

Distribution of Ant Species of Hawaii¹

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INTRODUCTION

The ant fauna of the Hawaiian Islands offers many unique opportunities for study. Among these are: (1) an excellent body of background resources dating from the 19th century, including many well preserved and labeled specimens; (2) isolated locations with well-defined ecological zones that exist in close proximity to one another on 6 islands of varying size and terrain and (3) a completely synthetic ant fauna made up of tramp species from many parts of the world, existing in artificial sympatric associations that are likely found in no other place in the world.

Specialized studies of the ants of Hawaii span the majority of the past century. Forel's (1899) paper on Formicidae in *Fauna Hawaiiensis* was based on extensive collections by Perkins. Of the 20 forms reported, 1 is now considered to have been incorrectly labeled as to locality (*Pogonomyrmex occidentalis* Cresson), 1 mis-identified (*Paratrechina obscura* Mayr), and 1 (*Aphaenogaster longiceps* F. Smith) an immigrant that apparently did not become established (Wheeler 1934). Gulick (1913) prepared a key and synopsis of the Hawaiian ants known at her time and added 6 new forms to those listed by Forel to give a total of 23 species.

In 1934, 2 highly significant papers that greatly increased the knowledge concerning Hawaiian ants were published. Wheeler (1934) added 9 new species to those known from the Hawaiian Islands; Phillips (1934), in a study of the ants in pineapple fields, presented a thorough ecological study of many of the species. The several new species that have been reported separately since 1934 have been summarized by Wilson and Taylor (1967) in "Ants of Polynesia". In their publication, 3 ponerine species recognized by Wheeler, (*Ponera kalakauae* (Forel), *Ponera gleadowii decipens* Forel and *Ponera punctatissima schauinslandi* Emery) have been synonymized with *Ponera punctatissima* and placed in the genus *Hypoponera*. A new ponerine species, *Amblyopone zwaluwenbergi* (Williams) was added for a total of 6 species in the subfamily Ponerinae. Three new species of the subfamily Myrmicinae were added, *Strumigenys godeffroyi* Mayr, *Strumigenys rogeri* Emery, and *Cardiocondyla emeryi* Forel. One Dolichoderinae, *Iridomyrmex humilis*, and one Formicinae, *Anoplolepis longipes* (Jerdon) were also added. In addition, several changes were made in synonymy.

The isolated character of the Hawaiian Islands with 6 accessible land masses varying in size and topography offers an excellent opportunity for

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study. Two factors of great importance in ant ecology—rainfall and vegetation—have been carefully studied and mapped. Annual rainfall data are available for almost every accessible area of the main islands and have been developed into monthly and annual isohyet maps (Taliaferro, 1959). The vegetative zones of each island have been described and mapped in excellent detail by Ripperton and Hosaka (1942). These data, together with topographical maps make the Hawaiian Islands an ecologist's delight.

Due to extensive collecting in many areas bordering the Pacific, the concepts of the origin of the Hawaiian ant fauna have undergone a drastic revision since Wheeler's 1934 paper. At that time, 6 species were considered to be endemic. In addition, Wheeler recognized 9 subspecies or varieties as being endemic. Wilson and Taylor (1967) consider the Hawaiian Islands to be populated entirely with introduced species of ants, producing what is termed a "completely synthetic ant fauna." Except for a limited number of species, all Hawaiian ants have been found elsewhere under circumstances that deny their endemism in Hawaii.

The study which is reported in this paper was undertaken to update the knowledge of the species of ants found in Hawaii and to determine the extent of their distribution on the 6 main accessible islands. In addition, data were obtained concerning some of the factors affecting species distribution on each island. While it is recognized that this study is far from complete, careful collections were made in each major ecological zone on each island. Because of the theory advanced by Wilson and Taylor (1967) that the species found in Hawaii appear to be approaching an equilibrium species density and that new species will probably be established as a result of competitive replacement, collection data from many areas are included to record present distribution for future studies (Appendix 1). These data include locality information in the usual manner and the Universal Transverse Mercator Grid designation of the collection site to the nearest 100 m for Oahu and the nearest 1000 m for the other islands.

AN ANNOTATED LIST OF THE ANTS OF HAWAII AND THEIR KNOWN
DISTRIBUTION ON THE ISLANDS

This tabulation of the ants presently known from Hawaii has been edited to conform as closely as possible to the nomenclature used by Wilson and Taylor. Four species new to Hawaii, 3 of which may be species new to science, have been added to give a total of 42 species of ants presently recorded from Hawaii. It should be remembered that of these 42 species, 6 species which are designated as rare or not recently collected may now be extinct in Hawaii. These are:

- | | |
|---|--|
| 1. <i>Amblyopone zwaaluwenburgi</i> (Williams) = <i>Stigmatomma</i> (Fulakora) <i>zwaaluwenburgi</i> Williams | 4. <i>Trichoscapa membranifera</i> Emery = <i>Strumigenys membranifera</i> Emery |
| 2. <i>Monomorium latinode</i> Mayr | 5. <i>Plagiolepis exigua</i> Forel |
| 3. <i>Strumigenys lewisi</i> Cameron | 6. <i>Brachymyrmex obscurior</i> Forel = <i>Brachymyrmex heeri</i> var. <i>aphidicola</i> Forel |

References to the pertinent literature have been adequately reviewed by Wilson and Taylor (1967) and Wheeler (1934) and are not included. The abbreviated synonymy as shown is used to relate the nomenclature used by Wilson and Taylor (1967) to the nomenclature used by Wheeler (1934) and that used in the Proceedings of the Hawaiian Entomological Society. Species distribution records are footnoted for the first published report of the species on each island.

A generalized description of each species is presented as an aid in identification. The average body length, excluding antenna, of a specimen in the normal walking position is given for each species. Under name headings, the numbers (1, 2, 3, etc.,) designate references of collection surveys or studies. Number 14 is the number of the current study.

Ant Species Distribution

| | | | | | | |
|--|------|---------|-------|------|-------|--------|
| | Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |
|--|------|---------|-------|------|-------|--------|

Family Formicidae

Subfamily Ceraphachyinae

1. **Syscia silvestrii** Wheeler
 =*Cerapachys* (*Syscia*) *silvestrii*
 Wheeler

| | | | | | | |
|--|---|---|----|--|--|---|
| | 2 | 3 | 14 | | | 2 |
|--|---|---|----|--|--|---|

Description: A small, reddish-brown ant easily recognized by the short, stout antennal scapes and the extremely large nodes on the petiole and post petiole. (2.2 mm)

Ecology: A hypogaecic ant most often collected under rocks. Apparently widespread on Oahu, although infrequently collected due to its cryptic habits. Found in areas of 20 to 70 inches of rainfall. Probably predacious. Colonies small, usually less than 30 individuals.

Subfamily Ponerinae

2. **Amblyopone zwaluwenburgi** (Williams)
 =*Stigmatomma* (Fulakora)
zwaluwenburgi Williams

| | | | | | | |
|--|---|--|--|--|--|--|
| | 6 | | | | | |
|--|---|--|--|--|--|--|

Description: A very small (1.8 mm), rufotestaceous ponerine characterized by short, linear mandibles.

Ecology: The only reported collection of this cryptobiotic species was from soil in a cane field in Honolulu. This ant was not collected in the survey reported here.

3. **Hypoponera punctatissima** (Roger)
 =*Ponera gleadowii decipiens* Forel
 =*Ponera kalakauae* (Forel)

| | | | | | | |
|--|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 3 | 2 |
|--|---|---|---|---|---|---|

Description: A small ponerine recognized by short antennal scapes that fail to reach the median occipital border by a distance greater than their maximum diameter. Eyes small, but distinct, containing several facets. A highly variable species that may represent more than 1 species.

Ant Species Distribution

| | Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |
|--|------|---------|-------|------|-------|--------|
|--|------|---------|-------|------|-------|--------|

Ecology: Collected only from soil and under rocks in cane fields; however, probably more widely distributed than is reported due to its small size and cryptobiotic habits.

8. **Leptogenys falcigera** Roger

= *Leptogenys falcigera insularis*

Wheeler

| | | | | | |
|---|---|---|---|---|----|
| 1 | 2 | 1 | 1 | 1 | 14 |
|---|---|---|---|---|----|

Description: A large (7 mm), blackish ponerine easily recognized by its size and curved, elongate mandibles. This is the largest ponerine known from Hawaii.

Ecology: Appears to be widely distributed over the lower elevations where rainfall is from less than 20 inches to more than 70 inches. Usually noticed as individual forms walking on the ground or tree trunks. Found nesting under rocks and in dead tree trunks in dry areas on Oahu, Molokai, and Maui, also under the bark of a paper bark tree in a wet area on Lanai.

Subfamily Myrmicinae

9. **Pheidole (P.) fervens** Fr. Smith

| | | | | | |
|----|--|--|--|--|----|
| 14 | | | | | 14 |
|----|--|--|--|--|----|

Description: Most easily recognized by dark brown color and large completely rugose head of the soldier cast. Waist with two nodes, short propodeal spines. (2.3 mm, soldiers 4.5 mm)

Ecology: Present known distribution on Oahu restricted to the higher elevations and rainfall areas of the Koolau range along the lower edge of the forest reserve. Widely distributed around Hilo, apparently occupying the same ecological niche that is occupied by *Pheidole megacephala* in other similar areas.

10. **Pheidole (P.) megacephala** (F.)

(Big-Headed Ant)

| | | | | | |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|

Description: Readily recognized by its dark brown color and the presence of big-headed soldiers in which the occipital region is smooth and shiny. Waist with 2 nodes, propodeum armed with spines. (2.2 mm, soldiers 3.4-3.8 mm)

Ecology: The dominant ant of the Hawaiian Islands, found in a great variety of habitats ranging from sea level to the top of Mt. Kaala (4000 ft), although usually restricted to areas of less than 3000 ft elevation. Food habits are extremely variable, including household food, tending honeydew-producing insects, and preying on small arthropods.

11. **Solenopsis geminata** (F.)

= *Solenopsis geminata* variety

rufa (Jerdon) (Fire Ant)

| | | | |
|---|----|----|---|
| 1 | 10 | 14 | 5 |
|---|----|----|---|

Description: Light to dark reddish-black ants with a smooth head; no propodeal spines. Sting on abdomen. Waist consists of 2 nodes.

Ant Species Distribution

| | | | | | |
|------|---------|-------|------|-------|--------|
| Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |
|------|---------|-------|------|-------|--------|

There are major and minor worker castes with a wide size range. Ten-segmented antenna with a 2-segmented club. (3.1–3.3 mm, soldiers up to 8 mm)

Ecology: Most prevalent in drier areas where it replaced *Pheidole megacephala*. Found in wetter areas, especially around Hilo. Range overlaps that of *Pheidole megacephala* and *P. fervens* in several areas. Appears to tend honeydew-producing insects and to feed on other arthropods. Nests most often found under rocks or in the soil.

12. **Solenopsis "a"**

14

14

Description: A small, reddish-black ant similar to *Monomorium minutum* but distinguished by the 2-segmented club on the 10-segmented antenna. A distinct species at present unnamed because of the taxonomic confusion in the genus. Specimens on deposit in Bishop Museum and University of Hawaii collections. (1.6 mm)

Ecology: Widely distributed on Maui and the Mt. Tantalus region of Oahu. On large areas of Maui, this is the dominant and sometimes the sole ant species collected. Large nests with several queens found under rocks, in the soil near the base of trees, and in plant material.

13. **Solenopsis "b"**

14

Description: Similar to *Solenopsis "a"* but lighter in color (1.4 mm).

Ecology: Also found on Mt. Tantalus and near Waipio where it was nesting under the leaf sheath of a cane stalk. Taxonomic status uncertain.

14. **Monomorium floricola** (Jerdon)

1

1

14

1

1

14

Description: Small, monomorphic workers with the waist consisting of 2 nodes, entire body smooth and shining with no propodeal spines. A 3-segmented antennal club. Head and abdomen usually dark black. Thorax yellowish and distinctly lighter in color than head and abdomen. (1.5 mm)

Ecology: Widely distributed in uncultivated and cultivated land and in residential areas. Reported (Wilson and Taylor 1967) to be almost wholly arboreal; however, often collected on rocks and at the soil surface. Common household pest, probably omnivorous.

15. **Monomorium fossulatum** Emery

= *Monomorium fossulatum seychellense*

Emery

2

2

2

14

2

Description: A typical *Monomorium*, usually light reddish-yellow with a darker abdomen. Readily recognized by the very small (0.03 mm) eyes. (1.5 mm)

Ecology: A widely distributed, ground-dwelling species frequently taken in Berlese samples.

Ant Species Distribution

| | Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |
|---|------|---------|-------|------|-------|--------|
| 16. Monomorium latinode Mayr | 2 | | | | | |
| Description: A distinctive polymorphic species having a wide, short postpetiolar node and a postpetiole that is larger than the petiole when seen in side view. | | | | | | |
| Ecology: Apparently collected only once in Nuuanu Valley in 1923. Extensive collecting in the same area has failed to reveal a single specimen. Perhaps this species has been completely replaced by other species. | | | | | | |
| 17. Monomorium minutum Mayr | | | | | | |
| = <i>Monomorium minutum</i> variety | | | | | | |
| <i>liliuokalanii</i> Forel | 1 | | 2 | | | 2 |
| Description: Small, blackish to dark brown, monomorphic workers distinguishable from <i>M. floricola</i> by having the thorax, head and abdomen equal in color. The entire petiole is about as long as deep. (1.5 mm) | | | | | | |
| 18. Monomorium pharaonis (Linne) | | | | | | |
| (Pharaoh Ant) | 2 | | | | | 2 |
| Description: A small, yellowish ant with body entirely shagreened and opaque, similar to other <i>Monomorium</i> species in size and general body outline. (2.0 mm) | | | | | | |
| Ecology: An occasional species collected from widely scattered locations. | | | | | | |
| 19. Monomorium destructor (Jerdon) | 1 | | 2 | | | |
| Description: A polymorphic species with the head width of the smaller workers greater than 0.4 mm. Yellowish-red in color with terminal segment of the antenna about as long as the next 2 together. Distinguished from <i>Solenopsis</i> by the 3-segmented antennal club. (2.3 mm) | | | | | | |
| Ecology: Primarily collected near sea level in dry sandy areas nesting under boards, cans, etc. Distribution appears to be quite limited. | | | | | | |
| 20. Cardiocondyla emeryi Forel | 14 | 14 | 14 | 14 | 14 | 14 |
| Description: A small (1.6 mm) yellowish-red ant with black abdomen and antennal clubs. Distinguished by fine but dense punctations on the head and thorax, short propodeal spines, a bilaterally compressed petiolar node, mesonotum gently sloping to the mesometanotal groove, and 2 nodes on the waist with the postpetiolar node much wider than the petiolar node. | | | | | | |
| Ecology: An active ant, abundant at lower elevations and in lower rainfall areas. Both ground-inhabiting and arboreal. Nests in soil, under rocks, and in plant cavities. | | | | | | |
| 21. Cardiocondyla nuda (Mayr) | | | | | | |
| = <i>Cardiocondyla nuda</i> variety | | | | | | |
| <i>minutior</i> Forel | 1 | 1 | 2 | 2 | 2 | 2 |
| Description: A small, dark brownish-black ant with densely punctate | | | | | | |

Ant Species Distribution

| | | | | | | |
|--|------|---------|-------|------|-------|--------|
| | Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |
|--|------|---------|-------|------|-------|--------|

head and thorax, short propodeal spines, postpetiolar node wider than petiolar node which is semi-globular in outline when viewed from above, mesometanotal groove absent or very weak. (1.6 mm)

22. **Cardiocondyla wroughtoni** (Forel)= *Cardiocondyla wroughtoni*variety *hawaiiensis* Forel

2 1 2 2 3 2

Description: Similar to *C. emeryi* except that the propodeal spines are longer, the mesonotum declines abruptly to the mesometanotal groove, and the petiolar node is subglobular in outline when viewed from above. (1.9 mm)

Ecology: Although widely distributed, most abundant in higher and wetter areas than *C. emeryi*.

23. **Cardiocondyla "a"**

14 14 14 14 14 14

Description: Readily distinguishable by its dull punctate head, broad postpetiolar node and by being larger than other members of the genus in Hawaii. Propodeal spines are very short. Mesometanotal groove is distinct. Taxonomic status questionable. (2.2 mm)

Ecology: Widely distributed on all islands. In certain localities it appears to be the dominant ant species where neither *Pheidole megacephala* or *Iridomyrmex humilis* are present.

24. **Tetramorium guineense** (F.)

1 1 2 2 1

Description: A large yellowish-red to reddish-black ant distinguished by the striated face, reticulated thorax and petiolar nodes, and long slightly curved propodeal spines. (3.1 mm)

Ecology: Widely distributed, extremely abundant in certain habitats, occasionally the dominant ant in restricted areas. Nests under rocks, in soil, and in decaying plant parts. Has been observed tending honeydew-producing insects.

25. **Tetramorium simillimum** (Fr.

Smith)

2 14 14 14

Description: Reddish-yellow head and thorax with black abdomen, striated head and thoracic notum, short propodeal spines, short, blunt hairs on body. Distinguished also by peduncle of the petiole being thick compared to *T. tonganum*. (2.0 mm)

Ecology: Extremely widely distributed and common to abundant over most of its range. Nests in many varied sites.

26. **Tetramorium tonganum** Mayr

2 14 14

Description: Intermediate in size between *T. simillimum* and *T. guineense*. Distinguished by reticulate thorax, long slender body hairs;

Ant Species Distribution

| | Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |
|--|------|---------|-------|------|-------|--------|
| Subfamily Dolichoderinae | | | | | | |
| 32. Iridomyrmex humilis (Mayr) | | | | | | |
| (Argentine Ant) | 4 | | 12 | 7 | 11 | 7 |
| Description: A medium sized (2.5) reddish-black ant with a 1-segmented waist bearing a sharp pointed node. No standing hairs on the thorax. | | | | | | |
| Ecology: Found in a variety of habitats ranging from sea level to 6000 ft. Tends honeydew-producing insects. Usually very abundant in habitats where present. Predacious and highly antagonistic to <i>Pheidole megacephala</i> . Nests are extremely numerous in infested areas. May be a pest in houses. | | | | | | |
| 33. Tapinoma melanocephalum (F.) | 1 | 1 | 3 | 3 | 1 | 2 |
| Description: A very small, fast-moving ant with a dark brownish-black head and light antennae and abdomen. Single segmented waist. Thorax without standing pilosity. (1.5 mm) | | | | | | |
| Ecology: A very abundant, ground inhabiting or arboreal ant that is widely distributed. | | | | | | |
| 34. Technomyrmex albipes (Fr. Smith) | 2 | 2 | 2 | 3 | | 2 |
| Description: A medium-sized blackish ant having a very dull, punctate thorax with only 2 to 4 standing hairs and a rudimentary petiolar node. (2.4 mm) | | | | | | |
| Ecology: Nowhere very abundant, usually found in areas having more than 60 inches of rainfall. Often numerous in forested areas from 1000 to 5000 ft elevation. | | | | | | |
| Subfamily Formicinae | | | | | | |
| 35. Plagiolepis exigua Forel | | 2 | | | | 2 |
| Description: A small, robust yellowish ant with 11-segmented antennae, a cone-shaped defensive spray orifice on the 7th abdominal segment. Distinguished by the antennal scape exceeding the occipital corner by less than the length of the 1st funicular segment. | | | | | | |
| Ecology: Although reported from Hawaii, this species may well be confused with <i>P. alluaudi</i> which is the only <i>Plagiolepis</i> collected in this study. Reported to have about the same ecological requirements as <i>P. alluaudi</i> . | | | | | | |
| 36. Plagiolepis alluaudi Forel | | | | | | |
| = <i>Plagiolepis mactavishi</i> Wheeler | 2 | 2 | 2 | 3 | 3 | 14 |
| Description: Similar to the description for <i>P. exigua</i> but separated by having antennal scapes exceeding the occipital corner by at least the length of the 1st 2 funicular segments combined. This is the smallest ant found in Hawaii. | | | | | | |

Ant Species Distribution

| | | | | | | |
|--|------|---------|-------|-----|-------|--------|
| | Oahu | Molokai | Kauai | Mau | Lanai | Hawaii |
|--|------|---------|-------|-----|-------|--------|

Ecology: Very abundant, widespread, and nesting in many varied habitats, both ground inhabiting and arboreal.

37. **Brachymyrmex obscurior** Forel

= *Brachymyrmex heeri* variety

aphidicola Forel 2

Description: A small, robust, brown ant, similar to *Plagiolepis* but having 9-segmented antennae.

Ecology: Collected only once by Lyons from orchid baskets in Honolulu, probably never became established in the Hawaiian Islands.

38. **Camponotus variegatus** (Fr. Smith)

= *Camponotus maculatis mitis var hawaiiensis*

= *Camponotus variegatus hawaiiensis*

Forel (Carpenter Ant) 1 2 3 2 3 2

Description: A large, polymorphic, yellow to yellowish-red ant. Head and mesonoma yellowish, abdomen yellowish with subtriangular medium to dark areas on posterior edges of the dorsum of each abdominal segment. This is the largest ant found in the Hawaiian Islands. (7.5 mm, soldiers 11.0 mm)

Ecology: Mostly restricted to drier areas, although occasionally found in houses in areas of over 40 inches of rainfall. Nests under rocks, trash and in dead tree branches. Nocturnal; only an occasional specimen seen during daylight hours. Frequent household pest.

39. **Anoplolepis longipes** (Jerdon) 8 9

Description: Medium large, monomorphic, yellow to reddish-yellow ant with a long slender body, long antennae and almost total lack of standing hairs on the dorsum of the thorax. Abdomen often darker than head and thorax. Extremely active and fast moving. (4.0 mm)

Ecology: A recent immigrant that appears to be extending its range on Oahu. Found very abundantly in dry areas, along edges of gullies in the central plateau and in one area on the windward side, mauka of Kaneohe.

40. **Paratrechina (P.) longicornis**

(Latreille) 1 1 2 2 14 1

Description: Robust, dark brown to black, fast moving ant, very small petiolar node. Seventh abdominal segment with cone shaped orifice. Antennal scapes with erect hair and shorter than 1.5 times the length of the head and closed mandibles. Thorax with numerous irregularly arranged standing hairs. Head width usually greater than 0.65 mm. (2.6 mm).

Ecology: Abundant to common in many different habitats. Nesting

| | Ant Species Distribution | | | | | |
|--|--------------------------|---------|-------|------|-------|--------|
| | Oahu | Molokai | Kauai | Maui | Lanai | Hawaii |

under rocks, in dead limbs and stalks, etc. Predaceous, also attending homopterous insects. Often observed feeding at extrafoliar nectaries of many plants.

41. **Paratrechina** (Nylanderia)**bourbonica** (Forel)

| | | | | | |
|---|---|---|---|----|---|
| 1 | 1 | 2 | 2 | 14 | 1 |
|---|---|---|---|----|---|

Description: Robust, dark brown to black, fast-moving ant, very small petiolar node. 7th abdominal segment with cone-shaped orifice. Antennal scapes with erect hair and shorter than 1.5 times the length of the head and closed mandibles. Thorax with numerous irregularly arranged standing hairs. Head width usually greater than 0.65 mm. (2.6 mm)

Ecology: Abundant to common in many different habitats. Nesting under rocks, in dead limbs and stalks, etc. Predaceous, also attending homopterous insects. Often observed feeding at extra-foliar nectaries of many plants.

42. **Paratrechina** (Nylanderia) **vaga**(Forel) = *Paratrechina sharpi*

Wheeler

| | | | | |
|---|----|----|----|----|
| 1 | 14 | 14 | 14 | 14 |
|---|----|----|----|----|

Description: Very similar to *P. bourbonica* in certain habitats, usually distinguished by being lighter in color with abdomen darker than the thorax, smaller (head width 0.45–0.62 mm) and having fewer, more regularly placed standing hairs on the thorax. (2.2 mm)

Ecology: Occurs sympatrically with *P. bourbonica* in many habitats, almost as widely distributed with apparently favoring the same ecological conditions.

1. Forel 1899
2. Wheeler 1934
3. Phillips 1934
4. PHEs XI (1): 108
5. PHEs XII (2): 223
6. PHEs XII (3): 639
7. PHEs XIV (2): 222

8. PHEs XV (1): 10
9. PHEs XV (3): 387
10. PHEs XVI (2): 183
11. PHEs XVI (2): 185
12. PHEs XVII (3): 328
13. Wilson & Taylor 1967
14. New records reported in this paper

SPECIES ASSOCIATIONS

Because of the possibility of many artificial sympatric associations being unique to the Hawaiian Islands, preliminary studies were conducted to enumerate these associations. Ant species were considered to be associated if both species were collected in a restricted area where their ranges could be clearly seen to overlap. The only species association that was clearly antagonistic was *Pheidole megacephala* and *Iridomyrmex humilis* in which very

clear lines of demarcation were always present.

Collection areas were generally restricted to a radius of 10 yards or less. Data from all collection sites have been used, consisting of cultivated fields, uncultivated areas, residential areas, public parks and junctions between these areas. Time did not permit a careful study of the nature of the interaction; thus, only the presence of the two species is reported.

A total of 595 species associations are possible when the 6 species not collected and the 1 species of *Solenopsis* that was collected only once are excluded. Of this number, 383 associations have been observed. This represents 64.4% of the maximum possible number. A large % of the associations not observed can be attributed to the cryptic habits of 1 or both of the species (145 or 24.4%). There is no doubt that more concentrated collecting, especially with the Berlese funnel or similar apparatus would reduce this number greatly. A few of the possible associations may not occur because of the restricted distribution of the species however, it appears that this factor will account for only a small percentage of the interactions. These data are presented in a complete matrix of 1190 interactions for ease in reading the chart (Table 2).

HABITAT PREFERENCE STUDIES

Ripperton and Hosaka (1942) characterized the vegetative zones of Hawaii on the same 3 factors that appear to be of major importance in ant distribution: rainfall, altitude and vegetative species. The following 5 major vegetative zones are recognized:

1. Zone A. Sea level to 1,000 ft elevation. Rainfall 20 inches or less. Xerophytic shrub with coastal fringe of trees.
2. Zone B. Sea level to 3,000 ft elevation. Rainfall 20-40 inches. Xerophytic shrub with some trees in upper part.
3. Zone C. Sea level to 4,000 ft. Rainfall 40-60 inches. Mixed open forest to mixed open forest and shrub in lower part.
4. Zone D. Sea level to 7,000 ft. Rainfall 60 inches or more. Open forest to shrub and closed forest in lower part.
5. Zone E. 4,000 to over 10,000 ft. Rainfall 50 inches or less. Above tree line to open forest and shrub in lower part.

Data from more than 100 collection sites were analyzed to obtain information on the preference of each species for the 5 major zones. (Table 1 and Appendix 1). Although the many limitations of these data are recognized, it has been found that these data often can be used to predict the species most likely to be found in a given area.

Collection information from all of the islands was combined for this analysis of the data. The following 4 arbitrary categories of habitat preference were used:

1. Not collected (N). The species was not collected in a given zone. The probability of it being present in that zone varies in inverse proportion to the ease with which it can be collected, the probability remaining quite high for some of the rare, cryptobiotic species.
2. Low preference (L). The species was collected in a given zone from 1 to 16% of the total number of times that it was collected in all zones.

3. Moderate preference (M). On the same basis as above, the species was present in a given zone from 17 to 33% of the times that it was collected.
4. High preference (H). The species was present in a given zone in 34% or more of the collections in which it was taken.

The categories were selected on the hypothesis that a species found frequently in each of the 4 zones (A-D) preferred by the Hawaiian ants did not have a high preference for any 1 zone while a species found more

TABLE 1. *Vegetative zone preference and number of times collected for the ant species collected during the 1966-67 study period*

| Species | Vegetation Zone | | | | | No. of times Collected |
|-------------------|-----------------|---|---|---|---|------------------------|
| | A | B | C | D | E | |
| H. opaciceps | L | L | M | H | L | 38 |
| H. punctatissima | M | M | M | M | | 15 |
| H. sinensis | N | N | H | H | | 6 |
| H. zwaluwenburgi | H | N | N | H | | 2 |
| P. swezeyi | N | N | H | N | | 1 |
| L. flacigera | L | L | H | M | | 8 |
| S. silvestrii | H | M | M | N | | 7 |
| P. fervens | N | N | N | H | | 6 |
| P. megacephala | M | M | M | L | | 64 |
| S. geminata | H | M | N | L | | 23 |
| S. "a" | N | N | H | H | | 8 |
| S. "b" | N | H | N | N | | 1 |
| M. floricola | H | M | M | M | | 20 |
| M. fossulatum | M | M | M | M | | 18 |
| M. minutum | M | N | M | M | | 11 |
| M. pharaonis | N | H | H | N | | 1 |
| M. destructor | M | M | N | N | | 4 |
| C. emeryi | H | M | M | L | | 46 |
| C. nuda | M | M | M | L | | 27 |
| C. "a" | M | M | M | M | L | 34 |
| C. wroughtoni | L | N | L | H | | 12 |
| T. guineense | M | M | M | H | | 28 |
| T. simillimum | M | M | M | M | | 35 |
| T. tonganum | N | N | M | H | | 9 |
| S. godeffroyi | N | N | L | H | | 12 |
| S. rogeri | L | N | M | H | | 24 |
| Q. emmae | N | N | H | N | | 2 |
| I. humilis | M | M | H | N | L | 13 |
| T. melenocephalum | H | L | M | M | | 25 |
| T. albipes | N | N | M | H | | 11 |
| P. alluaudi | M | M | M | M | | 42 |
| C. variegatus | H | M | L | N | | 12 |
| A. longipes | H | M | L | N | | 18 |
| P. longicornis | H | L | L | L | | 18 |
| P. bourbonica | M | N | H | M | | 33 |
| P. vaga | M | L | H | M | | 29 |

APPENDIX I. Results of ant collections arranged by location, date, vegetative

| DATE | LOCATION | VEGETATIVE ZONE | UTM GRID | H. opaciceps | H. punctatissima | H. sinensis | H. zwaluwburgi | P. swezeyi | A. zwaluwburgi | L. falcigera |
|-----------------------|-------------------------------------|-----------------|--------------|--------------|------------------|-------------|----------------|------------|----------------|--------------|
| <i>ISLAND OF OAHU</i> | | | | | | | | | | |
| May 10 | Ewa, 3000' W. of pump 10 jct RR | A | E J 91365981 | | | | | | | |
| Mar. 28 | Ewa, jct Olai St. and B.P.N.A.S. | A | E J 96305884 | | | | | | | |
| Mar. 28 | Ewa, .38 mi S pump 10 & Malakole | A | E J 90985964 | | | | | | | |
| Mar. 28 | Ewa, 500' S Malakole & new rt 90 | A | E J 91466074 | | | | | | | |
| Oct. 6 | Makakilo, rt 90 at entrance | A | E J 91486084 | | | | | | | |
| May 10 | Rt 90 3000' W of Malakole Rd | A | E J 90546104 | | | | | | | |
| May 10 | 500' S 1000' E Kolaeloa & pump 10 | A | E J 94325918 | | | | | | | |
| May 10 | Ewa pump 10 makai across rd | A | E J 92305979 | | | | | | | |
| May 10 | Ewa, around pump 10 | A | E J 92305980 | | | | | | | |
| May 10 | Ewa gauge 726 across RR in gully | A | E J 90546060 | | | | | | | |
| May 10 | Ewa gauge 726 | A | E J 90546062 | | | | | | | |
| Nov. 6 | Diamond Head Rd E of lighthouse | A | E J 23485132 | | | | | | | |
| May 16 | Ewa pump 10 rd near rt 90 | A | E J 90546104 | | | | | | | |
| May 16 | Ewa pump 10 rd 1/4 mi. from rt 90 | A | E J 90186104 | | | | | | | |
| May 16 | Ewa pump 10 rd 3/8 mi from rt 90 | A | E J 90386094 | | | | | | | |
| May 16 | Ewa pump 10 rd 1/2 mi from rt 90 | A | E J 90406085 | | | | | | | |
| May 16 | Ewa 200' off pump 10 rd gauge 726 | A | E J 90506078 | | | | | | | |
| May 16 | Ewa 1000' off pump 10 rd gauge 726 | A | E J 90606093 | | | | | | | |
| May 16 | Ewa Malakole & rd N of pump 10 rd | A | E J 91326046 | | | | | | | |
| June 19 | Ewa jct pump 10 & Malakole Rd | A | E J 91076008 | | | | | | | |
| June 19 | Ewa, houses N of pump 10 | A | E J 92246038 | | | | | | | |
| May 13 | Queens Surf Beach Ewa of bath house | B | F J 21925272 | | | | | | | |
| June 23 | Pineapple field N of Crestview | B | F J 04006818 | | | | | | | |
| June 23 | Panakaui Gulch .5 mi N Crestview | B | F J 04106897 | | | | | | | |
| June 23 | .5 mi makai Kam Hwy on Mahoe | B | F J 02846812 | | | | | | | |
| June 23 | Water tank Mahoe .5 mi N Waipahu | B | F J 02926702 | | | | | | | |
| June 23 | E end of Waipahu St. W of jct | B | F J 04186653 | | | | | | | |
| June 30 | Dole field 4109, near old Res. 36 | B | F J 03587094 | | | | | | | |
| June 30 | Dole field 4109, by mango tree | B | F J 03767118 | | | | | | | |
| June 28 | Foster Gardens | B | F J 18205800 | | | | | | | |
| June 28 | Keawe & Ilalo St. Honolulu | B | F J 17585587 | | | | | | | |
| Oct. 6 | Waipahu | B | F J 03006600 | | | | | | | |
| Oct. 27 | Kalihi | B | F J 17026070 | | | | | | | |
| Oct. 27 | Sand Island Keehi side | B | F J 15425623 | | | | | | | |
| Oct. 6 | Waipahu, Field 405 near rd. | B | F J 03006650 | | | | | | | |
| Oct. 28 | Waialua | B | F J 92188652 | | | | | | | |
| Oct. 30 | Aina Haina, cement water tank | B | F J 29095569 | | | | | | | |

APPENDIX I.

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|---|----------------|----|---|
| Oct. 25 U. of H. campus | C F J 22305610 | | |
| May 12 Waimanalo Exp. Sta. Hdq. | C F J 33396020 | + | + |
| May 12 Waimanalo W of Dairy Farm | C F J 30526100 | + | + |
| Nov. 2 Kahuku Camp B | C F J 05059744 | | + |
| Mar. 30 Haleiwa, Pupukea Rd. | C E J 96929454 | | |
| June 30 Wahiawa, Calif. & hill makai | C F J 0278 | | |
| June 30 Wahiawa, end of Leilehua St. | C F J 0278 | | |
| June 20 Waimanalo water tank S Exp. Sta. | C F J 34065988 | + | |
| June 20 Waimanalo 41-740 Kaulukanu St. | C F J 31505980 | | |
| June 22 Kaneohe Kulukeve & Kahekili Hway. | C F J 23226846 | | |
| June 22 Kaneohe Keaokola & Kahekili Hwy. | C F J 23326824 | | |
| July 1 Waimanalo, NW of Dairy by cane | C F J 30526100 | + | + |
| Sept. 30 Manoa falls trail | D F J 24025986 | | |
| Oct. 22 1800' Tantalus | D F J 22766030 | | |
| Nov. 22 Makai end of Manoa falls trail | D F J 24015986 | + | |
| Nov. 8 Poamoho foot trail ca. 2000' | D F J 10338182 | | |
| Nov. 4 Summit of Mt. Kaala | D E J 88607888 | | + |
| Nov. 4 Mt. Kaala 2800' | D E J 8979 | | |
| Nov. 4 Mt. Kaala 2700' | D E J 8979 | | |
| June 30 Wahiawa edge of forest Calif. St. | D F J 03907921 | | |
| June 16 Manoa Cliff trail | D F J 22225984 | + | + |
| June 15 Makai end of Roundtop Dr. | D F J 21055740 | | + |
| June 20 Waimanalo Ahiki & Waikupanoka | D F J 33175978 | + | + |
| June 20 Waimanalo W end Kaulukanu St. | D F J 31485960 | + | + |
| June 20 Waimanalo Bridge W Kaulukanu St. | D F J 31605980 | + | |
| June 22 Kaneohe Mauka end of Haiku Rd. | D F J 21766820 | + | |
| June 20 Mt. Kaala summit | D E J 88607888 | | + |
| June 26 Kolekole Pass | D E J 91587532 | + | |
| <i>ISLAND OF LANAI</i> | | | |
| July 20 1.5 mi W of BM 1252 on Rt. 441 | A GH157971 | | |
| July 20 1 mi W of BM 1252 on Rt. 441 | A GH164962 | | + |
| July 20 .5 mi W of BM 1252 on Rt. 441 | A GH170982 | + | |
| Jan. 29 Makaiwa | A G J 282036 | | |
| Jan. 29 East Lanai jeep trail above Naha | A GH954990 | | + |
| Jan. 29 Kaumalapau Harbor | A G J 090002 | | |
| Jan. 29 Puualealea | B G J 156070 | | |
| Jan. 29 Lanai City | C G J 162048 | | |
| Jan. 29 Cemetery area | C G J 166056 | | + |
| July 20 Fallow field Mauka of Lanai City | C G J 170044 | | + |
| July 20 Munro trail | C G J 180060 | | + |
| July 20 Munro trail | C G J 192060 | ++ | + |
| <i>ISLAND OF KAUAI</i> | | | |
| July 13 2 mi Mauka of Barking Sands | A DK218389 | | |
| July 13 1.5 mi Mauka of Barking Sands | A DK214388 | | |
| July 13 Polihale Beach | A DK226446 | | |
| July 13 Radio Sta. 3/4 mi Mana of Kekaha | A DK252300 | | |

APPENDIX I.

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| July 13 Pump E of Kekaha | A | DK274290 | | |
| July 13 Puolo Point Rt. 543 | A | DK316220 | | |
| Jan. 17 Hanapepe Lookout | B | DK400240 | | |
| Jan. 17 Hanapepe Town | B | DK394234 | | |
| Jan. 17 Waimea Canyon Lookout | B | DK310424 | | |
| Jan. 17 Waimea Canyon & Kokee Rd. jct. | B | DK306424 | + | |
| Jan. 17 .5 mi W jct. 52 & 50 | B | DK508278 | | |
| Jan. 18 Kapaa Beach | B | DK666426 | | |
| Jan. 18 Wailua River | C | DK646386 | | |
| Jan. 17 Kokee Park Hdq. | C | DK320480 | | |
| Jan. 17 Kokee Park Kawaikaini | C | DK335462 | + | |
| Jan. 17 Kokee Kumuwela Lookout | C | DK340500 | | |
| Jan. 18 Puhi 2.5 mi W | C | DK572292 | | |
| Jan. 18 Wailua River mauka Exp. Sta. Paved | C | DK572386 | + | |
| July 13 1.5 mi makai of Wailua Falls | C | DK595356 | | + |
| July 14 2 mi E of Kalaeua Rt. 56 | C | DK616558 | | + |
| July 14 Waipahee Falls | C | DK615478 | + | |
| July 13 4.3 mi W jct. 50 & 501, stream | D | DK508278 | | |
| July 14 Hanalei Bay | D | DK466556 | + | |
| July 14 Mauka of bridge E of Hanalei | D | DK490560 | + | |
| Jan. 18 Jeep trail mauka Wailua Exp. Sta. | D | DK562416 | + | |
| <i>ISLAND OF MAUI</i> | | | | |
| Feb. 2 Maalae Bay | A | GJ584040 | | |
| Feb. 2 2 mi N Lahaina | A | GJ404132 | | + |
| Feb. 3 1 mi S end of paved Hwy. 31 | A | GH660902 | | |
| Feb. 3 Maalae Bay jct 31 & 35 | A | GJ638008 | | |
| Feb. 3 Kalama Beach Park | A | GH650950 | | |
| Feb. 2 Honokahau | B | GJ435246 | | |
| Feb. 4 11.3 mi Hana of Ulupalakua | B | GH866830 | | |
| Feb. 4 Between Makena & Ulupalakua | B | GH678858 | ? | |
| Feb. 2 1 mi Wailuku of Iao Needle | C | GJ560116 | | |
| Feb. 2 Wailuku Heights | C | GJ580104 | | |
| Feb. 2 Kahakuloa | C | GJ526258 | | |
| Feb. 3 .5 mi Hana of Ulupalakua | C | GH710852 | | |
| Feb. 2 Kaupo | C | GH994850 | | |
| Feb. 3 Makawao | C | GJ796087 | + | |
| Feb. 3 Haiku | C | GJ784155 | | |
| Feb. 2 Iao Needle Park | D | GJ550114 | + | |
| Feb. 4 Rt. 36 mauka of airport | D | GJ674122 | | |
| Feb. 3 Wailua Village | D | GJ980080 | | + |
| Feb. 3 Hosmers Grove | E | GH848986 | | |
| Feb. 3 Haleakala Rd. ca. 5000' | E | GH824982 | + | |
| <i>ISLAND OF HAWAII</i> | | | | |
| June 5 Hapuna | A | KC040134 | | |
| June 5 Hapuna ca. 200' | A | KC050140 | + | |
| June 5 Puako | A | KC024110 | | |

APPENDIX I.

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| June 5 Rt. 26 2000' | B | K C 148170 | + | |
| Dec. 29 Kahaluu Beach Park | B | J B 884684 | | |
| Dec. 29 Kailua Kona | B | J B 854750 | | |
| Dec. 29 U. of H. Exp. Sta., Kona | B | J B 934608 | | |
| Dec. 29 Pahala | B | K B 390244 | + | |
| Dec. 29 City of Refuge | B | J B 946492 | | |
| June 7 Naulu Picnic Area, Vol. Nat'l. Park | C | K B 756392 | | |
| Dec. 27 Akaka Falls | D | K B 744972 | | |
| Dec. 27 Keaau Orchard | D | K B 864738 | | |
| Dec. 27 Meadowgold Plant, Hilo | D | K B 818822 | | |
| Dec. 27 Lava Tree State Park | D | K B 998590 | | |
| Dec. 27 Rainbow Falls | D | K B 776812 | | |
| Dec. 28 Eye of the Eel Crater | D | K B 690430 | | |
| June 8 Rainbow Falls | D | K B 776812 | | |
| June 7 1 mi SE of Keaau on Rt. 11 | D | K B 846700 | | |
| June 7 13 mi SE of Hilo on Rt. 11 | D | K B 794646 | + | |
| June 7 17 mi SE of Hilo on Rt. 11 | D | K B 752600 | + | ++ |
| June 7 18.5 mi SE of Hilo on Rt. 11 | D | K B 746576 | + | |
| June 7 23 mi SE of Hilo on Rt. 11 | D | K B 702525 | + | |
| June 6 2.5 mi on Kahakai off Rt. 13 N Pahoa | D | K B 924652 | + | |
| June 6 1 mi S Keaau on Rt. 13 | D | K B 868699 | | |
| June 6 1.5 mi S Keaau on Rt. 13 | D | K B 870697 | + | |
| June 6 2 mi S of Keaau on Rt. 13 | D | K B 878692 | | |
| June 6 2 mi S of Pahoa on Rt. 13 | D | K B 956568 | + | |
| June 6 Olaa | D | K E 860710 | + | |
| June 8 Kipuka ki Fire Cache Vol. Nat'l. Park | E | K B 574514 | | |
| June 8 Mauna Loa Strip Rd. 5000' | E | K B 556514 | + | |
| June 8 Mauna Loa Strip Rd. 4100' | E | K B 534544 | | |
| <i>ISLAND OF MOLOKAI</i> | | | | |
| July 18 Kaunakakai City Park | A | G J 054338 | | |
| Jan. 28 Kolo Wharf | A | F J 880338 | | |
| Jan. 28 Moku | A | G J 130316 | | |
| Jan. 28 Waialua 4 mi Halawa Bay side | B | G J 354384 | | |
| July 18 Forest Camp Rd. approx. 1000' | B | G J 066384 | | |
| July 18 Beach Halawa Valley | C | G J 346427 | + | |
| July 18 Old Church Halawa Valley | C | G J 346427 | + | + |
| July 18 1 mi up Halawa Valley | C | G J 336427 | + | |
| July 18 Stream Halawa of Murphy Ranch | C | G J 350402 | + | |
| Jan. 28 Waialua Sandy Beach | C | G J 326350 | | |
| Jan. 28 Halawa Bay | C | G J 340427 | + | |
| Jan. 28 Smith and Bronte Landing Site | C | G J 230306 | | |
| July 18 Mauka of Forest Camp | D | G J 090394 | | |
| July 18 Water Res. mauka of Forest Camp | D | G J 118399 | + | |
| Jan. 28 Phallic Rock area | D | G J 070432 | + | |
| July 18 .5 mi up Halawa Valley | C | G J 340427 | | |

than 1/3rd of the time in a given zone could not have equal preference for zones A, B, C, and D, and thus did have a high preference for 1 or 2 of the zones. The validity of these data thus increases with the ease with which a species can be found. The total number of times the species was collected is given in the last column of Table 2. These data are based on the following number of collections from all of the 6 main accessible islands: (1) Zone A 44 collections (2) Zone B 32 collections (3) Zone C 34 collections (4) Zone D 44 collections and (5) Zone E 2 collections.

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