

## Numbers of Hawaiian Species: Supplement 3, with Notes on Fossil Species<sup>1</sup>

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This is the third supplement to our earlier tabulations of species known from the Hawaiian Islands (Eldredge & Miller, 1995, 1997; Miller & Eldredge, 1996); this paper includes notes on the fossil species known to occur in the Hawaiian Islands.

Many papers in Keast & Miller (1997), especially Miller (1997), discussed the status and biogeography of terrestrial organisms in Hawai'i, in the context of the biogeography of the Pacific Basin. The Hawaiian Islands, by virtue of their geographic isolation, rich volcanic soils, and enormous topographic and climatic diversity, have produced a highly endemic biota, which includes many of the world's outstanding examples of adaptive radiation. The native biota includes more than 22,400 species (Table 1). The approximately 8,800 terrestrial and aquatic plants and animals have evolved from as few as 1,000 original colonists (Gagné, 1988; see also Sakai *et al.*, 1995), although we suspect the total number of native species and colonists will increase with further study.

The Hawaii Biological Survey continually posts species checklists in searchable interfaces on the web at:

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

More than 15,000 species are currently available (including terrestrial arthropods, native and alien land and freshwater snails, foraminiferans, flowering plants, amphibians, reptiles, birds, and mammals; marine invertebrates are being added). Many gaps in knowledge of the biota of the Hawaiian Islands remain, and many species of protists, algae, fungi, arthropods, and parasitic helminths need to be investigated.

Recent surveys of overall biodiversity within particular geographic regions include: Bermuda (Sterrer, 1998), Galapagos (Peck, 1997), Illinois (Post, 1991), Netherlands (Nieuwerkerken & Loon, 1995), New Guinea (Sekhran & Miller, 1996; Miller, 1997), and South Africa (Huntley, 1989, 1994). Surveys dealing only with animal diversity include India (Zoological Survey of India, 1991), and the Madeira Islands (Baéz, 1993). Miller *et al.* (1998) provided a very preliminary summary of numbers for major taxa in the Afrotropical region.

### **Bacteria**

The current status of leptospirosis is reviewed by Katz *et al.* (1997) as it pertains to the resident military population.

### **Fungi**

Sixteen additional species of rust fungi, including 3 endemic species, reported from Hawai'i (Gardner, 1997); Desjardin & Hemmes (1997) add 17 taxa of Hygrophoraceae,

1. Contribution No. 1998-004 to the Hawaii Biological Survey.

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including 6 new species; 14 species of arbuscular mycorrhizal (AM) fungi were isolated from roots of plant from sand dunes of Kaua'i (Koske & Gemma, 1996); 1 species reported from lateral line canals of hammerhead sharks (Crow *et al.*, 1995).

#### **Lichens**

The pantropical distribution of the new species *Chaenothecopsis pilosa* Tibell & Ryman, 1995, includes Hawai'i (Tibell & Ryman, 1995); 2 previously recorded species from the genus *Chiodecton* to new combinations *Synnesia hawaiiensis* (Zahlbruckner) Tehler and *S. effusa* (Fee) Tehler (Tehler, 1997).

#### **Liverworts**

Grolle (1991) changed the combination of an endemic liverwort to *Drepanolejeunea ungulata* (Steph.) Grolle.

#### **Mosses**

Eight indigenous moss species added to Hawaiian mosses (Hoe, 1979).

#### **Flowering Plants**

In our first and second supplements we did not fully account for changes in status of flowering plants that were published outside of *Records of the Hawaii Biological Survey*. In order to correct the running totals. Table 1 reports the current (March 1998) totals from a database of Hawaiian plants maintained by Dr. Warren L. Wagner at the Smithsonian Institution, in collaboration with the Hawaii Biological Survey. Because a new checklist of plants based on this database should be published in the near future, we do not provide the full documentation here. Also, forty-eight species added, including 29 grasses (Herbst & Clayton, 1998), 18 species from various groups (Flynn & Lorence, 1998; Herbarium Pacificum Staff, 1998; Herbst, 1998; Mosyakin & Wagner, 1998; Sato, 1998), and 1 fossil cotton species (Woodcock & Webb, 1998); 1 former species (*Xanthosoma roseum*) questionably included (Staples, 1998).

#### **Protozoa: Ciliophora**

*Bryometopus hawaiiensis* Foissner, 1994, previously considered endemic to Hawai'i, was reported from Spain (Olmo & Tellez, 1996).

#### **Protozoa: Rhizopoda**

Twenty-two species of rhizopods were collected in 1909 in the neighborhood of Honolulu (Penard, 1911), this record has been previously overlooked.

#### **Cnidaria: Anthozoa**

New species *Narella nuttingi* Bayer, 1997 (originally reported as *Stachyodes dichotoma* Versluys, 1906 by Nutting (1908) from *Albatross* explorations in Hawaiian waters) (Bayer, 1997); *Gardineria hawaiiensis* Vaughan, 1907, designated as type species of new scleractinian family Gardineriidae (Stolarski, 1996); new record of *Montipora turgescens* collected at Midway Atoll (Coles, 1998).

**Table 1.** Estimates of numbers of known species of the Hawaiian biota (based on Eldredge & Miller, 1995, 1997; Miller & Eldredge, 1996; and including this paper and other papers in this issue of the *Records*). Algae and fungi remain the same as previous editions, since the numbers are based on estimates, other categories are based on counts. NIS = non-indigenous species (i.e., not native to the region).

Taxon	Total	Endemic	NIS
Algae	811	2	5?
Other protists	1128	2?	?
Fungi	1357	?	?
Lichens	723	240	?
Flowering plants	2074	908	1051
Other plants	763	241	44
Cnidarians	356	75	10
Insects	7998	5245	2598
Other arthropods	914	269	527
Molluscs	1650	956	86
Annelids	309	80	32
Crustaceans	1195	55+	50
Echinoderms	283	150	0
Other invertebrates	1333	439	29+
Fish	1198	139	73
Amphibians	5	0	5
Reptiles	27	0	23
Birds	294	63	46
Mammals	44	1	19
Totals	22462	8864	4598

### Kinohyncha

First record of members of this phylum, unidentified species of *Echinoderes* [Order Cyclophagida, Suborder Cyclophagae, Family Echinoderidae], reported from 70 m sewage outfall, collected in 1986 (Bailenson, 1997).

### Tardigrada

Thirty-one species in 10 genera and 4 families reported in 1986 (Gon *et al.*, 1986).

### Nematoda

Coral reef parasite, *Spirocamallanus istiblenni* Noble, 1996, redescribed (Rigby & Font, 1997); *Camallanus cotti* Fujita, 1927, redescribed from freshwater goby from Hawai'i (Rigby *et al.*, 1997).

### Annelida: Polychaeta

*Pottsipelogenia treadwelli* Pettibone, 1997, proposed as a replacement name for *Psam-*

*molyce fijiensis* Treadwell, 1906 (Pettibone, 1997); 4 species of Namanereidinae, including 2 new nonindigenous records, reported from Hawaiian waters (Glasby *et al.*, 1998).

### Mollusca

Gosliner & Graheim (1996) noted that 430 species of opisthobranch mollusks were known from Hawaiian waters of which 41% are thought to be undescribed; 244 species have been previously reported (Ghiselin, 1992); Kay (1979) noted some 150.

### Arthropoda: Crustacea: Decapoda

New species *Pachycheles attaragos* Harvey & DeSanto, 1997 (Porcellanidae) (Harvey & DeSanto, 1997); new species *Cycloes marisrubri* Galil & Clarke, 1996 (Calapp-

**Table 2.** Penaeoid and sergestoid shrimps in Hawai'i as per Pérez Farfante & Kensley (1997).

Name as Originally Described	Revised Name
PENAEOIDEA	
Aristeidae	
<i>Aristeus armatus</i> Bate, 1881	<i>Plesiopenaeus armatus</i> (Bate, 1991)
Bethesicymidae	
<i>Gennadas intermedius</i> Bate, 1888	<i>Bentheogennema intermedia</i> (Bate, 1888)
	<i>Bethesicymus urinator</i> Burkenroad, 1936
	<i>Benthonectes filipes</i> Smith, 1885
	<i>Gennadas parvus</i> Bate, 1881
Penaeidae	
<i>Penaeus marginatus</i> Randall, 1840	<i>Melicertus marginatus</i> (Randall, 1840)
	<i>Metapenaeopsis gaillardi</i> Crosnier, 1991
<i>Penaeus velutinus</i> Dana, 1852	<i>Metapenaeopsis velutina</i> (Dana, 1852)
<i>Penaeus richtersii</i> Miers, 1884	<i>Trachypenaeopsis richtersii</i> (Miers, 1884)
Sicyoniidae	
	<i>Sicyonia laevis</i> Bate, 1881
Solenoceridae	
<i>Solenocera lucasii</i> Bate, 1881	<i>Hadropenaeus lucasii</i> (Bate, 1881)
<i>Haliporus obliquirostris</i> Bate, 1881	<i>Hymenopenaeus obliquirostris</i> (Bate, 1881)
	<i>Solenocera rathbunae</i> Ramadan, 1938
SERGESTOIDEA	
Luciferidae	
	<i>Lucifer chacei</i> Bowman, 1967
Sergestidae	
	<i>Petalidium suspiriosum</i> Burkenroad, 1937
	<i>Sergestes erectus</i> Burkenroad, 1940
<i>Sergestes bigemmus</i> Burkenroad, 1940	<i>Sergia bigemnea</i> (Burkenroad, 1940)
<i>Sergestes maximus</i> Burkenroad, 1940	<i>Sergia maxima</i> (Burkenroad, 1940)

idae), replacement name for *Cycloes granulosa* (Galil & Clarke, 1996); new species *Cinetorhynchus fasciatus* Okuno & Tachikawa, 1997 (Okuno & Tachikawa, 1997); new combinations *Cinetorhynchus hiatti* (Holthuis & Hayashi, 1967) for *Rhynchocinetes hiatti*, *Cinetorhynchus hendersoni* (Kemp, 1925) for *Rhynchocinetes intermedius* Edmondson (Rhynchocinetidae) (Okuno, 1997); new species *Mandibulophoxus hawaiiola* Muir & DeFelice, 1998 (Amphipoda, Gammaridea, Phoxocephalidae) (Muir & DeFelice, 1998).

Pérez Farfante & Kensley (1997) reviewed the 7 families of penaeoid and sergestoid shrimps, providing information on 18 species, including 8 new records (see Table 2).

#### **Arthropoda: Insecta and Related Forms**

Nishida (1997a, 1997b) provided a full bibliography and updated checklist for the Hawaiian insects and related arthropods; particularly noteworthy publications include the symposium on Hawaiian entomology held at the XX International Congress of Entomology (Liebherr & Polhemus, 1997); plant bug genus *Nesiomiris* revised (Gagné, 1997); a handbook to the damselfly genus *Megalagrion* published (Polhemus & Asquith, 1996); milliped species reports (Shelley, 1998b, 1998c, 1998d; Shelley & Swift, 1998), 4 species deleted from fauna (Shelley, 1998a; Shelley *et al.*, 1998); Swift & Norton (1998) reported a total of 81 species of oribatid soil mites (Acari: Orbitida), including 49 new records for the Hawaiian Islands. One species of dolichopodid fly (*Thinophilus hardyi* Evenhuis & Grootaert, 1997) thought to be endemic, was recently reported from the Galapagos (Bickel & Sinclair, 1997).

#### **Echinodermata**

Mah (1998) reported 5 new records for starfishes from Hawaiian waters, all from Bishop Museum specimens.

#### **Chordata: Ascidiacea**

Forty-five species are reported from Hawaiian waters (Abbott *et al.*, 1997); an additional one, *Symplegma reptans* (Oka), was noted as being newly introduced into Pearl Harbor (Coles *et al.*, 1997).

#### **Chordata: Pisces**

New genus and species of labrid fish, *Ammolabrus dicrus* Randall & Carlson, 1997, from Wai'anae, O'ahu (Randall & Carlson, 1997).

#### **Chordata: Amphibia**

One species (*Eleutherodactylus coqui*) has recently been noted as established on Maui (Campbell, 1994, 1996; McKeown, 1998).

#### **Chordata: Reptilia**

Retroviral infections are widespread in Hawaiian green turtles (*Chelonia mydas*) in both apparently normal and those with fibropapillomas (Casey *et al.*, 1997).

#### **Chordata: Aves**

Twenty species have been added to the checklist of Hawaiian birds since 1995 to total 294 (Pyle, 1997): 63 resident native species, 55 resident nonindigenous species, 13 breed-

**Table 3.** Fossil scleractinian corals from the Hawaiian Islands

Coral Species	Oahu		Midway	
	Nanakuli	Kahuku	Post-Miocene	Miocene
Acroporidae				
<i>Acropora</i> sp.				x
<i>Montipora patula</i>	x			
Agariciidae				
<i>Pavona clavus</i>			x	
<i>P. duerdeni</i>	x	x		
<i>P. maldivensis</i>			x	
Balanophyllidae				
<i>Balanophylla</i> sp.	x			
Faviidae				
<i>Cyphastrea ocellina</i>	x	x	x	
<i>Favia</i> sp. A,B,C				x
<i>Favites</i> cf. <i>chinensis</i>				x
<i>Leptastrea purpurea</i>	x			
<i>Plesiastrea</i> cf. <i>curta</i>				x
Agariciidae				
<i>Leptoseris</i> cf. <i>incrustans</i>				x
Fungiidae				
<i>Fungia scutaria</i>	x			
Oculinidae				
<i>Galaxea haligena</i>				x
Pocilloporidae				
<i>Pocillopora damicornis</i>	x			
<i>P. eydouxi</i>	x			
<i>P. ligulata</i>	x	x	x	
<i>P. meandrina</i>	x	x	x	
<i>P.</i> cf. <i>hemprichi</i>				x
<i>Seriatopora</i> cf. <i>hystrix</i>				x
<i>Stylophora gemmans</i>				x
<i>S. pistillata</i>				x
Poritidae				
<i>Porites compressa</i>	x	x		
<i>P. lobata</i>	x	x	x	
<i>Porites</i> sp. A,B,C				x
Thamastreidae				
<i>Psammocora</i> sp.	x			
Caryophylliidae				
<i>Paracyathus gardineri</i>	x			

ing visitor species, 163 nonbreeding visitor species; an additional 150+ nonindigenous, not established species have been sighted; Moniz (1997) provided evidence from archaeological assemblages that at least 4 additional seabirds bred historically in the Hawaiian Islands.

**FOSSIL SPECIES:** This compilation of fossils known from the Hawaiian Islands is preliminary and will be further updated (additional information is most welcome).

**Protozoa: Radiolaria:** Fossil

A core drilled during the Ocean Drilling Program was analyzed to contain 108 species of Quaternary, Eocene, and Cretaceous radiolarians (Hull, 1993), see the Bishop Museum web site for species.

**Protozoa: Foraminifera:** Fossil

The foraminiferans are fully enumerated in the Burch & Burch checklist and bibliography, see the Bishop Museum web site.

**Flowering Plants:** Fossil

One species of fossil cotton reported (Woodcock & Webb, 1998).

**Cnidaria: Scleractinia:** Fossil

A total of 27 species of fossil scleractinian corals have been reported from the Hawaiian Islands (Hagstrom, 1979; Wells, 1982) (see Table 3).

**Arthropoda: Crustacea: Ostracoda:** Fossil

Holden (1967) reported 35 species of ostracods from drowned terraces, 13 described as new species, many of these species are extant and are found at depths of less than 50 fathoms; Holden (1976) reported 115 taxa (25 described as new species, 10 new subspecies, 50 as “sp.”) from Midway Atoll drill holes, only 8 species are considered in common with those of Holden (1967); see the Bishop Museum web page for species lists.

**Mollusca:** Fossil

Kay (1979) briefly reviewed the fossil history of the Hawaiian molluscan fauna, indicating that the data are “too sparse and unstudied to draw conclusions on the course of history of the marine mollusks of the Hawaiian Islands . . .” (p. 14). A number of publications list a variety of species and since many include out-of-date taxonomy, a list of species has not been compiled at this time, in addition most of the species reported from “fossil” limestone are currently found living on Hawaiian reefs. The major publications reporting fossil marine mollusks are: Ostergaard (1928, 62 gastropod and 20 bivalve species); Dall *et al.* (1938, 188 bivalve species, many reported as “new species”); and Kosuge (1969, 159 gastropod and 32 bivalve species); Hagstrom (1979, 156 gastropod and 36 bivalve species); 2 species of land snails (Endodontidae) are reported from Pleistocene limestone drill holes from Midway Atoll (Solem, 1977); 16 or more land snail species are known to have inhabited the ‘Ewa Plain, O‘ahu, prior to human habitation (Christensen & Kirch, 1986).

**Chordata: Aves:** Fossil

Fifty-one species of fossil birds have been reported from the Hawaiian Islands; Olson & James (1991) reported 35 species, describing new nonpasseriform species; James & Olson (1991) described 16 new fossil passeriform species and discuss 8 possible additional new species.

**Chordata: Mammalia:** Fossil

One undescribed fossil species of bat is known (F.G. Howarth, pers. comm.).

**Acknowledgments**

We thank the libraries of Bishop Museum, Smithsonian Institution, and University of Hawaii at Mānoa for access to literature and also thank Warren L. Wagner (Smithsonian Institution) for his assistance. We thank the John D. and Catherine T. MacArthur Foundation for their continued support of the Hawaii Biological Survey, including some of the compilations referenced in this summary.

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