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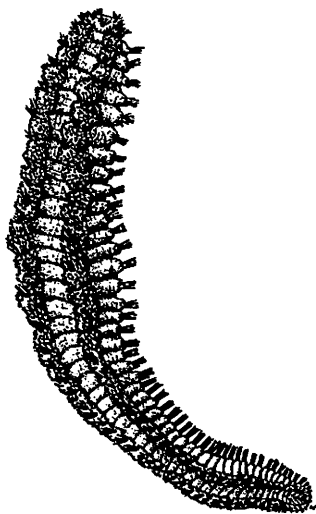
BISHOP MUSEUM OCCASIONAL PAPERS

RECORDS OF THE
HAWAII BIOLOGICAL SURVEY
FOR 2000
PART I: ARTICLES


NEAL L. EVENHUIS

AND

LUCIUS G. ELDREDGE, EDITORS



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BISHOP MUSEUM

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RECORDS OF THE HAWAII BIOLOGICAL SURVEY FOR 2000 Part 1: Articles

Editors' Preface

We are pleased to present the seventh annual compilation of *Records of the Hawaii Biological Survey*. The number and diversity of taxa reported in these issues attest to the continuing value of the *Records* as part of the ongoing effort to inventory the Hawaiian biota accurately.

The Hawaii Biological Survey, established by the Hawaii State Legislature in 1992 as a program of 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 by State Law to 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

Some of the highlights of *Records of the Hawaii Biological Survey for 2000* include:

- an update of numbers of species in Hawai'i;
- a complete inventory of terrestrial insects and relatives from Midway Atoll;
- sixty-eight new nonindigenous species reported from Hawai'i during 2000;
- new records of plants, insects, and other invertebrates resulting from field surveys and continued curation of Hawaiian collections at Bishop Museum and elsewhere.
- an index to all articles and taxa published in the *Records* since its conception in 1994

An intensive and coordinated effort has been made by the Hawaii Biological Survey to make our products, including many of the databases supporting papers published here, available to the widest user-community possible through our web server. Products currently available include taxonomic authority files (species checklists for terrestrial arthropods, flowering plants, non-marine snails, marine invertebrates, foraminiferans, fossil taxa, and vertebrates), bibliographic databases (vascular plants, non-marine snails, and insects), specimen databases (fungi, fish, invertebrates, portions of the insect collection) and type specimens (entomology; botany—including algae and fungi; and vertebrates), collections data (lists of holdings for select groups of flies as well as Cicadellidae and Pentatomidae), detailed information and/or images on endangered, threatened, and extinct plants and animals; as well as our staff publication lists. Additional reference databases include: the list of insect and spider collections of the world (based on Arnett, Samuelson & Nishida, 1993, *Insect and spider collections of the world*) with links to institutional web pages where known; and the historical world Diptera taxonomists list with names of over 4,600 authors who have described flies.

Our Main Web Addresses:

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Hawaii Endangered and Threatened Species Web Site

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“Insect and Spider Collections of the World” Home Page

<http://hbs.bishopmuseum.org/codens/>

Hawaii Biological Survey’s “Good Guys/Bad Guys” website

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World Diptera taxonomist list

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The Hawaii Biological Survey now publishes a newsletter (*HBS Reports*) to inform our colleagues and the public about our recent activities. The pdf file may be downloaded from the HBS website:

<http://hbs.bishopmuseum.org/pdf/hbs-reports1.pdf>

The *Records of the Hawaii Biological Survey for 2000* were compiled with the assistance of George Staples (botany) and Frank Howarth (entomology), who helped review papers in their disciplines; and was partially supported by funds from the John D. and Catherine T. MacArthur Foundation. Many of the new records reported here resulted from curatorial projects funded by the National Science Foundation and field surveys funded by the David and Lucile Packard Foundation, U.S. Geological Survey Biological Resources Division, U.S. Fish and Wildlife Service, U.S. Department of Defense Legacy Program, and the 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 the editors listed below for consideration for publication in the next *Records*. Submission and format of papers must follow our guidelines. Information on submission of manuscripts and guidelines for contributors may be obtained on the web (via pdf format) at:

<http://hbs.bishopmuseum.org/guidelines.pdf>

or by mail from: Hawaii Biological Survey, Department of Natural Sciences, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817-2704, USA.

—*N.L. Evenhuis &
L.G. Eldredge, editors*
[email: hbs@bishopmuseum.org]

New Hawaiian Plant Records for 2000

STAPLES, GEORGE W., CLYDE T. IMADA, & DERRAL R. HERBST (Hawaii Biological Survey, Bishop Museum, 1525 Bernice St., Honolulu, HI 96817–2704, USA; email: gstaples@bishoppmuseum.org)

These previously unpublished Hawaiian plant records report 16 new state (including naturalized) records, 25 new island records, and 14 nomenclatural and taxonomic changes that affect the flora of Hawai'i. The ongoing incorporation of the state Endangered Species Program herbarium developed by the Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife (DLNR/DoFaW), into the BISH herbarium has brought to light a number of voucher specimens from the 1970s and 1980s that are first records for the state or for particular islands. These records supplement information published in Wagner *et al.* (1990, 1999) and in the Records of the Hawaii Biological Survey for 1994 (Evenhuis & Miller, 1995), 1995 (Evenhuis & Miller, 1996), 1996 (Evenhuis & Miller, 1997), 1997 (Evenhuis & Miller, 1998), 1998 (Evenhuis & Eldredge, 1999), and 1999 (Evenhuis & Eldredge, 2000). All identifications were made by the authors except where noted in the acknowledgments, and all supporting voucher specimens are on deposit at BISH except as otherwise noted.

Acanthaceae

Barleria repens Nees

New naturalized record

A relatively recent introduction to Hawai'i as an ornamental plant groundcover, this species was noted to spread out of planted areas and to have the potential to become invasive when it was first correctly identified (Staples & Herbst, 1994). Now there is evidence that *B. repens* has begun to move out of gardens and to appear in settings where it is clearly not cultivated. Collectors on all islands should monitor its distribution and abundance in the event that control measures become necessary.

This South American herb is typically less than 12" tall, has opposite, elliptic-ovate leaves 1–2" long, and axillary salmon-pink flowers about 1.75" long with a 5-lobed limb 1–1.5" across. The base of the flower is enclosed in 2 large papery bracts that persist in fruit, turning semi-transparent with darker veins. The slender capsule splits open forcibly and flings out the 4 flat, plate-shaped, 0.25" diameter seeds.

Material examined. O'AHU: Kuli'ou'ou Ridge trail, mixed alien mesic forest of *Acacia confusa*, *Psidium*, *Lantana*, 8 Sep 2000, F. Kraus *s.n.* (BISH 665308).

Dicliptera chinensis (L.) Juss.

New island record

This species is frequently confused (in the herbarium) with *Blechnum pyramidatum* (Lam.) Urban [Syn. *B. brownei* Juss.]. When several specimens were recently reidentified in the Bishop Museum herbarium, the following specimen was found to represent a new island record for the Big Island.

Material examined. HAWAII: Hāmākua Ditch, Lālākea, at the main weir, start of lower Hāmākua Ditch, 20° 04' N, 155° 25' W, elev. 1000 ft, 2 Aug 1996, D.R. Herbst 9792.

Hemigraphis reptans (G. Forst.) T. Anderson

New island record

The range of *H. reptans* in the Hawaiian Islands was reported to be Kaua'i, O'ahu, and Hawai'i (Wagner *et al.*, 1990). The following specimen documents its existence as a naturalized plant on Moloka'i; elsewhere in these Records it is documented from Maui (Oppenheimer & Bartlett, 2002). The species is grown as a cultivated ornamental on all inhabited islands and is likely to escape cultivation anywhere it is grown.

Material examined. MOLOKA'I: North shore, Waiehu landshelf, nearly prostrate herb growing in disturbed area, elev. 20–30 ft, 8 Sep 1987, S. Anderson *s.n.* (BISH 605522).

Justicia spicigera* Schldl.*New naturalized record**

The following specimens document this Central American species as naturalized in the Hawaiian Islands. It was formerly known only in cultivation as an ornamental plant. It is likely that it has escaped on other islands as well. Mexican indigo is a shrub to 6' tall with opposite leaves, the blades oblong-lanceolate to ovate, up to 7" long; inflorescences are few-flowered, one-sided racemes composed of 1.5" long, orange or red, 2-lipped flowers, the lower lip recurved.

Material examined. O'AHU: Honolulu, lower Round Top in disturbed dry forest along roadside above stream, near 2010 Round Top Drive, elev. ca. 61 m, 25 Mar 1998, G. Ray & E. Gibney 100. MOLOKA'I: Hälawa Valley, naturalized in areas along road, elev. ca. 100 ft, 9 Jul 1983, K. Nagata 2671.

Odontonema cuspidatum* (Nees) Kuntze*New island record**

Fire spike was first reported as a naturalized species by Lorence *et al.* (1995) from the island of Kaua'i. The following collections document its widespread distribution on the Big Island. Elsewhere in these *Records* it is documented as naturalized on Maui (Oppenheimer & Bartlett, 2002). Grown throughout the state as an ornamental shrub, *O. cuspidatum* is likely to escape and become naturalized anywhere it is grown.

Material examined. HAWAII: Ka'ü Distr., Keauhou Ranch, growing in a collapsed lava tube about 30 ft from Pu'u 'Ö'ö Road, in midst of a pasture area, elev. 4020 ft, 4 Jan 1980, L.W. Cuddihy (ESP) 93; along Saddle Road about 10 mi from Waimea, in forest above pasture area, 1 May 1990, D. Mueller-Dombois s.n. (BISH 573852); Keaukaha, about 50 ft from Kalaniana'ole Hwy, found in small ravine off Nēnē St., elev. 20 ft, 12 Jan 1973, S. Ishikawa 208; South Kona Distr., near Ho'okena, growing on roadside with *Schinus* and other non-native vegetation, elev. ca 1000 ft, 22 Aug 1987, L.W. Cuddihy 2073.

Amaranthaceae***Achyranthes aspera* L.****New island record**

The following specimen represents the first documented record for the existence of this naturalized species on Moloka'i.

Material examined. MOLOKA'I: roadside at the 19 mile marker east of Kaunakakai, ca. 15 m elev., 28 May 1998, N. Matayoshi s.n. (BISH 652141).

Annonaceae***Annona cherimola* Mill.****New naturalized record**

Field collectors recorded the cherimoya as naturalized on the Big Island as early as 1926 and it has been sporadically collected ever since from trees that were clearly not cultivated. Not treated in the *Manual* (Wagner *et al.*, 1990, 1999), this is the second recorded Annonaceae naturalized in the Hawaiian Islands, the first being *Artabotrys hexapetalus* (L.f.) Bhandari (Nagata, 1995).

The cherimoya is a semi-deciduous tree to 25' tall with alternate, distichous, elliptic to obovate leaves 4–6" long, their undersides grayish velvety hairy; the axillary trimerous flowers greenish white, ca. 1" long; and the aggregate fruits ovoid, 4–7" long, the surface bullate, pale green, the flesh white.

Material examined. HAWAII: Kona side of Wai'ōhinu, forming large thicket in moderately dry region on mauka side of road, completely naturalized, 25 Jul 1926, O. Degener 7276; North Kona Distr., Pu'uwa'awa'a, "wild," Aug–Sep 1917, J.F. Rock 12961; same loc., 30 Aug 1916, A.S. Hitchcock 14507; Pu'uuhuluhulu, pasture near escarpment transect, elev. 2640 ft, common at this site and Pu'uwa'awa'a cone, population sterile, 26 Dec 1989, W. Takeuchi 5777.

Apiaceae***Coriandrum sativum* L.****New island record**

Previously reported as naturalized on O'ahu, this specimen documents Chinese parsley (coriander) as a naturalized plant on Kaua'i.

Material examined. KAUA'I: Waimea Distr., Kōke'e State Park, in fence line at NE side of Div. of Forestry and Wildlife nursery site, elev. 3980 ft, 2 Apr 1997, *T. Flynn & G. Kawakami 6123* (BISH, NY, PTBG, US).

Torilis arvensis* (Huds.) Link*New state record**

This specimen, originally collected as *Daucus pusillus* Michx., was reidentified by Lincoln Constance in 1991 but overlooked until now. It represents the first state record for a second species of *Torilis* in the Hawaiian Islands. *Torilis arvensis* is native to central and southern Europe and is naturalized in California (Hickman, 1992). It can be distinguished from *T. nodosa* by the following key (adapted from Hickman 1992: 166):

1. Plants erect; peduncle longer than leaf; umbel open, not head-like; outer and inner fruit-halves equally prickly *T. arvensis*
 1. Plants spreading; peduncle shorter than leaf; umbel dense, head-like; outer fruit-half prickly, inner only tubercled *T. nodosa*

Material examined. KAUA'I: Kalalau Trail, in dry disturbed soil along trail at Pōhakuao, 14 Jun 1989, R. Hobdy, *S. Perlman & S. Gon 3059*.

Araliaceae***Schefflera actinophylla* (Endl.) Harms****New island record**

Octopus tree, already well known as an invasive arboreal weed on Kaua'i, O'ahu, Maui, and Hawai'i is here reported for the first time from Moloka'i. Although this voucher may have been from a planted tree, it documents the occurrence of *S. actinophylla* on the island and suggests one area where adventive seedlings and naturalized populations should be sought.

Material examined. MOLOKA'I: Kalaupapa National Historical Park, within the settlement area, 17 Sep 2000, *B.H. Gagne 3154*.

Asteraceae***Crepis vesicaria* L. subsp. *taraxacifolia*****New state record**

(Thuill.) Thuill.

This is the first record in Hawai'i for this western European subspecies of *Crepis vesicaria*, which has become widely established in the Canary Islands, Madeira, North America, New Zealand, and Australia (Babcock, 1947). A detailed discussion of the variation in this species, with a key to subspecies, descriptions, and illustrations, is available in Babcock's monograph of *Crepis* (Babcock, 1947).

Material examined. HAWAI'I: Puna Distr., Halepua'a ahupua'a, along side of Puna Trail in shade of mango trees, on cinder, ca 100 ft, 16 Apr 1979, *L. Yoshida 79.099*.

Euchiton japonicus* (Thunb.) Anderb.*New island record**

Following the adjustment in the taxonomic concepts for the tribe Gnaphalieae adopted by Wagner et al. (1997), *E. japonicus* was first recognized to be naturalized in Hawai'i based on a single Big Island collection. This specimen represents the first record from Maui.

Material examined. MAUI: East Maui, Kipahulu Valley, Haleakalā National Park, 1340 m, 10 Jul 1983, *A. Medeiros 462*.

Hypochoeris radicata* L.*New island record**

Rough cat's-ear was reported to be naturalized on all the main Hawaiian Islands except Ni'ihau and O'ahu (Wagner et al. 1990). The following specimen, from a roadside where hydromulching had recently taken place, is the first documentation for it on O'ahu.

Material examined. O'AHU: Honolulu, Upper Nu'uuanu Valley along Pali Hwy., near upper junction with Nu'uuanu Pali Dr., 21° 21' N, 157° 48' W, elev. 1000 ft, 1 Sep 1999, R. Heu s.n. (BISH 662906).

***Taraxacum officinale* W.W. Weber ex F.H. Wigg. Correction**

The authorship for the common dandelion as stated in the *Manual* (Wagner et al., 1990) is at odds with other reference works (Mabberley, 1997). It appears that the authority should be changed to "W.W. Weber ex F.H. Wiggers" as noted above.

Zinnia maritima* HBK*Taxonomic change**

Syn. *Z. palmeri* A. Gray

The completion of accounts of the Asteraceae in several floras for Mexico and Central America has brought to light some name changes affecting species naturalized in Hawai'i. The weedy zinnia reported in the *Manual* (Wagner et al., 1990) as *Z. palmeri* was reduced to synonymy under the widespread and variable *Z. maritima* by Rogers McVaugh in the Compositae account for the Flora Novo-Galiciana (McVaugh, 1984).

Zinnia peruviana* (L.) L.*New island records**

Previously documented from the islands of Lāna'i, Maui, and Kaho'olawe (Wagner et al. 1999: 379), the following collections extend the range of *Zinnia peruviana* to the islands of Moloka'i and Hawai'i. Although the specimen from Moloka'i was collected in 1948 and was annotated by the authors of the *Manual* in 1984, it seems to have been overlooked when the account of *Zinnia* was written (Wagner et al. 1990). Fosberg noted that the species was "said to be very abundant at other seasons."

Material examined. MOLOKA'I: Nā'iwa, road above 'Umipa'a, weedy along stony roadside, 22 Feb 1948, F.R. Fosberg 29558. HAWAI'I: South Kohala Distr., collected east of Queen Ka'ahu-manu Highway between Mauna Lani Drive and Puakō turnoff, elev. 200 ft, 4 Feb 1991, E. Funk s.n. (BISH 662876).

Begoniaceae***Begonia vitifolia* Schott****Nomenclatural change**

Misapplied: *B. reniformis sensu* Hawaiian authors

According to determinations for Hawaiian voucher material made by J. Doorenbos, a specialist in *Begonia* taxonomy, the plants naturalized in Hawaii are not *B. reniformis* but are instead the similar (and easily confused) *B. vitifolia*.

Cactaceae***Opuntia monacantha* (Willd.) Haw.****Nomenclatural change**

Syn. *Opuntia vulgaris sensu* Hawaiian authors, not of P. Miller; *O. cordobensis sensu* Hawaiian authors, not of Spegazzini.

Correct application of the name *Opuntia vulgaris* Mill. has long been confused, because Miller based the name on a mixture of elements that can be interpreted in various ways. A thorough nomenclatural review of the problem has established that 2 distinct taxa were included in Miller's taxonomic concept and the correct name for one of these, an erect, spiny species native to eastern South America, is *O. monacantha* (Leuenberger, 1993). Although the name *O. vulgaris* is widespread in older botanical and horticultural refer-

ence literature and will likely continue to appear in popular gardening books, the nomenclatural working group for the International Organization for Succulent Plant Study had already accepted Leuenberger's conclusion and the name change was taken up in an official checklist of Cactaceae names (Hunt, 1992), as well as in other references (Walters et al. 1989).

Routine verification of the voucher specimens for Cactaceae as part of the In Gardens of Hawaii II project revealed that naturalized and cultivated Hawaiian prickly pear specimens that had been called *O. vulgaris* and *O. cordobensis* are actually *O. monacantha*.

Ceratophyllaceae

Ceratophyllum demersum L.

New island record

Grown as an aquatic ornamental in Hawai'i at least since 1934, *Ceratophyllum demersum* was previously known to have become naturalized in Kanahā Pond, Maui, and in Waipi'o Valley, Hawai'i. The following collection documents its presence as a naturalized plant in the Salt Lake area of O'ahu. Elsewhere in these *Records* it is documented as naturalized on West Maui (Oppenheimer & Bartlett, 2002).

Material examined. O'AHU: Honolulu Distr., growing in Salt Lake periphery channel with *Bacopa* and *Ipomoea aquatica*; the colony covered about one acre, 3 Oct 2000, E. Funk s.n. (BISH 666283).

Chenopodiaceae

Bassia hyssopifolia (Pall.) Kuntze

New island record

Previously known in Hawai'i from a few collections made on O'ahu and Maui, *Bassia* was recently collected on Moloka'i. Elsewhere in these *Records* a range extension is documented for East Maui (Starr et al. this volume).

Material examined. MOLOKA'I: Kawela, growing along Kamehameha V Hwy, near sea level, 16 Dec 1999, D. Herbst, R. Palmer, & D. Paul 9875.

Chenopodium album L.

New island record

This annual herb, previously collected as a naturalized weed only from the Kula area on Maui (Wagner et al., 1990), has now been collected twice on the Big Island.

Material examined. HAWAI'I: western slope of Mauna Kea, west of Pu'u La'au, locally common in open understory of *Sophora/Myoporum* forest with *Lepidium*, *Bromus*, *Plantago*, and *Senecio madagascariensis*, elev. ca 6200 ft, 23 Sep 2000, C. Imada & M. Legrande 2000-21; South Kohala Distr., in open grassland east of Queen Ka'ahumanu Hwy. between Mauna Lani Drive and Puakō turnoff, 200 ft. elev., 4 Feb 1991, E. Funk s.n. (BISH 662898).

Chenopodium ambrosioides L.

New island record

Based upon the specimen cited below, the range of *Chenopodium ambrosioides* now includes the island of Kaua'i. It also has been documented from the islands of O'ahu, Lāna'i, Maui, and Hawai'i.

Material examined. KAUA'I: Nā Pali Coast, growing along stream in Awa'awapuhi Valley, ca. 300 ft elev., 19 Jul 1979, C. Corn et al. ESP-386.

Crassulaceae

In the course of having Crassulaceae voucher specimens identified for the In Gardens of Hawai'i II project, a number of specimens previously called *Kalanchoe* were renamed by Dr. Nigel Taylor as *Bryophyllum* species. A follow-up query to Dr. Taylor brought this response: "Please note that a consensus of Crassulaceae workers now accept *Bryophyllum*

(incl. *Kitchingia*) as distinct from *Kalanchoe*" (Taylor, pers. comm. 1995). This was sufficient impetus to investigate the situation in the botanical and horticultural literature.

For many years *Bryophyllum* Salisburi has been submerged in the larger genus *Kalanchoe* Adanson. The horticultural literature in general has maintained all species in *Kalanchoe* (L.H. Bailey Hortorium, 1976; Everett, 1980–1982; Huxley *et al.*, 1992, Cullen *et al.*, 1995). The *Manual* (Wagner *et al.*, 1990: 567–68) likewise reported 2 naturalized species of *Kalanchoe* (and one garden escape) for the Hawaiian Islands; subsequently, 2 further species were documented as naturalized on Kaua'i (Lorence *et al.*, 1995).

However, when the search was broadened to include botanical literature from the Afro-Malagasy region, it became clear that researchers studying wild plants in their area of origin recognize both genera (Fernandes, 1983; Wickens, 1982, 1987, and references cited therein). And, a recent attempt at a consensus classification for the Crassulaceae has accepted both genera, while pointing out the need for further systematic study, because removing *Bryophyllum* may result in a paraphyletic *Kalanchoe* (Eggl *et al.*, 1995). According to this classification, *Bryophyllum* comprises about 35 Madagascan species, and *Kalanchoe s.str.* includes about 50 species distributed in Africa, Arabia, Madagascar, and Asia (Eggl *et al.*, 1995).

Species of *Bryophyllum* and *Kalanchoe* are popular garden plants in Hawai'i, with a few species widespread in home gardens and numerous others cultivated by succulent plant enthusiasts. To aid in the correct identification of the two genera, the following diagnostic features may be helpful:

- 1. Flowers pendulous; sepals \pm united, calyx tubular or broadly campanulate; stamen filaments attached near base of corolla tube *Bryophyllum*
- 1. Flowers usually erect or upward-angled, not pendulous; sepals joined only at base; stamen filaments attached above middle of corolla tube *Kalanchoe*

All 4 species heretofore reported as naturalized in the Hawaiian Islands (plus one garden escape) are now classified as *Bryophyllum*, and name changes are necessary for them. One new island record is reported. It should be noted that recent evidence indicates that some genuine *Kalanchoe* species are also naturalized and these will be reported in a later paper. The following key, adapted from the Crassulaceae account written for A Tropical Garden Flora (Staples & Herbst, in press), will aid in identification of the 5 *Bryophyllum* species naturalized in the Hawaiian Islands.

- 1. Leaves (at least lower ones) \pm cylindrical or pencil-like, apex flaring, petiole absent or not distinct from blade (2).
 - 1. Leaves with a broad blade set off from narrower petiole (3).
 - 2(1). Plant scrambling or climbing, stem to 20 ft long; leaves opposite; corolla pale green-purple to violet-black *B. beauverdii*
 - 2. Plant erect, stem to 6 ft tall; leaves usually in whorls of 3; corolla pale orange to deep magenta *B. tubiflorum*
 - 3(1). All (or at least some) leaves compound *B. pinnatum*
 - 3. All leaves simple (4).
 - 4(3). Leaf blade broadest at or above middle, apex rounded *B. fedtschenkoi*
 - 4. Leaf blade broadest at base, apex long-tapering *B. daigremontianum*

***Bryophyllum beauverdii* (Raym.-Hamet)**

A. Berger

Taxonomic changeSyn. *Kalanchoe beauverdii* Raym.-Hamet

Noted in the *Manual* (Wagner *et al.*, 1990: 567) as a garden escape based on a single voucher from the Big Island, further collecting will likely prove this species to be fully naturalized. Unlike all other *Bryophyllum* species in the Islands, it is a vining-scrambling plant that can reach 2 meters in length.

Bryophyllum daigremontianum

(Raym.-Hamet & H. Perrier) A. Berger

Taxonomic change**& New island record**Syn. *Kalanchoe daigremontiana* Raym.-Hamet & H. Perrier

First reported as naturalized on Kaua'i (Lorence *et al.*, 1995), the following specimen represents the first documentation for *B. daigremontianum* as a naturalized species on O'ahu. The species has been abundant at the locality for years, a popular walking trail used by hundreds of city residents on weekends; it is surprising that no one has collected it before.

Material examined. O'AHU: Ko'olau Poko Distr., Makapu'u Point state wayside, 21° 18' N, 157° 39' W, naturalized in disturbed coastal dry mixed community, 7 Nov 1996, C. Annable & D. Atha 3119.

Bryophyllum fedtschenkoi

(Raym.-Hamet & H. Perrier) Lauz.-March.

Taxonomic changeSyn. *Kalanchoe fedtschenkoi* Raym.-Hamet & H. Perrier***Bryophyllum pinnatum* (Lam.) Oken**Syn. *Kalanchoe pinnata* (Lam.) Pers.**Taxonomic change*****Bryophyllum tubiflorum* Harv.**Syn. *Kalanchoe tubiflora* (Harv.) Raym.-Hamet**Taxonomic change****Cyperaceae*****Bolboschoenus maritimus* (L.) Palla subsp.***paludosus* (A. Nelson) T. Koyama**New island record**

This indigenous wetland sedge had been collected on all of the main Hawaiian Islands except for Lāna'i and Hawai'i. This represents the first collection from Hawai'i.

Material examined. HAWAII: North Kona Dist., Makalawena, along margin of 'Ōpae'ula Pond, 8 Nov 2000, P. Van Dyke *s.n.* (BISH 666167).

Fabaceae***Clitoria heterophylla* Lam.****New state record**

This specimen documents the existence of a second naturalized *Clitoria* species in the Hawaiian Islands. *Clitoria heterophylla*, native to Madagascar and the Mascarene Islands (Polhill, 1990) and cultivated in Java (Backer & Bakhuizen, 1963), is a twining herb with 5–7 leaflets per leaf, the leaflet shape varying from node to node along the stem, often orbicular to broadly obovate, blue flowers, and slightly curved or straight oblong pods up to 4.5 cm long, containing 5–10 subrectangular brown seeds. It can be distinguished from *C. ternatea*, butterfly pea, by means of the following key (translated and adapted from Polhill 1990).

1. Leaflets ovate to elliptic, usually 1.5–6.5 × 1–4 cm; corolla length 3.5–5.5 cm; pods 6–12.5 × 0.7–1.2 cm..... *C. ternatea*
 1. Leaflets heteromorphic, varying from node to node, linear to suborbicular, 0.4–3.5 × 0.1–1 cm; corolla length 2–3 cm; pods 1.5–3.5 × 0.4–0.5 cm *C. heterophylla*

Detailed descriptions are available in both cited sources. The collector noted that "more than one population was present in a pasture with *Panicum maximum*, California grass, sourgrass, and *Waltheria*."

Material examined. HAWAII: 'Upolu Point, field next to airport, Oct 1997, V. Caraway 153.

Cytisus palmensis (H. Christ) Hutch.

New island record

Scotch broom has not previously been reported from the Big Island. The following specimens document its existence near Hale Pohaku, where it may have been planted or could be a self-sown weed.

Material examined. HAWAII: Hāmākua Distr., Mauna Kea, Hale Pōhaku, growing in *Eucalyptus* planting makai of the dormitories, 6 Oct 1981, S. Anderson 451.

Kummerowia striata (Thunb.) Schindl.

Taxonomic change

Syn. *Lespedeza striata* (Thunb.) Hook. & Arn.

Routine taxonomic verification of voucher specimens in BISH revealed that the single specimen called *Lespedeza striata* in the *Manual* (Wagner *et al.*, 1990) is now referred to the segregate genus *Kummerowia* Schindl. Consultation of legume nomenclature references (e.g., Wiersema *et al.*, 1990) revealed that numerous floras accept this segregate as a valid taxon. While not reported as conclusively naturalized in the *Manual*, the name change for this species is noted here.

The status of *K. striata*, as well as that of a number of other forage legumes included in the *Manual* based on single voucher specimens made many years ago, requires further field research and elucidation. It is not clear that these persist at the present time as part of the naturalized flora. The current status of such legume taxa warrants further investigation.

Lupinus arboreus Sims

New state record

An erect shrub, to about 2 m tall, with much branched stems. Leaves palmately compound with 5–11 oblanceolate, folded or flat hairy leaflets. Inflorescence 10–25 cm long, flowers subwhorled, loosely arranged. Calyx with conspicuous lobes 3–6 mm wide at base, densely hairy; corolla yellow, 13–18 mm long. Fruits 3–6 cm long by 7–10 mm wide, villos.

Lupinus arboreus is native to California and is presently found along the U.S. west coast from Los Angeles County north to Washington; it has also been introduced to other parts of the world, mostly for use as a sand binder. This species was discovered during an extensive botanical survey of the Pōhakuloa Training Area by a team from the Center for Ecological Management of Military Lands, Department of Forestry Sciences, Colorado State University, Fort Collins, Colorado. Its discovery was reported by Shaw in 1997, but is repeated here as the original report (Shaw, 1997) was not widely distributed. The plant was growing in a *Sophora chrysophylla* association in Mauna Kea State Park and was considered rare.

Material examined. HAWAII: Mauna Kea State Park, 0.2 miles east of the Saddle Road on Cavalry Trail, 6480 ft elev., collected ca. 1990, Douglas, Hindes, Durkin & Popolizio s.n. (BISH 666241).

***Pueraria montana* (Lour.) Merr. var. *chinensis* Nomenclatural change**
(Ohwi) Maesen & S.M. Almeida

Syn. *Pueraria lobata* (Willd.) Ohwi var. *thomsoni* (Benth.) Maesen
Geesink (*in Wagner et al.*, 1990), following the taxonomy adopted by the most recent reviser of the genus (Maesen, 1985), reported 2 varieties of *Pueraria* from the Hawaiian Islands: var. *thomsoni* from Kaua'i and var. *lobata* from O'ahu, Maui, and Hawai'i. Subsequently, nomenclatural corrections that changed the name of the species and varieties occurring in Hawai'i were published (Maesen & Almeida, 1988). The name changes for the species and its variety *lobata* were reported earlier (Herbst & Wagner, 1999), but the second variety in Hawai'i was apparently overlooked. We here report the name change for the variety heretofore known as *thomsoni*, now called *chinensis*.

***Senna surattensis* (Burm. f.) New island record**
H.S. Irwin & Barneby

Reported in the *Manual* (Wagner *et al.*, 1990) to be naturalized on Kaua'i, O'ahu, and Maui, the following collections may have been overlooked when the distribution of *S. surattensis* was being compiled. They document that *S. surattensis* was well established on Moloka'i by the 1930s.

Material examined. MOLOKA'I: Puna'ula Valley, wooded canyon bottom, elev. 100 ft, 28 Dec 1932, H. St. John & F.R. Fosberg 12831; along highway 46 some 7 mi E of Kaunakakai, elev. 10 ft, 31 Aug 1972, S. Ishikawa 139; Mapulehu Valley, margin of cultivated field, elev. 200 ft, 28 Dec 1932, H. St. John *et al.* 12763.

Lamiaceae

***Plectranthus prostratus* Gürke New naturalized record**

Native to eastern Africa, *P. prostratus* has been cultivated in Hawai'i as a groundcover and container plant. It is a succulent, mat-forming herb with decumbent stems that root at the nodes; opposite, firm-fleshy leaves 0.5" long with triangular to broadly ovate blades, often with obscurely scalloped or angled margins; erect inflorescences of long-pedicelled, violet, 0.2" long flowers, the pedicels radiating out from the main rachis like spokes of a wheel; and 4 tiny nutlets contained in the persistent, papery calyx.

This sprawling herb was apparently originally planted in its present location but appears to be naturalizing in the area. It is growing in open *Leucaena* scrub along with *Verbesina*, *Coccinia*, *Sida fallax*, and *Momordica*, and forms groundcover masses on thin soil and rocks.

Material examined. O'AHU: Makapu'u, on dry rocky bluff on mauka side of entrance to Sea Life Park, 21 May 2000, C. Imada 2000-14.

Lemnaceae

***Landoltia punctata* (G. Mey.) Les Taxonomic change**
& D.J. Crawford

In a recent publication, Les & Crawford (1999) proposed that *Spirodela punctata* was sufficiently distinct from the other 2 described species of *Spirodela* to warrant being placed in its own genus. They accordingly erected the genus *Landoltia*, which was named to commemorate Elias Landolt for his contributions to the systematics and biology of the Lemnaceae in his more than 45 years of studying the family. *Landoltia* can be distinguished from *Spirodela* by the following characters:

Character	Spirodela	Landoltia
Prophyllum at base of frond	present	present, but reduced
Number of veins in frond	7-16	3-7
Number of roots	7-21	(1-)-2-7(-12)
Root length	up to 4 cm	up to 7 cm
Frond L to W ratio	1-1.5	1.5-2 times

Spirodela punctata (G. Mey.) C.H. Thomps., recently documented from the state (Wagner *et al.*, 1997: 57-59; Wagner *et al.*, 1999: 1902), is now referred to *Landoltia punctata* (G. Mey.) Les & D.J. Crawford.

Liliaceae

Zephyranthes citrina Baker

New island records

First reported in the state from Kaua'i in 1995 (Lorence *et al.*, 1995), this is the first naturalized record of the yellow rain lily from O'ahu and Maui. Collector's notes for the O'ahu voucher indicate that the plants appeared about one week after a rainstorm and the population extended in patches for about one mile along the roadside. Flowers were observed in the same area in mid-July 2000, but when we returned to make a voucher a few days later the flowers had disappeared. The collector's notes for the Maui specimen indicate that the population appeared to be sparingly naturalized along the roadside and that capsules with seeds were present, as well as flowers.

Collectors are encouraged to watch for the ephemeral blooms of rain lilies on all islands and to try and collect vouchers to better document their existence and abundance throughout the state. It would also be useful to know if these plants are spreading through seed or by vegetative means only.

Material examined. O'AHU: growing on roadside between Waialua and Schofield Barracks along the winding section of road [e.g., Hwy. 830, Kaukonahua Rd.], elev. 300-400 ft, 14 Sep 1992, C. Corn s.n. (BISH 665946). MAUI: East Maui, Pā'ia, on west side of Baldwin Ave., just mauka of Pā'ia School, in grassy roadside verge, 20° 54' N, 156° 21' W, 28 Aug 2000, F. Starr & K. Martz 000828-1.

Malvaceae

Bastardia viscosa (L.) HBK

New state record

Small shrub, the stems viscid and often with long hairs. Leaves ovate to cordate, 4-8 cm long with serrate to nearly entire margins and an acute to acuminate apex, both surfaces with stellate hairs, the lower surface often viscid; petioles 0.5-1 times the length of the blade. Flowers solitary in leaf axils, usually in leafy terminal panicles; pedicels at least twice as long as calyces; calyces 4-5 mm long, viscid; petals yellow, 5-7 mm long; styles 6-8. Fruits 5-6 mm in diameter, 6-8-celled, stellate pubescent.

Bastardia viscosa occurs in low elevation, disturbed habitats from southern Texas to Peru. In Hawai'i it is known from a single collection made in secondary vegetation near Ho'okena Beach, South Kona, Hawai'i. An illustration of the species can be found in Fryxell (1988: 119).

Material examined. HAWAII: South Kona Distr., along road to Ho'okena Beach, in secondary vegetation of *Jasminum*, *Leucaena*, *Chamaesyce*, *Portulaca*, *Bidens*, and *Pithecellobium*, ca 30 m elev., 23 Jan 1997, T. Flynn & D. Lorence 6120a.

Sida spinosa L.

New island record

Previously reported to be naturalized on O'ahu and the Big Island (Wagner *et al.*, 1990) and subsequently discovered on Kaua'i (Lorence *et al.*, 1995) and Maui (Oppenheimer *et al.*, 1999), this is the first documentation for *S. spinosa* on Lāna'i.

Material examined. LĀNA'I: a weed at the airport, 7 Jul 1986, R. Hobdy 2577.

Myricaceae

Recent systematic review of the genera in the Myricaceae (Wilbur, 1994) has resulted in the splitting of *Myrica* into 3 genera. This leads to a name change for fire tree, an aggressive naturalized pest species in the Hawaiian Islands.

Morella faya (Aiton) Wilbur

Nomenclatural change

Syn. *Myrica faya* Aiton

Wilbur's recognition of the genus *Morella* Lour. as a segregate from *Myrica* necessitated several new combinations for North American taxa. His new combination for the Azorean *M. faya*, fire tree, made in a footnote (Wilbur, 1994: 103), is easily overlooked.

Myrtaceae

Leptospermum laevigatum (Gaertn.) F. Muell. New naturalized record

Earlier reported to be a candidate for naturalized status (Herbarium Pacificum staff, 1999), this specimen documents the occurrence of *L. laevigatum* on O'ahu as an unambiguously naturalized element in the flora.

Material examined. O'AHU: Lā'ie, Lā'ie Trail, growing along dirt road in disturbed forest of *Eucalyptus*, *Casuarina*, *Syzygium cumini*, 8 Apr 2000, C. Imada 2000-5.

Rhodomyrtus tomentosa (Aiton) Hassk.

New island record

Although Wester (1992: 144) noted that downy rose myrtle was present on Lāna'i, the authors of the *Manual* seem to have overlooked the following voucher specimen, which documents the species' presence on that island. The collectors noted that the plants were "evidently set out in rows...for reforestation" but this was surely the nucleus for an infestation of this aggressive invasive species.

Material examined. LĀNA'I: northwest side of Kapano Gulch, elev. ± 2000 ft, 28 Jul 1963, O. & I. Degener 28503.

Poaceae

Avena barbata Pott ex Link

New island record

Formerly noted as occurring only on O'ahu (Wagner *et al.*, 1990), this is the first naturalized record of slender wild oat from the Big Island.

Material examined. HAWAI'I: South Kohala Distr., Nohonaohae cinder cone, elev. ca 3000 ft, growing in summit crater, 19 Mar 1980, L.W. Cuddihy 238.

Brachiaria mollis (Sw.) Parodi

New state record

Syn. *Panicum molle* Sw.

Native to the West Indies, widespread in Mexico and Central America, and extending to South America, this is the first collection for this grass in the Hawaiian Islands. In recent literature, the species has been classified as either *Brachiaria* or *Panicum*, depending on the generic concepts adopted (McVaugh, 1983). The following diagnosis and comments are adapted from the grass account in the *Flora Novo-Galicianana* (McVaugh, 1983): plant a coarse annual, 20(–100) cm tall, the leaves and sheaths softly and finely pubescent, not papillose, the panicles shortly exserted or included, the branches (racemes) spreading, spikelets pilose, stalked, 3–4 mm long, solitary or paired, acuminate, the achene pale, transversely rugulose. How this grass associated with riverbanks and moist places in its native environment came to be growing at the eastern tip of O'ahu in a dry, rocky site subjected to intense insolation and salt spray exposure is a mystery.

Material examined. O'AHU: Makapu'u Head, on rocky crag above sea, side trail off the paved road, only seen in one area but locally abundant there, 14 Dec 1997, G. Staples & B. Pope 1153 (BISH, K, US).

***Eragrostis leptostachya* (R. Br.) Steud.**

New island record

Formerly documented only from Moloka'i (Herbst & Clayton, 1998: 27), a grass collected by Ken Nagata on Maui in 1997 was identified as this species by W.D. Clayton.

Material examined. MAUI: Spreckelsville, rare, along cane haul roads, elev. ca 9 m, 14 May 1997, K. Nagata 4450.

***Phyllostachys aurea* Rivière & C. Rivière**

New naturalized record

Long cultivated in the Hawaiian Islands as an ornamental, this is the first report of this dwarf bamboo as a naturalized element in the flora. The sizable population on windward O'ahu apparently spread vegetatively from a roadside ornamental planting; it now fills more than one acre of steep hillside and has formed a virtual monoculture, excluding other plant species. Populations of a similar small bamboo have been observed in the Puna District of Hawai'i island, but remain unvouchered.

Phyllostachys aurea has arching culms 4–15 ft tall that vary from green to golden yellow in color, typically have thick walls, prominent nodes, with a whitish waxy ring below each stem node. The distichous leaves are up to 6 per twig, lanceolate-oblong, glabrous, paler on the underside, with deciduous white cilia at the opening of the leaf sheath. This bamboo has not been observed to flower in Hawai'i up to the present time.

Material examined. O'AHU: Kailua, along Pali Hwy, just makai (seaward) of junction with Kamehameha Hwy, extensive thicket spreading downslope from road on steep hillside, 28 Nov 1992, G. Staples & D. Herbst 880; same loc., 27 Dec 1992, G. Staples, D. Herbst, & S. Medbury 883.

Rosaceae

***Rosa xdamascena* Mill.**

New naturalized record

The existence of the summer damask rose as a cultivated plant is well documented in the Hawaiian Islands, where this hybrid has been grown since the early 1820s (Nagata, 1985). It has not heretofore been reported as naturalized, but there is increasing evidence that it escapes cultivation and spreads locally and aggressively by vegetative means in higher elevation sites where cooler, moist conditions prevail. The Big Island specimen cited below notes on the label "Volcano, where thoroughly naturalized." Field collectors are encouraged to look out for it and better document its existence, distribution, and abundance on all islands. We report all vouchers in BISH to facilitate further collecting efforts and field observations on the biology of this rose.

Material examined. MOLOKA'I: Kawela, Pu'u o Ka'e'ha, cultivated by mountain cabin, elev. 3500 ft, 23 Dec 1932, H. St. John et al. 12476; Waikolu Valley, at the head and east rim, elev. 3600 ft, 18 Jun 1962, Y. & K. Kondo s.n. (BISH 64520); Kamakou Preserve, near head of Hanalilolilo Trail, elev. 1050 m, 17 Jul 1984, W.L. Wagner et al. 5397. MAUI: East Maui, top of Olinda Road, cultivated and escaping from garden, spreading from abandoned plantings, 20° 48' N, 156° 16' W, 30 Oct 1997, F. Starr & K. Martz 971030-1. HAWAI'I: Kilauea, Volcano, Aug 1908, Forbes, Brigham, & Thompson s.n. (BISH 64524).

Rubiaceae

***Coffea liberica* Hiern**

New naturalized record

Liberian coffee plants were noted in all size classes in alien lowland forest along the Maunawili Falls trail. The slender-trunked trees were up to 20 ft tall. It can be distin-

guished from *Coffea arabica* (also naturalized in this area) by its larger leaves (6–14" long) usually widest above the middle and with the apex rounded or obtuse and briefly tapering (3–8" long, widest near the middle, apex acuminate in *C. arabica*); and corolla lobes (5–)6–11 (vs. 5–7).

Material examined. O'AHU: Maunawili Valley, Maunawili Falls trail, forming solid stands in alien lowland forest, 22 Jul 2000, C. Imada & G. Staples 2000-11.

Sapindaceae

Filicium decipiens (Wight & Arn.) Thwaites **New naturalized record**

Fern tree is a commonly cultivated street tree on O'ahu, where its deeply divided, fern-like leaves with distinctive winged rachises produce an attractive, densely rounded crown. It was mentioned in Wagner *et al.* (1990) as a species that might escape cultivation. Seedlings were collected in an alien lowland forest adjacent to a Maunawili subdivision. Adult trees were not noted in the surrounding area, and it is probable that the seeds of the fleshy purple fruit had been bird-dispersed into the forest.

Material examined. O'AHU: Maunawili Valley, Maunawili Falls trail, seedlings noted in alien lowland forest under mango canopy, 22 Jul 2000, C. Imada & G. Staples 2000-10.

Scrophulariaceae

Antirrhinum orontium L.

New island record

Previously known only from O'ahu and Maui, this is the first record for this naturalized species from Kaho'olawe.

Material examined. KAHO'OLAWE: area around Lae o Hikiula (Kūheia), more prevalent further inland, 6 Jul 2000, Z.E. Ellshoff *s.n.* (BISH 664558).

Torenia L.

The *Manual* treated as sparingly naturalized a single species, *T. asiatica* L., found in wet areas of the Big Island from Hilo to Volcano (Wagner *et al.*, 1990: 1246). Identification of Hawaiian voucher material of *Torenia* by Dr. Takasi Yamazaki in the course of the In Gardens of Hawai'i II project revealed that 3 species are present in the islands, the most widespread in cultivation being *T. fournieri* Lindl. ex E. Fourn., and 2 naturalized species, *T. asiatica* and *T. glabra* Osbeck. Much of the BISH voucher material previously identified as *T. asiatica* has actually proved to be *T. glabra*.

The following key provides diagnostic characters to separate these three species; it is adapted from the revision of the genus *Torenia* in Indochina (Yamazaki, 1985), where full descriptions, synonymies, and illustrations are to be found for all 3 species. All specimens examined are cited for *T. asiatica* and *T. glabra* to give collectors a better grasp of their known range and to clarify the taxonomic concepts adopted here. No specimens are cited for *T. fournieri*: it is cultivated on all inhabited islands and could escape from cultivation wherever it is grown if suitable moist habitats are available.

1. Longer pair of stamens without appendages on filaments; stems \pm erect, not rooting at nodes *T. fournieri*
1. Longer pair of stamens with filiform or clavate appendages on filament near attachment point to corolla; stems prostrate, rooting from lower nodes 2.
2. Corolla 2–2.5 cm long; calyx 10–13 mm long, narrowly 5-winged (wings ca 0.8 mm wide) *T. glabra*
2. Corolla 3–3.5 cm long; calyx 13–15 mm long, 5-ridged *T. asiatica*

Torenia asiatica* L.*Taxonomic clarification**

Native to India, Burma, Thailand, and Malesia (Yamazaki, 1985), there is only a single *bona fide* specimen of *T. asiatica* known from the Hawaiian Islands. It was collected in *Metrosideros* rain forest.

Material examined. HAWAI'I: Upper Waiākea Forest Reserve, along Disappointment Trail (Pu'u Maka'ala access road), off Stainback Hwy., elev. ca 3600 ft, 26 Jul 1983, W.L. Wagner, R. Gustafson, & W.C. Martin 4843.

Torenia glabra* Osbeck*New naturalized record**

T. asiatica sensu Hawaiian authors

Native to Nepal, Bhutan, Assam, Vietnam, southern and central China, and the Japanese island of Kyushu (Yamazaki, 1985), the majority of Hawaiian specimens of naturalized *Torenia* are actually this species. Although widespread on the Big Island, a single weedy specimen has been collected at the back of Mānoa Valley in a wet, sheltered area. Interestingly, the earliest specimen collected (in 1977, *Degener 35245*) noted that this species is a "pretty exotic dangerously spreading among grass and moss."

Material examined. O'AHU: Honolulu, Lyon Arboretum, weedy groundcover, naturalizing in section H-34, 4 Sep 1996, K. Shigematsu s.n. (BISH 645937). HAWAI'I: South Hilo Distr., Waiākea, Keaukaha Military Reservation, 19° 43' N, 155° 25' W, elev. 60 ft, 5 Jul 1996, D.R. Herbst 9781; Hilo Forest Reserve, Humu'ula Trail, elev. 2800 ft, 21 Oct 1982, R. Imoto (ESP) 372; Puna Distr., Kamoamoā ahupua'a, Volcano Rd. on lava flow below Pu'u Kamoamoā, elev. ca. 2360 ft, 6 Jun 1979, J.D. Jacobi & P.K. Higashino 1334; Hawai'i Volcanoes National Park, Small Tract, 'ōla'a, more than 0.5 mile from road in closed *Cibotium/Metrosideros* forest, elev. 3900 ft, L.W. Cuddihy 1918; NW of Glenwood, on North Peck Rd., 6 Sep 1980, F.R. Fosberg 60544; near Mountain View, along back roads, elev. ca. 1500 ft, 1 Apr 1983, K. Nagata 2642; land of 'ōla'a, along North Kūlani Rd., about 1/2 mile from Mountain View, elev. 1400 ft, 16 Dec 1975, D. Herbst & S. Ishikawa 5595; Volcano, abandoned forestry cabin on Kalanikoa St., 13 Jun 1977, O. Degener 35245.

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The Spread of Gymnosperms on Maui: A Neglected Element of the Modern Hawaiian Flora

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There are no gymnosperms native to the Hawaiian Islands (Carlquist, 1980: 82; Mueller-Dombois & Fosberg, 1998: 477; Wagner *et al.*, 1999: 3) and none are known to have been brought here by the early Polynesian settlers (Sohmer & Gustafson, 1987: 17). However, many species have been introduced since the western contact. These have been used for landscaping, reforestation, timber, and Christmas trees; and they are now a conspicuous part of our flora. Estimates of the number of taxa present in Hawai'i vary; St. John & Fosberg (1940) listed 26 genera in 9 families occurring in the state. A later summary by St. John (1973: 9–13) listed 7 families, 25 genera, and 95 taxa. Neal (1965) discussed approximately 5 families, 17 genera, and 59 species. An unpublished checklist at BISH (Imada, Staples, & Herbst, in prep.) lists 11 families, 40 genera, 197 species, and 228 taxa. A recent account (Staples & Herbst, in press) identifies and describes 54 species in 20 genera, belonging to 7 families, of the most commonly cultivated gymnosperms found in home gardens. It would not be surprising to find additional species growing in botanical gardens, arboreta, forest reserves, or private collections.

Nevertheless, information concerning taxa that are adventive, escaping, or naturalized in the Hawaiian archipelago, and their local range, is minimal. Undoubtedly, there are many more gymnosperms that are reproducing and spreading to varying degrees without human aid, although it is difficult to pinpoint the extent and rate of spread at any point in time. Cycads and ginkgo, although present (Neal, 1965: 29–32) do not yet seem to be adventive.

Preliminary collecting efforts on Maui are reported here, along with a key to the species discussed. Seven species, representing 6 genera and 5 families, are documented as naturalized in this paper. Information is supported by voucher specimens at the Bishop Museum Herbarium Pacificum, Honolulu (BISH). The paucity of collections of gymnosperms at BISH reflects neither the total number of species present nor their distribution in the Hawaiian Islands. The early specimens cited were apparently all collected from cultivated material, but are included here to give some idea as to where they occur and how long these taxa have been in the state.

Additionally, 2 other species are sparingly reproducing in the Polipoli / Kula Forest Reserve area of East Maui (R. Hobdy, pers. comm.). Monterey cypress, (*Cupressus macrocarpa* Hartweg ex Gordon,) a native of the central California coast, has leaves in pairs, instead of threes or fours, as in *Callitris* (Neal 1965: 45), the only other member of the Cupressaceae reported here.

Pinus pinaster Ait., the cluster pine, from the Mediterranean, differs from the other 2 species of *Pinus* discussed here by having needles in clusters of 2, not 3 (Little & Skolmen 1989: 58). Smith (1985: 198–99) also reported the infestation of this species in the Polipoli area between 1600 and 2200 m, and its potential to form monotypic stands. Loope *et al.* (1992: 564) noted it to be an aggressive invader of native shrubland in Haleakalā National Park.

Wagner & Herbst (Wagner *et al.*, 1999: 1855; pers. comm.) are planning to publish an updated, complete vascular flora of Hawai'i, including gymnosperms, in the near future. Collectors on all the Hawaiian Islands are encouraged to document the occurrence of

these naturalized gymnosperm species so that we can begin to understand their distribution and effects on native ecosystems.

KEY TO THE SPECIES OF GYMNOSPERMS IN HAWAII¹

1. Fruit fleshy (2).
1. Fruit a dry, woody cone (3).
2. Fruit <1 cm in diameter; dark at maturity, glaucous *Juniperus bermudiana*
2. Fruit >1 cm in diameter; yellow at maturity *Nageia falcatus*
3. Cones disintegrating at maturity *Araucaria columnaris*
3. Cones coherent at maturity (4).
4. Cone <3 cm long; globose (5).
4. Cone >3 cm long; ovate (6).
5. Cone scales 20–30; branchlets flat *Cryptomeria japonica*
5. Cone scales 6–8; branchlets cylindrical or 3–4 angled *Callitris columellaris*
6. Cones in clusters of 5–10; sheath at base of needles 25 mm long *Pinus patula*
6. Cones 3–5 in a cluster; sheath at base of needles 10–13 mm long *Pinus radiata*

Araucariaceae

***Araucaria columnaris* (Forst.) Hook.**

A native of New Caledonia (Neal, 1965: 39), the Cook Pine in Hawai'i is often mistakenly called Norfolk Island pine (*A. heterophylla* (Salisb.) Franco). It has been used for Christmas trees (Little & Skolmen, 1989: 54) as well as reforestation, lumber, and as an ornamental (Neal, 1965: 39). On West Maui, unpublished Maui Pineapple Co. records note that thousands of trees were planted on Honolulu Plantation lands early in the 1900s; the species has escaped and is now naturalized. In several locations there are thousands of seedlings that carpet the ground beneath mature trees, as well as randomly spaced individuals of all size classes in surrounding areas. Some plantings, however, do not appear to be reproducing; this may be due to variability in seed viability, as reported for *A. heterophylla* (Shigeura & McCall, 1972: 11). The seed seems to be spread by wind, an effective mechanism, as the female cones are borne at the tops of the trees. Heavy rain wash and stream flow may be a secondary means of dispersal. Genuine *Araucaria heterophylla* and *A. cunninghamii* Ait. ex Lamb. (Moreton Bay or hoop pine) have also been planted, to a lesser extent, but do not appear to be spreading, although the former species has been reported as such (Mueller-Dombois & Fosberg, 1998: 504), without specificity.

Material examined. MAUI: West Maui, Lahaina Distr., ridgetop dividing Kahana and Kahanaiki, 488–671 m, escaping into Kahanaiki, 6 Aug 1999, *Oppenheimer H89911*; N of Honokōwai Valley, escaping from forestry plantings near the road to Haela'au Cabin (Kaulalewelewe), 579 m, 11 Nov 1999, *Oppenheimer & J. Kunna H119911*; Pōhakupule Stream, spreading from large planted grove, 341 m, 27 Apr 2000, *Oppenheimer, J. Kunna & D. Huber H40026*. Earliest Hawaiian collection seen: *T. C. Zschokke s.n.*, 17 Sep 1925, Kāne'ohe, O'ahu.

Cupressaceae

***Callitris columellaris* F. Muell.**

The white cypress-pine, from Queensland, Australia (St. John, 1973: 12) is escaping from forestry plantings along the road to Haela'au Cabin in the Māhinahina Gulch area. Abundant, randomly spaced plants of different size classes can be observed among the

parent trees; long distance dispersal has not seemed to occur yet. Locally it is also known as Australian white cedar.

Material examined. MAUI: West Maui, Lahaina Distr., along the road to Haela'au Cabin (Kaulalewelewe), 486 m, 26 Nov 1998, *Oppenheimer H119814, H119815*. Earliest Hawaiian collection seen: O'ahu, Wahiawā, 31 May 1944, *C.G. Lennox s.n.*; earliest Maui collection seen: 4 Feb 1958, *H.F. Clay s.n.*, without locality.

Juniperus bermudiana L.

This dioecious tree is endemic to the Atlantic island of Bermuda, where it is reportedly becoming rare (Little & Skolmen, 1989: 74). It has been grown in Hawai'i as an ornamental, as well as for hedges, windbreaks, and reforestation; 6,500 trees having been planted in forest reserves on all islands between 1921 and 1953 (Little & Skolmen, 1989: 74; Neal, 1965: 49). On West Maui, it has become locally abundant, possibly due to frugivorous birds, which may easily disperse the small, fleshy fruits. It is common in mesic forests and shrublands, on ridges and slopes, in the Honokowai and Māhinahina areas at 366–701 m elevation, and north to Honokahua.

Material examined. MAUI: West Maui, Lahaina Distr., Māhinahina Gulch, spreading from forestry plantings along the road to Haela'au cabin (Kaulalewelewe), 486 m, 26 Nov 1998, *Oppenheimer H119816, H119817*. Earliest Hawaiian collection seen: O'ahu, Waiāhole, 4 Feb 1938, *E.Y. Hosaka & M.C. Neal s.n.*

Pinaceae

Pinus patula Schiede & ex Schltdl. & Cham.

The Jelecote pine or Mexican weeping pine, native to the mountains of eastern Mexico, has been planted on the islands of Maui and Hawai'i (Little & Skolmen, 1989: 58). Between 5000 and 7000 ft. in the Kula Forest Reserve area, it is reproducing and spreading. Smith (1985: 198) reported an infestation adjacent to Hosmer Grove and the potential of the species to form monotypic stands. Loope *et al.* (1992: 554) also noted that, if unchecked, this species, along with *P. pinaster* and *P. radiata*, "would eventually convert large expanses of native shrubland to alien coniferous forest" in the Hosmer Grove area. This taxon is easily recognized by its distinctive drooping or "weeping" needles.

Material examined. MAUI: East Maui, Makawao Distr., Ka'ono'ulu, Waipoli Rd., 1951 m, 1 Aug 1999, *Oppenheimer H89902*. Earliest Hawaiian collection seen: Maui, Olinda, 4 May 1944, *J. Silva s.n.*

Pinus radiata D. Don

The Monterey pine is native to the central California coast, where it is considered to be rare (Little, 1980: 289; Little & Skolmen, 1989: 60). Neal (1965: 40) reported it as one of the most successful of about 50 species of pines used in Hawai'i for reforestation. It is also commonly grown on commercial plantations in New Zealand, Australia, Chile, and S. Africa (Little, 1980: 289). Little & Skolmen (1989: 60) stated it grew better at a wider elevational range than all the others tried in the state, but was no longer being planted due to disease, fungus, and wind damage. The cones supposedly remain closed until opened by hot weather or fire (Little, 1980: 289). On East Maui, it is invading pastures and native subalpine shrublands (Loope *et al.*, 1992: 554; 564). It is also invasive in New Zealand (Owen, 1998: 16).

Material examined. MAUI: East Maui, Makawao Distr., Ka'ono'ulu, invading pasture and subalpine shrubland, Waipoli Rd., 1951 m, 1 Aug 1999, *Oppenheimer H89901*. Earliest Hawaiian collection seen: *G. R. Ewart III s.n.*, 13 Jan 1932, Waiki'i, Hawai'i.

Podocarpaceae***Nageia falcatus* (Thunb.) Kuntze**

Syn. *Podocarpus gracilior* Pilg.

A dioecious small tree or large shrub, native to central Africa (Neal, 1965: 33), the African fern pine superficially resembles *Eucalyptus* or phyllodial *Acacia*. It is not uncommon in yards and gardens in the upcountry Maui region. So far, seedlings have only been observed at one site, around the parent tree, planted in 1952.

Material examined. MAUI: East Maui, Makawao Distr., numerous seedlings beneath cultivated tree, Pu'u Māhoe Arboretum, 732 m, 11 Jul 1999, *Oppenheimer H79918*. Earliest Hawaiian collection seen: C. Potter & M. Neal s.n., 24 Mar 1961, Honolulu, O'ahu; earliest Maui collection seen: H. F. Clay s.n., Sep 1962, Kula.

Taxodiaceae***Cryptomeria japonica* (L.f.) D. Don**

Native to China and Japan (Little & Skolmen, 1989: 64), *sugi* was widely planted in forest reserves early in the twentieth century (Little & Skolmen, 1989: 64) but may have been introduced earlier as an ornamental (Degener & Degener, 1958). Related to the coast redwoods (*Sequoia sempervirens* (D. Don) Endl.) of California and Oregon, it is the only taxon in the genus. Carlson & Bryan (1959: 55) reported seed production when trees were 15 to 20 years old, with only a small percentage being fertile. They also noted naturally occurring seedlings in the Honaunau Forest on the island of Hawai'i. Maui Pineapple Co. records (unpublished) show that this species was planted at Honolua Plantation on West Maui in various locations. D.T. Fleming planted it along the newly built trail from Kaulalewelewe to Pu'u Kukui after its completion in March, 1928. Occasional seedlings have been observed in wet forests at elevations above 900 m; it also spreads slightly by layering, and cut limbs will root if left on wet ground.

Material examined. MAUI: West Maui, Lahaina Distr., Pu'u Kukui Trail, 945 m, occasional seedlings from planted tree, 2 Oct 1999, *Oppenheimer H109901*; Pu'u Kukui, fruiting branch from planted tree and occasional seedling, 1764 m, 16 Feb 2000, *Oppenheimer H20005*. Earliest Hawaiian collection seen: Lāna'i, Wai'opa, 6 Mar 1916, G.C. Munro 518, 519; earliest Maui collection seen: Kaupō Gap, Haleakalā National Park, 6500 ft, 12 Dec 1936, G.E. Olson 30.

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A Review of the Insects and Related Arthropods of Midway Atoll¹

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Introduction

This paper presents results of a recent (1997–1999) survey of terrestrial arthropods of Midway Atoll and lists 546 species identified from 1891 to 1999. The last published compilation (Suehiro, 1960) listed 221 species, and the first complete listing from the 1923 Tanager Expedition published 38 species (Bryan *et al.*, 1926). The increasing number of arthropod species reflected in these surveys is likely related to the increase in plant species present, increased contact between Midway and the outside world by means of surface and air vessels, and increased effort on the part of the U. S. Fish & Wildlife Service to inventory the arthropod fauna. The percentage of the fauna composed of native species (17%) is small and some of these species were not recollected during the present survey. Also, a large number (33%) of historically recorded alien species were not recollected. More recently introduced immigrants may have displaced some of them. The present list includes 205 new island records from Midway including 29 new records for the Hawaiian archipelago. Continued introductions resulting from frequent visits to Midway by uninspected air and surface vessels will result in serious pest problems there. Some observations are included on insects now present on Midway that may become serious pests if introduced to the main Hawaiian islands. Two species in particular, *Protactia pryeri* (Janson) and *Scudderia paronae* Griffini should be monitored. Other concerns that should be addressed include ants, vespids wasps, and soil arthropods. A full bibliography of Midway terrestrial arthropod references is also included.

Midway is located approximately 1200 miles northwest of Honolulu and is the second oldest (28.7 ma) emergent atoll in the Hawaiian Archipelago.

In 1997, administration of Midway Atoll was transferred from the U.S. Navy to the U.S. Fish & Wildlife Service (USFWS). The USFWS, as part of an initial biological assessment of the atoll, and the Hawaii Biological Survey (HBS) at Bishop Museum supported 6 field trips to Midway to survey the terrestrial arthropod fauna. The trips were made on the following dates: 12–19 February 1997, 11–18 May 1997, 27 August–2 September 1997, 14–21 December 1997, 29 April–6 May 1998, and 20–23 October 1999. Additional material was collected with the assistance of USFWS personnel on Midway, who periodically serviced a Malaise trap in operation for an entire year. Specimens accumulated during this survey were returned to Bishop Museum in Honolulu for curatorial services and identification.

Historical Background

Relatively few entomologists have ever visited Midway and collections from that atoll are uncommon. The survey reported here has amassed the largest amount of Midway arthropod material ever accumulated. The earliest documented record of insect collecting on Midway is that of Henry Palmer in 1890, where insects were collected incidental to a bird

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survey. Several specimens from that collection were reported by Rothschild (1894). The first comprehensive survey for Midway arthropods was conducted in 1923 by the Tanager Expedition (Bryan *et al.*, 1926). The results of that survey listed 38 species of insects in 12 orders. Suehiro (1960) published a list of 221 species of arthropods in 20 orders based mainly on collections made by C.F. Clagg, E.J. Ford, Jr., and Y. Oshiro during the 1950s, but also including earlier records from the atoll. J.C. Downey *et al.*, the Pacific Biological Survey, and the Smithsonian Institution engaged in exhaustive surveys of seabird parasites from 1959 to 1969. Those surveys resulted in an updated list of Pthiraptera (lice), increasing the number of Midway species from 4 (Suehiro, 1960) to 42 (Keler, 1958; Ward & Downey, 1973). We here report 546 species in 25 orders, a 147% increase in species representation as compared to the Suehiro list.

From 1936–1942, F.C. Hadden was stationed at Midway as a plant quarantine inspector for aircraft flights that used Midway as a refueling station (Hadden, 1941). Hadden concentrated on species intercepted on aircraft. For the most part, the species intercepted by Hadden did not become established on Midway, and they are not included here. Hadden's Midway quarantine collection is maintained at the Bishop Museum.

A list of the known collectors of insects and related arthropods on Midway and the dates of their collections is given in Table 1. An annotated chronology of documented insect collecting is found in Appendix 3. Additional specimens may reside elsewhere, as some unidentified U.S. Navy personnel may have also collected on Midway.

Table 1. Documented (and Probable) Insect Collectors on Midway (1890–1999). (BPBM = Bishop Museum; HSPA = Hawaiian Sugar Planters' Association; UH = University of Hawaii; USDA = U.S. Department of Agriculture; USFWS = U.S. Fish & Wildlife Service; USN = U.S. Navy)

Year	Dates	Collector(s)
1890	July 13–17	Henry C. Palmer and George C. Munro
1902	August 21	W.A. Bryan
1905	?	G.P. Wilder
1923	?	D.T. Fullaway (Tanager Expedition).
1936–1942		F.C. Hadden (HSPA)
1938–1940	(3 short visits)	F.A. Bianchi (HSPA)
1951	March 21–27	C.B. Keck (USN)
1956–1959	(several visits)	C.F. Clagg & Y. Oshiro (USN)
1959–1961		J.C. Downey
1960	June	J.R. Einmo (USDA)
1960	November	E.J. Ford, Jr. (USDA)
1960–1962		H.I. Fisher & E.D. Klimstra
1963–1969		Pacific Ocean Biological Survey & Smithsonian Institution
1964	September 29–30	J.W. Beardsley (UH)
1964?–1966		C.F. Clagg (USN)
1970	December 13–17	J.L. Gressitt (BPBM)
1973	March	M.L. Goff & M.L. Cunningham (BPBM)
1978	April 17–18	L. Pinter (USN)
1983	July 16–19	W.C. Gagné (BPBM)
1997–1998	See text	G.M. Nishida (BPBM), A. Asquith (USFWS), G.A. Samuelson (BPBM), <i>et al.</i>
1999	October 20–23	J.W. Beardsley (BPBM)

Field Methods and Equipment

Arthropods were collected on Midway using the following methods and equipment:

Hand collecting. Plant foliage was scanned for both mobile and sessile specimens; loose bark, decomposing wood and leaf litter were searched; stones and debris of various sorts were moved for examination of the substrate beneath. This method was also employed at night assisted by a headlamp.

Aerial netting. Flying individuals were netted in the air with a fine mesh insect net, or by sweeping with the net over plants or substrate, or by stalking individuals resting on perches. Disturbed individuals that fell or were knocked to the ground were picked up manually.

Plant beating. Stout canvas beating net or a canvas collecting sheet and beating stick were used to strike plant foliage to dislodge arthropod specimens. These were then aspirated with a hand-held aspirator, or hand picked, and placed in collecting vials. This method was also employed at night.

Malaise trapping. A Malaise trap, a fine mesh trap designed to intercept flying insects and cause them to crawl upward on the trap surface into collecting chambers, was set up at favorable locations where it was serviced periodically to remove accumulated specimens and refresh the killing agent. The trap was operated at several localities on Midway over a one-year period. Excellent collections were obtained by this method; several species taken in the Malaise trap were not taken by any other method.

Trapping with attractive yellow surfaces. Yellow pan trapping was attempted. These traps are yellow-colored containers partly filled with water plus a surfactant, which serves to drown flying insects that are attracted to and attempt to land on the yellow surface. These traps were not effective on Midway when albatrosses were present. Virtually all the traps were overturned or filled with debris by the bird's activities; the technique subsequently was abandoned. The use of yellow sticky traps also was attempted. These traps are yellow cards covered with an adhesive substance and employ the same attractive principal as the pan traps. Because of concern that small birds might become stuck to these cards, this method also was abandoned. Eventually, a modified yellow window trap (a yellow cloth saturated with a pyrethroid insecticide in a partly closed container, with a collecting container beneath the cloth) was developed and proved serviceable.

Pitfall trapping. Pitfall traps consist of a baited container placed in a hole in the ground with the mouth of the container at ground level to collect crawling species. A dozen traps were set out on Midway but did not prove to be very effective. Their effectiveness was likely affected by the presence of high numbers of ants.

Tullgren funnel extraction. This device uses heat (usually provided by an incandescent light bulb) to extract small arthropods from soil, leaf-litter or similar material. As the substrate sample slowly dries downward from the top near the heat source, arthropods migrate downward into a collecting device at the bottom of the funnel. On Midway, Tullgren extractions from litter and soil yielded numerous mites, Collembola, and the like.

UV light collecting. Many nocturnally active arthropods are attracted to ultraviolet light. At suitable times, a white sheet was set up as a reflector and a landing site, and a portable UV lamp was used to attract insects, which were then hand picked from the sheet.

Laboratory Procedures

Specimens collected on Midway were taken to Bishop Museum in Honolulu where select samples were sorted and labeled for dispersal to both intramural and extramural specialists. Some material was pin or point mounted, labeled, and presorted prior to dispersal, other material was dispersed in fluid (usually 70% ethyl alcohol). Identified specimens returned by specialists were given an identifying number and the data were added to a computerized database of Hawaiian terrestrial arthropod species maintained by the Museum. Unprocessed residues from the Malaise trap collections are maintained in fluid for long-term storage and future study. The voucher specimens for all species listed in the current survey and the unprocessed remainder are deposited with the Hawaii Biological Survey at Bishop Museum.

Results and Discussion

A full list of species identified from Midway, from 1891 to the present, is given in Appendix 1. The list, arranged alphabetically by order, family, and scientific name, provides common names if these are available, indicates the residency status, and furnishes information regarding year of collection. Following this are four columns that give the collection status of the species.

Tables 2 and 3 summarize the information detailed in Appendix 1, according to insect order, or, for other arthropods, a larger group (e.g.: acari or mites). Table 2 shows that about 7.5% of the fauna (41 species) are endemic. Several of these, known only from Midway and that have not been seen for decades, may be extinct (e.g.: *Agrotis fasciata* (Rothschild)). Only 9% (50 species, mostly migratory bird parasites) are indigenous.

Although 30 species are listed in Appendix 1 as having been purposely introduced into the Hawaiian Archipelago, there are no published records of purposeful introductions into Midway for biological control of pests, or otherwise. These species are listed in the appendix as "p/adv", although some of them may have been brought purposely to Midway by entomologists or others without the introduction being recorded in the entomological literature. In total, 455 species (83%) of the Midway arthropod fauna are considered to be adventive (accidentally introduced during historic times). This large proportion of alien species is not unexpected, as Midway has long been a center of human activity, including frequent visits by both surface vessels and aircraft, during its 142 years of recorded history. Human activity at Midway is summarized in Appendix 2.

Table 3 summarizes all known records of terrestrial arthropods reported from Midway. The first column is the total number of species reported for that particular group. The total includes literature and specimen records. The second column lists the number of species within the group collected during this survey. The third column lists the number of new island records for the group. Likewise, the fourth column lists the number of new state (or archipelago) records. The fifth column is the number of species listed previously that were recollected on this project. The sixth column lists those on the literature list that were not recollected during the course of this project. The seventh column indicates numbers of species that have yet to be verified as to presence or absence or those that were not sought for this project. For example, species parasitic on vertebrates, the lice and some of the parasitic mites, were not collected because earlier works including Keler (1958), Ward & Downey (1973), and others were considered quite thorough. Still requiring verification are the springtails (Collembola), some of the flies (Diptera), some moths (Lepidoptera), the barklice (Psocoptera), and the thrips (Thysanoptera); their listed numbers are asterisked.

Table 2. Arthropod groups listed by their residency status

	Total	Endemic	Indigenous	Purposely	
				Introduced	Adventive
Blattaria (Cockroaches)	8	0	0	0	8
Coleoptera (Beetles)	78	4	3	13	57
Collembola (Springtails)*	19*	8*	0*	0*	11*
Dermoptera (Earwigs)	3	1	1	0	2
Diptera (Flies)*	62	7*	4*	1*	49*
Embiidina (Webspinners)	1	0	0	0	1
Heteroptera (True Bugs)	15	4	0	0	11
Homoptera (Scales et al.)	43	1	0	0	42
Hymenoptera (Bees & Wasps)	112	2	0	13	94
Isoptera (Termites)	3	0	0	0	3
Lepidoptera (Butterflies & Moths)*	36	4*	0*	1*	29*
Mantodea (Mantids)	1	0	0	0	1
Neuroptera (Lacewings etc.)	2	0	0	1	1
Odonata (Dragonflies)	1	0	1	0	0
Orthoptera (Grasshoppers etc.)	9	0	0	0	9
Phthiraptera (Lice)	42	0	38	0	4
Psocoptera (Booklice, Barklice)	1	0	0	0	1
Thysanoptera (Thrips)	6	0	0	0	6
Thysanura (Silverfish)	1	0	0	0	1
Araneae (Spiders)	26	2	0	0	24
Acari (Mites)	63	7	3	0	53
Chilopoda (Centipedes)	3	1	0	0	2
Pseudoscorpionida (Pseudoscorpions)	1	0	0	0	1
Scorpionida (Scorpions)	1	0	0	0	1
Isopoda (Pillbugs, Sowbugs)	9	0	0	0	9
Totals:	546	41	50	30	425

The total number of species known from Midway (546) includes both historical records and those obtained from the 1997–1999 survey. The number of these species now actually present probably is considerably less than 546. The number of species obtained from all literature sources prior to the initiation of the present survey was 332. Of those, only 121 have so far been identified from the 1997–1999 material, and 72 of the species definitely were not recollected.

The number of species so far identified from the 1997–1999 survey is 331. Another 88 species recorded from Midway are members of ectoparasitic groups considered to be well documented in relatively recent publications and were not sought in the present survey. The sum of these 2 figures (419) gives an approximation of the number of identified species presently established on the atoll. Of the 331 species from the 1997–1999 survey so far identified, 176 (53%) are new island records for Midway, and 29 (9%) are new state records based on this project, a total of 62% of the known established species. Sixty-two percent is a remarkably high number of new records, and is probably a result of a relatively high rate of arthropod immigration to Midway in combination with a relatively incomplete knowledge of the fauna.

The data of Appendix 1 show that the Midway fauna does not reflect normal representation of major arthropod groups found in continental assemblages. Many insect orders are not represented on Midway, particularly those associated with fresh water habitats. The Hymenoptera, especially the parasitoid groups, are more strongly represented than

Table 3. Summary of species included in Appendix 1

Group	Total Species Reported	No. Collected 1997-99	No. New Island Records	No. New State Records	No. Species Recollected	No. Not Recollected	No. Others
Blattaria	8	6	2	0	4	2	
Coleoptera	78	57	29	5	23	21	
Collembola	19	?	?	?	?	?	19
Dermaptera	3	3	0	0	3	0	
Diptera	62	26+	9	2	14	?	36
Embiidina	1	1	0	0	1	0	
Heteroptera	15	9	3	0	6	6	
Homoptera	43	38	28	0	10	5	
Hymenoptera	112	99	61	13	25	13	
Isoptera	3	3	1	0	2	0	
Lepidoptera	36	22+	8	0	13	2	12
Mantodea	1	0	0	0	0	1	
Neuroptera	2	1	0	0	1	1	
Odonata	1	1	0	0	1	0	
Orthoptera	9	5	2	0	3	4	
Phthiraptera	42	?	?	?	?	?	42
Psocoptera	1	?	?	?	?	?	?
Thysanoptera	6	?	?	?	?	?	6
Thysanura	1	0	0	0	0	1	
Araneae	26	18	11	2	5	8	
Acari	63	29+	14	6	7	7	34
Chilopoda	3	3	2	0	1	0	
Pseudoscorpionida	1	1	0	0	0	0	
Scorpionida	1	0	0	0	0	1	
Isopoda	9	9	6	1	2	0	
Totals:	546	331	176	29	121	72	89

expected, although this may represent more efficient collecting of these minute arthropods on Midway than is normally achieved in continental survey collections.

The identification of the collections made during the 1997-99 Midway survey is not complete, and perhaps a more accurate assessment of the faunal composition than one based simply on available identifications would be one based on those groups that are presently the most completely identified: the Coleoptera (beetles), the Homoptera (aphids, scales and relatives), the Hymenoptera (bees and wasps), and the Araneae (spiders). Of the 57 species of beetles collected in this survey, 34 (60%) are new to Midway. Of the 18 spiders collected during this survey, a remarkable 72% (13) are new island records. Of the 38 species of scales and their relatives, 28 (74%) are new island records. Of the 99 species of bees and wasps collected, 74 (75%) are new island records. These figures confirm a very high rate of introduction and establishment of terrestrial arthropods on Midway.

Forty-four of the 546 species listed from Midway do not occur in the main Hawaiian Islands. Five of the 44 are endemic and about 20 are indigenous species reported only from Midway, leaving about 19 native species not represented in those more southern islands. Add that to about 16 new archipelago records (29 are listed, but 13 of those also occur in the southern islands) and that totals about 35 species that potentially could be introduced into the southern part of the archipelago from Midway.

The recollection rate of native species was disappointing. Of the 4 endemic beetles

listed, 1 is a new record and potentially endemic, the other 3, previously recorded, were not recollected. Though not completely studied, interim results from the bugs and moths also suggest an impact on the native fauna. Of the 4 previously listed native seed bugs, only 2 were recollected. Of the 3 native moths, only 1 has been identified as recollected. These native species may still exist and their absence may be a result of exceptionally low population numbers or may just be a factor of chance in collecting. However, the consistency of non-collection among all groups suggests at the very least, the reduction of the presence of native species on Midway.

A disproportionate number of general predators and parasitic wasps occur on a relatively meager host base. For example, 13 ladybird beetles (coccinellids), were collected on the atoll, all are purposely introduced to the southern islands. Seven of the 13 are new island records for Midway. The total is 17% of the total number of beetles on Midway, and also 16% of all the coccinellids reported for all of Hawai'i. Of 80 parasitic wasps, 11 were purposely introduced to the southern islands, but perhaps more significantly, 62 are new island records. This level of representation of predators and parasites was unexpected and suggests that a program of introduction of species for biological control of pest species took place; however, the existence of such a program is not documented.

Ants are an unfortunate major, ubiquitous component of the Midway ecosystem. In some places, particularly Eastern Island, ants dominate. They are undoubtedly a major disruptive force on what remains of the native ecosystem there, and could become an impediment to the reestablishment of native plants. Ants have been observed tending aphids, scales, and other sap-feeding species on Midway. In so doing, they probably reduce the effectiveness of parasites and predators on these pests, allowing populations of the pests to increase significantly. Ants are sometimes so numerous on Midway that nesting birds may be covered with them, apparently causing aggravation, a situation we observed several times during this survey. The effect of ants on nesting birds has not been studied on Midway, but is believed to be significantly detrimental.

Vespid wasps are another apparent problem on Midway. Many vespids are extremely efficient predators of caterpillars. The moth fauna of Midway is not only represented by relatively few species, but also appeared to be at low population levels during this survey. Night collecting using an ultraviolet light and a sheet was relatively unproductive compared to other localities in Hawai'i. Despite diligent attention to the sheet, a disappointing low number (21) of moth species were collected on Midway and, except for a few very common alien forms, most of the species were represented by only a few individuals. Of 27 species listed prior to this survey, only 13 (48%) were recollected. Windy conditions may have limited nocturnal moth activity during periods when night survey collections were made. However, the very visible presence of hunting vespid wasps during the day suggests that these exerted a significant amount of predation pressure on larval Lepidoptera on Midway.

Of the Midway insect fauna presently known, two alien species, *Protaetia pryeri* (Janson), and *Scudderia paronae* Griffini, potentially could cause problems if introduced into the larger southeastern Hawaiian Islands. *Protaetia pryeri* (the emerald beetle) is a large, brilliantly colored scarab that was described from the Ryukyu Islands (Janson, 1888). Its habits there are unknown. On Midway, adults of the emerald beetle emerge from the soil as early as late April and a few stragglers remain through December. Peak emergence is during the late spring and early summer. The grubs live in the soil, where they feed on organic debris and possibly roots. The adults have been reported to feed on

plant foliage, fruits, and flowers in Midway gardens. Concentration of grubs seemed highest in areas of ironwood (*Casuarina*) although they were also collected under *naupaka* (*Scaevola*) and other plants. Ruddy turnstones (*Arenaria interpres*), bristle-thighed curlews (*Numenius tahitiensis*), and *kolea* or Pacific golden-plovers (*Pluvialis fulva*) were observed feeding on the grubs.

The katydid, *Scudderia paronae*, was observed feeding heavily on the growing tips of *naupaka* (*Scaevola*), especially on Eastern Island, creating distorted leaves and probably stunting growth of the plants. *Naupaka* may be an alternate host for this insect as it was most often seen in association with *Verbesina*. When the observation of *naupaka* feeding was made, *Verbesina* had mostly died back on Eastern Island and new growth had not yet appeared. *S. paronae* was first reported in the Hawaiian Islands from Kure Atoll in 1982 on *Eragrostis* (Conant 1985), suggesting that the species may be a generalized herbivore. Midway is a new island record for this species, although it might have established itself on Midway first and been overlooked before it migrated to Kure. In any case, it appears the species can disperse readily, and potentially could move to the other islands of Hawai'i.

Twenty of the 63 mite species identified to date are new island records; 7 of these are new state records. Most of the mites were found associated with soil. Hadden (1941) estimated that 9,000 tons of soil were brought to Midway from Honolulu during the time he resided on the atoll. Though the exact origin of the soil is unknown, a significant portion of the resident mites probably were transported to Midway by this means. However, results of this survey indicate that about 1/3 of the species reported from Midway do not occur in the southern Hawaiian archipelago and could be accidentally transported there.

Numbers of Arthropod Species Relative to the Number of Plant Species

An atoll such as Midway would ordinarily have a paucity of available niches. This is reflected in the Tanager Expedition collections from 1921, which collected only 38 species of arthropods. The number of species expanded to 221 by 1960. The number of niches available was artificially expanded by the purposeful introduction of plants for windbreaks, food, and aesthetic purposes. Other plants were accidentally introduced and became established. Availability of diverse plant species, combined with ease of migration, permitted the establishment of herbivores and their associated predators and parasites and probably fostered the presence of detritivores. The number of arthropod species parallels the increase in plant species (see Figure 1). For example, W.A. Bryan reported 11 species of plants in 1902. The Tanager Expedition in 1923 reported 23 species of plants and 38 species of arthropods. Prior to 1923, the cable station already had been introducing plants to Midway. Hadden listed 54 cultivated plants in 1941, bringing the plant total to 77 species. In 1960, Suehiro reported 221 arthropod species. In 1998, Bruegmann listed 265 species of plants of which 35 were not recollected, a total of 230 resident plants. This survey reports 546 species of arthropods, of which 72 were definitely not recollected, a total of 474 species. Some of the uncollected arthropods may have been associated with the non-recollected plants. As many of the alien plant species are likely relatively recently introduced, they provide new opportunities for colonization. Howarth (1985) first described this phenomenon and used examples from the main Hawaiian Islands. Thus the number of potential new species of arthropods eventually becoming established on Midway is quite high.

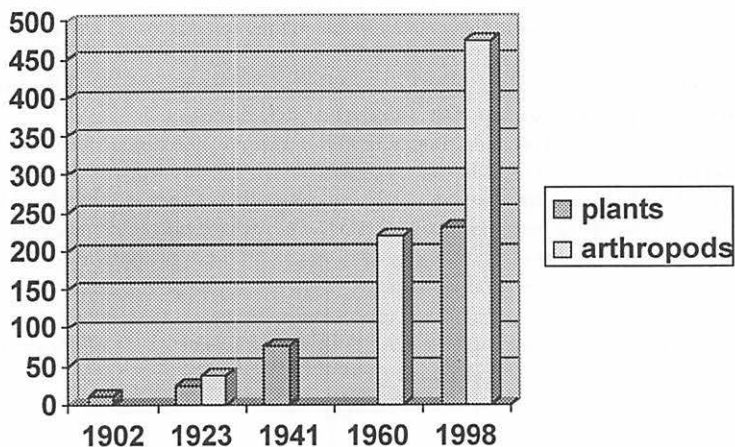


Figure 1. Relative numbers of plants and arthropods reported from Midway. Sources: 1902 = W.A. Bryan; 1923 = Tanager Expedition (E.H. Bryan et al.); 1941 = F.C. Hadden; 1960 = A. Suehiro; 1998 = M. Bruegmann, 1997-1999 Midway Survey.

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Appendix 1. Current list of arthropod species from Midway.

(Abbreviations: origin: adv = adventive, end = endemic, ind = indigenous, pur = purposely introduced, p/adv = purposely introduced to main Hawaiian islands, but adventive to Midway) (status: NIR = new island record, NSR = new archipelago or state record, pir = new island record for project, psr = new state record for project) (checklists: 23 = Tanager Expedition, 60 = Suehiro list, 98 = present project; ? = not sought or study not completed, X = not recollected) (determiners: DJB = D.J. Bickel, DJP = D.J. Preston, FGH = F.G. Howarth, GAS = G.A. Samuelson, GMN = G.M. Nishida, JB = J. Beatty, JWB = J.W. Beardsley, KA = K. Arakaki, KS = K. Sattler, MA = M. Asche, NJR = N.J. Reimer, NLE=N.L. Evenhuis, RJW: R.J. Woodrow, RRS = R.R. Snelling, RS=Rowland Shelley, SFS = S.F. Swift, S&N = S.F. Swift & R.A. Norton, ST = S. Taiti, WJK = W.J. Knight, WM=William Muchmore)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
INSECTA							
Order BLATTODEA	ROACHES						
Family Blaberidae							
	<i>Diploptera punctata</i> (Eschscholtz, 1822)	Pacific beetle cockroach	adv	NIR		98	GMN
	<i>Pycnoscelus indicus</i> (Fabricius, 1775)	Burrowing cockroach	adv		60	98	GMN
Family Blattellidae							
	<i>Blattella germanica</i> (Linnaeus, 1767)	German cockroach	adv		60	X	
	<i>Blattella lituricollis</i> (Walker, 1868)	False German cockroach	adv		60	98	GMN
	<i>Supella longipalpa</i> (Fabricius, 1798)	Brownbanded cockroach	adv		60	X	
	<i>Symptloce pallens</i> (Stephens, 1835)		adv	NIR		98	GMN
Family Blattidae							
	<i>Periplaneta americana</i> (Linnaeus, 1758)	American cockroach	adv		23	60	98
	<i>Periplaneta australasiae</i> (Fabricius, 1775)	Australian cockroach	adv			60	98
Order COLEOPTERA	BEETLES						
Family Alleculidae							
	? <i>Lobopoda</i> sp.		adv?	psr		98	GAS
Family Anobiidae							
	<i>Lasioderma serricorne</i> (Fabricius, 1792)	Anobiid beetles	adv	NIR		98	GAS
Family Anthicidae							
	<i>Anthicus tobias</i> Marseul, 1879	Antlike flower beetles	adv	NIR		98	GAS
Family Anthribidae							
	<i>Araecerus fasciculatus</i> (DeGeer, 1775)	Fungus weevils	adv	pir		98	GAS
	<i>Araecerus levipennis</i> Jordan, 1924	Coffee bean weevil	adv		60	X	
	<i>Exillus lepidus</i> Jordan, 1922	Koa haole seed weevil	adv		60	98	GAS

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Coleoptera (continued)							
Family Bostrichidae	Branch and twig borers						
	Heterobostrychus aequalis (Waterhouse, 1884)	adv			60	X	
Family Bruchidae	Seed beetles						
	Acanthoscelides macrophthalmus (Schaeffer, 1907)	adv	pir			98	GAS
	Mimosestes nubigens (Motschulsky, 1874)	adv			60	X	
	Stator pruininus (Horn, 1873)	adv			60	X	
Family Cerambycidae	Longhorned beetles						
	Ceresium unicolor (Fabricius, 1787)	adv			60	98	GAS
	Sybra alternans (Wiedemann, 1825)	adv			60	98	GAS
Family Cerylonidae	Cerylonid beetles						
	Euxestus erithacus (Chevrolat, 1864)	adv			60	X	
	Murmidius sp.	adv?	psr			98	GAS
Family Chrysomelidae	Leaf beetles						
	Diachus auratus (Fabricius, 1801)	adv			60	X	
Family Ciidae	Minute tree-fungus beetles						
	Cis sp.	end?	NIR			98	GAS
Family Cleridae	Checked beetles						
	Necrobia rufipes (DeGeer, 1775)	adv			60	98	GAS
Family Coccinellidae	Ladybird beetles						
	Coelophora inaequalis (Fabricius, 1775)	p/adv			60	98	GAS
	Cryptolaemus montrouzieri Mulsant, 1853	p/adv	pir			98	GAS
	Curinus coeruleus (Mulsant, 1850)	p/adv	pir			98	GAS
	Diomus debilis (LeConte, 1852)	p/adv	pir			98	GAS
	Diomus notescens (Blackburn, 1889)	p/adv			60	98	GAS
	Nephus biluceumarius (Mulsant, 1850)	p/adv	pir			98	GAS
	Nephus ?bipunctatus Kugelann	p/adv	pir			98	GAS
	Olla v-nigrum (Mulsant, 1866)	p/adv			60	98	GAS
	Rhyzobius forestieri (Mulsant, 1853)	p/adv			60	98	GAS
	Rhyzobius lophanthae (Blaisdell, 1892)	p/adv	NIR			98	GAS
	Rodolia cardinalis (Mulsant, 1850)	p/adv			60	98	GAS
	Scymnodes lividigaster (Mulsant, 1853)	p/adv			60	98	GAS
	Telsimia nitida Chapin, 1926	p/adv	NIR			98	GAS

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Coleoptera (continued)							
Family Corylophidae							
	Minute fungus beetles						
	Sericoderus sp.	adv?	NIR			98	GAS
Family Curculionidae							
	Weevils						
	Asynonychus godmani Crotch, 1867	Fuller rose beetle	adv		60	98	GAS
	Dryophthorus distinguendus Perkins, 1900		end		60	X	
	Dryophthorus squalidus Sharp, 1878		end	1958		X	
	Dryotribus mimeticus Horn, 1873		adv	1906		X	
	Dryotribus wilderi Perkins, 1916		ind		23	60	98
	Oodemas laysanensis Fullaway, 1914	Laysan oodemas weevil	end		23	60	X
	?Orchidophilus ?not aterraima (Waterhouse)		adv?	NIR			98
	Oxydema fusiforme Wollaston, 1873		adv			60	98
	Oxydema longulum (Boheman, 1859)		adv			60	X
	Pentarthrum halodorum Perkins, 1926		adv		23	60	X
	Pentarthrum obscurum Sharp, 1878	Obscure pentarthrum weevil	adv?	1906			X
	Sphenophorus venatus vestitus Chittenden, 1904	Hunting billbug	adv	NIR			98
Family Dermestidae							
	Dermestid or skin beetles						
	Attagenus fasciatus (Thunberg, 1795)	Wardrobe beetle	adv			60	X
	Dermestes ater DeGeer, 1774	Black larder beetle	ind?		23	60	98
	Dermestes maculatus DeGeer, 1774	Hide beetle	ind			60	98
	Trogoderma anthrenoides (Sharp, 1902)		adv			60	X
Family Elateridae							
	Click beetles						
	?Cardiophorus sp.		adv?	psr			98
	Conoderus amplicollis (Gyllenhal, 1817)	Gulf wireworm	adv	pir			98
	Conoderus exsul (Sharp, 1877)		adv		23	60	98
	Conoderus pallipes (Eschscholtz, 1830)		adv			60	98
	Prodrasterius collaris (Candeze, 1859)		adv	NIR			98
Family Histeridae							
	Hister beetles						
	Saprinus lugens Erichson, 1834		adv			60	98
Family Lyctidae							
	Powderpost beetles						
	Lyctus brunneus (Stephens, 1830)	Powderpost beetle	adv			60	X
Family Mycetophagidae							
	Hairy fungus beetles						
	Typhaea stercorea (Linnaeus, 1758)	Hairy fungus beetle	adv			60	X

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Coleoptera (continued)							
Family Nitidulidae							
	Sap beetles						
	<i>Carpophilus dimidiatus</i> (Fabricius, 1792)	Corn sap beetle	adv		60	X	
	<i>Carpophilus maculatus</i> Murray, 1864		adv	NIR		98	GAS
	<i>Conotelus mexicanus</i> Murray, 1864		adv	pir		98	GAS
Family Oedemeridae							
	<i>Ananca bicolor</i> (Fairmaire, 1849)	False blister beetles	adv		60	X	
Family Ptiliidae							
	Genus? species?	Feather-winged Beetles	adv?	NIR		98	GAS
Family Scarabaeidae							
	<i>Adoretus sinicus</i> Burmeister 1855	Scarab beetles					
	<i>Anomala sulcatula</i> Burmeister, 1844	Chinese rose beetle	adv		60	X	
	<i>Pleurophorus parvulus</i> (Chevrolat, 1864)		adv	pir		98	GAS
	<i>Protaetia fusca</i> (Herbst, 1790)	Mango flower beetle	adv	pir		98	GAS
	<i>Protaetia pryeri</i> (Janson, 1888)	Emerald beetle	adv	psr		98	GAS
Family Scolytidae							
	<i>Hypothenemus</i> sp.	Bark beetles	adv?	NIR		98	GAS
	<i>Xyleborus perforans</i> (Wollaston, 1857)		adv	NIR		98	GAS
Family Silvanidae							
	<i>Oryzaephilus surinamensis</i> (Linnaeus, 1758)	Flat grain beetles	adv	NIR		98	GAS
Family Staphylinidae							
	<i>Atheta coraria</i> (Kraatz, 1856)	Rove beetles	adv	pir		98	GAS
	<i>Carpelimus fulvipes</i> (Erichson, 1840)		adv	pir		98	GAS
	? <i>Platystethus</i> sp.		adv	NIR		98	GAS
	<i>Scopaeus</i> sp.		adv?	psr		98	GAS
Family Tenebrionidae							
	<i>Alphitobius diaperinus</i> (Panzer, 1796)	Darkling beetles	adv	NIR		98	GAS
	<i>Alphitobius laevigatus</i> (Fabricius, 1781)	Lesser mealworm	adv	1958		98	GAS
	<i>Blapstinus dilatatus</i> LeConte, 1851	Black fungus beetle	adv		60	98	GAS
	<i>Gonocephalum adpressiforme</i> Kaszab, 1951		adv		60	98	GAS
	<i>Platydemia subfascia</i> (Walker, 1858)		adv		60	X	
	<i>Tribolium castaneum</i> (Herbst, 1797)	Red flour beetle	adv		60	98	GAS

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Collembola	Springtails						
Family Entomobryidae							
Entomobrya unostrigata Stach 1930		adv	1992			?	
Lepidocyrtus hakea Christiansen & Bellinger, 1992		end	1992			?	
Lepidocyrtus heterophthalmus Carpenter 1904		adv	1992			?	
Lepidocyrtus hukulii Christiansen & Bellinger, 1992		end	1992			?	
Lepidocyrtus immaculatus Folsom, 1932		end	1992			?	
Lepidocyrtus kuakea Christiansen & Bellinger, 1992		end	1992			?	
Lepidocyrtus mele Christiansen & Bellinger, 1992		end	1992			?	
Lepidocyrtus olena Christiansen & Bellinger, 1992		end	1992			?	
Lepidocyrtus pallidus Reuter, 1890		adv	1992			?	
Seira pihulu Christiansen & Bellinger, 1992		end?	1992			?	
Seira terrestris (Folsom, 1932)		adv	1992			?	
Family Hypogastridae							
Brachystomella contorta Denis 1931		adv?	1992			?	
Family Isotomidae							
Cryptopygus thermophilus (Axelson, 1902)		adv	1992			?	
Folsomides parvulus Stach 1922		adv	1992			?	
Proisotoma centralis Denis 1931		adv	1992			?	
Proisotoma nigromaculosa Folsom, 1932		adv	1992			?	
Family Onychiuridae							
Onychiurus folsomi (Schaeffer, 1900)		adv	1992			?	
Tullbergia yosiii (Rusek, 1967)		adv	1992			?	
Family Sminthuridae							
Sminthurides tolelua Christiansen & Bellinger, 1992		end	1992			?	
Order Dermaptera	Earwigs						
Family Carcinophoridae							
Anisolabis maritima (Bonelli, 1832)		ind			60	98	FGH
Euborellia annulipes (Lucas, 1847)	Ringlegged earwig	adv		23	60	98	GMN
Family Labiduridae							
Labidura riparia (Pallas, 1773)	Striped earwig	adv			60	98	GMN

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Diptera	Flies		(partly studied)				
Family Agromyzidae	Leafminers						
<i>Amauromyza maculosa</i> (Malloch, 1913)	Blotch leafminer	adv			60	98	KA
<i>Calycomyza humeralis</i> (Roser, 1840)	Aster leafminer	adv	1980			98	KA
<i>Liriomyza sativae</i>		adv	NIR			98	NLE
<i>Melanagromyza splendida</i> Frick, 1953		adv	NIR			98	KA
<i>Phytoliriomyza</i> sp.		adv			60	?	
<i>Pseudonapomyza spicata</i> (Malloch, 1914)		adv	NIR			98	KA
Family Anthomyiidae	Anthomyiid flies						
<i>Fucellia boninensis</i> Snyder, 1965		adv	1960			?	
Family Asteiidae	Asteiid flies						
<i>Loewimyia ?bifurcata</i> Sabrosky		adv	NSR?			98	KA
Family Calliphoridae	Blowflies						
<i>Chrysomya megacephala</i> (Fabricius, 1794)	Oriental blow fly	adv			60	?	
<i>Lucilia graphita</i> Shannon 1926		end		23	60	?	
<i>Lucilia sericata</i> (Meigen, 1826)	Greenbottle fly	adv			60	?	
<i>Rhinia apicalis</i> (Wiedemann, 1830)		adv			60	98	KA
Family Canacidae	Beach flies						
<i>Canaceoides angulatus</i> Wirth, 1969		adv	1969			?	
<i>Nocticanace</i> sp.		?			60	?	
Family Cecidomyiidae	Gall midges						
<i>Giardomyia pallidithorax</i> Hardy 1960		end			60	?	
<i>Parallelodiplosis bimaculata</i> Hardy 1960		end			60	?	
Family Ceratopogonidae	Biting midges						
<i>Dasyhelea calvescens</i> Macfie, 1938		ind			60	?	
Family Chironomidae	Midges						
<i>Clunio littoralis</i> Stone & Wirth, 1947*		end				98	NLE
<i>Polypedilum nubiferum</i> (Skuse, 1889)		adv	NIR			98	KA
Family Chloropidae	Chloropid flies						
<i>Cadrema pallida</i> (Loew, 1865)		adv		23	60	98	KA
<i>Siphunculina striolata</i> (Wiedemann, 1830)		adv			60	?	

* Confirmed island record; previously listed with question mark by Hardy (1960)

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Diptera (continued)	Flies						
Family Chyromyidae	Chyromiid flies		(partly studied)				
<i>Chiomyia</i> sp.			adv?		60	?	
Family Culicidae	Mosquitoes						
<i>Aedes albopictus</i> (Skuse, 1894)	Asian tiger mosquito		adv		60	98	GMN
<i>Culex quinquefasciatus</i> Say, 1823	Southern house mosquito		adv		60	98	GMN
Family Dolichopodidae	Long-legged flies						
<i>Chrysosoma globiferum</i> (Wiedemann, 1830)			adv	23	60	98	DJB
<i>Chrysotus longipalpis</i> Aldrich, 1896			adv?		60	98	DJB
<i>Dactylomyia vockerothi</i> (Bickel, 1998)			adv			98	DJB
<i>Krakatauia micronesiana</i> Bickel, 1994			ind?			98	DJB
<i>Medetera grisescens</i> Meijere, 1916			end		60	98	DJB
<i>Syntormon flexibile</i> Becker, 1922			adv			98	DJB
Family Drosophilidae	Pomace flies						
<i>Drosophila simulans</i> Sturtevant 1919			adv		60	?	
Family Ephydriidae	Shore flies						
<i>Clasiopella uncinata</i> Hendel, 1914			adv			1952	?
<i>Hecamede granifera</i> (Thomson, 1869)			adv		60	?	
<i>Piacopsidella grandis</i> (Cresson, 1925)			adv			1980	?
<i>Scatella stagnalis</i> (Fallen, 1813)			adv			NIR	98
Family Fanniidae	Fanniid flies						
<i>Fannia pusio</i> (Wiedemann, 1830)	Chicken dung fly		adv		60	?	
Family Lauxaniidae	Lauxaniid flies						
<i>Homoneura unguiculata</i> (Kertész, 1913)			adv		60	98	KA
Family Milichiidae	Milichiid flies						
<i>Desmometopa tarsalis</i> Loew 1865			adv		60	?	
<i>Desmometopa</i> sp.			adv		60	?	
<i>Milichiella lacteipennis</i> (Loew, 1865)			adv	23	60	98	KA
Family Muscidae	Muscid flies						
<i>Hydrotaea aenescens</i> (Wiedemann, 1830)			adv		60	?	
<i>Hydrotaea chalcogaster</i> (Wiedemann, 1824)			adv	23	60	?	
<i>Musca domestica</i> Linnaeus 1758	House fly		adv	23	60	?	
<i>Muscina levida</i> (Harris, 1776)			adv		60	?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Diptera (continued)	Flies		(partly studied)				
Family Psychodidae	Sand Flies						
Psychoda williamsi Quate 1954		end			60	?	
Family Sarcophagidae	Flesh Flies						
Goniophyto bryani Lopes 1938		ind			60	?	
Helicobia morionella (Aldrich, 1930)		adv			60	?	
Sarcophaga argyrostoma (Robineau-Desvoidy, 1830)		adv			60	?	
Sarcophaga dux Thomson 1869		adv			60	?	
Family Sciaridae	Darkwinged Fungus Gnats						
Bradysia molokaiensis (Grimshaw, 1901)		end		23	60	?	
Bradysia tritici (Coquillett, 1895)		adv			60	?	
Family Sphaeroceridae	Small Dung Flies						
Coproica ferruginata (Stenhammar, 1855)		adv		23	60	?	
Coproica hirtula (Rondani, 1880)		adv	1967			?	
Leptocera fuscipennis (Haliday, 1833)		adv	1969			?	
Thoracochaeta brachystoma ((Stenhammar, 1855)		adv	1969			?	
Trachypella nuda Rohacek & Marshall 1986		adv	1969			?	
Family Syrphidae	Flower flies						
Simosyrphus grandicornis (Macquart, 1842)		adv			60	98	KA
Family Tephritidae	Fruit flies						
Acinia picturata (Snow, 1894)		p/adv	NIR			98	KA
Bactrocera dorsalis (Hendel, 1912)	Oriental fruit fly	adv	1981			?	
Dioxyna sororcula (Wiedemann, 1830)		adv	NIR			98	KA
Family Tethinidae	Tethinid flies						
Dasyrhicnoessa insularis (Aldrich, 1931)		ind?			60	98	KA
Tethina variseta (Melander, 1951)		adv			60	98	KA
Order Embiidina	Webspinners						
Family Oligotomidae							
Oligotoma saundersii (Westwood, 1837)	Saunders embiid	adv			60	98	GMN

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Heteroptera	True bugs						
Family Anthocoridae	Minute pirate bugs		(partly studied)				
<i>Orius persequens</i> (White, 1877)		adv		23	60	98	GMN
Family Cydnidae	Negro bugs						
<i>Geotomus pygmaeus</i> (Dallas, 1851)	Oceanic burrower bug	adv			60	X	
<i>Rhytidoporus indentatus</i> Uhler, 1877		adv	NIR			98	JWB
Family Lygaeidae	Seed bugs						
<i>Geocoris pallens</i> Stål, 1854	Western bigeyed bug	adv	NIR			98	DJP
<i>Nysius fullawayi fullawayi</i> Usinger, 1942	Fullaway's seed bug	end		23	60	98	GMN
<i>Nysius kinbergi</i> Usinger 1959		end			60	X	
<i>Nysius palor</i> Ashlock 1963		end?			60	98	JWB
<i>Nysius terrestris</i> Usinger 1942		end			60	X	
Family Nabidae	Damsel bugs						
<i>Nabis capsiformis</i> Germar, 1837	Pale damsel bug	adv		23	60	98	DJP
Family Pentatomidae	Stink bugs						
<i>Brochymena quadripustulata</i> (Fabricius, 1775)	Rough stink bug	adv	NIR			98	GMN
Family Reduviidae	Assassin bugs						
<i>Empicoris rubromaculatus</i> (Blackburn, 1889)	Thread bug	adv			60	98	DJP
<i>Empicoris whitei</i> (Blackburn, 1881)		adv			60	X	
<i>Zelus renardii</i> Kolenati 1856	Leafhopper assassin bug	adv			60	98	JWB
Family Rhopalidae	Scentless plant bugs						
<i>Liorhyssus hyalinus</i> (Fabricius, 1794)	Hyaline grass bug	adv			60	X	
Family Tingidae	Lace bugs						
<i>Corythucha morrilli</i> Osborn & Drake 1917	Morrill lacebug	adv	1988			X	
Order Homoptera	Aphids, scales, and relatives						
Family Aleyrodidae	Whiteflies						
<i>Trialeurodes vaporariorum</i> (Westwood, 1856)	Greenhouse whitefly	adv	NIR			98	
Family Aphididae	Aphids						
<i>Aphis craccivora</i> C.L. Koch 1854	Cowpea aphid	adv			60	X	
<i>Aphis gossypii</i> Glover, 1877	Cotton aphid, melon aphid	adv			60	98	JWB
<i>Hyperomyzus lactucae</i> (Linnaeus, 1758)	Sow thistle aphid	adv	NIR			98	JWB
<i>Hysteronera setariae</i> (Thomas, 1878)	Rusty plum aphid	adv	NIR			98	JWB
<i>Lipaphis erysimi</i> (Kaltenbach, 1843)	Turnip aphid	adv	NIR			98	JWB
<i>Rhopalosiphum maidis</i> (Fitch, 1855)	Corn leaf aphid	adv	NIR			98	JWB
<i>Schizaphis rotundiventris</i> (Signoret, 1860)		adv	NIR			98	JWB

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Homoptera (continued)							
Family Cicadellidae							
	Leafhoppers						
	Balclutha timberlakei (Osborn, 1935)	end		60	X		
	Deltocephalus sonorus Ball, 1900	adv	NIR		98		WJK
	Empoasca solana DeLong, 1931	adv	NIR		98		WJK
Family Coccidae							
	Soft Scales						
	Coccus viridis (Green, 1889)	adv		60	98		JWB
	Kilifia acuminata (Signoret, 1873)	adv		60	X		
	Parasaissetia nigra (Nietner, 1861)	adv		60	98		JWB
	Saissetia miranda (Cockerell, 1899)	adv	NIR		98		JWB
Family Delphacidae							
	Delphacid planthoppers						
	Opiconsiva paludum (Kirkaldy, 1910)	adv		60	X		
	Toya dryope (Kirkaldy, 1907)	adv	NIR		98		MA
Family Diaspididae							
	Armored scales						
	Aonidiella inornata McKenzie, 1938	adv	NIR		98		JWB
	Chrysomphalus aonidum (Linnaeus, 1758)	adv		60	98		JWB
	Chrysomphalus dictyospermi (Morgan, 1889)	adv	NIR		98		JWB
	Clavaspis herculeana (Doane & Hadden, 1909)	adv	NIR		98		JWB
	Duplaspidotus claviger (Cockerell, 1901)	adv	NIR		98		JWB
	Hemiberlesia lataniae (Signoret, 1869)	adv	NIR		98		JWB
	Lepidosaphes ?laterochitinsa Green, 1925	adv?	NIR		98		JWB
	Lepidosaphes tokionis (Kuwana, 1902)	adv	NIR		98		JWB
	Odonaspis ruthae Kotinsky, 1915	adv	NIR		98		JWB
	Pinnaaspis strachani (Cooley, 1899)	adv		60	98		JWB
	Pseudaulacaspis cockerelli (Cooley, 1897)	adv	NIR		98		JWB
Family Eriococcidae							
	Acanthococcus araucariae (Maskell, 1878)	adv	NIR		98		JWB
Family Flatidae							
	Flatid planthoppers						
	Melormenis basalis (Walker, 1851)	adv	NIR		98		DJP
Family Margarodidae							
	Giant coccids						
	Icerya purchasi Maskell, 1878	adv		60	98		DJP
Family Membracidae							
	Treehoppers						
	Spissistilus festinus (Say, 1830)	adv		60	98		JWB
	Vanduzeeea segmentata (Fowler, 1895)	adv		60	98		GMN

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Homoptera (continued)							
Family Pseudococcidae							
	Mealybugs						
	Antonina graminis (Maskell, 1897)	Rhodesgrass mealybug	adv	NIR		98	JWB
	Chorizococcus rostellum (Lobdell, 1930)		adv	NIR		98	JWB
	Dysmicoccus neobrevipes Beardsley, 1959		adv	NIR		98	JWB
	Ferrisia consobrina Williams & Watson, 1988		adv	NIR		98	JWB
	Laminicoccus pandani (Cockerell, 1895)		adv	NIR		98	JWB
	Palmicultor palmarum (Ehrhorn, 1916)	Palm mealybug	adv		60	X	
	Phenacoccus madeirensis Green 1923	Madeira mealybug	adv		60	98	JWB
	Phenacoccus solani Ferris, 1918		adv	NIR		98	JWB
	Planococcus citri (Risso, 1813)	Citrus mealybug	adv		60	98	JWB
Family Psyllidae							
	Heteropsylla sp.	Jumping plantlice	adv	NIR		98	GMN
Order Hymenoptera							
	Bees, wasps, ants						
Family Agaonidae							
	Fig wasps						
	Pleistodontes froggatti Mayr, 1906		p/adv	NIR		98	JWB
Family Anthophoridae							
	Cuckoo bees, carpenter bees						
	Ceratina arizonensis Cockerell, 1898		adv	NIR		98	RRS
	Xylocopa sonorina F. Smith, 1874	Sonoran carpenter bee	adv		60	98	GMN
Family Aphelinidae							
	Aphelinids						
	Aphytis sp., ?hispanicus Mercet		adv	psr		98	JWB
	Aspidiotiphagus lounsburyi (Berlese & Paoli, 1916)		adv	pir		98	JWB
	Azotus sp.		adv	pir		98	JWB
	Centrodora xiphidii (Perkins, 1906)		adv	pir		98	JWB
	Coccophagus ceroplastae (Howard, 1895)		adv	pir		98	JWB
	Encarsia pergandiella Howard, 1907		p/adv	pir		98	JWB
	Encarsia sp.		adv	psr		98	JWB
	Eretmocerus sp.		adv	psr		98	JWB
Family Bethylinidae							
	Bethylids						
	Epyris sp.		adv?		60	X	
	Sierola sp.		adv?	pir		98	JWB

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Hymenoptera (continued)	Bees, wasps, ants						
Family Braconidae	Braconids						
<i>Apanteles carpatus</i> (Say, 1836)		adv			60	98	JWB
<i>Apanteles</i> sp.		adv	pir			98	JWB
<i>Chelonus blackburni</i> Cameron, 1887		adv		23	60	98	JWB
<i>Cotesia plutellae</i> (Kurdjumov, 1912)		p/adv	pir			98	JWB
<i>Cotesia marginiventris</i> (Cresson, 1865)		p/adv			64	98	JWB
<i>Lysiphlebus testaceipes</i> (Cresson, 1880)		p/adv	1941			98	JWB
<i>Paralorhogas pallidiceps</i> (Perkins, 1910)		adv	pir			98	JWB
<i>Phanerotoma hawaiiensis</i> Ashmead, 1901		adv			60	98	JWB
<i>Rhaconotus vagrans</i> (Bridwell, 1920)		adv	pir			98	JWB
<i>Urosigalphus bruchi</i> Crawford 1907		p/adv			60	X	
Family Ceraphronidae	Ceraphronids						
<i>Aphanogmus</i> sp.		adv	NIR			98	JWB
<i>Ceraphron plebeius</i> Perkins, 1910		adv	pir			98	JWB
<i>Ceraphron</i> sp.		adv	psr			98	JWB
Family Chalcididae	Chalcidids						
<i>Antrocephalus apicalis</i> (Walker, 1874)		adv	pir			98	JWB
<i>Antrocephalus pertorvus</i> (Girault, 1917)		adv			60	98	JWB
<i>Proconura</i> n.sp.		adv	psr			98	JWB
Family Diapriidae	Diapriids						
<i>Trichopria</i> sp.		adv	psr			98	JWB
Family Encyrtidae	Encyrtids						
<i>Adelencyrtus odonaspidis</i> Fullaway, 1913		adv	pir			98	JWB
<i>Aeptencyrtus bruchi</i> DeSantis, 1957		adv	psr			98	JWB
<i>Anagyrus swezeyi</i> Timberlake, 1919		adv		23	60	98	JWB
<i>Blepyrus insularis</i> (Cameron, 1886)		adv	pir			98	JWB
<i>Cheiloneurus</i> sp.		adv	pir			98	JWB
<i>Coccidoxenoides peregrina</i> (Timberlake, 1919) Oriental mealybug parasite		adv		23	60	98	JWB
<i>Dicarnosis ripariensis</i> Kerrich, 1978		adv	psr			98	JWB
<i>Diversinervus elegans</i> Silvestri 1914		adv	1977			98	JWB
<i>Encyrtus infelix</i> (Embleton, 1902)		adv	pir			98	JWB
<i>Gyranusoidea phenacocci</i> (Beardsley, 1970)		adv	pir			98	JWB

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Hymenoptera (continued)	Bees, wasps, ants						
Family Encyrtidae (continued)	Encyrtids						
<i>Leptomastidea abnormis</i> (Girault, 1915)		p/adv	pir			98	JWB
<i>Metaphycus flavus</i> (Howard, 1881)		adv	pir			98	JWB
<i>Neodusmetia sangwani</i> (Subba Rao, 1957)		adv	pir			98	JWB
<i>Plagiomerus</i> sp.		adv	pir			98	JWB
Family Eucolidae	Eucolids						
<i>Gronotoma micromorpha</i> (Perkins, 1910)		adv	pir			98	JWB
Family Eulophidae	Eulophids						
<i>Aprostocetus hagenowii</i> (Ratzeburg, 1852)		adv	pir			98	JWB
<i>Aprostocetus</i> sp.		adv?	pir			98	JWB
<i>Elachertus advena</i> Timberlake, 1926		adv		23	60	98	JWB
<i>Hemiptarsenus semialbiclavus</i> (Girault, 1916)		adv	pir			98	JWB
<i>Neochrysocharis formosa</i> (Westwood, 1833)		adv	pir			98	JWB
<i>Neotrichoporoides viridimaculata</i> (Fullaway, 1955)		adv	pir			98	JWB
<i>Tetrastichus beardisleyi</i> Fullaway, 1956		adv	pir			98	JWB
Family Eupelmidae	Eupelmids						
<i>Anastatus koebelei</i> Ashmead, 1901		adv?	pir			98	JWB
Family Eurytomidae	Seed chalcids						
<i>Tetramesa</i> sp.		adv	pir			98	JWB
Family Evaniidae	Ensign wasps						
<i>Evania appendigaster</i> (Linnaeus, 1758)	larger ensign wasp	adv			60	98	JWB
Family Formicidae	Ants						
<i>Camponotus variegatus</i> (F. Smith, 1858)	Hawaiian carpenter ant	adv			60	X	
<i>Cardiocondyla emeryi</i> Forel, 1881		adv	NIR			98	RRS
<i>Cardiocondyla nuda</i> (Mayr, 1866)		adv		23	60	98	NJR
<i>Monomorium floricola</i> (Jerdon, 1851)		adv	1967			X	
<i>Monomorium monomorium</i> Bolton, 1987		adv		23	60	X	
<i>Monomorium pharaonis</i> (Linnaeus, 1758)	Pharaoh ant	adv	NIR			98	NJR
<i>Paratrechina bourbonica</i> (Forel, 1886)		adv		23	60	X	
<i>Paratrechina longicornis</i> (Latreille, 1802)	Crazy ant	adv			60	98	RRS
<i>Pheidole megacephala</i> (Fabricius, 1793)	Bigheaded ant	adv		23	60	98	RRS

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Hymenoptera (continued)	Bees, wasps, ants						
Family Formicidae	Ants						
<i>Plagiolepis alluaudi</i> Emery, 1894	Little yellow ant	adv			60	98	RRS
<i>Solenopsis geminata</i> (Fabricius, 1804)	Fire ant	adv			60	98	NJR
<i>Tapinoma melanocephalum</i> (Fabricius, 1793)	Tiny yellow house ant	adv		23	60	X	
<i>Tetramorium bicarinatum</i> (Nylander, 1847)	Guinea ant	adv		23	60	98	NJR
<i>Tetramorium simillimum</i> (F. Smith, 1851)		adv	NIR			98	RRS
Family Ichneumonidae	Ichneumons						
<i>Anomalon californicum</i> (Cresson, 1879)		adv	pir			98	JWB
<i>Casinaria infesta</i> (Cresson, 1872)		adv	pir			98	JWB
<i>Diplazon laetatorius</i> (Fabricius, 1781)		adv			60	98	JWB
<i>Venturia</i> sp.		adv			60	98	JWB
Family Megachilidae	Leafcutting Bees						
<i>Chalicodoma umbripennis</i> (F. Smith, 1853)		adv			60	98	RRS
<i>Megachile fullawayi</i> Cockerell, 1914		adv	NIR			98	RRS
<i>Megachile timberlakei</i> Cockerell, 1920		adv	NIR			98	RRS
Family Mymaridae	Fairyflies						
<i>Anagrus frequens</i> Perkins, 1905		p/adv	pir			98	JWB
<i>Anagrus nigriventris</i> Girault, 1911		adv	pir			98	JWB
<i>Anaphes calendrae</i> (Gahan, 1927)		p/adv	pir			98	JWB
<i>Camptoptera</i> sp.		adv	psr			98	JWB
<i>Gonatocerus</i> sp. <i>litoralis</i> group		adv	psr			98	JWB
<i>Gonatocerus</i> sp. <i>membraciphagus</i> group		adv	psr			98	JWB
<i>Gonatocerus ornatus</i> Gahan, 1918		adv	pir			98	JWB
<i>Stephanodes reduvii</i> (Perkins, 1905)		end?		23	60	98	JWB
Family Platygasteridae	Platygasterids						
<i>Fidiobia</i> sp.		adv	pir			98	JWB
Family Pteromalidae	Pteromalids						
<i>Chlorocytus longiscapus</i> Graham, 1965		adv	pir			98	JWB
<i>Halticoptera circulus</i> (Walker, 1833)		adv	pir			98	JWB
<i>Heteroschema</i> sp.		adv	pir			98	JWB
<i>Lariophagus texanus</i> Crawford 1910		p/adv			60		
<i>Spalangia cameroni</i> Perkins, 1910		p/adv	pir			98	JWB

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Hymenoptera (continued)	Bees, wasps, ants						
Family Scelionidae	Scelionids						
Anteromorpha dubiosa (Perkins, 1910)		adv	pir			98	JWB
Encyrtoscelio sp.		adv	pir			98	JWB
Idris perégrinus (Perkins, 1910)?		adv	pir			98	JWB
Telenomus nawai Ashmead, 1904	Armyworm egg parasite	adv	1960			98	JWB
Telenomus vulcanus Perkins, 1910		end?	pir			98	JWB
Telenomus sp.		adv	psr			98	JWB
Family Signiphoridae	Signiphorids						
Signiphora sp.		adv	pir			98	JWB
Family Sphecidae	Sphecid wasps						
Ampulex compressa (Fabricius, 1781)	Emerald cockroach wasp	p/adv		60	X		
Chalybion bengalense (Dahlbom, 1845)		adv	NIR			98	RRS
Dolichurus stantoni (Ashmead, 1904)	Black cockroach wasp	p/adv		60	X		
Isodontia apicalis (F. Smith, 1856)		adv		60	X		
Isodontia mexicana (Saussure, 1867)		adv	NIR			98	JWB
Sceliphron caementarium (Drury, 1770)	Mud dauber	adv		60	X		
Family Trichogrammatidae	Trichogrammatids						
Oligosita sp.		adv	pir			98	JWB
Trichogramma sp.		adv	pir			98	JWB
Uscana sp.		p/adv	pir			98	JWB
Family Vespidae	Paper wasps, etc.						
Pachodynerus nasidens (Latreille, 1832)	Keyhole wasp	adv		60	98		RRS
Parancistrocerus fulvipes (Saussure)		adv	NSR			98	RRS
Polistes aurifer Saussure, 1853	Golden paper wasp	adv		60	98		RRS
Polistes exclamans Viereck, 1906	Common paper wasp	adv	NIR			98	RRS
Polistes jadvigae Dalla Torre, 1904		adv	NIR			98	RRS
Ropalidia marginata (Le Peletier, 1836)		adv		60	X		
Order Isoptera	Termites						
Family Kalotermitidae	Drywood termites						
Cryptotermes brevis (Walker, 1853)	West Indian drywood termite	adv		60	98		RJW
Incisitermes immigrans (Snyder, 1922)	Lowland tree termite	adv	NIR			98	RJW

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Isoptera (continued)	Termites						
Family Rhinotermitidae	Dampwood termites						
<i>Coptotermes formosanus</i> Shiraki, 1909	Formosan subterranean termite	adv			60	98	RJW
Order Lepidoptera	Butterflies and moths		(partially studied)				
Family Arctiidae	Tiger moths						
<i>Utetheisa pulchelloides</i> Hampson, 1907		adv?	1991			X	
Family Cosmopterigidae	Cosmopterigid moths						
<i>Asymphorodes dimorpha</i> (Busck, 1914)		adv		23	60	98	DJP
<i>Asymphorodes</i> sp.		adv?				98	KS
<i>Hyposmocoma neckerensis</i> (Swezey, 1926)	Necker petrochroan leaf miner	end	1926			98	KS
<i>Hyposmocoma rubescens</i> Walsingham, 1907		end	1907			98	KS
<i>Pyroderces rileyi</i> (Walsingham, 1882)	Pink scavenger caterpillar	adv			60	98	DJP
Family Crambidae	Crambid moths						
<i>Hellula undalis</i> (Fabricius, 1781)	Imported cabbageworm	adv			60	98	DJP
<i>Herpetogramma licarsialis</i> (Walker, 1859)	Grass webworm	adv	NIR			98	DJP
<i>Spoladea recurvalis</i> (Fabricius, 1775)	Hawaiian beet webworm	adv			60	98	DJP
Family Geometridae	Measuringworms						
<i>Cyclophora nanaria</i> (Walker, 1861)		adv	NIR			98	DJP
<i>Macaria abydata</i> Guenee, 1857		adv	NIR			98	DJP
Family Gracilariidae	Gracilariid moths						
<i>Stoeberhinus testaceus</i> Butler, 1881		adv		23	60	98	DJP
Family Noctuidae	Noctuid moths, cutworms, armyworms						
<i>Achaea janata</i> (Linnaeus, 1758)	Croton caterpillar	adv			60	?	
<i>Agrotis fasciata</i> (Rothschild, 1894)	Midway agrotis noctuid moth	end		23	60	?	
<i>Agrotis ipsilon</i> (Hufnagel, 1767)	Black cutworm	adv	NIR			98	DJP
<i>Chrysodeixis eriosoma</i> (Doubleday, 1843)	Green garden looper	adv		23	60	98	DJP
<i>Helicoverpa zea</i> (Boddie, 1850)	Corn earworm	adv	1963			?	
<i>Hypena laceratalis</i> Walker, 1858		p/adv	NIR			98	DJP
<i>Leucania loreyimina</i> Rungs, 1953		adv	1991			98	DJP
<i>Pseudaletia unipuncta</i> (Haworth, 1809)	Armyworm	adv			60	?	
<i>Spodoptera exempta</i> (Walker, 1856)	Nutgrass armyworm	adv			60	?	
<i>Spodoptera litura</i> (Fabricius, 1775)		adv		23		?	
<i>Spodoptera mauritia</i> (Boisduval, 1833)	Lawn armyworm	adv	1973			?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Lepidoptera (continued)	Butterflies and moths		(partially studied)				
Family Nymphalidae	Brushfooted butterflies						
<i>Vanessa cardui</i> (Linnaeus, 1758)	Painted lady	adv	NIR			98	GMN
Family Plutellidae	Diamondback moths						
<i>Plutella xylostella</i> (Linnaeus, 1758)	Diamondback moth	adv		23	60	98	DJP
Family Pterophoridae	Plume moths						
<i>Lioptilodes parvus</i> (Walsingham, 1880)		adv			60	?	
<i>Megalorhipida leucodactylus</i> (Fabricius, 1793)		adv	1913		60	98	DJP
Family Pyralidae							
<i>Pyralis manihotalis</i> Guenee, 1854		adv			60	?	
Family Sphingidae	Hawk moths, hornworms						
<i>Agrius cingulata</i> (Fabricius, 1775)	Sweetpotato hornworm	adv	1984			98	DJP
<i>Deilephila nerii</i> (Linnaeus, 1758)	Oleander hawk moth	adv	1986			X	
Family Tineidae	Clothes moths & others						
<i>Erechthias simulans</i> (Butler, 1882)		adv			60	98	DJP
<i>Monopis meliorella</i>		adv	NIR			98	KS
<i>Opogona aurisquamosa</i> (Butler, 1881)		adv			60	?	
Family Tortricidae	Tortricid moths						
<i>Amorbia emigratella</i> Busck, 1910	Mexican leafroller	adv			60	?	
<i>Bactra</i> sp. nr. <i>straminea</i> (Butler, 1881)		adv?	NIR			98	DJP
<i>Crociosema blackburni</i> (Butler, 1881)		end?		23		?	
Order Mantodea	Mantids						
Family Mantidae							
<i>Tenodera angustipennis</i> Saussure, 1869	Narrowwinged mantid	adv			60	X	
Order Neuroptera	Lacewings						
Family Chrysopidae	Common lacewings						
<i>Chrysoperla comanche</i> (Banks, 1938)	Comanche lacewing	adv		23	60	98	JWB
Family Hemerobiidae	Brown lacewings						
<i>Symphorobius barberi</i> (Banks, 1903)	Barber brown lacewing	p/adv			60	X	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Odonata	Dragonflies, damselflies						
Family Libellulidae	Common skimmers						
<i>Pantala flavescens</i> (Fabricius, 1798)	Globe skimmer	ind	1968			98	GMN
Order Orthoptera	Grasshoppers, katydid, crickets, and relatives						
Family Acrididae	Shorthorned grasshoppers						
<i>Oxya japonica</i> (Thunberg, 1824)	Japanese grasshopper	adv			60	X	
Family Gryllidae	Crickets						
<i>Gryllodes sigillatus</i> (Walker, 1869)	Flightless field cricket	adv			60	98	GMN
<i>Modioceryllus conspersus</i> (Schaum, 1862)	Small field cricket	adv	NIR			98	GMN
<i>Myrmecophila quadrispina</i> Perkins, 1899		adv			60	X	
Family Pyrgomorphidae	Coneheaded grasshoppers						
<i>Atractomorpha sinensis</i> Bolivar, 1905	Pinkwinged grasshopper	adv			60	X	
Family Tettigoniidae	Katydids, longhorned grasshoppers						
<i>Conocephalus saltator</i> (Saussure, 1859)	Longhorned grasshopper	adv		23	60	98	GMN
<i>Elimaea punctifera</i> (Walker, 1869)	Narrowwinged katydid	adv			60	98	GMN
<i>Scudderia paronae</i> Griffini, 1896		adv	NIR			98	GMN
<i>Xiphidiopsis lita</i> Hebard, 1922		adv			60	X	
Order PHTHIRAPTERA	Lice		(not sought)				
Family Hoplopleuridae							
<i>Polyplax spinulosa</i> (Burmeister, 1839)	Spined rat louse	adv	1980			?	
Family Menoponidae							
<i>Actornithophilus bicolor</i> (Piaget, 1880)		ind	1973			?	
<i>Actornithophilus ceruleus</i> (Timmermann, 1954)		ind	1973			?	
<i>Actornithophilus incisus</i> (Piaget, 1880)		ind	1973			?	
<i>Actornithophilus umbrinus</i> (Burmeister, 1838)		ind	1973			?	
<i>Austromenopon becki</i> (Kellogg, 1906)		ind	1973			?	
<i>Austromenopon paululum</i> (Kellogg & Chapman, 1899)		ind	1973			?	
<i>Austromenopon pinguis</i> (Kellogg, 1896)		ind	1973			?	
<i>Colpocephalum angulaticeps</i> Piaget, 1880		ind	1973			?	
<i>Trinoton querquedulae</i> (Linnaeus, 1758)	Large duck louse	adv	1973			?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Phthiraptera (continued)							
Family Philopteridae							
Anaticola aneris (Linnaeus, 1758)	Slender goose louse	ind	1973			?	
Anatoecus sp.		ind	1973			?	
Carduceps zonarius (Nitzsch, 1866)		ind	1973			?	
Columbicola columbae (Linnaeus, 1758)	Slender pigeon louse	adv	1973			?	
Docophoroides ferrisi Harrison, 1937		ind	1973			?	
Docophoroides niethammeri Timmermann, 1969		ind	1973			?	
Episbates pederiformis (Dufour, 1835)		adv?	1973			?	
Halipeurus leucophryna Timmermann, 1960		ind	1973			?	
Halipeurus mirabilis Thompson, 1940		ind	1973			?	
Halipeurus spadix Timmermann, 1961		ind	1973			?	
Harrisoniella copei Timmermann, 1969		ind	1969			?	
Harrisoniella densa (Kellogg, 1896)		ind	1958			?	
Lunaceps hopkinsi Timmermann, 1954		ind	1973			?	
Naubates harrisoni Bedford, 1930		ind	1973			?	
Paraclisis confidens (Kellogg, 1899)		ind	1958			?	
Paraclisis giganticola (Kellogg, 1896)		ind	1958			?	
Pectinopygus annulatus (Piaget, 1880)		ind	1973			?	
Pectinopygus gracilicornis (Piaget, 1880)		ind	1973			?	
Pectinopygus sulae (Rudow, 1869)		ind	1973			?	
Perineus concinnus (Kellogg & Chapman, 1899)		ind	1958			?	
Quadriceps birostris (Giebel, 1874)		ind	1973			?	
Quadriceps hopkinsi Timmermann, 1952)		ind	1973			?	
Quadriceps obscurus (Burmeister, 1838		ind	1973			?	
Quadriceps ornatus striolatus (Nitzsch, 1866		ind	1973			?	
Quadriceps separatus (Kellogg & Kuwana, 1902)		ind	1973			?	
Saemundssonina albemarlensis (Kellogg & Kuwana, 1902)		ind	1973			?	
Saemundssonina hexagona (Giebel, 1874)		ind	1973			?	
Saemundssonina lari lari (O. Fabricius, 1780)		ind	1973			?	
Saemundssonina remota Timmermann, 1951		ind	1973			?	
Saemundssonina scolopacisphaeopodis (Schränk, 1803)		ind	1973			?	
Saemundssonina snyderi (Kellogg & Paine, 1910)		ind	1973			?	
Trabeculus hexakon (Waterston, 1914)		ind			60	?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Psocoptera	Booklice, barklice		(not studied)				
Family Ectopsocidae							
<i>Ectopsocus perkinsi</i> Banks, 1931			adv		60	?	
Order Thysanoptera	Thrips		Not Studied				
Family Phlaeothripidae							
<i>Haplothrips gowdeyi</i> (Franklin, 1908)	Black flower thrips		adv		60	?	
Family Thripidae	Common thrips						
<i>Chirothrips mexicanus</i> Crawford, 1909			adv		60	?	
<i>Frankliniella minuta</i> (Moulton, 1907)			adv		60	?	
<i>Heliothrips haemorrhoidalis</i> (Bouche, 1833)	Greenhouse thrips		adv		60	?	
<i>Thrips hawaiiensis</i> (Morgan, 1913)	Hawaiian flower thrips		adv		60	?	
<i>Thrips tabaci</i> Lindeman, 1889	Onion thrips		adv		60	?	
Order Thysanura	Silverfish, bristletails						
Family Lepismatidae	Silverfish						
<i>Ctenolepisma longicaudatum</i> Escherich, 1905			adv		60	X	
ARACHNIDS							
Order Araneae	Spiders						
Family Araneidae	Orbweavers						
<i>Neoscona oaxacensis</i> (Keyserling, 1864)			adv		60	98	JB
Family Clubionidae	Twoclawed hunting spiders						
<i>Chiracanthium mordax</i> L. Koch, 1866	Pale leaf spider		adv		60	98	JB
<i>Clubiona alveolata</i> L. Koch, 1873			adv	psr		98	JB
Family Corinnidae							
<i>Corinna cetrata</i> (Simon, 1888)			adv	pir		98	JB
Family Gnaphosidae	Hunting spiders						
<i>Camillina elegans</i> (Bryant, 1940)			adv	1997		X	
Family Heteropodidae	Giant crab spiders						
<i>Heteropoda venatoria</i> (Linnaeus, 1767)	Large brown spider		adv		60	98	JB
Family Linyphiidae	Sheetweb spiders						
<i>Colonus</i> sp.			adv?		60	X	
Family Ochyzeratidae							
<i>Theotima radiata</i> (Simon, 1891)			adv	pir		98	JB

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Araneae (continued)	Spiders						
Family Oonopidae	Minute jumping spiders						
Ischnothyreus omus Suman, 1965		end	NIR			98	JB
Oonops sp.		adv?			60	X	
Opopaea lena Suman, 1965		end	NIR			98	JB
Family Pholcidae	Longlegged spiders						
Artema atlanta Walckenaer, 1837		adv	NIR			98	JB
Smeringopus pallidus (Blackwall, 1858)		adv	NIR			98	JB
Family Salticidae	Jumping spiders						
Hasarius adansoni (Audouin, 1826)		adv			60	98	JB
Menemerus bivittatus (Dufour, 1831)		adv			60	98	JB
Messua cf. felix (Peckham & Peckham, 1901)		adv	pir			98	JB
Phintella versicolor (C.L. Koch, 1846)		adv	pir			98	JB
Plexippus paykulli (Audouin, 1826)		adv	pir			98	JB
Family Scytodidae	Spitting spiders						
Scytodes fusca Walckenaer, 1837		adv			60	X	
Scytodes longipes Lucas, 1845		adv			60	X	
Family Tetragnathidae							
Tetragnatha nitens (Audouin, 1826)		adv	pir			98	JB
Family Theridiidae	Combfooted spiders						
Achaearanea tepidariorum (C.L. Koch, 1841)		adv			60	X	
Coleosoma adamsoni (Berland, 1934)		adv	psr			98	JB
Latrodectus hesperus Chamberlin & Ivie, 1935	Western black widow spider	adv	1980			X	
Latrodectus mactans (Fabricius, 1775)	Black widow spider	adv	1980			X	
Theridion melanostictum Cambridge, 1876		adv	pir			98	JB
Order Acari	Mites		(partly studied)				
Family Acaridae							
Tyrophagus putrescentiae (Schrank, 1781)	Mold mite	adv	1975			98	SFS
Family Alloptidae							
Laminalloptes phaetontis (Fabricius, 1775)		ind?	1997			?	
Family Argasidae	Soft ticks						
Ornithodoros capensis Neumann, 1901		adv	1967			?	
Family Atopomelidae							
Listrophoroides cucullatus (Trouessart, 1893)		adv	1975			?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Acari (continued)	Mites						
Family Bdellidae							
Bdella sp.		adv?	NIR			98	SFS
Bdellodes longirostris Hermann, 1804		adv	NIR			98	SFS
Spinibdella cronini (Baker & Balock, 1944)		adv	1987			?	
Family Carabodidae							
Austrocarabodes imperfectus (Sellnick, 1959)		ind	1966			98	SFS
Family Cheyletidae							
Cheletomimus berlesei (Oudemans, 1904)		adv	1985			?	
Cheletomimus duosetosus Muma, 1964		adv	1985			?	
Hemicheyletia wellsii (Baker, 1949)		adv	1987			?	
Hemicheyletia sp.		end?				98	SFS
Family Cosmochthoniidae							
Cosmochthonius sp.		adv	NIR			98	SFS
Phyllozetes sp.		adv	psr			98	S&N
Family Cryptognathidae							
Favognathus goffi Swift, 1996		adv?	1968			98	SFS
?Favognathus variabilis Swift, 1996		adv?	NIR			98	SFS
Family Ctenacaridae							
Ctenacarus araneolus (Grandjean, 1932)		adv	pir			98	S&N
Family Cunaxidae							
Dactyloscirus nr. glebulentus Den Heyer, 1908 ?		adv	NSR			98	SFS
Neocunaxoides sp.		adv?	NIR			98	SFS
Pulaeus sp. 1		adv?	NSR			98	SFS
Pulaeus sp. 2		adv?	NSR			98	SFS
Family Cymbaeremaeidae							
Scapheremaeus fisheri Aoki, 1966		end?	1966			98	SFS
Family Epilohmanniidae							
Epilohmannia sp.		adv	pir			98	S&N
Family Ereynetidae							
?Ereynetes sp.		adv?	?NIR			98	SFS
Family Euphthiracaridae							
Rhysotritia ardua (C.L. Koch, 1841)		adv	1966			?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Acari (continued)	Mites						
Family Eupodidae							
Eupodes sp.		adv?	NIR			98	SFS
Family Galumnatidae							
Galumna australis pembedoni (Jacot, 1934)		end?	1966			98	SFS
Galumna climata (C.L. Koch, 1841)		adv	1966			98	SFS
Family Laelapidae							
Androlaelaps hermaphrodita (Berlese, 1887)		adv	1980			?	
Hypoaspis queenslandicus (Womersley, 1956)		adv	1982			?	
Hypoaspis scimita (Womersley, 1956)		adv	1982			?	
Laelaps echidnina Berlese, 1887		adv	1958			?	
Family Listrophoridae	Fur mites						
Afrolistrophorus musculus (Wilson & Lawrence, 1967)		end?	1975			?	
Family Macrochelidae							
Holostaspella n.sp.		adv?	1985			?	
Macrocheles similis Krantz & Filipponi, 1964)		adv	1985			?	
Family Macronyssidae							
Ornithonyssus bacoti (Hirst, 1913)	Tropical rat mite	adv	1975			?	
Family Myobiidae							
Myobia musculi (Schrank, 1781)		adv	1975			?	
Radfordia affinis (Poppe, 1896)		adv	1980			?	
Radfordia ensifera (Poppe, 1896)		adv	1987			?	
Family Myocoptidae							
Myocoptes musculus (C.L. Koch, 1838)		adv	1975			?	
Family Lohmanniidae							
Annectacarus sp.		adv	psr			98	S&N
Family Ologamasidae							
Gamasiphis sp.		adv?	pir			98	SFS
Family Oribatulidae							
Oribatula sp.		adv	psr			98	S&N
Family Paratydeidae							
Neotydeius sp.		adv?	1987			?	
Family Raphignathidae							
Raphignathus sp.		adv?	pir			98	SFS

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
Order Acari (continued)	Mites						
Family Scheloribatidae							
Schelorbates muiri Jacot, 1934		ind	1966			98	SFS
Family Sejidae							
Sejus armatus (Fox, 1947)		adv	1987			?	
Sejus sp.		adv?				98	SFS
Family Sphaerochthoniidae							
Sphaerochthonius suzukii Aoki, 1977		adv	pir			98	S&N
Family Stigmaeidae							
Stigmaeus sp.		adv?	NIR			98	SFS
Family Tarsonemidae							
?Tarsonemus sp.		adv?	NIR			98	SFS
Family Tectocepheidae							
Tectocepheus velatus (Michael, 1880)		adv	1966			?	
Family Tetranychidae	Spider mites						
Bryobia praetiosa C.L. Koch, 1835	Clover mite	adv	1986			?	
Tetranychus cinnabarinus (Boisduval, 1867)	Carmine spider mite	adv	1986			?	
Tetranychus ludeni Zacher, 1913		adv			60	?	
Family Trombiculidae	Chiggers						
Guntheria domrowi (Brennan, 1965)		adv	1984			?	
Neoschoengastia gettmani Goff, 1984		end?	1984			?	
Neoschoengastia n.sp.		end?	1985			?	
Neotrombicula megensi Goff, 1975		end?	1975			?	
Womersia midwayensis Goff, Sievert & Sileo, 1989		end?	1989			?	
Family Tydeidae							
Tydeus tuttlei Baker, 1965		adv	1987			?	
Family Uropodidae							
Uropoda sp.		adv?	1987			?	
Family Xolalgidae							
n.gen. n.sp.		adv?	1987			?	

Appendix 1. Current list of arthropod species from Midway (continued)

Taxon	common name	origin	status	checklists			determiners
				23	60	98	
CHILOPODA	Centipedes						
Family Henicopidae							
<i>Lamyctes africana</i> (Porat, 1871)		adv	pir			98	RS
Family Lithobiidae							
<i>Lithobius moanana</i> (Chamberlin, 1926)		end	pir			98	RS
Family Scolopendridae							
<i>Scolopendra subspinipes</i> Leach, 1815	Large centipede	adv		60	98		GMN
PSEUDOSCORPIONIDA	Pseudoscorpions						
<i>Lechytia sakagamii</i> Morikawa, 1952		adv			98		WM
SCORPIONES	Scorpions						
Family Buthidae							
<i>Isometrus maculatus</i> (DeGeer, 1778)	Lesser brown scorpion	adv		60	X		
CRUSTACEA							
ISOPODA	Pillbugs and sowbugs						
Family Armadillidae							
<i>Venezillo parvus</i> (Budde-Lund, 1885)		adv	pir			98	ST
Family Halophilosciidae							
<i>Halophiloscia couchii</i> (Kinahan, 1858)		adv	psr			98	ST
Family Philosciidae							
<i>Littorophiloscia culebrae</i> (Moore, 1901)		adv	pir			98	ST
Family Porcellionidae							
<i>Agabiformius lentus</i> (Budde-Lund, 1885)		adv	pir			98	ST
<i>Porcellio laevis</i> Latreille, 1804		adv	1996			98	ST
<i>Porcellio lamellatus lamellatus</i> Budde-Lund, 1885		adv	pir			98	ST
<i>Porcellionides pruinus</i> (Brandt, 1833)		adv	1996			98	ST
Family Scyphacidae							
<i>Armadilloniscus ellipticus</i> (Harger, 1878)		adv	pir			98	ST
Family Trachelipodidae							
<i>Nagurus nanus</i> (Budde-Lund, 1908)		adv?	pir			98	ST

Appendix 2. Chronology Of Documented Human Activity At Midway (except period of U.S. Navy Control)

- 1859 July 8. Middlebrook Islands (Midway) discovered by Captain N.C. Brooks on the *Gambia*.
- 1867 September 30. Captain William Reynolds on the *Lackawanna*, took possession of the atoll for the U.S. The crew seined fish, then went ashore to cook them and picnic. The survey was for the purpose of ascertaining whether a coal depot could be established for the convenience of Pacific mail ships.
Sometime later. A coal shed was erected on Sand Island, a cargo of coal landed and one man left in charge, but he left at first opportunity with a schooner seeking freshwater.
- 1870 March 24. U.S.S. *Saginaw* sent to Midway to dredge channels in preparation for a naval station. The *Kate Piper* was chartered to carry supplies back and forth from Honolulu, and assist in the dredging.
- 1886 November 16. The *General Siegel*, on a shark-fishing expedition from Honolulu, stopped to provision with bird eggs and was wrecked on a reef. Seven or eight men were marooned and made use of buildings abandoned by the dredging party. Survivors eventually sailed for the Marshall islands, leaving one crewmember on Midway.
- 1888 February 8. The *Wandering Minstrel* was wrecked in Welles Harbor with about 30 survivors.
March 15. Six survivors leave with a boat and are presumed lost.
October 13. Three of the stranded visitors including the one remaining from the previous wreck left on a small boat, eventually reaching the Marshall Islands.
- 1889 March 26. Remaining castaways rescued.
- 1890 July 11. Rothschild Expedition lands two scientists (ornithologists Henry Palmer and George C. Munro), who collect birds and a few insects.
- 1891 July 12. The Charles G. Wilson arriving from the Marshalls, lands to secure water.
- 1900 A survey party from the U.S.S. *Iroquois*, sent to make soundings for a trans-pacific cable, observed Japanese poachers killing birds for their feathers. Complaints about Japanese squatters on the islands caused the Islands to be placed under the Navy Department.
- 1903 April 29. First contingent of the Pacific Commercial Cable Company arrived on the *Hanalei* and put up temporary structures and tents. The contingent found the *Yeiju Maru* anchored in the lagoon and its crew killing birds ashore.
June 3. The U.S.S. *Iroquois* arrived and its commander ordered the Japanese to leave the islands. The *Iroquois* assisted in landing the shore ends of the cable.
July 4. The trans-Pacific cable completed.
October 23. Chartered at Honolulu to carry supplies, the *Julia E. Whalen* is wrecked.

- 1903–1930 Naval vessels visit Midway intermittently. A regular supply ship visited Midway from Honolulu once a month.
- 1904 May. A garrison of marines sent out. A lighthouse and dock are constructed. The Midway colony consisted of approximately 100 people.
- 1905 The cable station's permanent buildings completed. Two donkeys imported from Honolulu in 1905 and released on Eastern Islands; in a few years there was a herd of twenty or more.
July 4. The trans-Pacific cable completed.
- 1906 September 16. The Pacific Mail S.S. *Mongolia* went aground on the western side.
December 28. The *Carrollton*, with a load of coal from Newcastle to Honolulu is lost on Midway.
- 1908 Marines leave Midway. The remaining cable personnel reduced to about thirty.
- 1909 Two canaries brought to Sand Island and bred in a cage. After a dozen or more birds were reared they were liberated.
- 1920 October. First arrival of a naval plane.
- 1935 April 12. The ship *North Haven* arrived to bring equipment and supplies for developing an air station between San Francisco and the Philippines. Soon regular weekly trips were bringing visitors through Midway.
- 1935 May. Navy held fleet maneuvers around Midway.
- 1940 Construction began on a Naval Air Station and a garrison of 850 marines established.
- 1941–1998 U.S. Navy operates atoll as a Naval Base.
- 1997 April. U.S. Fish & Wildlife Service takes over atoll as a wildlife refuge.

Appendix 3. Chronology Of Insect Collecting And Biological Introductions On Midway

- 1890 July 13–16. Moths observed and collected by the ornithologists, Henry Palmer and George C. Munro. Laysan rails are released on Eastern I. July 17. Spiders noted to be “in good variety”. Two moths were captured. The “skineating beetle is scarce but small blue blow flies are very numerous and very tame.”
- 1894 First insect from Midway, *Peridroma fasciata* described by W. Rothschild.
1900 August 21. W.A. Bryan arrived for a few hours and made some observations and collected some plants. He noted that Sand Island is barren, covered with dunes with but a few hardy shrubs and grasses on the top of most of the dunes. Eastern was “clothed in green down to the beach.” “The most important plants determined for Midway are: *Cenchrus calyculatus* Cav., *Boerhaavia tetrandra* Forst., a variety near *Lepidium oahuensis* Chan. l. Schl., *Capparis sandwichiana* DC., *Ipomoea insularis* Stend., *Scaevola koenigii* Vahl., *Tribulus cistoides* Linn., and *Eragrostis cynosuroides* (Retz). In addition to the above are three widely distributed beach plants, two of which are grasses that are as yet undetermined.” This is followed by a list of birds collected.
- 1905 G.P. Wilder took a few insects.
- 1905–1921 D. Morrison of the Cable Station imported the grass, *Ammophila arenaria* from beaches near San Francisco, set out ironwood trees, *Casuarina equisetifolia*, as windbreaks, and numerous other kinds of ornamental and useful trees, shrubs, and herbs. Shiploads of soil were brought from Honolulu and used for gardens and other plant growth. He also imported canary birds and Laysan finches in 1906 and fostered the flightless rails that had been introduced from Laysan.
- 1923 The Tanager expedition [with D.T. Fullaway] obtained a few specimens from Midway. Dr. D.R. Chisholm, the resident physician at the Cable Station and others added notes and plant specimens.
- 1923 Fullaway visited Eastern Island and noted a fringe of *Scaevola* with central open space. A grove of ironwood occupied the eastern end, and a herd of donkeys lived on the island. In contrast, Sand Island was reclaimed with soil from Honolulu and planted to trees and gardens.
- 1931 December. Dr. Chisholm collected additional plants, including ornamental trees and weeds that were excluded in the earlier plant collections.
- 1935 F.C. Hadden stationed on Midway on November 24, 1936. His duty was to inspect and fumigate the clipper planes going in both directions. About 200 insect species were intercepted on planes arriving on Midway. Most planes came from Honolulu, Wake, Guam, Manila or Hong Kong.
- 1938–1940 F.A. Bianchi took 3 short successive yearly visits to Midway, concentrating on aphids and thrips.
- 1942 Jan. 12: F.C. Hadden left Midway.
- 1956–1958 C.F. Clagg with U.S. Naval District Public Works & Yoshio Oshiro, a construction worker with Hawaiian Dredging Company, brought numerous specimens from Midway.

- 1959 November. E.J. Ford, Jr. made an intensive survey of the atoll.
- 1959–1961 J.C. Downey surveyed seabird ectoparasites.
- 1960–1962 H.I. Fisher & E.D. Klimstra
- 1970 J.L. Gressitt collected for one week.
- 1971 March. M.L. Goff & M.L. Cunningham, collected on Midway, concentrating on mites.
- 1983 W.C. Gagne spent a few days on Midway.
- 1997–1998 G.M. Nishida collected on Midway Atoll on 5 separate trips accompanied by A. Asquith on 1 trip, and G.A. Samuelson on another. A number of Midway refuge personnel assisted with the servicing of a Malaise trap that remained up for over a year.
- 1999 October 20–23: J.W. Beardsley collected, concentrating on scales, aphids, and parasitic wasps.

Numbers of Hawaiian Species for 2000

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This is the sixth supplement to the earlier tabulations of species known from the Hawaiian Islands (Eldredge & Miller, 1995, 1997, 1998; Miller & Eldredge, 1996; Eldredge, 1999, 2000). Future supplements will include the year date for the compilation, rather than a supplement number itself.

The rich biodiversity of the Hawaiian Islands is comprised of nearly 24,000 species (Table 1). Hawai'i accounts for only about 0.2% of the land area of the United States, yet it has 31% of the nation's federally listed endangered species and 42% of its endangered birds. Almost 75% of the historically documented extinctions of plants and animals in the United States have occurred in the Hawaiian Islands (Allison & Miller, 2000).

Hawaii Biological Survey is continually posting species checklists in searchable interfaces for the Hawaiian biota on our web server at <http://hbs.bishopmuseum.org/>. More than 20,000 species are currently available (including terrestrial arthropods, native and alien land and freshwater snails, foraminiferans, marine invertebrates, flowering plants, fungi, amphibians, reptiles, birds, and mammals).

In the Fall of 2000, the Northwest Hawaiian Rapid Assessment and Monitoring Program (NOW-RAMP) collected extensively in all the Northwest Islands. Large numbers of new species and new records will result from the collections; these specimens are still being investigated and will be included in future updates of Hawaiian species numbers.

The total numbers for the marine invertebrates are different from previous supplements. They are taken from the checklist of the Hawaiian marine invertebrates, which includes names, describers, and principal literature to Hawaiian species:

http://www2.bishopmuseum.org/HBS/invert/list_home.htm

[This checklist also includes non-arthropod invertebrates not covered by Nishida, 2002.] The numbers of nonindigenous marine invertebrate species are taken from a manuscript in preparation by J.T. Carlton and L.G. Eldredge: Marine bioinvasions in Hawai'i: the introduced and cryptogenic marine and brackish water animals and plants of the Hawaiian Archipelago.

Bacteria

Biological surveys were conducted in Lake Kauhakō. Lake Kauhakō is situated in the crater of an extinct, late Pleistocene volcano on the Kalaupapa Peninsula on the north side of Moloka'i, Hawai'i. At 248 m deep, it is the fourth deepest lake in the United States. Filamentous cyanobacteria and "*Prochlorococcus*"-like autotrophs occurred only in the upper 2 m (Donachie *et al.*, 1999).

Fungi: Hemiascomycetes

A new yeast species, *Pichia hawaiiensis* was described from *Charpentiera* trees on the Big Island (Phaff *et al.*, 2000).

1. Contribution No. 2002-008 to the Hawaii Biological Survey.

Table 1. Estimates of numbers of known species of Hawaiian biota (based on Eldredge & Miller, 1995, 1997, 1998; Miller & Eldredge, 1996; Eldredge, 1999; Eldredge, 2000, including this paper and other papers in this issue of the *Records*). Other protists, lichens and fungi, cnidarians, echinoderms, birds, and mammals remain the same as previous editions; other categories are based on updated counts.

Taxon	Total	Endemic	NIS
Algae	885	80+	18
Other protists	1128	2?	?
Fungi and Lichens	2088	240	?
Flowering plants	2264	918	1101
Other plants	766	241	47
Cnidarians	277	75	12
Insects	8427	5462	2609
Other arthropods	1191	366	735
Molluscs	1339	962	96
Annelids	388	80	56
Crustaceans	1179	68+	73+
Echinoderms	313	150	0
Other invertebrates	1846	449	112
Fishes	1216	149	73
Amphibians	8	0	8
Reptiles	27	0	23
Birds	294	63	53
Mammals	44	2	19
Totals	23,680	9456	5073

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.

Flowering Plants

A review of the *Bruguiera* mangrove taxa from Hawai'i shows only one (*B. sexangula*) to occur, the other two (*B. gymnorhiza* and *B. exaristata*) have been misidentified (Allen *et al.*, 2000). One new species of *Tetraplasandra* (*T. flynni* Lowry & Wood) from Kaua'i described and conservation status indicated (Lowry & Wood, 2000). Analysis of rDNA on the woody *Viola* species in Hawai'i show their origin to probably be Arctic (Ballard & Sytsma, 2000).

Porifera

The new species, *Tethya ornata*, was described from a floating dock at Coconut Island (Sara *et al.*, 2000).

Acanthocephala

New record, *Acanthocephalus bufonis* (Shiely), reported from the toad *Bufo marinus* (Barton & Pichelin, 1999).

Nematoda

The nematodes *Atractis scolopori* (Gedoelst) and *Atractis squamatae* Harwood are reported for the first time in Hawai'i as parasites of the introduced brown anole, *Anolis sagrei*; these

parasites most likely entered Hawai'i with introduced brown anoles (Goldberg & Bursey, 2000).

Platyhelminthes

The acoel flatworm subspecies *Notoscelis gullmarensis maculata* Karing, Mack-Fira & Dorjes raised to species level as *Notoscelis maculata* (Kozloff, 2000).

Rotifera

Two new species of rotifers, smaller varieties of the s-type, *Brachionus rotundiformis* and *Brachionus calyciflorus*, have been obtained for aquaculture (Tamaru, 2000).

Phoronida

Five *Phoronis* species are noted from Hawaiian waters, three have been previously reported, but two, *Phoronis muelleri* Selys-Longchamps, and *Phoronis pallida* Silen are new records (Bailey-Brock & Emig, 2000).

Annelida

The spionid polychaete *Boccardia proboscidea* Hartman, 1940, was reported as having been introduced to an oyster culture farm at Keāhole, Hawai'i, with a shipment of *Ostrea edulis* from Maine (Bailey-Brock, 2000). One new species of dorvilleid polychaete (*Ophyrotrocha adherens* Paavo, Bailey-Brock & Akesson) cultured in Sweden in 1971, known since 1993 from Māmala Bay and Barbers Point on O'ahu (Paavo *et al.*, 2000), associated with sewage outfalls.

Mollusca

The smooth shelled blue mussel, *Mytilus galloprovincialis* Lamarck, arrived in Pearl Harbor, O'ahu, Hawai'i on 22 June 1998, as a member of the fouling community of the USS *Missouri* and spawning activity was observed; small mussels were collected on 30 September 1998 in a submarine ballast tank in Pearl Harbor (Apte *et al.*, 2000). Two newly reported freshwater clams, *Musculium partumeium* (Say) and *Pisidium casertanum* (Poli) [Sphaeriidae] were reported from an ancient, continuously cultivated taro pond complex and are thought to have been initially introduced by the earliest Hawaiian settlers with moist taro stock (Burky *et al.*, 2000).

Arthropoda: Acari

Review of the Hawaiian raphignathoid family Camerobiidae with three new species: *Neophyllobius bisetalis* Bolland & Swift, *N. mamaneae* Bolland & Swift, *Tycherobius hawaiiensis* Bolland & Swift (Bolland & Swift, 2000).

Arthropoda: Insecta: Coleoptera

A monographic revision of Hawaiian carabid beetles of the genus *Blackburnia* includes one new subgenus (*Procaccus* Liebherr & Zimmerman), 33 new species, and 12 new synonymies (Liebherr & Zimmerman, 2000). The Hawaiian dermestid genus *Labrocerus* revised resulting in 3 new species (*L. auratus* Beal, *L. argyroxiphii* Beal, *L. producens* Beal), eight new synonymies, and *Argocerus depressus* Sharp now *Labrocerus depressus* (Sharp); *Argocerus similaris* Sharp now *L. similaris* (Sharp) (Beal, 2000).

Arthropoda: Insecta: Diptera

Two new dolichopodids; one *Sigmatineurum* from seeps on the Big Island (*S. englundii* Evenhuis) (Evenhuis, 2000b) and one *Campsicnemus* from leaf axils of a lobeloid (*C. gloriamontis* Evenhuis) from Pu'u Pukui, West Maui (Evenhuis, 2000a).

Arthropoda: Insecta: Heteroptera / Homoptera

A new genus and species of Miridae (*Asteliamiris johnpolhemusi* Schwartz & Polhemus) from Maui (Schwartz & Polhemus, 2000). Revision of the reduviid genus *Saicella* Usinger with descriptions of 4 new species (*S. kipahulu*, *S. lilinoe*, *S. mulli*, *S. perkinsi*) (Polhemus, 2000). A new genus of grass-feeding delphacids (*Emoloana* Asche) with two new species (*E. menehune* Asche and *E. pohakua* Asche), and transfer of 9 species-group taxa from *Kelisia* to *Emoloana* (Asche, 2000a). New name for the misidentified invasive introduced whitefly *Paraleyrodes naranjæ* = *Paraleyrodes pseudonaranjæ* Martn (Martin, 2000). The fulgorids *Syndelphax disonymus* (Kirkaldy), *Kallitaxila granulata* (Stål), and *Cedusa* sp. are new records (Asche, 2000b).

Arthropoda: Insecta: Hymenoptera

The fairyfly family Mymaridae was the subject of a number papers by the late John W. Beardsley. Key to genera of Mymaridae in Hawai'i and new records of species from the islands, *Acmopolynema bifasciatipennis* (Girault) misidentified, now *A. uma* Schauff; 7 undetermined spp. of *Alaptus* Westwood; *Anaphes calendrae* (Gahan); 3 undetermined species of *Camptoptera* Förster; *Chaetomymar bagicha* (Nayarayanan, Subba Rao & Kaur); *Cleruchus* sp.; *Dichopus ?psyche* Girault; *Erythmelus funicili* (Annecke & Doutt) plus 3 undetermined species of *Erythmelus*; *Mymar taprobanicum* Ward; *Ooctonus* sp.; *Schizophragma bicolor* (Dozier); *Stephanodes similis* (Förster) is a misidentification for *S. reduvioli* (Perkins); *Stethynium triclavatum* Enoch and one undetermined *Stethynium*; and one undescribed new genus (Beardsley & Huber, 2000). A review of the mymarid genus *Anagrus* Haliday from Hawai'i resulted in one new species (*A. oahuensis* Triapitsyn & Beardsley), two new synonyms [*Paranagrus osborni* Fullaway and *Anagrus panicolae* Sahid now *Anagrus optabilis* (Perkins)], and 3 new records for Hawai'i: *A. ?columbi*, *A. empoascae*, *A. takeyanus* (Triapitsyn & Beardsley, 2000). A new fairyfly genus *Kikiki* Huber & Beardsley and one new species (*K. huna* Huber) from Moloka'i (Huber & Beardsley, 2000b). Review of the genus *Gonatocerus* with *G. capitatus* Gahan, *G. pygmaeus* Girault plus 4 undetermined species as new records (Huber & Beardsley, 2000a).

The family Mymaromattidae is recorded as new from Hawai'i, represented by an undetermined species of *Palaeomymar* Meunier (Beardsley *et al.*, 2000). One new introduced fig wasp (*Josephiella microcarpae* Beardsley & Rasplus), probably originating from Asia (Beardsley & Rasplus, 2000). A eulophid wasp, *Aprostocetus* sp. from *Eucalyptus* galls is recorded as new (Beardsley & Perreira, 2000).

Arthropoda: Insecta: Isoptera

The Indomalaysian and Australian termite *Cryptotermes cynocephalus* Light is a new record and may indicate pest status (Scheffrahn *et al.*, 2000).

Arthropoda: Insecta: Orthoptera

Two new species of *Laupala* crickets (*L. makai* Shaw from O'ahu; *L. meleweki* Shaw from Kaua'i (Shaw, 2000).

Arthropoda: Pseudoscorpionida

The Chthonioidea of Hawaii are reviewed with one new genus, *Vulcanochthonius* Muchmore including *V. howarthi* (Muchmore) [transferred from *Tyrannochthonius*] plus two new species, *V. aa* Muchmore, *V. pohakuloae* Muchmore, new species *Tyrannochthonius oahuanus* Muchmore, and new records for the state *Chthonius tetrachelatus* (Preyssler) and *Lechytia sakagami* Morikawa (Muchmore, 2000).

Arthropoda: Crustacea: Decapoda

Edmondson (1946, p. 226) reported a "rhizocephalan" from the Hawaiian crab *Pachycheles pisoides* as a "Sacculina-like form"; Boschma (1953) suggested that it was "obviously a lernaediscid"; Boyko & Harvey (2000) examined several hundred *P. pisoides* from Bishop Museum and found three parasitized with a cryptoniscid isopod. New genus and new species of deep-sea benthopelagic calanoid copepod, *Griceus buskeyi* Ferrari & Markhaseva, described (Ferrari & Markhaseva, 2000a). New species, *Brachycalanus flemingeri* Ferrari and Markhaseva described from specimens collected off of Kona (Ferrari & Markhaseva, 2000b).

The caridean shrimp previously identified as *Lysmata paucidens* was newly reported as *Lysmata trisetacea* (Heller) by Wicksten (2000). In family Polychelidae, *Polycheles asper* Rathbun [now *Homeryon asper* (Rathbun)], *Polycheles granulatus* Faxon [now *Pentacheles laevis* Bate], *Polycheles synderi* Rathbun [now *Pentacheles synderi* (Rathbun)], *Polycheles phosphorus* Rathbun described as new species *Polycheles surdus* Galil (Galil, 2000). A new species, *Calappa pokipoki* Ng [family Calappidae] described (Ng, 2000). The biogeography of the 6 species of trapeziid crabs in the Hawaiian Islands is detailed (Castro, 1999). The systematics of the stomatopod formerly called *Gonodactylus aloha* is redefined as *Gonactylaceus mutatus* (Lanchester) (Barber & Erdmann, 2000). The interspecific fighting between the *Lybia edmonsoni*, a small xanthid crab, and the minute sea anemone (*Triactis producta*) in each of its claws is described (Karplus *et al.*, 2000). Schubart & Ng (2000) reevaluated the status of the plagusiid crabs, *Plagusia tuberculata* formerly reported from Hawai'i is synonymized under *P. squamosa* (Herbst). The Indo-Pacific palicid crabs have been revised by Castro (2000); *Manella spinipes* is now *Crossotonotus spinipes* (DeMan), *Palicus maculatus* and *Cymopolia medipacifica* are now *Exopalicus maculatus* (Edmondson), *Cymopolia fisheri* is now *Pseudopalicus investigatoris* (Alcock), *Palicus oahuensis* is now *Pseudopalicus oahuensis* (Rathbun).

Chordata: Pisces

Two new species described from Hawaiian waters: *Gymnothorax polypondylus* Bohlke & Randall and *Gymnothorax prismodon* Bohlke & Randall [Muraenidae] (Bohlke & Randall, 2000). The rare viper shark, *Trigonognathus kabeyai* Mochizuki and Ohe, 1990 was reported from the Hawaiian Islands (northwest of Kure Atoll) for the first time (Wetherbee & Kajiura, 2000). A new species, *Synchiropus hawaiiensis* Fricke, [Callionymidae] was described (Fricke, 2000).

Chordata: Amphibia

The acanthocephalan parasite, *Acanthocephalus bufonis*, reported from the toad *Bufo marinus* in Hawai'i for the first time (Barton & Pichelin, 1999).

Chordata: Reptilia

Eight helminth parasites are reported from the brown anole *Anolis sagrei* (Polychrotidae); two, *Atractis scelopori* and *Atractis squamatae*, were previously unknown in Hawai'i.

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Part 1: Articles

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