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Status and Distribution of Ants In The Crater District of Haleakala National Park[1]

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ABSTRACT: The Crater District of Haleakala National Park was surveyed for ants. Three species were found. Argentine ants (*Iridomyrmex humilis*) occurred only within 1 km of the park headquarters and the nearby research facility. *Hypoponera opaciceps* was found in small numbers throughout the Crater District. *Cardiocondyla emeryi* was present only at the head of Kaupo Gap. Possible impacts of these ant species on the endemic, flightless insects of the park are discussed.

THREE SPECIES OF ANTS have become established in the Crater District of Haleakala National Park: *Iridomyrmex humilis* (Mayr) (the Argentine ant), *Hypoponera opaciceps* (Mayr), and *Cardiocondyla emeryi* (Forel). The Argentine ant and *H. opaciceps* were known previously from the park (Beardsley 1980). The presence of *C. emeryi*, however, is first reported in this paper.

The primary purpose of this study was to determine the range of the Argentine ant within the Crater District of the park and to assess the potential impact of this species on the endemic, flightless insects inhabiting the crater (e.g., flightless carabid beetles, lacewings, moths, and flies; see Beardsley 1980). During this survey, information was also gathered on the distributions of *Hypoponera opaciceps* and *Cardiocondyla emeryi*. The possible threat posed by these ant species to the endemic insects was evaluated.

The Argentine ant is native to Argentina. With the inadvertent assistance of humans, Argentine ants have spread throughout the northern and southern temperate zones, with populations now established in Africa, Australia, Europe, South America, and North America. The ants became established on Oahu, Hawaii, in 1940 (Zimmerman 1941), and by 1950 they had begun to invade other islands. By the early 1960s the Argentine ant had been reported on all of the six main islands except Molokai. (See review of pertinent literature by Wilson and Taylor 1967.)

Argentine ants are voracious feeders and consume a wide range of foods including honeydew, carrion, and other insects. They can be very effective predators on small insects, particularly those with low mobility. In addition, by monopolizing a high proportion of suitable cover objects (rocks, logs, etc.), the ants may prevent other insects from using these items for refuge and thus may have a significant negative impact on invertebrate populations. In the Solomon Islands another species of *Iridomyrmex* (*I. cordatus* Fr. Smith) has been shown to eliminate all potential prey, i.e., other insects and invertebrates, from the immediate vicinity of their colony (Greenslade 1972). The Argentine ant may have a similar effect, although this has not been adequately documented.

The Argentine ant reaches extremely high densities in many areas (Heer 1892 in Wheeler 1910, Tremper 1975). The high population density of Argentine ants, as well as their very aggressive nature towards other invertebrates, makes them exceedingly effective competitors. Where Argentine ants are abundant they monopolize food sources, foraging areas,

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and nest sites, and may eliminate all other ants from the area. This replacement has been well-documented in Hawaii (Fluker and Beardsley 1970), Bermuda (Haskins and Haskins 1965; Crowell 1968; Lieberburg, Kranz, and Seip 1975), and California (Tremper 1975).

The inadvertent introduction of the Argentine ant into Haleakala National Park has serious implications for the native invertebrate fauna of the park. The endemic flightless insects found in the crater region of Haleakala are particularly vulnerable to predation and displacement by Argentine ants. If Argentine ants become well-established in the crater, they could conceivably cause the extinction of these unique forms (Beardsley 1980:7–9). Dense populations of the Argentine ant now occur in the vicinity of the park headquarters. This paper reports the extent of the ant's range within the park and evaluates the threat posed to endemic insects living in the crater itself.

The habits of the other two ant species found in the park, *H. opaciceps* and *C. emeryi*, are less well known than those of the Argentine ant. *Hypoponera opaciceps* is a very widespread species occurring on many islands of the South Pacific including the six main Hawaiian Islands. The species probably originated in the New World where it is common from the southern United States to Uruguay (Wilson and Taylor 1967).

Cardiocondyla emeryi is native to India (Wilson and Taylor 1967) but has been widely distributed by human commerce and is now found on many islands in the Pacific region. In Hawaii *C. emeryi* has been reported from the six largest islands where it is abundant at lower elevations with relatively little rainfall (Huddleston and Fluker 1968). The species was not known previously from Haleakala National Park.

METHODS

Transect Methods

We employed two techniques to census ants: (1) turning cover items to locate colonies and (2) using baits to attract workers. A cover-item transect consisted of 50 rocks that appeared to provide suitable cover. When ants were located under a rock, we recorded whether only a few workers or a colony were present. If there was a colony, we also noted the presence of any reproductives or brood.

The second census method involved a combination of bait transects and cover rocks. The baiting was designed primarily to locate workers and to estimate their density. At each bait location a small portion of honey and liver paté was placed on a white file card cut to approximately 6.5 × 7.5 cm. The use of file cards does not interfere with ant activity (Fellers 1977) and greatly facilitates the relocation of baits and the counting of ants.

Bait transects consisted of 50 baits set out in two parallel rows of 25 each. Baits were placed approximately 2 m apart. Baits were left in place for 40 min after which we collected them and recorded the number of ants present.

At each baiting locality we also turned 25 suitable cover objects. This additional census technique provided a means of direct comparison between bait and cover-item transects.

At each locality (sampled by either method) we recorded air temperature in the shade, ground temperature in both the sun and the shade, general vegetation type, major plant species present, general soil description, qualitative description of soil moisture, slope, and relative abundance of suitable cover items.

For a more detailed description of the transect methods, see Fellers and Fellers (1981).

Transect Placement

During the study 56 transects were conducted, 32 cover-item transects (R-1–R-32) and 24 bait transects (1–24), for a total coverage of 2200 rocks and 1200 baits (Figure 1).

Twenty-one of the bait transects were conducted along or near Haleakala Highway (Route 378). Transects were conducted at 200-foot intervals along the road, in elevations from 6800 up to 8200 ft. Above 8200 ft transects were spaced at 400-ft intervals up to 9800 ft. Three additional roadside localities (2, 5, and 6) were added later in areas of particular interest. Bait transects were also con-

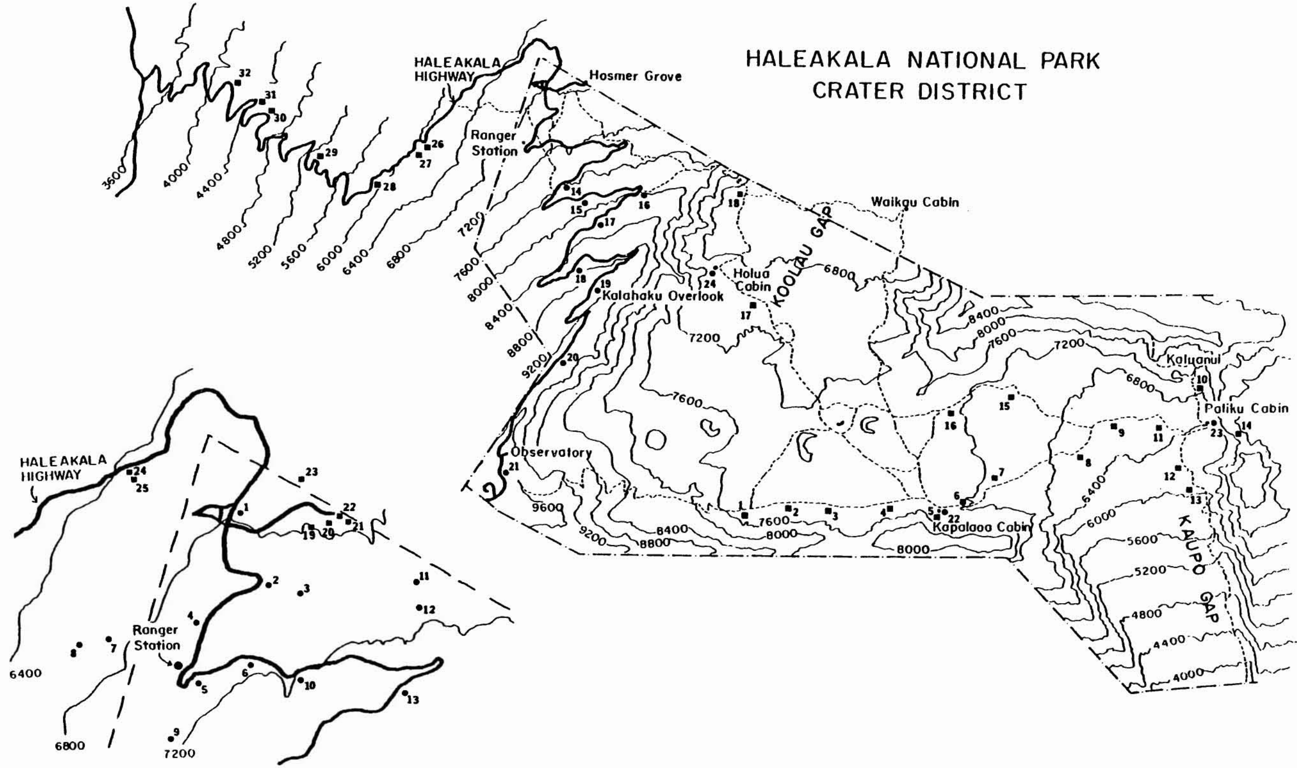

FIGURE 1. Map of Haleakala National Park showing locations of transects. The inset is an enlargement of the area around the park headquarters (labeled Ranger Station). Circles 1–24 indicate locations of bait transects. Squares 1–32 indicate localities for cover-item transects (referred to as localities R-1 through R-32 in the text).

TABLE 1

ARGENTINE ANTS FOUND AT BAIT TRANSECTS

LOCALITY	ELEVATION (ft)	NO. ANTS	% BAITS OCCUPIED	% ROCKS OCCUPIED	REPRODUCTIVE INDEX*
1	6800	2315	100	56	50
2	6900	2980	100	84	19
3	6960	1062	96	16	25
4	7000	2750	100	84	57
5	7080	2430	100	80	50
6	7140	17	16	8	0
7	6700	6085	100	68	24
8–24	6600–9800	0	0	0	0

* Percentage of rocks that harbored Argentine ants where reproductives and/or brood were present.

ducted at the three cabins within the crater: Kapalaoa, Paliku, and Holua.

Cover-item transects were carried out at 18 sites within the crater. We spaced these transects fairly evenly through habitat with at least some vegetation and appropriate cover. Fourteen cover-item transects were also conducted near Hosmer Grove and on the lower slope of Haleakala below the park boundary.

All transects were conducted between 17 June and 28 June 1980.

TABLE 2

ARGENTINE ANTS FOUND AT COVER-ITEM TRANSECTS

LOCALITY	ELEVATION (ft)	% ROCKS OCCUPIED	REPRODUCTIVE INDEX*
R-19	6780	70	40
R-20	6760	2	0
R-24	6430	52	27
R-30	4600	2	0
R-31	4400	16	13
R-32	4150	24	42
All other cover-item transects		0	0

* Percentage of rocks that harbored Argentine ants where reproductives and/or brood were present.

RESULTS

Iridomyrmex humilis (*The Argentine Ant*)

The Argentine ant has a very restricted range in the Crater District of the park. Only eight of the 44 transects conducted within park boundaries revealed the presence of Argentine ants (Tables 1 and 2). All eight sites were on the lower northwestern slope of Haleakala, within approximately 1 km of either the park headquarters or the research facility (located across Haleakala Highway from the road to Hosmer Grove; see Figure 1). These sites were characterized by a fairly dense cover of shrubs, primarily pukiawe, ohelo, and mamane. The ground had a moderately steep slope with fine soil and scattered rocks.

Argentine ants were also found in several places outside the park, below park headquarters, and along Haleakala Highway. No Argentine ants were located on the northwestern slope above 7200 feet or anywhere within the crater itself. Figure 2 shows the transect sites that were inhabited by the Argentine ant and gives an extrapolated range of this species in the vicinity of the park.

In those areas that were occupied, Argentine ant populations were very dense. Five of the seven bait transects within their range had over 2000 ants and attracted ants to every bait (Table 1). One of these transects (locality 7) had an estimated 6085 ants at the 50 baits, the largest number at any of the localities tested. Both bait and cover-item transects demonstrated that a high proportion of the suitable rocks harbored ants. As many as 84% of the

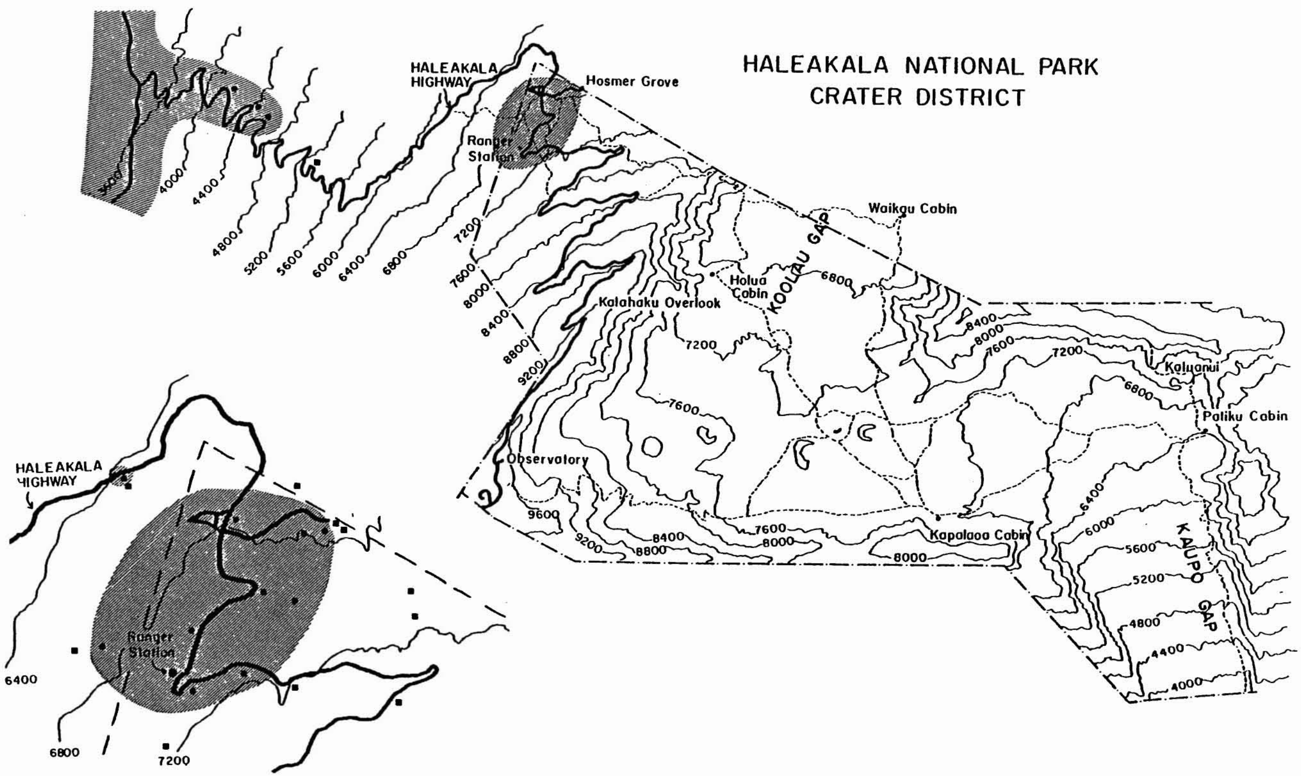

FIGURE 2. Map of Haleakala National Park showing the distribution of the Argentine ant. Circles indicate transects where Argentine ants were found. The extrapolated range of this species is indicated by the shaded areas. Localities just outside the range which did not have Argentine ants are shown by squares.

TABLE 3

NUMBERS OF ARGENTINE ANTS AT THE CENTER VERSUS EDGE OF THEIR RANGE AT HALEAKALA NATIONAL PARK

LOCALITY AT CENTER OF RANGE (Locality A)	LOCALITY AT EDGE OF RANGE (Locality B)	NO. ANTS, LOCALITY A (at baits)	NO. ANTS, LOCALITY B (at baits)	DISTANCE BETWEEN LOCALITIES A & B (m)
5	6	2430	17	450
7	8	6085	0	150
LOCALITY AT CENTER OF RANGE (Locality A)	**LOCALITY AT EDGE OF RANGE (Locality B)**	**% ROCKS OCCUPIED AT LOCALITY A**	**% ROCKS OCCUPIED AT LOCALITY B**	**DISTANCE BETWEEN LOCALITIES A & B**
R-19	R-20	70	2	100
R-24	R-25	52	0	100
R-32	R-31	16	2	500

TABLE 4

CORRELATION BETWEEN NUMBER OF ARGENTINE ANTS AT BAITS AND NUMBER OF ROCKS OCCUPIED BY ANTS

LOCALITY	NO. ANTS AT BAITS	NO. ROCKS* OCCUPIED
6	17	2
3	1062	4
1	2315	14
5	2430	20
4	2750	21
2	2980	21
7	6085	17

Correlation coefficient $r = 0.655$
$t = 1.9382$; $p < 0.05$

*Out of 25 rocks turned.

rocks were occupied in some transects (Tables 1 and 2). Rocks occupied by Argentine ants were rarely used by any other invertebrates. This observation suggests that the ants are superior competitors and may eliminate other invertebrates from these important refuges.

The Argentine ant population in the park was reproductively active as evidenced by brood or reproductive individuals that were present in many colonies (Tables 1 and 2). There was a general trend for reproduction to be stronger in the center portion of the range and somewhat decreased towards the periphery, although this trend was not statistically significant ($p > 0.35$, Wilcoxon Rank Sum Test, Hollander and Wolfe 1973).

At the edge of the range the numbers of ants attracted to baits dropped abruptly over a very short distance (Table 3). In bait transects 7 and 8, for example, the number of ants fell from 6085 to zero over a distance of approximately 150 m. Similarly, in the 450 m between transects 5 and 6, ant numbers dropped from 2430 ants (50 of 50 baits occupied) to 17 ants (8 of 50 baits occupied).

Not surprisingly, the number of suitable rocks harboring ants was proportional to the number of ants present at baits, with fewer rocks occupied in areas with fewer ants (Table 4, $p < 0.05$). In no case did we find ants at baits without also locating them under rocks.

Hypoponera opaciceps

This small, secretive species was found throughout the Crater District (Figure 3). It occupied areas with dense brushy vegetation, trees, sparse shrubs, grassland, or even cinder with only scattered bracken ferns. Wherever this species occurred, it was found in very low numbers (usually 1–2 individuals) under only a small proportion of the rocks turned (< 15%; for details of distribution see Fellers and Fellers 1981). On only two occasions did we find *H. opaciceps* colonies.

Hypoponera opaciceps never came to baits and could best be located by turning rocks and watching for movement for at least 30 sec. Because the first reaction of this tiny ant was

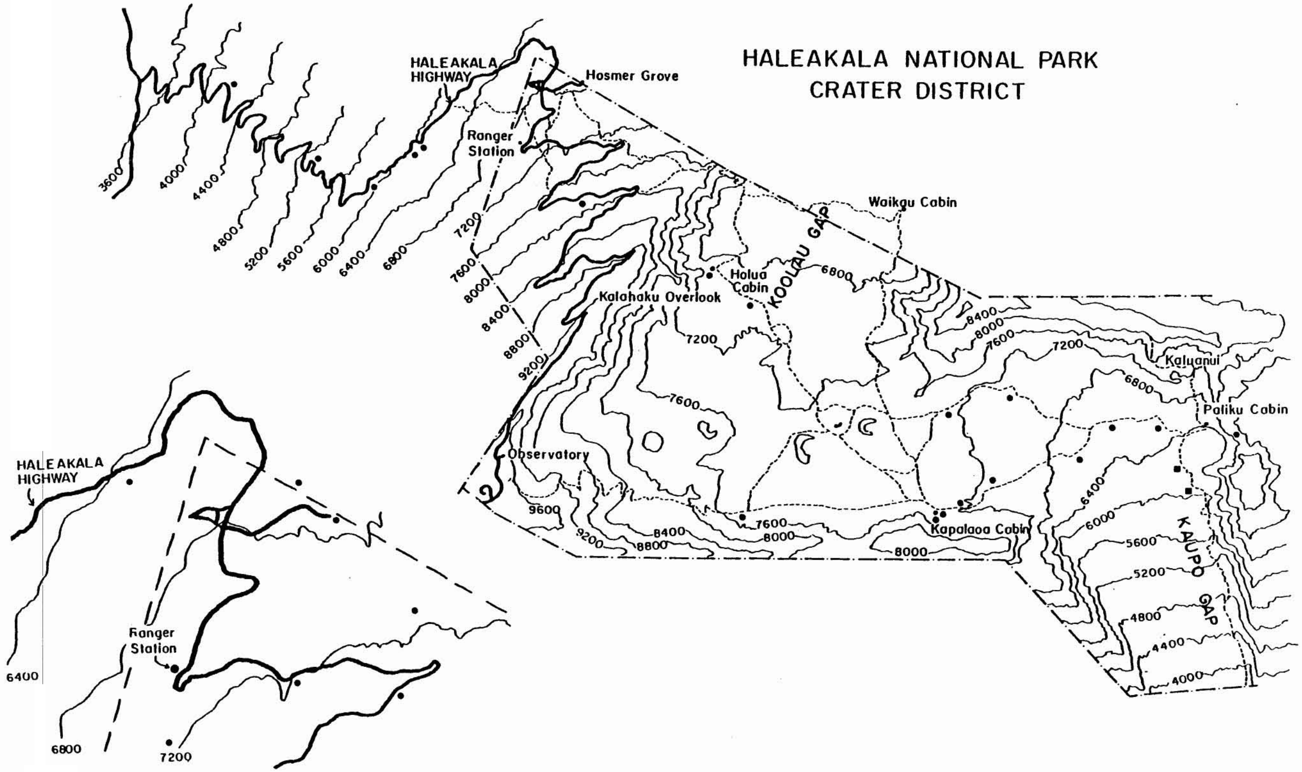

FIGURE 3. Map of Haleakala National Park showing the distributions of *Hypoponera opaciceps* and *Cardiocondyla emeryi*. Localities where *H. opaciceps* were found are indicated by circles; squares show localities for *C. emeryi*.

to freeze, it could be easily overlooked even by careful observers. In fact, on the first day of our survey we did not expect to find *H. opaciceps* and were looking primarily for Argentine ants. Hence we did not search as carefully at localities 1, 14, and 16 to 21, although we feel that *H. opaciceps* is likely to have been present at any but the first of these localities.

Hypoponera opaciceps was rarely found at the same locality as the Argentine ant. At sites where both species occurred (locality R-32, also between localities 7 and 8 and between localities 5 and 9 where no complete transects were conducted) the Argentine ant was at the very edge of its range. At locality R-32 Argentine ants were under several rocks on one side of the road while *H. opaciceps* was on the other side of the road where there were no Argentine ants. Although this difference in distribution appeared to be real, it is possible that we overlooked the relatively inconspicuous *H. opaciceps* in areas where Argentine ants were extremely numerous and active.

Cardiocondyla emeryi

Cardiocondyla emeryi was found at two localities (R-12, R-13), both situated in the crater at the head of Kaupo Gap (Figure 3). The species was relatively uncommon at these localities, occupying only 8% and 2%, respectively, of the rocks turned. These colonies, however, were very active with many workers, reproductives, and brood.

DISCUSSION

The distribution of Argentine ants in Haleakala National Park follows a very distinct pattern. Ants are abundant within about 1 km of park buildings but their numbers decrease abruptly to zero at the edge of their range. This pattern is repeated outside the park boundary along Haleakala Highway, where ants are present only within about 1 km of houses. One isolated population exists along Haleakala Highway at 6430 feet, 1.77 km northwest of the park boundary. This population occupies a disturbed site along a short section of abandoned dirt road. The range of this population is very restricted, however, as no ants were present 125 meters upslope from the highway.

Argentine ants probably became established at Haleakala in the vicinity of the park buildings. Discussions with park employees indicate that ants have been present for at least 7 to 10 years (Carole Beadle and Adele Fevella, personal communication). Although it is possible that the current distribution represents the distance the Argentine ant has spread in that time, this hypothesis seems unlikely.

The most likely explanation for the current distribution of the ants is that park buildings moderate the occasionally harsh climate at Haleakala. If Haleakala is only marginal habitat, the Argentine ant may do well during relatively mild years but may be unable to survive harsh years except with the moderating effect of buildings. If this were the case, ants would die out everywhere during harsh years except in the vicinity of the buildings. During intervening mild periods ants would spread gradually until they were knocked back again by the next harsh season. In this way the ants' range would fluctuate as influenced by the weather of the previous year.

Huddleston and Fluker (1968) report that the Argentine ant in Hawaii is commonly found in habitats from sea level to 6000 feet. Thus Argentine ants at Haleakala are at the very edge of their altitudinal range and are likely to encounter marginally acceptable conditions.

The specific climatic factors that regulate the Argentine ant population are most likely to be cold temperatures or prolonged drought. Both of these factors are important in determining the range of the Argentine ant in other parts of the world. Mallis (1941) states that the Argentine ant is limited in its distribution by its moisture requirements and "by an inability to thrive where it cannot be protected from long periods of cold weather such as is encountered at higher altitudes." Argentine ants from California were shown to be intolerant of dry conditions in physiological experiments (Tremper 1975). This physiological limitation correlated well with their range in

California where they occurred only in moist areas.

We considered several other possible explanations for the range of the Argentine ant at Haleakala. Once the data were collected, none of these hypotheses seemed very likely. A brief description of these hypotheses follows.

1. *Unusually heavy rains in 1980.* For several reasons it seems unlikely that the distribution of Argentine ants was significantly influenced by the unusually heavy rains that occurred from January to early April 1980. If Argentine ants had ever been established at any of the cabins in the crater, their presence would have been readily noted by maintenance personnel. The ant colonies near park headquarters had numerous reproductives and eggs indicative of well-established, healthy colonies, not ones recovering from a climatic catastrophe. Also, the distribution and density of these colonies is greater than could have been established in the two months between the end of heavy rains and our surveys.

2. *Elevation.* Ants could have occurred everywhere below a particular elevation. This possibility is ruled out by the disappearance of ants below the park buildings and by the lack of correlation between the ants' upper boundary and any particular elevation.

3. *Habitat.* Ant distribution might have been determined by a specific habitat factor such as soil type or vegetation. We could find no habitat change that corresponded with the ants' range. In fact, there appeared to be more variation between different areas occupied by ants (e.g., 2 and R-32) than between adjacent areas with and without ants (e.g., R-7 and R-8).

4. *Human disturbance of habitat.* Ants could exist only in areas where the habitat was disturbed by human activity. While ants at Haleakala were fairly near buildings, the habitat did not appear to be disturbed significantly except in the immediate vicinity of the buildings.

One major aspect of this study was to survey the interior of Haleakala crater for Argentine ants that might be threatening the endemic insect fauna. We found no Argentine ants in the crater, which indicates there is no immediate danger. Our observations of the habitat, however, indicate that at least some areas in the crater are suitable for ants with respect to vegetation, soil conditions, and cover objects.

Ants could easily be transported into the crater by park visitors, rangers, pack animals, or supply helicopters. Apparently no introduction has yet occurred or past introductions have not become established. Given the ease with which ants are transported, it seems likely that ants have been introduced in the past but have not been able to establish new colonies. Two explanations can be offered to account for this lack of success.

1. The same climatic factors that regulate ant populations near the park headquarters are also operating in the crater. The crater floor is at a high enough elevation to occasionally experience winter temperatures below freezing. It is subject also to periods with no rain. Thus harsh conditions could make the crater unsuitable for Argentine ants. The cabins may not provide sufficient moderation of the weather, perhaps because they are not occupied continuously or because they are not heated adequately in winter.

2. Past introductions may have included workers but no queen or brood. This explanation seems somewhat unlikely, however, because the small queens of this species sometimes forage with workers and are thus relatively easily transported. In addition, workers move the brood into temporary nest sites quite frequently. This behavior would facilitate introduction of brood into supplies which then could be carried into the crater.

Hypoponera opaciceps was known previously from two localities within Haleakala National Park (Hosmer Grove and Kuiki; Beardsley 1980) and from one locality along Haleakala Highway. Huddleston and Fluker (1968) report that it is most frequent in the wet mountain areas of Hawaii but is also found occasionally in areas with less than 16 cm (40 in) of rain. We found *H. opaciceps* to be very widespread in the Crater District, from wet areas such as the notch above Paliku to relatively dry areas such as the cinder zone at the base of Sliding Sands Trail. *H. opaciceps* also occupies a wide variety of habitats from areas of bracken fern to grassland to dense shrub.

Hypoponera opaciceps belongs to the subfamily Ponerinae. Members of this subfamily are known to be predacious (Wheeler 1910). However, our observations indicate that *H. opaciceps* is probably not a serious threat to the native invertebrate fauna. Colonies of this species were not abundant at any locality and are known to be quite small (fewer than 50 individuals; Huddleston and Fluker 1968). The ant itself is small and slow-moving, spending most of its time under cover and rarely appearing on the surface. We noted that rocks occupied by *H. opaciceps* also supported a variety of other invertebrates (although these may also have been exotics).

Our survey suggests that *H. opaciceps* may be displaced by the Argentine ant. We found very little overlap in the ranges of these two species despite the broad habitat tolerance of *H. opaciceps*. The Argentine ant is well-known for its aggressiveness and has supplanted other ant species in several parts of the world including Oahu, Bermuda, and California (Haskins and Haskins 1965, Crowell 1968, Fluker and Beardsley 1970, Lieberburg, Kranz, and Seip 1975, Tremper 1975). A similar replacement may be occurring at Haleakala.

Cardiocondyla emeryi was found at two localities (R-12 and R-13) in the crater at the head of Kaupo Gap. The species may be moving up the gap from populations at lower elevations; however, further work would be needed to establish the exact distribution of *C. emeryi* in the park.

Members of the genus *Cardiocondyla* are not particularly aggressive towards other ant species, nor are they very efficient foragers (Wilson 1971). However, little is known about the impact of *C. emeryi* on other insects. Although we found colonies of *C. emeryi* to be sparsely distributed, they were quite active and contained both reproductives and brood. They occupied more of the space beneath rocks than *H. opaciceps* but less than the Argentine ants. At present *C. emeryi* seems unlikely to have any significant effect on the native insect fauna (Roy Snelling, personal communication). If the species were to become more abundant, it could compete with the native invertebrates for food and space.

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