

## How many species are there in Hawaii?<sup>1</sup>

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### Introduction

The Hawaiian Islands are the most isolated island group in the world. The 8 main southeastern islands, with their sequentially younger geological ages, great physiographic and climactic variation, are ideal natural laboratories for evolutionary and ecological research (see Howarth 1990, Kay 1994 for further background). Although the Hawaiian biota has been subjected to systematic study since shortly after the founding of Linnaean nomenclature, these results are scattered through publications and collections around the world. Moreover, many gaps remain in the knowledge of Hawaii's biota, especially for the smaller organisms such as viruses, bacteria, freshwater algae, protists, and soil invertebrates other than insects and mollusks. This paper is a first approximation by Bishop Museum's Hawaii Biological Survey to answer the frequently asked question: "How many species are there in Hawaii?"

In compiling this list, we have collected and assembled data and wisdom of the staff of Bishop Museum, libraries of the Bishop Museum and the University of Hawaii, and many colleagues in Hawaii and around the world. The marine portions draw heavily from the ongoing project *Reef and shore fauna of Hawaii*. The terrestrial invertebrate data derive primarily from an invertebrate survey pilot project supported by the John D. and Catherine T. MacArthur Foundation in the late 1980s. An early version of the terrestrial and freshwater portions of the list was circulated at the Hawaii Conservation Biology Initiative annual meeting in 1992. The interest of that group prompted us to continue the effort. We know that the present list is incomplete in several ways: 1) we expect that some literature has been missed; 2) we know that additional information, including unpublished new species, exist in museum collections; and 3) further fieldwork will produce additional records. The Hawaii Biological Survey is creating comprehensive databases for basic taxonomic, distributional, and biological information on all the organisms occurring in Hawaii, so we welcome additions and corrections to this list.

Classification of animals generally follows Parker (1982), with the use of kingdoms in the sense of Margulis & Schwartz (1988). Some artificial categories of convenience are used (for examples, marine mollusks). Freshwater categories generally include brackish water dwellers. Viruses and bacteria are not included because too few data are available, although the plant parasitic species were reviewed by Raabe *et al.* (1981). Human parasites are also not included. Unless noted, all numbers represent described species reported in the literature and often under-represent the eventual total which can be expected based on further exploration. On the other hand, there may be many more names in the literature for some groups because the taxa have not been reviewed or revised to eliminate the synonyms. The numbers from the *Reef and shore fauna* manuscripts include previously unpublished records.

The term endemic is problematic. In the terrestrial environment it is easy to determine the boundaries of the Hawaiian Islands, but the fact that a species is known only from Hawaii may mean only that it has not yet been reported elsewhere. This is especial-

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ly a problem in groups that require specialized sampling techniques and that may have been better studied in Hawaii than in many other places (e.g., planktonic crustaceans, soil mites). In the marine environment this problem is worse because the ocean provides a medium for movement throughout the Indo-west Pacific. Moreover, it is difficult to determine boundaries. Thus, we expect that most of the taxa currently listed as endemic to Hawaii's marine environment will ultimately prove to be more widely distributed.

**Definitions**

For the marine environment "Hawaii" includes the coastal areas to the deepest waters, including all the waters surrounding all of the islands of the archipelago.

*Nonindigenous species* (NIS) are those species that do not naturally occur in the Hawaiian Islands and have arrived either accidentally or intentionally through biological control efforts, aquaculture imports, etc. These species have also been referred to as alien, exotic, adventive, or introduced species (Frank & McCoy 1990).

*Indigenous species* are those species which naturally occur in the islands but are not endemic to the islands (i.e., they also occur naturally elsewhere).

For birds, *visitors* are nonresident species; *migratory* birds follow a repeatable pattern of occurrence in the islands.

*Subfossil/fossil* species in Hawaii are used in the context of birds and bats that became extinct prior to the arrival of Captain Cook. Invertebrate fossils discovered through core sampling, archaeological digs, and other techniques have not been included in the data tabulated below.

*Extinct* species are those forms that no longer exist in their natural habitat. It is difficult at best to attempt a tabulation of how many of the species originally described from the Hawaiian Islands have become extinct through natural processes or with the advent of humans and the concomitant destruction of native habitats and associated species through time. Data on known extinct vertebrates are included in the notes, but not in Table 1.

**Table 1. Estimates of Numbers of Species of the Hawaiian Biota**

<b>Taxon</b>	<b>Total</b>	<b>Endemic</b>	<b>NIS</b>	<b>Reference(s)</b>
<b>PROTOCTISTA</b>				
Algae				
freshwater	120+	2	?	Vis <i>et al.</i> 1994; I.A. Abbott, pers. comm.
marine	470	?	5	I.A. Abbott, pers. comm.
Myxomycota	101	0	?	Eliasson, 1991
Protozoa				
Foraminifera	1000+	?	0	Phillips, 1977; Chave, 1987
Other protozoa	42	2?	0	Ball, 1963; Phillips, 1977; Larsen & Patterson, 1990; Boyko, 1994
<b>FUNGI</b>				
Fungi	1300	?	?	Baker & Goos, 1972; Goos, 1977; Kohlmeyer, 1969
Lichens	723	240	?	Smith, 1991, 1993
<b>PLANTAE</b>				
Bryophytes				
mosses	244	112	11	Hoe, 1979
liverworts	220	?	?	Miller & Whittier, 1990

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Taxon	Total	Endemic	NIS	Reference(s)
Fern Allies	24	7	2	W.H. & F. Wagner, pers. comm.
Ferns	205	124	27	W.H. & F. Wagner, pers. comm.
Gymnosperms	10?	0	10?	W. Appleby, pers. comm.
Angiosperms	1894	850	861	Wagner <i>et al.</i> , 1990; HBS Records for 1994*
<b>ANIMALIA</b>				
<b>Phagocytellozoa</b>				
Placozoa	1	0	0	Pearse, 1989
<b>Parazoa</b>				
Porifera				
marine	84	24	4+	Bergquist, 1977; Chave & Jones, 1991
freshwater	1	0	1	Svihla, 1941
<b>Eumetazoa</b>				
Cnidaria				
Hydroida				
marine	23	4	1	Cooke, 1977
deepwater	51	31	0	Nutting, 1905
freshwater	2	0	2	Matthews, 1966
Siphonophora	1	0	0	Eldredge & Devaney, 1977
Chondrophora	2	0	0	Eldredge & Devaney, 1977
Scyphozoa	13	0	5	Devaney & Eldredge, 1977; Cooke, 1984; Burch & Burch, 1995
Octocorallia	105	17	1	Devaney, 1977b; Grigg & Bayer, 1976; Muzik, 1978; Versevelt & Bayer, 1988; Bayer, 1990; Chave & Jones, 1991
Zoantharia	23	5	1	Cutress, 1977
Zoanthiniara	7	4	0	Walsh & Bowers, 1977
Scleractinia	99	12	0	Maragos, 1977, 1995; Grigg <i>et al.</i> , 1981; Cairns, 1984
Antipatharia	15	1	0	Grigg & Opresko, 1977; Chave & Jones, 1991
Ctenophora	10	0	1	Devaney, 1977a; R. Galt, pers. comm
Platyhelminthes				
marine	41	20	0	Poulter, 1987
freshwater/terrestrial	8	4	4	Hyman, 1939; Kawakatsu & Mitchell, 1984; Kawakatsu <i>et al.</i> , 1984
parasitic	519	371+	0	Yamaguti, 1968a, 1968b, 1970; Kaneko <i>et al.</i> , 1988; Dailey <i>et al.</i> , 1992
Nemertinea				
marine	26	5?	0	Coe, 1947; Devaney & Eldredge, 1987; J. Norenburg, pers. comm.
freshwater/terrestrial	2	0	2	Howarth & Moore, 1983; J. Norenburg, pers. comm.
Gnathostomulida	8	4	0	Sterrer, 1991
Rotifera				
marine	3	0	0	Hope, 1987
freshwater	27	?	0	P.N. Turner, pers. comm
Nematoda				
marine	54	23	0	Hope, 1987
plant/soil	127	?	?	Olveira, 1940; E.M. Noffsinger & E.P. Caswell (unpubl. 1989)
zooparasitic	33+	?	?	Chapin, 1925; Deardorff <i>et al.</i> , 1982; Deardorff, 1987; McKenzie & Davidson, 1989

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Taxon	Total	Endemic	NIS	Reference(s)
Priapulida	1	0	0	J. Bailey-Brock, pers. comm..
Mollusca				
Gastropoda				
marine	572	119	4	Kay, 1979; Kay & Palumbi, 1987
terrestrial	831±	759	50±	R.H. Cowie <i>et al.</i> , in press
freshwater	37±	7	30±	R.H. Cowie, pers. comm.
Bivalvia				
marine	129	66	1	Kay, 1979; Kay & Palumbi, 1987
freshwater	1	0	1	Burch, 1978; HBS Records for 1994
Polyplacophora	4	3	0	Kay, 1979
Scaphopoda	3	0	0	Kay, 1979
Cephalopoda	73	2	0	Kay, 1979; Berry, 1914; Roper & Young, 1975; Roper <i>et al.</i> , 1984; Young, 1991
Aplacophora	6	0	0	Kay, 1979
Annelida				
Oligochaeta				
marine	26	11	3?	Bailey-Brock, 1987; Erséus & Davis, 1989; Erséus, 1990
terrestrial	20	0	20	Nakamura, 1992; S.W. James, unpubl.
Archannelida	2	0	0	Bailey-Brock, 1987
Hirudinea				
marine	3	0	0	Bailey-Brock, 1987; Choy <i>et al.</i> , 1989
terrestrial	3	0	3	Moore, 1946
Polychaeta				
marine	250+	69+	4	Pettibone, 1986; Paxton & Bailey-Brock, 1986; Bailey-Brock & Hartman, 1987; Bailey-Brock, 1990, 1991; Fauchald, 1992
freshwater	1	0	0	Van Zwaluwenburg, 1948
Pogonophora	2	2	0	Southward, 1980
Echiura	6	0	0	Edmonds, 1987
Sipuncula	14	0	0	Edmonds, 1987
Arthropoda				
Insecta (nonmarine)				
Blattaria	19	0	19	Nishida, 1994
Coleoptera	1987	1358	597	Nishida, 1994; HBS Records for 1994
Collembola	168	95	71	Nishida, 1994
Dermaptera	24	9	14	Nishida, 1994
Diptera	1426	1048	631	Nishida, 1994
Heteroptera	316	214	96	Nishida, 1994; HBS Records for 1994
Homoptera	689	385	299	Nishida, 1994; HBS Records for 1994
Hymenoptera	1283	654	605	Nishida, 1994; HBS Records for 1994
Lepidoptera	1153	950	192	Nishida, 1994; HBS Records for 1994
Mallophaga	102	5	44	Nishida, 1994
Neuroptera	60	51	8	Nishida, 1994
Odonata	41	31	8	Nishida, 1994; HBS Records for 1994
Orthoptera	290	263	26	Nishida, 1994; Otte, 1994
Psocoptera	135	89	42	Nishida, 1994
Thysanoptera	147	29	116	Nishida, 1994
Remaining orders	62	6	45	Nishida, 1994
Insecta (marine)	4	1	0	Herring, 1961, 1965; N.L. Evenhuis, pers. comm.
Araneae	198	119	71	Nishida, 1994; HBS Records for 1994
Chilopoda	24	12	12	Nishida, 1994
Diplopoda	26	16	9	Nishida, 1994
Palpigrada	1	0	1	Nishida, 1994

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Taxon	Total	Endemic	NIS	Reference(s)
Paupoda	2	0	1	Nishida, 1994
Pseudoscorpionida	12	12	0	Nishida, 1994
Shizomida	1	0	1	Nishida, 1994
Scorpionida	1	0	1	Nishida, 1994
Crustacea				
Branchiopoda	4	0	0	Ueno, 1936
Ostracoda				
marine	31	?	0	J.C. Holden, MS; Kornicker, 1976; Danielopol & Hartmann, 1986; Hartmann, 1991
freshwater	1	?	?	Vávra, 1906
Copepoda	100	?	?	L.G. Eldredge, MS; Motoda, 1963; Lewis, 1966, 1967; Humes, 1976; Wells, 1986; Kunz, 1993; HBS Records for 1994
Cirripedia	58	?	0	W.A. Newman, MS; Pilsbry, 1907; Boschma, 1953
Stomatopoda	17	11	1	L.G. Eldredge, MS
Mysidacea	14	?	0	L.G. Eldredge, MS; Ortmann, 1906
Tanaidacea	8	7	0	M. Miller, MS
Isopoda				
marine	27	?	?	M. Miller, MS; Richardson, 1906
terrestrial	51	15	26	Nishida, 1994
Amphipoda				
marine	172	?	8	Barnard, 1970; Brusca, 1973, 1978
terrestrial	9	6	3	Nishida, 1994
Euphausiacea	27	?	0	Ortmann, 1906; Brinton, 1962
Decapoda				
Penaeidae	20	0	0	L.G. Eldredge, MS
Sergestidae	10	0	0	L.G. Eldredge, MS
Stenopodidea	5	4	1	L.G. Eldredge, MS
Caridea	149	?	1	L.G. Eldredge, MS
Astacidea	1	0	1	Eldredge, 1994
Thalassinidea	8	?	1	L.G. Eldredge, MS
Palinuridea	13	2	0	L.G. Eldredge, MS
Anomura	43	?	0	L.G. Eldredge, MS
Brachyura	189	?	7	L.G. Eldredge, MS; HBS Records for 1994
Acari				
marine	19	17	2	Nishida, 1994
terrestrial	517	97	337	Nishida, 1994; HBS Records for 1994
Pycnogonida	12	?	0	J.H. Stock, MS; Child, 1972
Tardigrada	22	1	19	Nishida, 1994; McInnes, 1994
Phoronida	3	0	0	Emig & Bailey-Brock, 1987
Bryozoa	150+	?	?	Soule <i>et al.</i> , 1987
Entoprocta	?	?	?	Soule <i>et al.</i> , 1987
Brachiopoda	3	0	0	Emig, 1987; B.L. Burch, pers. comm.
Chaetognatha	8	1	0	Alvarino, 1978; Pierrot-Bults & Nair, 1991
Echinodermata				
Crinoida	16	15	0	L.G. Eldredge, MS; Clark, 1949
Asteroidea	82	53	0	L.G. Eldredge, MS; Clark, 1949
Echinoidea	75	35	0	L.G. Eldredge, MS; Clark, 1949
Holothuroidea	48+	19	0	L.G. Eldredge, MS; Clark, 1949
Ophiuroidea	57	28	0	D.M. Devaney & A.N. Baker, MS; Clark, 1949
Hemichordata	4	1	0	L.G. Eldredge, MS; Hadfield & Young, 1983; 1 undescribed sp.
Chordata				
Cephalochordata	1	0	0	Eldredge, 1967

Taxon	Total	Endemic	NIS	Reference(s)
Urochordata (Tunicata)				
Thaliacea	24	0	0	Metcalf & Hopkins, 1919; Yount, 1954; Soest, 1974a, 1974b
Larvacea	2	0	0	Taguchi, 1982; Kitalong, 1986
Ascidiacea	45	7?	2?	D.P. Abbott, MS; Tokioka, 1967
Pisces				
marine	1150+	134+	33	Eldredge, 1994; B. Mundy, pers. comm.
freshwater	45	5	40	Eldredge, 1994; Maciolek, 1984, Devick <i>et al.</i> , 1992
Amphibia	4	0	4	Vitousek <i>et al.</i> , 1987; C. Kishinami, pers. comm.
Reptilia	18	0	18	Vitousek <i>et al.</i> , 1987; Eldredge, 1994; C. Kishinami, pers. comm.
Aves	274	60	46	R.L. Pyle, pers. comm.
Mammalia				
terrestrial	20	1	19	Tomich, 1986
marine	24	0	0	Tomich, 1986
<b>totals</b>	<b>21,383</b>	<b>8,759</b>	<b>4,532</b>	

\* HBS Records for 1994 = articles in *Bishop Museum Occasional Papers* 41 and 42 of the Records of the Hawaii Biological Survey for 1994.

### Notes

**Algae:** Marine algae numbers are from an identification manual in preparation by I.A. Abbott & W. Magruder; numbers for freshwater and terrestrial species are only estimates, except for Vis *et al.* (1994) who reported 34 species; all other existing literature is outdated and unreliable (e.g., MacCaughey 1918).

**Protozoa:** Chave (1987) noted more than 1000 species in Hawaiian waters; Philipps (1977) reported on more than 400 species from depths less than 100 ft; Larsen & Patterson (1990) reported 31 benthic marine flagellate species, including 2 new species.

**Fungi:** Baker & Goos (1972), following Parris (1940) recorded 683 species, including Myxomycota (slime molds) but not lichens; Goos (1977) recorded 900 species of Fungi Imperfecti; Baker (1977) noted 1591 species of fungi from Hawaii and the central Pacific islands. Undoubtedly, the true number is much higher because the fungi are poorly studied in Hawaii (see also Goos & Gowing 1992). Hawksworth (1994) suggested that in a given geographical area there are about 6 times as many fungi in all habitats as there are native and naturalized plant species, which suggests that there may be 12,000 species of fungi. Endemism is very low (Baker & Goos 1972, Baker 1977, Goos 1977). Kohlmeier (1969) recorded 27 species of marine fungi including 2 nonindigenous species.

**Lichens:** Smith (1991) recorded 723 species, suggesting that there may be more than 800 species (his 1991 numbers include taxonomic changes published in Smith 1993). He recorded 240 species as supposedly endemic and suggested that the true number may be lower; 1 genus (*Ramalinopsis*) is endemic. See also Stenroos & Smith (1993).

**Ferns** (Polypodiophyta) and **fern allies** (Psilophyta and Lycophyta): Only native and naturalized (e.g., growing in the wild) species are listed; more than 200 additional species are cultivated (G. Staples, pers. comm.)

**Angiosperms:** Only native and naturalized species are listed; on the order of 8000 additional species are cultivated in agricultural settings and home gardens (G. Staples, pers. comm.).

**Porifera:** Of 80 species listed, 5 are known only from depths greater than 100 m, 5 recorded only from the Waikiki Aquarium, and 8 that might be considered doubtful species (Bergquist 1977).

**Cnidaria: Octocorallia:** Of 105 species listed, 4 are shallow water (Devaney 1977b),

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remaining are 1 species of bamboo coral (Muzik 1978) and 101 species of deep-water gorgonians (Grigg & Bayer 1976, Versevelt & Bayer 1988, Bayer 1990).

**Cnidaria: Scleractinia:** Of 98 species listed, 42 found in shallow water (Maragos 1977), 49 in deeper water (Cairns 1984), 3 from northwest islands (Grigg *et al.* 1981), 5 new records in Maragos (1995); of 91 published species, 50 are exclusively ahermatypic, 37 are exclusively hermatypic, 4 are facultative species (Cairns 1984).

**Platyhelminthes (Parasitic):** Of 511 species listed, 147 monogenetic species including 132 species described from 121 species of Hawaiian fishes (Yamaguti 1968b). Of 357 digenetic species, 314 species including 227 species described from Hawaiian fishes. Also 30 species not cited (Yamaguti 1970), 13 from Yamaguti (1965), 7 species of cestodes (Yamaguti 1968a), and non-indigenous, marine, cage-cultured, freshwater tilapia with 1 species of marine monogenean (Kaneko *et al.* 1988).

**Nemertinea:** Of the 28 species in the table, 6 species from Coe (1947), 7 benthic and 12 pelagic undescribed/unreported species, 2 introduced terrestrial species (J. Norenburg, pers. comm.) plus 1 parasitic (Humes 1942).

**Annelida: Oligochaeta:** Of 26 species listed, 23 Tubificidae (Erséus & Davis 1989); 1 new species by Erséus (1990); the other 2 are unidentified species (Bailey-Brock 1987).

**Annelida: Polychaeta:** Approximately 100 additional species are known, but not yet reported from Hawaiian waters (J. Bailey-Brock, pers. comm.).

**Nematoda: zooparasitic:** The figure given is very incomplete. Of 33 species, 22 are from intermingling herds of mammals on Molokai (McKenzie & Davidson 1989); 2 from monk seals (Chapin 1935), 8 larval forms from fishes (Deardorff *et al.* 1982), 1 parasitic record from an elasmobranch (Deardorff 1987).

**Mollusca: Gastropoda:** There are 763 nomenclaturally correct native land species; all endemic except 2–4 indigenous but not endemic species (Cowie *et al.*, in press), approximately 50 nonindigenous species (R.H. Cowie, pers. comm.); 7 endemic freshwater snails, approximately 30 nonindigenous species (R.H. Cowie, pers. comm.).

**Mollusca: Cephalopoda:** Of 73 species in the table, only 4 considered benthic (Kay 1979; Roper *et al.* 1984); for other pelagic species see Roper & Young (1975) and Young (1991).

**Crustacea: Branchiopoda:** Four species from Mauna Kea at elevations from 6500–13,700 ft [1980–4175 m] (Ueno 1936).

**Crustacea: Ostracoda:** Numerous species; J.C. Holden (MS) made identifications to only genera, he noted more than 100 fossil species; 30 benthic species (Kornicker 1976, Danielopol & Hartmann 1986, Hartmann, 1991); 1 freshwater species (Vávra 1906).

**Crustacea: Copepoda:** The 92 species listed include planktonic, benthic, and ectoparasitic forms; 5 interstitial species (Wells 1986).

**Crustacea: Cirripedia:** Of 58 species in the table, 11 are from deep water including 8 new species (Pilsbry 1907); 46 shallow-water species includes 3 acrothoracican species (W.A. Newman, MS key); 1 rhizocephalan parasite (Boschma 1953).

**Crustacea: Isopoda:** Of 27 marine species, 3 were collected in deep water (Richardson 1906); 6 species are parasitic epicarideans (Danforth 1970); of 51 terrestrial species 15 are endemic and 25 nonindigenous species.

**Crustacea: Amphipoda:** Of 172 species listed, 121 gammarideans (Barnard 1970), 4 gammarideans (Brusca 1973), 7 caprellids, 40 hyperiids (Brusca 1973, 1978).

**Entoprocta:** Soule *et al.* (1987) provided only unidentified generic descriptions; 55 species reported from Kaneohe Bay (Dade & Honkalehto 1986).

**Chaetognatha:** Seven pelagic species from distribution maps (Pierrot-Bults & Nair 1991); 1 benthic species described from Kure Atoll, Hawaii (Alvarino 1978).

**Echinodermata: Crinoidea:** Of 16 species listed in the table, 11 described as new species by Clark (1908); no shallow-water forms.

**Echinodermata: Asteroidea:** Of 82 species listed, 18 found in shallow water and 64 in deeper water; 1 species and 2 subspecies of shallow-water forms considered endemic (Devaney & Baker MS); 50 species endemic to deeper waters described as new (Fisher 1906).

**Echinodermata: Echinoidea:** Of 75 species, 21 found in shallow water (Eldredge MS), 53 in deeper water; *Cylpeaster eurypterus* known only from Pearl and Hermes Reef, and Midway and Kure atolls; 35 new species described from *Albatross* material.

**Echinodermata: Holothuroidea:** Of 48+ species in the table, 24 found in shallow water (Eldredge, MS), 24 in deeper water; 3 shallow-water and 1 deep-water for considered endemic (Clark & Rowe 1971); Fisher (1907) described 19 new species out of 46 reported; reports (unpublished) of additional species are known.

**Echinodermata: Ophiuroidea:** Of 57 species, 19 found in shallow water (Devaney & Baker MS), 38 in deeper water; 6 shallow-water and 22-deep-water forms endemic.

**Chordata: Urochordata: Thaliacea:** 19 species of Salpidae—cosmopolitan oceanic planktonic organisms in the circumglobal warm water zone (Yount 1958); 1 species of *Pyrosoma* (Metcalf & Hopkins 1919).

**Chordata: Pisces:** The 1150+ marine species listed include all species from all depths to 200 miles from shore—no freshwater, no undescribed, and no doubtful species are included; 1285 species when all conditions provided (B. Mundy, pers. comm.); Randall (1992) listed 536 species of shore fishes, with 25% endemism.

**Chordata: Aves:** The 274 species listed is an all-inclusive contemporary list: 60 resident native species, 46 resident nonindigenous species, 13 breeding visitor species, 155 nonbreeding visitor species. There are also 16 species extinct since Captain Cook, 35+ extinct before Captain Cook (subfossil), and 150± nonindigenous species not established bringing the total number of species known to occur or be sighted in Hawaii to 475± (R.L. Pyle, pers. comm). [Pyle (1992) listed 131 bird species; 53 nonindigenous species.] Thirty-two fossil species have been described by Olson & James (1991) and James & Olson (1991).

**Chordata: Mammalia:** Of 20 species of terrestrial mammals 19 are free-ranging species (the horse is no longer feral) and 1 species of bat (an additional undescribed subfossil species of bat is known; F.G. Howarth, pers. comm.); of 24 marine species, 2 are littoral marine (seals) and 22 are pelagic (whales and dolphins) (Tomich 1986).

### Summary

From literature and unpublished sources, approximately 21,383 species have been recorded from the Hawaiian Islands and surrounding waters. Of these, 8,759 are endemic to the Hawaiian Islands, and 4,532 are nonindigenous species of protists, fungi, plants, and animals. Of these approximately 15,000 species are terrestrial, 300 are found in freshwater, and 5,500 are marine-inhabiting. Endemism varies from very low (e.g., lower plants and many marine organisms) to very high (e.g., insects and snails). However, many gaps in the knowledge of Hawaii's biota (especially the smaller organisms—viruses, bacteria, protists, freshwater algae, etc.), still remain.

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