Alien Invertebrates

Introduced invertebrates can affect the composition and structure of vegetation directly and indirectly. Invertebrates can feed directly on plants or plant propagules and prey on pollinators of plant species. They also carry diseases that infect native plants and invertebrates; they may support higher levels of alien predators, which in turn deplete native invertebrates more effectively than would otherwise be possible; and they may hybridize with native forms (Howarth 1985).

Alien insects feed directly on endemic plants, sometimes doing extensive damage (Howarth 1985). Defoliation of māmāne (Sophora chrysophylla) by the moth Uresiphita polygonalis and the depredations of the plant louse Psylla uncatoides on koa (Acacia koa) can seriously disturb the stands involved. Many introduced invertebrates combine in lowland habitats to inhibit koa regeneration. Generalists such as aphids, whiteflies, scale insects, and termites may reduce the geographic ranges of some plant species, and rare plants may be especially jeopardized (Howarth 1985). The black twig borer (Xylosandrus compactus) and the associated fungus Fusarium solani affect 108 plant species in Hawai'i, some of them rare (Howarth 1985). Sohmer (1976) reported that the black twig borer completely destroyed all pāpala (Charpentiera obovata and C. tomentosa) shrubs and trees in Kalua'a Gulch, O'ahu, within a period of just six years. These two plants had formerly been abundant in the gulch. The introduced Australian fern weevil Syagrius fulvitarus killed the endemic fern Sadleria cyatheoides over large areas on O'ahu and Hawai'i Island until introduction of a braconid parasite (Doryctes syagrii) in the 1920s (Pemberton 1964).

Perhaps a thousand species of Hawaiian insects visit flowers and are potential pollinators, including yellow-faced bees (Hylaeaus spp.), moths, flies, beetles, and wasps. Native tephritid flies, possibly threatened by a planned eradication program for alien tephritids (e.g., medflies, Ceratitis capitata), need investigation (L.L. Loope, pers. comm.). The European honey bee, Apis mellifera, with a social foraging strategy unknown in native Hawaiian pollinators, may have reduced outcrossing of some native plants and increased outcrossing in others. Introduced carpenter bees (Xylocopa sonorina) and big-headed ants (Pheidole megacephala) are known to rob nectar from plants, reducing the chances of pollination and visits by native pollinators (Howarth 1985).

Perkins (1913) noted the devastating effect of the big-headed ant on nearly all endemic insects in plant communities below about 610 m (2,000 ft) elevation where ants were abundant. He described the dramatic boundaries between areas occupied by this species and ant-free areas, especially with regard to native beetle populations. Gagné (1979) stated that at elevations above about 760 m (2,500 ft), spiders and true bugs predominated on Hawai'i Island transects, whereas below this, the arthropod biomass is lower and comprised mostly of ants; at sea level, large roaches and their parasites were abundant. Unfortunately, big-headed ants extirpated many lowland arthropods before any detailed knowledge of the fauna was obtained (Zimmerman 1978). Since big-headed ants are active throughout the night and day and reach extremely high densities, a wide range of lowland pollinating insects has likely been reduced or eliminated during vulnerable life stages or rest periods.

The long-legged ant (Anoplolepis longipes) was introduced to Hawai'i in 1952. It currently dominates lowland areas on windward Hawai'i Island and is found up to
1,190 m (3,900 ft) in elevation in thermal areas (C. Jorgensen and H. Black, pers. comm. 1989). These ants reach extremely dense populations in some areas, are often found in trees, and seem to eat a variety of foods. They undoubtedly affect populations of arthropod pollinators of native plants that still remain in lowland areas.

The Argentine ant (*Iridomyrmex humilis*) was introduced to Hawai‘i in 1940 (Zimmerman 1941). It may be the only aggressive upland ant in Hawai‘i and has been found to greatly reduce many kinds of ground-dwelling arthropods in Haleakalā National Park at elevations above 1,980 m (6,500 ft) (Cole et al. 1986c). Invertebrates impacted include native species of *Nesoprosopis* bee, a known pollinator of native plants, and a number of endemic moths, bees, and flies that may pollinate the Haleakalā silversword, *Argyroxyphium sandwicense* subsp. *macrocephalum*, a species that requires cross pollination for seed set (Carr et al. 1986). Powell (1984) suggested that loss of native pollinators may be responsible for low seed set of the endangered Mauna Kea silversword (*Argyroxyphium sandwicense* subsp. *sandwicense*).

Ground-nesting yellowjackets (*Vespula pensylvanica*) became established in Hawai‘i in the late 1970s (Nakahara 1980) and are known to prey on many kinds of insects. They range as high as 2,740 m (9,000 ft) elevation. Large wasp colonies may capture and consume prey items at a rate of 10,000 per day for as long as six months; in natural areas, many prey species are native invertebrates (P.V. Gambino, pers. comm.). In native high-elevation shrublands of East Maui, endemic arthropods were prominent prey taken from yellowjacket workers returning to their nests (Gambino et al. 1987). Howarth (1985) noted sharp declines in several native arthropods at the same time as yellowjacket populations were increasing in Hawai‘i. Picture-wing flies in the family Drosophilidae are among those probably affected (Carson 1982). Many species of *Drosophila*, like many of the Hawaiian honeycreepers (Drepanidinae), evolved in association with endemic rain forest plants in the family Lobeliaceae (Kaneshiro and Boake 1987).

A number of generalized species of tachinid flies and ichneumonid and braconid wasp parasitoids attack various species of Lepidoptera and other insects. Wide host selection is characteristic of some parasitoids found in both Hawaii Volcanoes and Haleakalā National Parks (Stone and Loope 1987). Zimmerman (1958) believed that the introduction of various parasites to control moths of economic importance and the accidental importation of other parasites exterminated countless moth species. The ichneumonid wasp *Pristomeris hawaiensis* parasitizes 26 microlepidopterans plus other small moths, while the ichneumonid wasp *Trathala flavo-orbitalis* has a host list of more than 30 microlepidopterans and pyralids (Zimmerman 1978). In 1958, Zimmerman wrote: "It is now impossible to see the Hawaiian Lepidoptera in the natural proliferation of species and individuals of Perkins’ day. Many are forever lost." Surely, many more have also disappeared in the last 30 years.

Alien invertebrates can also transmit plant diseases. One example is the alien koa psyllid *Psylla uncatoides*, which was found to transmit native koa rusts (Leeper and Beardsley 1977). Alien aphids, leafhoppers, true bugs, and mites belong to groups that are efficient vectors (Howarth 1985). Mutualistic arrangements can also be detrimental to Hawaiian vegetation. For example, alien ants tend alien homopterans for honeydew. Some of these homopterans are important consumers of native plants and require ants to protect and disperse them. Ants, in turn, might not survive or increase in numbers and distribution without food produced from these plant-sucking insects (Howarth 1985). Honeydew produced by the native mealybug *Pseudococcus nudus* on pūkiawe (*Styphelia*...
tameiameiae) attracts and may provide an important carbohydrate source for yellow-jackets, which primarily feed on insects including native pollinators (Gambino et al. 1987).

Large numbers of alien invertebrates such as earthworms, ants, slugs, isopods, millipedes, and snails can cause "significant changes in the nutrient cycling process even if their direct impacts are obscure" (Howarth 1985). Changes in composition and structure of plant communities can result. Hybridization of aliens with close native relatives, can result in eventual extinction of species endemic to Hawai‘i (Wells et al. 1983).

Alien Plants

Of all the disruptive forces present today in the Hawaiian Islands, feral ungulates and invasive alien plants are the two most serious threats to natural areas that have so far escaped destruction by development, agriculture, or grazing. The native flora of the Hawaiian Islands is comprised of nearly 1,000 species, 89% of them endemic (Wagner et al., in press). By contrast, nonnative plants, introduced into the Hawaiian Islands either accidentally or intentionally for human use, number approximately 4,600 (St. John 1973). More than 800 alien plant species have become naturalized (i.e., reproducing and establishing themselves without human assistance), amounting to 47% of Hawai‘i’s flowering plant flora (Wagner et al., in press). Of these naturalized aliens, Smith (1985) recognized 86 as serious problems in native ecosystems. He suggested that 28 of these plant pests were capable of invading undisturbed native systems.

Alien plant introductions to Hawai‘i began with the arrival of the Polynesians, who brought with them about 32 species (Nagata 1985). Most of these were cultivars, and less than 25 types escaped cultivation and became naturalized (Smith 1985). Some have had such a long history in the Hawaiian Islands and have become so much a part of lowland forests that they were considered native by many earlier writers. These include kukui (Aleurites moluccana), mountain apple or ‘ōhi‘a ‘ai (Syzygium malaccense), and wild yam (Dioscorea pentaphylla) (Handy and Handy 1972). A few additional species previously thought to be either indigenous or later European introductions may actually be accidental Polynesian introductions (St. John 1978; Wester, in press).

With the arrival of Capt. Cook in 1778 and the subsequent influx of ships from Europe and North America, plant introductions accelerated. The first recorded western introductions into Hawai‘i were pumpkins, melons, and onions (Cucurbita pepo, Cucumis melo, Allium cepa), planted during Cook’s visit. In the 60 years following Cook’s voyage, at least 111 nonnative plant species were introduced (Nagata 1985). These were primarily fruit trees, vegetables, and ornamentals, many of which remained in cultivation and did not become naturalized. Notable exceptions are guava (Psidium guajava), strawberry guava (P. cattleianum), and koa haole (Leucaena leucocephala), which became major invaders of lowland ecosystems. Most of the alien plant species threatening the integrity of native systems today are introductions of the 20th century. Wester (in press) noted that the rate of plant introduction increased sharply at the end of the 19th century, and about five species per year have naturalized during the 20th century.