

DISTRIBUTION OF ANTS AND THEIR EFFECTS ON ENDEMIC BIOTA OF HALEAKALA AND HAWAII VOLCANOES NATIONAL PARKS: A PRELIMINARY ASSESSMENT

Arthur C. Medeiros, Lloyd L. Loope, and F. Russell Cole

Box 369  
Haleakala National Park  
Makawao, Maui, Hawaii 96768

and

Department of Biology  
Colby College  
Waterville, Maine 04901

INTRODUCTION

Ants (Hymenoptera: Formicidae) are among the most numerous and ubiquitous of terrestrial macroscopic organisms (Wilson 1985). Their advanced social biology and complex use of pheromones in communication and cooperative behavior have made them among the most important of arthropod predators (Brian 1983). Arthropod faunas exposed to ant predation have generally evolved adaptations toward avoidance of or coexistence with ants. "Strategies" allowing coexistence usually involve defense or appeasement mechanisms, such as heavy sclerotization or the production of noxious or sugary exudates.

The Hawaiian Islands apparently lack endemic ant species, although about 40 species have been inadvertently introduced in the past two centuries (Huddleston and Fluker 1968). Four species - Amblyopone zwaluwenburgi, Ponera swezeyi, Hypoponera opaciceps, and Hypoponera zwaluwenburgi - have somewhat unclear histories, and some of these may be native. These ants form only small colonies and, if native, do not appear to have played an important role in the evolution of the endemic insect fauna. Not surprisingly, the Hawaiian arthropod fauna has proved highly vulnerable to introduced ants. This paper 1) reviews literature and our observations on the status of ants in Haleakala and Hawaii Volcanoes National Parks, 2) reports on a reconnaissance survey of ant distribution in Hawaii Volcanoes National Park (Appendix I), 3) reviews preliminary results of our ongoing investigation of the effects of Argentine ants on the arthropod biota of Haleakala's high-elevation shrubland, and 4) provides recommendations regarding the "ant problem" to resource managers of both parks.

STATUS OF ANTS IN HALEAKALA AND HAWAII VOLCANOES

It is unknown when the first species of alien ants became established in the Hawaiian Islands. Because many of the ant species in Hawaii are also found throughout the Pacific Basin (Wilson and Taylor 1967), there is a strong possibility that some of the ants may have been introduced by Polynesian colonizers as early as the 4th century A.D. It is likely that many of the continental species of ants began arriving here with sailing vessels by the early 1800's. The distribution and subsequent impact of alien ants in the Hawaiian Islands has generally been confined to low to mid-elevation xeric and mesic sites, usually at elevations below 1200m. However, one very aggressive

ant species (Iridomyrmex humilis) is now established in high-elevation subalpine shrubland of Maui and Hawaii while another (Anoplolepis longipes) occupies windward riparian systems. Both these systems had previously lacked significant ant predation.

Twelve species of ants have been recorded within Haleakala (HALE) and/or Hawaii Volcanoes (HAVO) National Parks from sea level to as high as 2830m elevation (near the summit of Haleakala). Six species are somewhat common; of these, 3 are currently considered to represent a potential threat to the native fauna. Interestingly, the 3 species of problem ants in the Hawaiian Islands have worldwide reputations as among the most invasive and destructive of ant species.

### Potentially Threatening Species

#### Pheidole megacephala (Fabricius) (big-headed ant)

The damaging impact of one ant species in Hawaii has long been recognized. The elimination of the lowland native fauna by Pheidole megacephala was documented by the British biologist R.C.L. Perkins, who noted (1913) of Pheidole: "It is practically useless to collect where it is established.. Native beetles and many other insects are absent from the localities occupied by Pheidole, solely on account of its presence." Perkins reported this species as abundant up to 900m and present up to 1200m. He noted that "in some places on the coast there are localities so dry and hot that Pheidole cannot occupy them permanently, and here a remnant of the lowland fauna persists, unsuitable as are the conditions for insects in general." The first record of Pheidole megacephala in the Hawaiian Islands in the literature is in Blackburn and Cameron (1886).

O.H. Swezey recorded this ant at Napau Crater in HAVO in 1934 and at Volcano House in 1947 (C. Davis, pers. comm.). Gagné (1979) recorded it within HAVO at elevations of 15m and 760m during sampling of the arthropod fauna of Metrosideros canopies. We found it in HAVO in March 1986 at elevations from sea level to 1220m. In March-April 1986, we recorded Pheidole megacephala near the coast and in pastures of Haleakala's Kipahulu District and at 1250m in western Kaupo Gap.

#### Iridomyrmex humilis (Mayr) (Argentine ant)

The Argentine ant (Iridomyrmex humilis) is an invasive species native to Argentina and Brazil that has become widely naturalized throughout the northern and southern temperate zones and at higher elevations in the tropics (Fluker and Beardsley 1970). This highly aggressive species is considered one of the world's worst pest ants and has displaced native ants and/or previously established introduced ants in many parts of the world (e.g., Newell 1908, Erickson 1971, Lieberburg et al. 1975, Bond and Slingsby 1984). It established in Louisiana before 1891, apparently transported to the U.S. on freighters with shipments of fruit from Brazil. From there, the Argentine ant spread throughout the southern United States, reaching California by 1908.

During the 1930's, this species was frequently intercepted in Honolulu in goods shipped from California. Establishment was first recorded in the Ft. Shafter area of Honolulu in 1940 (Zimmermann 1941). It reached the island of Maui at Makawao by 1950 (Wilson and Taylor 1967), the island of Hawaii at

Kamuela by 1950 (Wilson and Taylor 1967), and Hawaii Volcanoes and Haleakala National Parks by 1967 (Huddleston and Fluker 1968).

The potential for severe damage to the rich endemic arthropod biota of upper Haleakala by the Argentine ant has been noted by local entomologists (Beardsley 1980, Howarth 1985; Gagné, pers. comm.). Beardsley (1980) noted: "The Argentine ant is likely to have a profound effect upon the native biota, particularly insects and other terrestrial arthropods, in those areas where it becomes permanently established. ..Insects such as the many precinctive, flightless endemic forms which occur on Haleakala are particularly vulnerable to ant predation. These endemic species evolved in an environment completely devoid of ants and thus have never developed the means to cope with ant predation."

At Haleakala, Argentine ants are established in two slowly expanding populations on the west slope at elevations of 2000-2260m and at 2740-2830m (Fellers and Fellers 1982, Medeiros and Loope unpubl.). The total area currently invaded is about 184ha (with individual populations covering 172ha and 12ha), about 1.5% of Haleakala National Park.

At Hawaii Volcanoes, Gagné (1979, 1981) sampled arthropods of the forest canopy of Metrosideros polymorpha stands (5 sites) at 1195-2440m and Acacia koa stands (3 sites) at 1280-2040m in 1971-73 by fogging portions of the canopy with pyrethrum and collecting arthropods underneath on cloth sheets. Argentine ants were present at all sites and were abundant in the canopies of both Metrosideros and Acacia. In this case, ground-nesting Argentine ants occurred in the canopy with 158 other arthropod species, primarily native species.

Our March 1986 survey encountered Argentine ants from the Kipuka Nene area at 970m to the Kipuka Puauulu area at 1220m. [Argentine ants were, however, seen on the Mauna Loa Strip Road at 1430m by J.W. Beardsley (pers.comm.) in June 1986.] The largest populations encountered were in the Kipuka Nene area with heavy infestations of the shelter, trash cans, and surrounding area. Other apparently smaller populations were observed in and around the research dorm area, Kipuka Puauulu parking lot, Kilauea Military Camp, and Namakani Paio campground. Argentine ants were not detected in our survey at sites on the Mauna Loa Strip Road at 1480m, 1780m, and 2010m. The latter site, especially, closely resembles the habitat in the Hosmer Grove-Headquarters area of HALE where these ants are abundant.

#### Anoplolepis longipes Jerdon (long-legged ant)

The long-legged ant, originally native to Africa, is widespread in the Old World tropics and dominant in disturbed areas of Micronesia and Melanesia (Wilson and Taylor 1967). It was first reported from the Hawaiian Islands in 1952 from Barbers Point on Oahu and was first collected on Hawaii in Kona in 1954. It first appeared in eastern East Maui in the 1970's and has since become extremely abundant and locally dominant on much of the leeward coast from Hana to Kihei, especially in the moist lowlands and upslope along streams. Hardy (1979) was the first to note the effect of Anoplolepis on formerly common native insects of riparian habitats of the lower Kipahulu District of HALE. Beardsley (1980) noted that this species poses a threat similar to the Argentine ant in decimation of the endemic insect fauna. One particularly noteworthy species in the riparian fauna is Megalagrion

pacificum. Once common, this endemic lowland damselfly is now extremely depleted in the islands (Moore and Gagné 1982). The pristine undiverted streams of eastern East Maui represent one of the last chances this insect has for continued survival.

A. longipes was first collected within HAVO in 1982, by L. Katahira at Wahaula (C. Davis, pers. comm.). In our March 1986 survey, this ant was abundant at Wahaula Visitor Center near sea level but seemingly absent at the nearby Kamoamoa campground where Pheidole was present. An apparent young founder colony of Anoplolepis was found along the main park highway at 365m elevation. A solitary worker of this species was discovered beneath a trash can at Namakani Paio campground at ca. 1200m.

In April 1986, we observed aggregations (hundreds of individuals in dense clusters) of Anoplolepis on rocks at the water's edge in Oheo Stream of HALE. This ant locally reaches an elevation of 500m or more in HALE's Kipahulu District and may have potential to extend much higher along streams.

#### Other Common Ant Species

##### Hypoponera opaciceps (Mayr)

This ant was described in Fauna Hawaiensis as Ponera perkinsi, an endemic Hawaiian species. Perkins (1913) notes it as being found, "in the mountains of all the islands, generally from 2000 to 4000 ft [610-1220m]." Wilson and Taylor (1967) changed this taxon to synonymy with the widespread tropical species, Hypoponera opaciceps, a New World native (southern U.S. to Uruguay).

Hypoponera was characterized by Fellers and Fellers (1982) as widespread but not abundant throughout the Crater District, occurring in all habitats from very wet (notch above Paliku) to dry (cinder cones of central Haleakala Crater). Fellers and Fellers (1982) suggested that H. opaciceps, though predacious, does not form large colonies and may not adversely affect the native arthropod fauna. They also suggested that the Argentine ant may be locally displacing this species at Haleakala.

Our observations agree with those of Fellers and Fellers. At HALE, we have recorded H. opaciceps as low as 200m (Waimoku Falls trail) and as high as 2800m (Kalahaku).

Hypoponera was found in our March 1986 survey in HAVO irregularly and in low numbers from Kipuka Nene at ca. 970m up to 1780m elevation on the Mauna Loa Strip Road. It was recorded by Swezey as Ponera perkinsi in the Napau Crater area in 1934 (C. Davis, pers. comm.).

##### Cardiocondyla emeryi

Cardiocondyla emeryi, native to Africa, probably established in the Hawaiian Islands in the 1930's (Wilson and Taylor 1967). It now occurs on most of the islands, primarily in leeward areas at low elevations (Huddleston and Fluker 1968). Fellers and Fellers (1982) first reported this species at 1830-1890m in upper eastern Kaupo Gap of HALE. It is present in the eastern crater, probably as a result of range expansion from populations in lower Kaupo gap. Though colonies of this species were reported as sparsely distributed, they were also noted as quite vigorous, with much reproduction. The distribution

and status of this species within Haleakala is still uncertain.

Cardiocondyla was found regularly in HAVO in dry rocky areas at 610-1780m elevation during our March 1986 survey. This species was often found under the same rock as a larger ant species, such as Paratrechina sp. Swezey had earlier recorded this species in the Napau crater area in 1934 (C. Davis, pers. comm.)

#### Paratrechina sp.

Our March 1986 survey at HAVO recorded a Paratrechina sp. at three sites in shrubland at 1160-1220m. We tentatively refer it to Paratrechina bourbonica, (Forel) since that species has been previously recorded at HAVO. Perkins (1899) recorded P. bourbonica from the coast to 120m elevation on Oahu, Molokai and Hawaii. C. Davis (pers. comm.) has records of this species from the following HAVO sites: Napau crater area (1934), Byrons Ledge (1934), and Kipuka Nene (1945). The IBP project found this species associated with the flowers of Metrosideros polymorpha at IBP site no.4 (Tree Molds area) at 1280m elevation (Mueller-Dombois et al. 1981).

#### Additional Recorded Ant Species

The remainder of the species listed here have not been encountered by us in either HALE or HAVO but have been recorded by others.

#### Cardiocondyla nuda (Mayr) and Cardiocondyla wroughtoni (Forel)

Huddleston and Fluker (1968) recorded both these species in HAVO. The morphological differences between them and C. emeryi are subtle. All Cardiocondyla specimens examined from our HAVO survey seemed to fit reasonably into C. emeryi. At any rate, the matter is a taxonomic problem and is probably of little concern for Park management.

#### Monomorium pharaonis (Linne)

C. Davis (pers. comm.) has a record of this species from "Kilauea" in HAVO.

#### Plagiolepis alluaudi Forel

This species was reported as present in sampling of Metrosideros canopies at sites of 15m and 760m elevation within HAVO (Gagné 1979).

#### Plagiolepis exigua Forel

This species was reported by Huddleston and Fluker (1968) as present in the Kipuka Puaulu area of HAVO in 1967.

#### Technomyrmex albipes (Fr. Smith)

C. Davis (pers. comm.) has a record of this species from Kipuka Ki of HAVO in 1944. Gagné (1980) recorded it as present in the lower Kipahulu district of HALE up to 500m.

## PRELIMINARY RESULTS OF INVESTIGATIONS OF THE EFFECTS OF ARGENTINE ANTS ON FAUNA OF HALEAKALA'S HIGH-ELEVATION SHRUBLAND

Argentine ants (*Iridomyrmex humilis*) have occupied the Park Headquarters-Hosmer Grove area of HALE (2070-2140m) for about 20 years. Another disjunct population at Kalahaku (ca. 2800m) was first noted in 1982. In order to determine what effects these ants may be having on the native ground-dwelling, arthropod fauna we chose two study areas at 2100m and 2800m, each with comparable paired adjacent sites (only several hundred meters apart), one with and one without ants. The lower elevation sites both had shrubland vegetation dominated by the native shrubs *Styphelia tameiameia*, *Vaccinium reticulatum*, *Sophora chrysophylla*, and *Coprosma montana*, with an understory dominated by the introduced grasses *Holcus lanatus* and *Anthoxanthum odoratum*. The upper elevation sites had sparse vegetation characterized by Whiteaker (1983) as "high-altitude desert." Total vegetation cover was no more than 10-15% in either area, with *Styphelia tameiameia* the dominant shrub. Grasses and herbs were primarily native and included *Deschampsia australis*, *Trisetum glomeratum*, *Agrostis sandwicensis*, and *Tetramalopium humile*. Substrate characteristics were similar within each pair of sites.

### Methods

Each pair of study sites included an area of at least several hectares with Argentine ants and an area of comparable size and habitat where Argentine ants were believed to be entirely absent. Both pitfall trapping and under-rock surveys were carried out within each pair of sites.

Pitfall traps (Greenslade 1964; Greenslade and Greenslade 1971), designated "large" (specimen jars, 9cm deep, 8cm in diameter) and "small" (baby-food jars, 6cm deep, 5cm in diameter), were partially filled with an anti-freeze solution (ca. 50% anti-freeze, 50% water) to preserve trapped organisms. A few drops of soap were added to each jar to reduce surface tension. At each of the four sites, traps were placed in two parallel transects, with each transect consisting of 3 large jars and 7 small jars. Along each transect, jars were placed 3-5m apart. Traps were buried flush with the soil surface; installation was made with as little disturbance to the surrounding surface (soil and litter) as possible. During placement, traps were baited with a finely blended mixture of canned sardines and salted sigamid (fish) spread around the inner lip of the jars. Each trap was sheltered from sun and rain by a large rock propped up on a small rock. Bait was replaced after the first week if dessication reduced its aroma. Traps were left in the field for 2 weeks, at the end of which time they were removed and taken to the laboratory for sorting and taxonomic determinations. Trapping was conducted three times at each pair of sites in April-May 1985, late-August 1985, and March 1986.

Invertebrates foraging primarily at night are attracted to the bait and fall into the preservative fluid. Specimens from each jar and each site were sorted into groups of major taxa and within the major taxa into similar-looking forms, "morphospecies," and counted. The chi-square test, using Yates' correction, was used to determine whether values for ant and non-ant areas differed significantly for individual taxa at particular sites. We are now in the process of obtaining identifications of morphospecies from specialists.

Under-rock surveys were carried out with a view toward obtaining complementary

data through a second method. Methods evolved from methods used by Fellers and Fellers (1982) and Medeiros and Loope (1986) for surveying Argentine ant populations. Rocks of specified characteristics (no smaller than 10cm X 15cm and firmly in contact with the soil) were scored for the presence of invertebrate "morphotaxa." Surveys were carried out in August 1985 and January-February 1986. Specimens of common and/or easily identified organisms were collected as vouchers for later identification. All organisms not readily identified were collected and later sorted for identification.

### Results and Discussion

The invertebrates from pitfall traps have been only partially sorted, many morphospecies have been only tentatively assigned to family or genus, and the data are not fully analyzed. The under-rock survey data are complete. In the interest of promptly addressing management concerns, we feel that the data produced so far are sufficiently conclusive to warrant a preliminary presentation.

The 2 techniques proved to complement each other in documenting ant impacts. Pitfall trapping (PT) yielded a broad size range of organisms and sampled over 130 invertebrate taxa. Under-rock surveys (URS) yielded sampling of far fewer taxa and only larger ones, but yielded some taxa unlikely to be caught in pitfall traps. Organisms can be classed in 3 groups based on effects of Argentine ants on their populations: those negatively affected, those positively affected, and those not seemingly affected.

#### Organisms negatively affected by the presence of Argentine ants

Organisms most negatively impacted by Argentine ants (\* indicates an alien) include the following (P < .001 that observed differences in PT data result from chance alone):

Large Lepidopteran larvae (Noctuidae; tentatively, an endemic Agrotis sp. or Peridroma sp.): The most dramatic contrast was found for PT data at the 2800m site for March 1986: 394 larvae in 20 traps (range of 11-40/trap) in non-ant area vs. 4 (1/trap in each of 4 traps) in 20 traps in ant area. Similar, but less striking, results were obtained with PT at the same site in April 1985 as well as in the January 1986 URS data. These large (length to ca.20mm) caterpillars seem to comprise a large portion of the animal biomass produced on upper Haleakala. They burrow in the ground during the day and feed on Styphelia at night. A similar, also abundant, taxon found in other areas near Haleakala's summit feeds on Dubautia menziesii. In summer months, adult noctuids (probable pollinators of native plants) are often seen diurnally in these same habitats and probably represent the adult forms of these taxa. We are planning future work on details of the life histories of noctuid moths of upper Haleakala.

Nesoprosopis sp. or spp., larvae: Destruction by ants of nests of this endemic, ground-dwelling bee was strongly suggested by January 1986 URS data for 2070m which showed 14 nests (4.7% of 322 turned rocks) in the ant-free area vs. 0 (of 322 turned rocks) in the area with ants. Nesoprosopis was rarely encountered in PT data. The genus Nesoprosopis comprises one of the more important pollination vectors in the Hawaiian Islands. We are planning future work on details of the life histories of and ant impacts on

Nesoprosopis of Haleakala.

Carabid beetles: URS data suggested dramatic effects of ants on carabids. Adults of Mauna frigida, the only species of a genus endemic to upper Haleakala, were encountered under 8 of 322 rocks in the non-ant area and under 0 of 322 rocks in the ant area at 2800m in January 1986. Adults of the endemic Mecyclothorax robustus were found under 6 of 300 rocks in the non-ant area vs. 0 of 300 in the ant area at 2070m in January 1986. PT data for 2070m in May 1985 yielded 330 (non-ant area) vs. 182 (ant area) carabids (all Mecyclothorax robustus) from 20 traps.

Spiders: 15 morphospecies were encountered, many in very low numbers. At least 3 morphospecies of small spiders show strong indications of being reduced by ants. One morphospecies had 38 individuals in the non-ant area vs. 0 in the ant area in lower elevation PT in May 1985.

\*Dermaptera (earwigs): In PT in May 1985 at 2070m, an earwig morphospecies (cf. \*Forficula auricularia) yielded 969 specimens in the non-ant area vs. 14 in the ant area. Earwigs were severely impacted by ants even though females defend their eggs laid on the ground and immature progeny.

Other organisms strongly suggested by the data to be negatively impacted by Argentine ants, include the following ( $P < .001$ ):

Diptera (Drosophilidae: Scaptomyza spp. A & C)  
Diptera (Phoridae I)  
Collembola Type #3 (suborder Symphypleona)  
Other ants (Hypoponera opaciceps)  
Hemiptera; Lygaeidae - immature Nysius  
Smaller Hymenoptera adults

Organisms positively affected by the presence of Argentine ants

Organisms apparently favored by the presence of Argentine ants (all aliens) include the following heavily sclerotized types ( $P < .001$ ):

\*Isopods (\*Porcellio laevis, "sowbugs"): In PT in May 1985 at 2070m, there were 640 specimens in traps from the non-ant area vs. 4736 in the ant area. Reasons why these abundant detritivores have higher numbers in the presence of ants are not apparent to us. Release from competition (with \*earwigs?) is a possibility. In contrast to the vulnerability of earwigs to ant predation, sclerotization and the trait of female sowbugs of carrying eggs and immatures with them apparently affords excellent protection for sowbugs.

\*Millipedes (Dimerogonus sp.): In PT in May 1985 at 2070m, there were 237 specimens in traps from the non-ant area vs. 520 in the ant area.

Others: Collembola Types #1 & #2, centipede



## Organisms not appreciably affected by the presence of Argentine ants

Many organisms may not be significantly affected by the presence of Argentine ants. These include the following (\* indicates aliens):

Lycosid spiders  
Coleoptera: \*Dermestidae  
Lepidoptera: some small larvae  
Homoptera: Delphacidae  
Diptera: Sciaridae  
Orthoptera: \*Metioche sp.  
\*Slugs (\*Milax gigates and others)  
\*Garlic snails (\*Oxychilus alliaris)

## Possible ecosystem-level effects of Argentine ants

Preliminary findings from our investigations of Argentine ant impacts in shrubland of upper Haleakala strongly suggest that certain organisms, including major pollinators of native shrubs and herbaceous plants, may be severely affected. If these ants were to become established throughout much of Haleakala's western slope and crater (habitat seemingly within the environmental range of the sites already occupied by ants), we can predict with some confidence that pollinators would be reduced and possibly eliminated in the long-run. Consequently, seed set would be reduced for species that depend on insects for cross-pollination. Bierzychudek (1981) and others have shown that low abundance of pollinators is frequently a limiting factor for seed set in natural plant populations. Carr et al. (1986) have shown that the Haleakala silversword (Argyroxiphium sandwicense) and its close relative Dubautia menziesii require cross pollination for seed set. Both these endemic species reproduce only by seed and would decline rapidly if seed set were greatly reduced.

## CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Three introduced ant species (Iridomyrmex humilis, Anoplolepis longipes, and Pheidole megacephala) have the potential for seriously depleting endemic arthropod faunas, including essential pollinators, of Hawaii Volcanoes and Haleakala National Parks. Our data presented above illustrate that the effects of the Argentine ant (Iridomyrmex humilis) on upper Haleakala (to be published elsewhere in more detail when identifications of morphospecies have been obtained) are significant, but localized, now and could become catastrophic if the ants greatly extend their range. Not only locally endemic arthropods, but also pollinator-dependent endemic plant species may be reduced or extirpated.

The lands below 1200m within Hawaii Volcanoes National Park were probably invaded by the big-headed ant (Pheidole megacephala) by the late 1800's. Native insect species of the orders Lepidoptera, Coleoptera, Neuroptera, Hymenoptera and Orthoptera were likely affected, some undoubtedly severely. The relatively new invasion of Anoplolepis longipes in the lowlands of the Park is perhaps not as devastating as it would be in a pristine area or one with riparian habitats. At HAVO there is the potential for impact of upper elevation shrubland and mesic forests by Argentine ants, but the status of this ant at HAVO needs further investigation. The urgency of the problem at

HAVO seems less than at HALE.

Until the 1950's, most of Haleakala National Park was free of any aggressive ant species. Currently, the two greatest threats by alien ants at HALE are: 1) the impact on native arthropod fauna of high-elevation shrubland by Iridomyrmex humilis, and 2) the impact on native arthropod fauna of riparian habitats and lower elevation rainforest by Anopolepis longipes.

Preventing ant establishment in an area may be easier than eliminating established populations of ants. Since biological control of ants is unlikely to succeed, the use of toxicants must be evaluated as a method of ant control. Such a toxicant should be reasonably selective in affecting only ants and should break down quickly in the environment to avoid damaging the native invertebrate fauna we are trying to protect. The application of toxicants into natural environments for ant control for conservation purposes has not to our knowledge been attempted and probably would not be considered except in the special case of the Argentine ant in high-elevation Hawaiian ecosystems.

Several factors make the Argentine ant a good target for toxicant control:

1) The queens of the Argentine ant bear wings only ephemerally and do not undergo nuptial flights. Rather these queens mate in the nest and either disperse by walking a short distance away or add to the multiple-queened condition of vigorous Argentine ant nests. This life-history trait produces individuals that are genetically closely related and form continuous populations that spread from their edges outward. This is in distinct contrast to ant species with flighted queens that may form scattered, discontinuous populations. The continuous population patterns of the Argentine ant as well as their relatively slow rate of spread appear to make this species well suited for control with a toxicant.

2) Argentine ants like many social Hymenoptera pass regurgitated food liquids among colony members, a process termed stomodeal trophallaxis. The rate of trophallaxis between ants increases as the relative value of the food increases, such that highly attractive baits will often be passed quickly throughout the nest. The combination of a highly attractive bait with a slow working toxicant may be passed effectively from foraging workers to other colony members including queens.

3) Argentine ants often form colonies of extremely large numbers of individuals that come to dominate their environs and usurp other ground-dwelling arthropods. These ants are highly active and sensitive to disturbance. They respond in large numbers to introduced baits. In areas of such high ant densities, the selective use of toxicants combined with baits is likely to have maximum impact on populations of Argentine ants.

Specific recommendations for HALE:

1) Attempt experimental control of the Kalahaku (2800m) population of Argentine ants using AMDRO or other insecticides.

2) Establish and enforce rules for visual examinations of Park materials prior to their transport into the backcountry with the intention of preventing the establishment of Argentine ants within Haleakala Crater. Become prepared to

eradicate any newly established disjunct population using AMDRO or other insecticides.

3) Monitor existing populations of Argentine ants on Haleakala's west slope while testing effectiveness of toxicant use on the Kalahaku population, with a view toward developing a long-term management strategy.

4) Monitor Anoplolepis longipes populations in lower Kipahulu Valley with a view toward developing a management strategy.

#### Specific recommendations for HAVO:

1) Monitor existing upper elevation populations of Argentine ants keeping in mind the potential of eventually using chemical control techniques pending results of pesticide use on the Kalahaku population of HALE.

2) Monitor upper elevation sites yearly along the Mauna Loa Strip Road for any disjunct establishments of Argentine ants.

#### ACKNOWLEDGMENTS

Valuable general advice on this project was given by W. Gagné, F. Howarth, J. Beardsley, and J. Riotte. Wayne Gagné and Al Samuelson provided indispensable help in the identification of native organisms. The Entomology Department of the B.P. Bishop Museum in Honolulu provided work space, advice, and encouragement to one of us (FRC) during a sabbatical in 1984-85. Ted Wolff and Bill Zvehlke assisted in sorting morphospecies from pitfall traps and tabulation of data. Karen Schlom and Eric Nishibayashi assisted with under-rock surveys and/or pitfall trapping. Chuck Stone and the research staff of Hawaii Volcanoes National Park provided crucial logistic assistance for our HAVO ant survey. Clif Davis provided previous HAVO records for several ant species. Special thanks are due to Kim Bridges for production of computer graphics for the oral presentation of this paper. Partial funding for this study was provided by a grant from the Natural Science Division and College Research Fund, Colby College.

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Appendix I. Results of a reconnaissance ant survey of Hawaii Volcanoes National Park to determine status and approximate distribution of ants within the park. Field work was conducted March 25-26, 1986. Participants: Karen Schlom, Margie Steigerwald, Chuck and Danielle Stone, A.C. Medeiros, and L.L. Loope. All the major roads from sea level to 2000m were traveled, with 15 periodic stops to assess areas for ants. When ants were found, they were collected for more conclusive identifications. The sites surveyed are numbered as follows:

- Site no. 1 - Research Center area (1190m)
- Site no. 2 - Kipuka Puauulu - Bird Park (1220m)
- Site no. 3 - Mauna Loa Strip Rd. (1480m)
- Site no. 4 - Mauna Loa Strip Rd. (1780m)
- Site no. 5 - End of Mauna Loa Strip Road (2000m)
- Site no. 6 - Kipuka Nene campground (975m)
- Site no. 7 - "Pizza Hut" on road to coast (610m)
- Site no. 8 - pulloff on switchback curve on road to coast (365m)
- Site no. 9 - Kamoamoia campground (near sea level)
- Site no. 10 - Waha'ula Visitor Center (near sea level)
- Site no. 11 - Hawaii Volcano Observatory construction site (1200m)
- Site no. 12 - Namakani Paio campground (1190m)
- Site no. 13 - Ka'u desert trailhead (Keamoku SEA) (945m)
- Site no. 14 - pulloff on road btwn. Site no. 13 and Park Headquarters (1100m)
- Site no. 15 - Kilauea Military Camp (1220m)

|                                 | SITE NO. |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|---------------------------------|----------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|                                 | 1        | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| <u>Anopolepis longipes</u>      |          |   |   |   |   |   |   | X |   | X  |    | X  |    |    |    |
| <u>Cardiocondyla cf. emeryi</u> |          | X | X | X |   |   | X |   |   |    | X  |    |    |    | X  |
| <u>Hypoponera opaciceps</u>     |          | X | X | X |   | X |   |   |   |    |    |    |    |    |    |
| <u>Iridomyrmex humilis</u>      | X        | X |   |   |   | X | X |   |   |    |    | X  |    | X  | X  |
| <u>Pheidole megacephala</u>     |          |   |   |   |   |   | X | X | X |    |    |    | X  | X  | X  |
| <u>Paratrechina sp.</u>         |          | X |   |   |   |   |   |   |   |    |    | X  |    |    | X  |