iv.1961 (Y. Miyatake), 1 specimen. Kalihi Valley, 60 m, 4.iii.1961 (Y. Miyatake), 3 specimens. Honolulu, Kalihi Valley, 27.iv.1966, in debris (W.Voss), 9 specimens. N end Koolau Mtns, 9.v.1964 (TWS), many specimens. Koolau Mtns, 650 m, Poamoho Trail, 23.xii.1972, sifting leaf litter in native rainforest (WCG & J. Jacobi), 4 specimens. Same data except 760 m, 15.ix.1973, mosses under dense shrubs (WCG), 1 specimen. Koolau Range, Kaumuhonu Peak, slopes 525 m, ca. 2 km NE Mt Tantalus, 19.v.1982, on moss soil under koa (GAS), 1 specimen.

MAUI: **New island record:** Haleakala Natl Park, Kipahulu Valley, 400 m, 24.vii.1980, moss on rock (no coll.), 1 specimen. Same data except Puu Ahuula, leaf litter (WAS), many specimens. Same data except Koukouai Gulch Ridge, in moss (G. Nishida), 4 specimens. Same data except Pua-aluu Stream, 100 m, 6.vii.1980, under *Eugenia jambos* bark (WCG), many specimens.

Platyarthridae

Trichorhina heterophthalma

New island record

Lemos de Castro, 1964

A pantropical species, it is common in disturbed habitats at low elevation.

KAUAI: **New island record:** Haena, Hwy 56, 13.v.1969 (DMA), *Casuarina* humus, 3 specimens. Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen.

Trichorhina tomentosa

New island records

(Budde-Lund, 1893)

This is a parthenogenetic species with a very wide ecological range. It is distributed throughout the tropical belt.

KURE: **New island record:** ii.1964 (F.Kelley), 1 female.

LAYSAN: **New island record:** 27.iv.-7.v.1959 (G. Butler), 12 females. 10.xii.1963, roots of bunch grass (N. Wilson), 6 females. 23.vii.1983, in bird burrow beneath *Cynodon dactylon* (WCG), 5 females.

KAUAI: Waimea, Hwy 55, 5.7 mi [9.2 km] from jct Hwy 50, 14.v.1969 (DMA), *Acacia decurrens* humus, 6 females.

OAHU: Honolulu, Kalihi, 120 m, 30.xii.1979, in *Pheidole* nest in wood (FGH), 3 females. Honolulu, Liliha, 12.iv.1984, litter (SFS), many females.

LANAI: **New island record:** 21.iii.1928, ex pineapple roots (J.F. I.[Ilingworth]), many females.

KAHOOLAWE: **New island record:** Moa Ula Iki, 425 m, 27.iv.1980, rotting wiliwili wood (FGH), 12 females.

MAUI: **New island record:** Haleakala Natl Park, Kipahulu Valley, near Kualoa Point, 5 m, 6.vii.1980, dead *Pandanus* branches (NLE & GAS), 1 female.

Trachelipodidae

Nagurus cristatus (Dollfus, 1889)

New island records

This is a parthenogenetic species, which is distributed pantropically.

OAHU: **New island record:** Honolulu, Kalihi Valley, 27.iv.1966, in debris (W. Voss), 1 female. Halawa Valley, 300 m, 19.v.1993, 26.v.1993, 3.vi.1993, 10.vi.1993, & 22.ix.1993, ex malaise trap (DJP), 6 females. Same data except 19.x.1995, beating ieie, 2 females. Same data except 350 m, 10.i.1994, *Prichardia* (FGH & DJP), 4 females.

MOLOKAI: **New island record:** Papio Stream, 180 m, 29.ix.1995, rotten mango stem (W.D. Perriera), 1 female.

MAUI: **New island record:** Kipahulu Valley, 500 m, 5.vii.1980, *Pandanus* leafaxils (GAS) 9 females. Kipahulu Valley, Puaaluu Stream, 100 m, 6.vii.1980, under *Eugenia jambos* bark (WCG), 4 females.

Nagurus nanus (Budde-Lund, 1908)

This eurytopic species is particularly common in disturbed habitats and synanthropically. It has a pantropical distribution.

OAHU: Honolulu, Kalihi, 120 m, 30.xii.1979, in *Pheidole* nest in wood (FGH), 3 specimens.

Nagurus sundaicus (Dollfus, 1898)

New state record

Widely distributed in the Oriental and Australian Regions. Previously recorded from China, Hong Kong, Indonesia, and the Loyalty Islands.

PEARL AND HERMES ATOLL: Southeast I, 28.v.1969 (DMA), 4 specimens. Southeast I, 26.iv.1923 (no coll.), 1 specimen.

Porcellionidae

Porcellio dilatatus dilatatus

New state record

Brandt, 1833

This species is of western Mediterranean origin and has been spread by humans to many parts of the world.

HAWAII: Puu Kamaoa, 10.vii.1923 (W. Meinecke), 4 specimens.

Porcellio laevis Latreille, 1804

New island records

Cosmopolitan species of Mediterranean origin. It is very common in synanthropic sites.

MIDWAY ISLANDS: **New island record:** Sand I, 29.i.1955 (C.F. Clagg), 1 specimen. No other data (C.F. Clagg), 4 specimens. Sand I, iv.1957 (Y. Oshiro), 1 specimen.

LISIANSKI: **New island record:** 7.viii.1983, under rocks on beach & under fallen coconuts (WCG), 8 specimens.

NIHAU: **New island record:** Kaali Spring, 16.viii.1947 (H. St. John & L.D. Tuthill), 1 specimen.

KAUAI: 21.v.1969 (R. Amerson), 3 specimens.

OAHU: Makaleha Valley, 13.i.1929 (no coll.), 1 specimen. Kamokunui Valley, 1.x.1933 (NLHK), 1 specimen. Honolulu, x.1941 (Y. Kondo), 4 specimens. Honolulu, Salt Lake, 16 & 19.vii.1977 (J. Nishioka), 5 specimens. West Loch Pearl Harbor, Honouliuli, 2.ii.1974, in beach or mangrove litter (FGH, WCG & F.D. Stone), 1 specimen.

MOLOKAI: **New island record:** Waikamoi, Kawela Road, 24.vii.1925 (A.F. Judd), 1 specimen. Halawa Valley, 23.iii.1970 (J.L. Gressitt), 1 specimen.

LANAI: ex pine soil, 30.viii.1927 (no collector), 12 specimens.

KAHOOLAWE: **New island record:** Beck's Cove, 11-14.ii.1980 (G.M. Nishida), 2 specimens. Moa Ula Iki, 425 m, 27.iv.1980, rotting wiliwili wood (FGH), 2 specimens.

MAUI: **New island record:** Haiku, xii.1927, ex pineapple refuse (EHB), 1 specimen. 2.5 mi S Kahakuloa, 21.i.1973, sifting litter (FGH & ELB), 1 specimen. Kaanapali, 2.xi.1992, on sand near vegetation (SFS), 4 specimens.

Porcellio lamellatus lamellatus

New island records

Budde-Lund, 1885

This is a littoral species found in the Mediterranean area and some Atlantic islands.

It has been introduced to Cuba, Argentina, Bermuda, and Rottneest Island, western Australia.

FRENCH FRIGATE SHOALS: **New island record:** Tern I, 22.iii.1984, under debris (WCG), 5 specimens.

KAUAI: **New island record:** Haena start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen.

MOLOKAI: **New island record:** 1 mi W Kamehameha, Coconut Grove, 1st stop near mauka edge of mangrove, 16.i.1974 (ELB & FGH), 4 specimens.

Porcellio scaber Latreille, 1804

New island record

This native to western Europe is now cosmopolitan in distribution. In the Hawaiian Islands, it is the most common species at high elevations in both grassland and forests.

KAUAI: Alakai Swamp, 1250 m, 1.iv.1969 (J.L. Gressitt), 1 specimen. Kokee, Alakai Swamp, 17.i.1973, wet moss at base of trees (FGH, ELB & WCG), 10 specimens. Same data except first bog, *Oreobolus* litter (FGH & WCG), 1 specimen. Nr. Kalalau Lookout, 17.i.1973, in moss (FGH & ELB), 5 specimens. 0.9 mi E Kokee State Park, 17.i.1973, mossy road cut bank (FGH & ELB), 6 specimens. Kokee State Park, Kawaikoi Stream, 1060 m, 27.v.1989, ohia bark (SFS), 7 specimens.

MAUI: **New island record:** Olinda, 10.iii.1932 (O. Bryant), 1 specimen. Olinda, iv.1967, on plant (NLHK), 8 specimens. Waikamoi Stream, 1220 m, 19.vii.1965 (TWS), 2 specimens. Koolau Forest Reserve, 1300 m, 23.i.1973, tree fern & moss litter (FGH & ELB), 10 specimens. Haleakala Natl Park, Kapalaoa Cabin, 2200 m, 18.vi.1980, at night on ground (WCG), 5 specimens. Haleakala Natl. Park, near Hosmer's Grove, 12.x.1983 (B. & WCG), 4 specimens.

HAWAII: HVNP [Hawaii Volcanoes Natl Park], 1/2 way between Volcano House & Crater Hotel, E side road, 4.viii.1922 (M.C. Neal), 1 specimen. HVNP, x.1975, ex *Hibiscadelphus* (J.K. Baker & S. Allen), 1 specimen. HVNP, Mauna Ulu, 1000 m, 1973 lava flow, 15.ii.1974, Cheese bait trap 100 m from vegetation (FGH & F.D. Stone), 1 specimen. Volcano, Olaa Forest-Wright Road, 25.i.1973, tree fern harvest area litter (FGH & ELB), 2 specimens. Saddle Road, Puu Huluhulu, 28.viii.1979, under stones (FGH), 2 specimens. Kohala Mtns, Honopue Valley, 600 m, 9-13.vi.1970 (WCG), 3 specimens. Kohala Mtns, Upper Hamakua Ditch Trail, 900 m, 26.i.1973, sifting moss, fern & leaf litter (FGH & ELB), 8 specimens.

Porcellionides pruinosus (Brandt, 1833)

New island records

A cosmopolitan species of Mediterranean origin. It is very common in synanthropic sites.

KURE: 21.iv.1978 (D. Grady), 2 specimens. iii. 1979 (R. Grady), 1 specimen.

MIDWAY ISLANDS: **New island record:** Sand I, iv.1957 (Y. Oshiro), 2 specimens. (C.F. Clagg) no other data, 5 specimens.

PEARL AND HERMES ATOLL: **New island record:** Southeast I, 26.iv.1923 (no collector), 2 specimens. Southeast I, 28.v.1969, burrow of wedgetailed shearwater (DMA), many specimens. 28.v.1969 (D. M. Allred), many specimens. Southeast I, 20.vii.1983 (WCG), 3 specimens. Grass I, 10.viii.1983 (WCG), 10 specimens.

LISIANSKI: **New island record:** 17.v.1923, grass patch (C. Grant), 12 specimens. iv.1923 (D.T. Fullaway), 2 specimens. 7.viii.1983, under rocks on beach (WCG), 1 specimen.

LAYSAN: 25.iv.1923, under rocks of guano (S.C. Ball), many specimens. 9.iv.1923, around wood shacks (D.T. Fullaway), 5 specimens. 27.iv.-7.v.1959 (G. Butler), 10 specimens. 10.xii.1965, roots of bunch grass (N. Wilson), 7 specimens. 22.vii.1983, at night (WCG), 4 specimens [no date] (J.W. Thompson), 9 specimens.

FRENCH FRIGATE SHOALS: **New island record:** Tern I, 22.iii.1984, under debris (WCG), 3 specimens.

NECKER: **New island record:** 18-20.vi.1923, under stones (EHB), 11 specimens.

NIHOA: **New island record:** 12.vi.1923, *Sporobolus* (EHB), 3 specimens. 10-12.vii.1924 (T.T.

Dranga), 3 specimens. E Palm Valley, 100 m, 26.iv.1983, in *Eragrostis* clumps (WCG), 3 specimens.

KAUAI: **New island record:** 21.v.1969 (R. Amerson), 1 specimen. Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen.

OAHU: Honolulu, Bishop Museum gardens, 1.vii.1971 (J. Tenorio & A. Adeniya), 5 specimens.

MOLOKAI: **New island record:** 1 mi W Kamehameha Coconut Grove, 1st stop near mauka edge of mangrove, 16.i.1974 (ELB & FGH), 2 specimens.

MAUI: **New island record:** Hana Beach, 24.i.1973, in false kamani litter (FGH & ELB), 5 specimens.

Armadillidiidae

Armadillidium vulgare (Latreille, 1804)

New state record

This species, native to the Mediterranean, has been spread by humans to many parts of the world, except higher latitudes and altitudes. It is common in many habitats, particularly in synanthropic sites such as houses, gardens, and cultivated lands.

OAHU: Kapalama, 240 m, 9.x.1993, under stone (FGH & DJP), 1 specimen.

Eubelidae

Elumoides monocellatus

New island record

Taiti & Ferrara, 1983

This species is common under stones and in litter at low altitudes, especially near the coast. It has a wide distribution in the Indian and Pacific area, from the Seychelles to Hawaii.

PEARL AND HERMES ATOLL: **New island record:** Southeast I, 28.v.1969 (DMA), 2 specimens.

Armadillidae

Cubaris murina Brandt, 1833

New island records

This is a pantropical species with synanthropic habits, abundant in very disturbed habitats.

NIIHAU: **New island record:** Kaali Spring, 16.viii.1947 (H. St. John & L.D. Tuthill), 1 specimen.

KAUAI: **New island record:** Moloaa, 75 m, 6.viii.1928, pineapple field (no collector), 1 specimen. Puu Konanae, 75 m, 6.viii.1928 (EHB), 1 specimen.

LANAI: **New island record:** ex pine soil, 30.viii.1927 (no coll.), 13 specimens.

KAHOOLAWE: **New island record:** Beck's Cove, 11-14.ii.1980 (G.M. Nishida), 3 specimens.

MAUI: **New island record:** Kipahulu Valley, above Puaaluu Stream, 25 m, 6.vii.1980, under *Eugenia jambos* bark (NLE & GAS), 5 specimens.

Hawaiodillo cf. *perkinsi* (Dollfus, 1900)

Comparison with the type of *perkinsi* (the only known specimen of this species collected in 1894 from Haleakala on Maui) is necessary to confirm identification of the Kauai material. This is an endemic genus with nothing known of its biology.

KAUAI: Kaunoo Hua Ridge, 21-22.vii.1937 (ECZ), 4 specimens.

Hawaiodillo sharpi (Dollfus, 1900)

Notable rediscovery

A single specimen of this endemic species was originally collected from 4,000 ft [1220 m] on Kauai in 1896. The specimen recorded here represents only the second known record of this species.

KAUAI: near Alakai Swamp, 8.viii.1937 (ECZ), 1 specimen.

Reductoniscus costulatus**New island record**

Kesselyak, 1930

This species common under stones and in leaf litter at low altitudes, especially near the coast. It has a wide distribution in the Indian and Pacific area, from the Seychelles to Hawaii.

KAUAI: **New island record:** Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen.

OAHU: Honolulu, Kalihi, 120 m, 30.xii.1979, in *Pheidole* nest in wood (FGH), 2 specimens. Liliha, 12.iv.1984. (SFS), 2 specimens. Tripler Army Medical Center, 13.iv.1995, *Ficus* litter (SFS), many specimens.

Spherillo hawaiensis* Dana, 1853*New island record**

This xerophilic species is a Hawaiian endemic previously reported from Kauai, Oahu, Molokai, and Lanai. Although there are no recent collections from those islands, it is still abundant on Nihoa.

NIHOA: **New island record:** 11–14.vi.1923 (EHB), 37 specimens. 11.vi.1923 (Thaonum), 1 specimen. 10–12.vii.1924 (T.T. Dranga), 7 specimens. 23.ix.1964, under *Eragrostis* (JWB), 4 specimens. Devil's Slide, 200 m, 30.iv.1983, in scree & adjacent cliff bases at night (WCG), 2 specimens. W Palm Valley, 100 m, 25.iv.1983, pitfall trap under shrubs (WCG), 2 specimens.

KAUAI: Honopu, 20.vi.1922 (EHB), 1 specimen.

OAHU: Nanakuli, 6.v.1923 (O. Oswald), 2 specimens. Kamokunui Valley, 1.x.1933 (NLHK), 2 specimens.

Venezillo parvus* (Budde-Lund, 1885)*New island records**

This pantropical species is very abundant in disturbed habitats at low altitude, under stones, logs, and in leaf litter.

KURE: **New island record:** ii.1964 (F. Kelley), 1 specimen.

KAUAI: **New island record:** Moloaa, 75 m, 6.viii.1928, pineapple field (no collector), 2 specimens. Puu Konanae, 75 m, 6.viii.1928 (EHB), 1 specimen. Haena, start of Kalalau-Napali Trail, 19.i.1973, leaf litter on beach (FGH & ELB), 1 specimen. Haena, Hwy 56, 13.v.1969 (DMA), *Hibiscus tilaceus* litter, 4 specimens. Haena, Hwy 56, 13.v.1969 (DMA), *Eugenia* litter, 1 specimen. Kapaa, Hwy 580, 6 mi [9.6 km] above Opaekaa Falls, 13.v.1969 (DMA), *Albizia* litter, 2 specimens.

OAHU: Head of Makua Valley, 450 m, 6.viii.1965 (WAS & C. Phillips), 3 specimens. Kalihi, 60 m, 4.iii.1961 (Y. Miyatake), 2 specimens. Liliha, 12.iv.1984 (SFS), 9 specimens. Kaneohe Bay, 25.iii.1973, mangrove litter (FGH), 2 specimens.

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Table 1. List of terrestrial isopods recorded from the Hawaiian Islands.

TAXON	Status	Ku	Mi	Pe	Li	Ly	Fr	Ne	Na	Nu	Ka	Oa	Mo	Ln	Kh	Ma	Ha
LIGIDAE																	
1. <i>Ligia exotica</i> Roux, 1828	adv											Oa					
2. <i>Ligia hawaiiensis</i> Dana, 1853	end										Ka	Oa	Mo			Ma	Ha
3. <i>Ligia perkinsi</i> (Dollfus, 1900)	end						Fr	Ne	Na		Ka	Oa					
STYLONISCIDAE																	
4. <i>Clavigeroniscus riqiteri</i> Arcangeli, 1930	adv																Ha
5. <i>Styloniscus mauritienis</i> (Barnard, 1936)	adv											Oa		Ln		Ma	Ha
6. <i>Styloniscus spinosus</i> (Patience, 1907)	adv										Ka	Oa		Ln		Ma	Ha
TRICHONISCIDAE																	
7. <i>Haplophthalminus danicus</i> Budde-Lund, 1885	adv										Ka	Oa		Ln		Ma	Ha
FAMILY ?																Ma	
8. <i>Buchnerillo</i> sp.	?											Oa					
SCYPHACIDAE																	
9. <i>Alloniscus oahuensis</i> Budde-Lund, 1885	adv										Ka	Oa	Mo	Ln?		Ha	
10. <i>Armadilloniscus ellipticus</i> (Harger, 1878)	adv											Oa					
11. <i>Armadilloniscus hawaiiianus</i> Taiti & Ferrara, 1989	?											Oa					
OLIBRINIDAE																	
12. <i>Olibrinus truncatus</i> Taiti & Ferrara, 1991	adv											Oa					
PHILOSCIIDAE																	
13. <i>Anchiphiloscia pilosa</i> (Budde-Lund, 1913)	adv										Ka	Oa				Ma	Ha
14. <i>Australophiloscia societatis</i> (Maccagno, 1932)	ind														Pe		
15. <i>Burmoniscus mauritienis</i> (Taiti & Ferrara, 1983)	adv										Ka	Oa	Mo			Ma	Ha
16. <i>Burmoniscus meesei</i> (Holthuis, 1947)	adv										Ka		Mo			Ma	Ha

Table 1. List of terrestrial isopods recorded from the Hawaiian Islands (continued).

TAXON	Status	Ku	Mi	Pe	Li	Ly	Fr	Ne	Na	Nu	Ka	Oa	Mo	Ln	Kh	Ma	Ha
17. <i>Burmoniscus okinawaensis</i> (Numomura, 1986)	adv										Oa					Ma	Ha
18. <i>Hawaiiiscia parvituberculata</i> Schultz, 1973	end									Ka?						Ma	
19. <i>Littorophiloscia bifasciata</i> Taiti & Ferrara, 1986	ind										Oa						Ha
20. <i>Littorophiloscia culebrae</i> (Moore, 1901)	adv			Pe	Li						Oa						
21. <i>Littorophiloscia hawaiiensis</i> Taiti & Ferrara, 1986	end					Ly											Ha
22. <i>Papuaphiloscia laevis</i> (Schultz, 1973)	?																Ha
23. <i>Tropicana minuta</i> Manicasterri & Taiti, 1987	adv										Ka	Oa				Ma	Ha
PLATYARTHRIIDAE																	
24. <i>Niambia</i> sp.	?										Oa						
25. <i>Trichorhina heterophthalma</i> Lemos de Castro, 1964	adv										Ka	Oa					
26. <i>Trichorhina tomentosa</i> (Budde-Lund, 1893)	adv	Ku				Ly					Ka	Oa		Ln	Kh	Ma	Ha
TRACHELIPODIDAE																	
27. <i>Nagurus cristatus</i> (Dollfus, 1889)	adv										Oa	Mo				Ma	Ha
28. <i>Nagurus nanus</i> (Budde-Lund, 1908)	adv										Oa						Ha
29. <i>Nagurus sudaicus</i> (Dollfus, 1898)	adv			Pe													
PORCELLIONIDAE																	
30. <i>Agabiformius lentus</i> (Budde-Lund, 1885)	adv																
31. <i>Porcellio dilatatus dilatatus</i> Brandt, 1833	adv																Ha
32. <i>Porcellio laevis</i> Latreille, 1804	adv		Mi		Li					Nu	Ka	Oa	Mo	Ln	Kh	Ma	Ha
33. <i>Porcellio lamellatus lamellatus</i> Budde-Lund, 1885	adv						Fr				Ka	Oa	Mo			Ma	Ha
34. <i>Porcellio scaber</i> Latreille, 1804	adv										Ka					Ma	Ha
35. <i>Porcellionides pruinosus</i> (Brandt, 1833)	adv	Ku	Mi	Pe	Li	Ly	Fr	Ne	Na		Ka	Oa	Mo			Ma	Ha

Table 1. List of terrestrial isopods recorded from the Hawaiian Islands (continued).

TAXON	Status	Ku	Mi	Pe	Li	Ly	Fr	Ne	Na	Nu	Ka	Oa	Mo	Ln	Kh	Ma	Ha
ARMADILLIDIIDAE																	
36. <i>Armadillidium vulgare</i> (Latreille, 1804)	adv											Oa					
EUBELIDAE																	
37. <i>Elumoides monocellatus</i> Taiti & Ferrara, 1983	adv			Pe													
ARMADILLIDAE																	
38. <i>Cubaris murina</i> Brandt, 1833	adv									Nu	Ka	Oa		Ln	Kh	Ma	Ha
39. <i>Hawaiodillo danae</i> (Dollfus, 1900)	end										Ka						
40. <i>Hawaiodillo perkinsi</i> (Dollfus, 1900)	end										Ka?					Ma	
41. <i>Hawaiodillo sharpi</i> (Dollfus, 1900)	end										Ka						
42. <i>Myrmecodillo pacificus</i> Taiti & Ferrara, 1991	?																Ha
43. <i>Reductoniscus costulatus</i> Kesselyak, 1930	adv										Ka	Oa					Ha
44. <i>Spherillo albospinosus</i> (Dollfus, 1900)	end																
45. <i>Spherillo carinulatus</i> Budde-Lund, 1904	end										Ka						
46. <i>Spherillo hawaiiensis</i> Dana, 1853	end							Na			Ka	Oa	Mo	Ln			
47. <i>Venezillo parvus</i> (Budde-Lund, 1885)	adv										Ka	Oa					Ha

Islands in boldface are new records recorded in this paper.

Island Distribution: Fr=French Frigate Shoals, Ha=Hawaii, Ka=Kauai, Kh=Kahoolawe, Ku=Kure, Li=Lisianski, Ln=Lanai, Ly=Laysan, Ma=Maui, Mi=Midway, Mo=Molokai, Ne=Necker, Ni=Niihau, Nu=Niihau, Oa=Oahu, Pe=Pearl & Hermes.

Status: End=endemic, ind=indigenous, adv=adventive, ?=unknown.