

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From literature and unpublished sources, approximately 22,056 species have been recorded from the Hawaiian Islands and surrounding waters.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.

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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 & Egger 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 *Cystobranchus* 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.).

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