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ANTS (HYMENOPTERA, FORMICIDAE) OF FLOREANA: LOST PARADISE?

By: Boris Pezzatti, Trimurti Irzan, and Daniel Cherix

INTRODUCTION

Ecological impacts of introduced mammals and plants on the endemic fauna and flora of Galápagos is an important problem that has been relatively well documented (e.g., Hoeck 1984, Hamann 1991, 1994). However, little is known about the impact of introduced arthropods (Baert 1994, Meier 1994). Especially among ants, so-called "tramp" species have been readily transported by humans. Due to their biological characteristics, these "tramp" species become rapidly established and can spread out easily. Although small in size, ants are among the most widespread and destructive invading species. Introduced into a new area, they become real pests and can either displace or eliminate native ant species or other arthropods, like the imported fire ants *Solenopsis invicta* Buren in the United States (see, e.g., Vinson 1994). One of the most recent introductions, with far-reaching consequences for the Galápagos ecosystem, is the little red fire ant, *Wasmannia auropunctata* (Roger) (Lubin 1984).

In the late 19th and early 20th centuries, several papers on ants were published based on material collected during early expeditions to the Galápagos Islands (Smith 1877, Emery 1893, Wheeler, 1919, 1924, 1933, Stitz 1932). No further studies on ants were published until 1972, when problems caused by the introduction of *W. auropunctata* arose (Silberglied 1972). Although a number of studies have been conducted, particularly on *W. auropunctata* and its control (Clark *et al.* 1982, Lubin 1984, 1985, Meier 1994, Ulloa-Chacón and Cherix 1990, 1994), the resulting knowledge is still considered fragmentary (Brandão and Paiva 1994).

The aim of this study was to determine patterns of distribution of the ant fauna on the island of Floreana, with special attention to introduced ants. For this purpose, species richness, abundance, and frequency of the ant fauna were studied (Pezzatti, Irzan, and Cherix, in prep.). In addition, different collecting methods were compared as a first step in the development of standardized methods for further investigation of ants on the Galápagos Islands (Irzan and Pezzatti 1997).

Floreana Island was selected for this research because both old (Wheeler 1919, 1924, 1933) and more recent data (Lubin 1984) on ant fauna were available. Moreover, the history of Floreana and its present situation made it an interesting study site. The early colonization and introduction of plants and animals have had an important influence on the native fauna and flora, and we supposed that the ant fauna would have been similarly affected.

MATERIAL AND METHODS

Study Site

The vegetation zones, originally described by Wiggins and Porter (1971) are partly represented on Floreana. The littoral zone and the transition zone are very reduced on the lee side of the island, i.e., on the northern and western slope (Dr. Alan Tye [Head, Department of Plants and Invertebrates of the Charles Darwin Research Station (CDRS)], Iván Aldaz [Botanist, CDRS], pers. comm.; pers. obs.).

In the humid highlands of Floreana, two different "sub-zones" of the *Scalesia* zone can be distinguished: one area

which is more or less typical of *Scalesia* zones, with *Scalesia pedunculata* as the main element, and a second one, where *Scalesia pedunculata* is absent and the tree layer is dominated by *Zanthoxylum fagara*. However, pristine zones hardly exist on Floreana nowadays (Hamann 1981; pers. obs.). In the humid zone, it was virtually impossible to find natural areas without guava trees, citrus trees, or the shrub *Lantana camara* (pers. obs.).

To study the ant fauna of Floreana, eight representative sampling sites were chosen (Figure 1). In order to allow a comparison between inhabited and natural zones of the island, four sites were situated on human-impacted territories and four corresponding ones in the natural zone.

The transect of the human-impacted sampling sites (A1-A4) lay on the western side of Floreana, stretching from the village Puerto Velasco Ibarra (Black Beach) on the west coast of the island to the agricultural zone in the highlands. In selecting the exact sites along this transect, the vegetation structure (herb vs. shrub and/or tree) was considered to be important because of its influence on the ant fauna. In order to collect those ants that could easily expand from the impacted to the natural areas, the hu-

man-impacted sampling sites should have a vegetation structure similar to that of the corresponding natural sites. Pastures, which are dominated by *Pennisetum pupureum*, do not have a corresponding natural vegetation structure. For this reason, they were not sampled, although they cover a large part of the cultivated area.

The natural sites (N1-N4) all lay on the northern side of Floreana. Climatic conditions there are similar to those on the western side of the island, where the human-impacted transect lay. Furthermore, the northern slope of the island is much more accessible than the southern one. The sites were situated in areas representative of their respective vegetation zones so that most characteristic species were included. Those "natural sites" are all free of direct human impact; however, the indirect influence of humans through feral donkeys, goats, and plants, originally brought to the area by humans, could not be avoided.

In addition, three more sites on the coast that were not included in the transects were sampled. These sampling sites were situated in the littoral zone on the lee side of Floreana. The vegetation is patchy. In order to make the three sites comparable, they were all chosen with
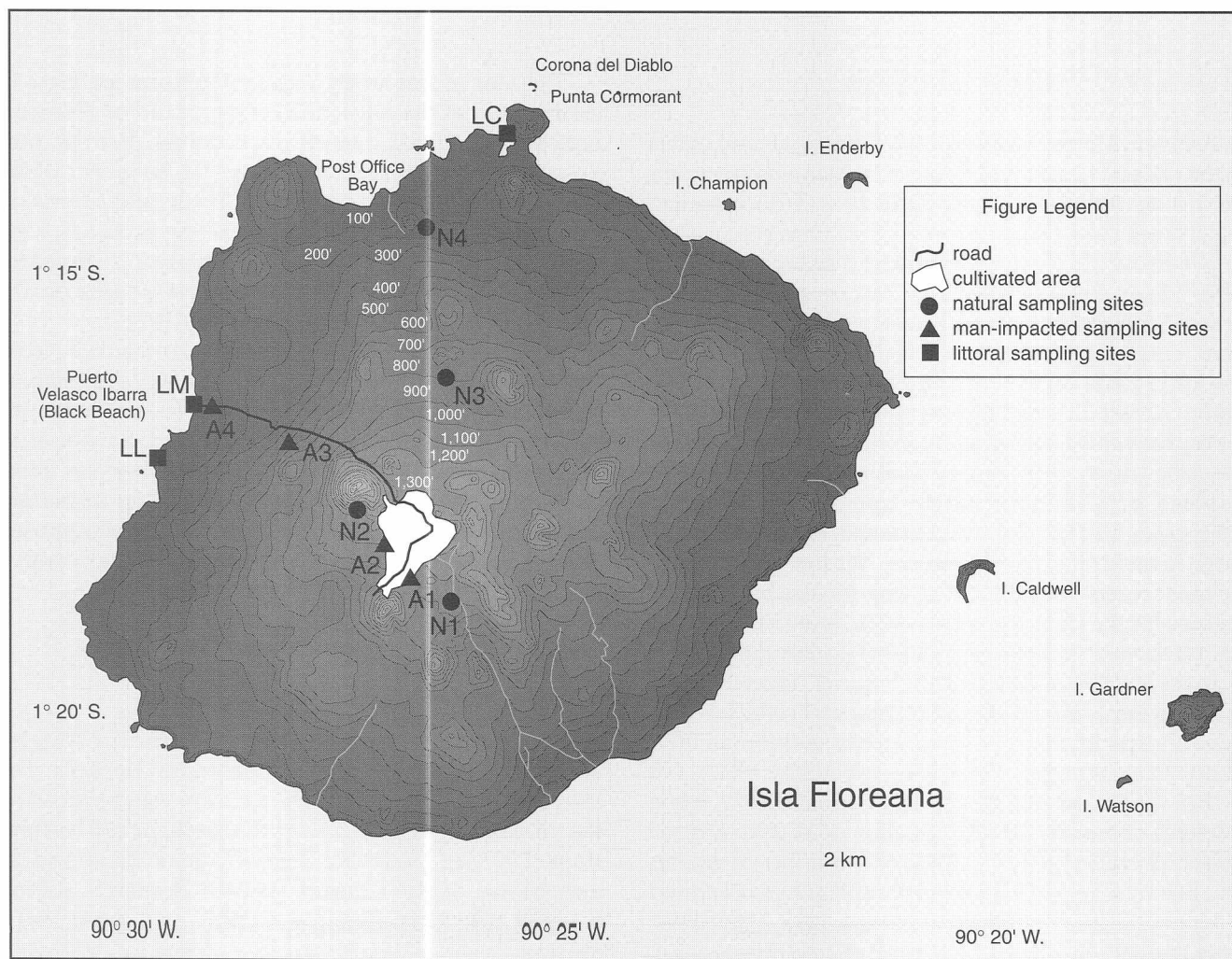

Figure 1. Map of Floreana with study sites indicated.

Cryptocarpus pyriformis as the dominant plant species in that area. One point lay in a natural zone (LL), two in human-impacted areas: one site was situated next to the dock of the village (LM) and the other (LC) lay in a tourist-impacted area (visitor site Punta Cormorant) in the north of the island (Figure 1 and Table 1).

To obtain a general picture of the ant fauna, sampling sites were chosen outside areas infested by *W.auropunctata*. According to several studies (Silberglied 1972, Clark *et al.* 1982, Lubin 1984, 1985, Meier 1994), only a few ant species can coexist with *W. auropunctata*.

Ant Collection

Field work was carried out during 8 weeks from December 1996 to the beginning of February 1997. Both qualitative and quantitative data were gathered with various methods. In addition to a general visual search, pitfall traps and baits were used. Pitfall traps consisted of plastic cups (65 mm internal diameter, 90 mm long) filled with about 50 ml of ethyl gylcol.

At each of the sites N1 to N4 and A1 to A4, three pitfall traps were placed in a triangle. The traps were left for 15 days. At sites LL, LM, and LC, pitfall traps were placed in the same way, but left for only 6 days.

We did not analyze quantitatively the number of ants collected with pitfall traps, since this can be influenced significantly by several factors and generally does not give a representative idea of abundance (see Seifert 1990).

As bait we used Eppendorf plastic vials half-filled either with a mixture of honey and water (bottled with a piece of cotton) or with tuna (in water and in oil). Both tuna in oil and tuna in water (without oil) were used, since oil can act as a repellent to some ant species.

Twenty-five numbered baiting points were laid systematically in a square of 8x8 m, each distant 2 m from one another. We sampled sites N1 to N4 and A1 to A4 twice with honey and twice with tuna to ensure reliable results. Baits were put in place between 2:00 pm and 4:00 pm and collected the following morning between 7:00 am and 9:00 am (17 h baiting time).

At sites LL, LM, and LC, the same baiting procedure was followed, but only once with carbohydrates and once with proteins.

The ants were counted for each baiting point separately.

Table 1. Description of the sampling sites, their altitude (meters above sea level), and main vegetation elements.
N: natural sampling sites   A: man-impacted sampling sites   L: littoral sampling sites

Code	Altitude m a.s.l.	Vegetation zone	Main vegetation elements	Comments
N1	300	humid	*Zanthoxylum fagara, Tournefortia rufosericea, Cordia leucophlyctis, Psidium guajava, Dichondria repens, Oxalis cornelli*	In the highlands, moist, soil well developed, herb layer existing, introduced plant species present
N2	330	humid	*Scalesia pedunculata,Croton scouleri, Cordia leucophlyctis,Capraria biflora*	Near main crater, moist, soil stony, seedlings of *S. pedunculata*, introduced plant species present
N3	215	upper arid	*Prosopis juliflora, Waltheria ovata, Clerodendrum molle*	Arid, soil sandy
N4	25	lower arid	*Prosopis juliflora, Parkinsonia aculeata, Castela galapageia, Cordia andersonii*	Arid, soil sandy with rocks
A1	335	humid	*Manhiot esculenta,* weeds	Manioc cultivation, soil well developed
A2	315	humid	*Citrus* sp., *Phyla nodiflora, Paspalum conjugatum, Kalanchoe pinnata*	Pasture with orange trees, in cultivation zone
A3	160	upper arid	*Hibiscus rosa-sinensis, Spondias purpurea, Terminalia catappa*	Garden of a private house with ornamental plants, near a spring; sole inhabited plot, surrounded by Park land
A4	10	lower arid	*Laurus nobilis, Jatropha curcas, Spondias purpurea*	Garden of a private house in the village Puerto Velasco Ibarra with ornamental plants
LL	1	littoral	*Cryptocarpus pyriformis*	South of Puerto Velasco Ibarra, gravel soil
LM	2	littoral	*Cryptocarpus pyriformis*	Close to the dock of Puerto Velasco Ibarra, domestic animals straying at night, rocky soil
LC	1	littoral	*Cryptocarpus pyriformis*	Tourist visitor site, sandy

Identifications were based on available keys and species descriptions (references in Table 2, and in "Literature cited" with asterisk). Additionally specimens were compared with the reference collection of H. Kutter at the Museum of Zoology of Lausanne and the reference collection of A. Forel at the Museum of Natural History of Geneva, both in Switzerland.

RESULTS AND DISCUSSION

Diversity of Ants

We collected and identified 25,241 ants (1,539 in pitfall traps and 23,702 with bait). They belong to 24 species (13 genera): 3 species of Ponerinae, 16 species of Myrmicinae, 1 species of Dolichoderinae, and 4 species of Formicinae (Table 2).

Among the collected species, four are new records for the ant fauna of the Galápagos Islands: *Monomorium destructor, Quadristruma emmae, Tetramorium caldarium,* and *T. lanuginosum. T. caldarium* is probably not new, but has been previously misidentified as *T. simillimum,* because of the close resemblance of these two species. The other species may represent recent introductions.

Additionally, in comparison with data from M. Coulter and M. Alvarez, as well as data from Y. Lubin and M. Alvarez (unpublished), four species are recorded for the first time on Floreana: *Strumigenys louisianae, Pheidole* spp. A and B, and one *Hypoponera* sp.

Paratrechina guatemalensis ssp. *itinerans* (Forel), *Cylindromyrmex striatus* Mayr, and *Monomorium pharaonis* (Linnaeus) were found on Floreana in previous works (respectively, Wheeler 1919, Stitz 1932, M. Coulter and M. Alvarez 1982, unpublished), but have not been encountered in this study.

The determination of species origin in Galápagos is an often discussed problem. Especially for small organisms such as ants, it is virtually impossible to decide whether or not a species arrived by natural means. We propose here a classification, considering the origin, in the case of tramp species, or the distribution for the other species.

Therefore we defined the following categories (see Table 2):

- Endemic (E);
- Native (N);
- Possibly Native (N/I): species which could have reached the Galápagos by natural means (originated from the Americas or distributed in the Americas);
- Old Introductions (OI): other species, which were already recorded for Galápagos by early collectors;
- Recent Introductions (RI): remaining species, which were only recorded in recent papers (Clark *et al.* 1982, Lubin 1984), and the present study.

The origins of most tramp species, as indicated in the literature, are only presumed. As already mentioned by Brandão and Paiva (1994), more detailed information

about the tramp ant species, in particular about their true origin, is needed to be able to classify them correctly.

Considering this characterization, the ant fauna of Floreana is mainly composed of introduced species. Among the 24 ant species encountered on Floreana, only two are endemic (*Camponotus macilentus* and *C. planus*) and only one is definitely native (*Solenopsis globularia* subsp. *pacifica* is native at the subspecies level). Most of the remaining are common tramp species, i.e., well-known pest ants which have been spread by commerce throughout the world (Hölldobler and Wilson 1990). Due to their sometimes extremely small size and their privileged relationship with the human environment (Passera 1994), these species are very easily transported unnoticed, and some of them probably arrived in Galápagos on ships of buccaneers, whalers, and early settlers. Some important characteristics allow tramp species to establish and disperse (Brandão and Paiva 1994, Hölldobler and Wilson 1990, Passera 1994):

- polygyny and high capacity to produce and rear new queens;
- unicoloniality and related low levels, or absence, of intraspecific aggression;
- generalism in feeding (omnivorous) and nest site preferences;
- tendency to move, permitting establishment in very unstable, human-made habitats, such as villages or cultivated areas;
- absence of nuptial flight for most of the time;
- interspecific aggression in some of the species, e.g., *W. auropunctata*;
- small size.

Patterns of Distribution and Displacement

The first important result of this study is the evidence showing that, on Floreana, introduced species (especially the earliest introductions) are by no means restricted to human-impacted zones, but have spread over the whole island into natural areas (Table 3). We found 16 species in the natural sampling sites (N1-N4), and 17 in the human-impacted ones (A1-A4). Adding the sampling sites in the littoral zone and the species found outside sampling sites, we collected a total of 17 species in the natural zone. The human-impacted zone seems to have a somewhat higher species richness, since we found 23 species there.

On the one hand, the biological characteristics of tramp species make them successful competitors of native ant species. On the other hand, the probable existence of empty niches may also facilitate the progression of these species into natural zones. Indeed, the extremely poor native ant fauna (three to seven species) leads to the hypothesis that the ant community was far from being saturated and several potential niches were not yet occupied by any ant species. This has certainly facilitated the colonization and establishment of introduced ants on the islands.

Table 2. Ant species found on Floreana during this study.

A Species recorded on Floreana by early collectors. Based on works of Smith (1883), Emery (1893), Wheeler (1919, 1924, 1933), and Stitz (1932).
B Species recorded on Floreana in recent works. Based on unpublished data of M. Coulter and M. Alvarez (1982) and Y. Lubin and M. Alvarez (1983), which were kindly made available from Y. Lubin.
C New for Galápagos (this study)
D Status in Galápagos. E = Endemic; N = Native; N/I = Possibly native; OI = Old introduction; RI = Recent introduction.
E Cosmopolitan tramp species. Some authors give a different distribution (cosmopolitan vs. pantropical) for these tramp species.
F Pantropical tramp species
G Mean body length of workers. Size classes: I < 2.5 mm; II 2.5-4 mm; III > 4 mm.

Ant species	A	B	C	D	E	F	Probable origin (only for tramp species)	G
Hypoponera sp. A[1]		(x)		?				II
Hypoponera sp. B				?				II
Odontomachus bauri Emery[2]	x	x		N/I				III
Cardiocondyla emeryi Forel		x		RI		•*	Africa (Wilson and Taylor 1967)	I
Cardiocondyla nuda (Mayr)		x		RI		•*	Africa (Wilson and Taylor 1967)	I
Monomorium destructor (Jerdon)			•	RI		•*	India (Bolton 1987) Africa (Wilson and Taylor 1967)	II
Monomorium floricola (Jerdon)	x	x		OI		•*	Tropical Asia (Emeryi 1921 in Wilson and Taylor 1967)	I
Pheidole sp. A[3]				?				II
Pheidole sp. B				?				I
Quadristruma emmae (Emery)			•	RI		•	Afrotropical region (Bolton 1983)	I
Solenopsis geminata (Fabricius)	x	x		N/I	•**		North to South America (Trager 1991)	II
Solenopsis globularia (F. Smith) subsp. *pacifica* W. M. Wheeler		x		N				I
Solenopsis sp.[4]		(x)		?				I
Strumigenys louisianae Roger[5]				N/I				I
Tetramorium bicarinatum (Nylander)		x		OI	•		South East Asia (Bolton 1979)	II
Tetramorium caldarium (Roger)			•[6]	OI	•		Africa (Bolton 1979)	I
Tetramorium lanuginosum Mayr			•	RI	•		Asia (Bolton 1976)	II
Tetramorium simillimum (F. Smith)	x	x		OI	•		Africa (Bolton 1979)	I
Wasmannia auropunctata (Roger)		x		RI	•*		American Tropics (Ulloa-Chacón and Cherix 1990)	I
Tapinoma melanocephalum (Fabricius)		x		OI		•*	Unknown (Wilson and Taylor 1967) African or Oriental origin (Smith 1965)	I
Camponotus macilentus F. Smith	x	x		E				III
Camponotus planus F. Smith	x	x		E				III
Paratrechina longicornis (Latreille)	x	x		OI		•*	Old World Tropics (Wilson and Taylor 1967)	II
Paratrechina sp.[7]		(x)		?				II

[*] Tramp species in strict sense, showing all typical characteristics (Passera 1994)
[**] Cited in Passera, with special mention
[1] Possibly *Hypoponera opaciceps* (Mayr)
[2] Widespread in Central and tropical South America (Brown 1976)
[3] Possibly *Pheidole williamsi* Wheeler
[4] Belongs to the subgenus *Diplorhoptrum*
[5] Widespread in the Americas (Brown 1962)
[6] Cited in Brandão and Paiva (1994), with reference to Clark *et al.* (1982), who did not publish these results
[7] Possibly *Paratrechina vaga* (Forel)

The second important result of this study is that the immigration of new ant species still continues. This could be due to the extraordinary increase in commercial exchanges and the dramatic development of tourism. In this study, four new ant species for the Archipelago have been detected, of which three, *M. destructor*, *Q. emmae*, and *T. lanuginosum*, are believed to be very recent introductions.

The present distribution of ants on Floreana cannot be described as a static state, but rather as a state of transition, meaning the current situation will probably continue to change in the following years. This means, in addition

Table 3. Distribution of ants on Floreana Island.
    • found at bait   ◊ found in pitfalls   Δ only by visual search (never in traps)

Species	N1	N2	N3	N4	A1	A2	A3	A4	ΣN	ΣA	LL	LM	LC	ΣL	Σ
Hypoponera sp. A	◊	◊			•◊	◊			◊	•◊					•◊
Hypoponera sp. B															Δ[1]
Odontomachus bauri	◊	•◊	•◊			◊	•	Δ	•◊	•◊	◊			◊	•◊
Cardiocondyla emeryi			•◊	•◊			•◊	•◊	•◊	•◊			•◊	•◊	•◊
Cardiocondyla nuda		◊			•		•◊		◊	•◊					•◊
Monomorium destructor								•◊		•◊					•◊
Monomorium floricola		•◊	•	•◊		•◊	•	◊	•◊	•◊	•◊		•◊	•◊	•◊
Pheidole sp. A												◊		◊	◊
Pheidole sp. B													Δ	Δ	Δ
Quadristruma emmae		◊							◊						◊
Solenopsis geminata	•◊	•◊			•◊	•	•	•◊	•◊	•◊			•◊	•◊	•◊
Solenopsis globularia subsp. *pacifica*			•◊	•◊				•◊	•◊	•◊	•	•◊	•◊	•◊	•◊
Solenopsis sp.	Δ	◊			•	•◊			◊	•◊	◊	•◊		•◊	•◊
Strumigenys louisianae						◊				◊					◊
Tetramorium bicarinatum						•◊				•◊		◊	•◊	•◊	•◊
Tetramorium caldarium		•◊	•◊				•◊	•◊	•◊	•◊	•			•	•◊
Tetramorium lanuginosum												◊		◊	◊
Tetramorium simillimum	•◊	•◊	•	•	•	•◊	•◊		•◊	•◊	•◊			•◊	•◊
Wasmannia auropunctata															Δ
Tapinoma melanocephalum		•◊	•◊	•	•	•	•	•◊	•	•◊	•◊	•◊	•◊	•◊	
Camponotus macilentus		•◊	•◊			◊	•◊	•◊	•◊	•◊	•◊	◊	•◊	•◊	
Camponotus planus			•◊					•◊				◊	◊	•◊	
Paratrechina longicornis		•◊					•◊	•◊	•◊	•	•◊	•◊	•◊	•◊	
Paratrechina sp.		•				•◊		•	•◊	•			•	•◊	
Species found at bait	2	7	8	7	6	7	8	8	**12**	**16**	8	6	7	**12**	17
Species found in pitfalls	4	10	6	6	2	8	5	8	**15**	**16**	6	7	9	**14**	21
Species found only visual	1							1	**1**	**1**			1	**1**	3
Total of species	5	11	8	7	6	10	9	10	**16**	**17**	10	8	10	**17**	24

[1] Found by visual search outside the sampling sites, in a sugar cane field
[2] Found by visual search outside the sampling sites, in the highlands

to distribution in space, we must consider distribution in time, and thus the possible dynamics of the introduced species.

Several aspects play a fundamental role in the interpretation of the distribution of introduced species: supposed introduction time and sites, different dispersal ways, and environmental pressure.

Supposed Introduction Time

Knowing the introduction time of a species could reveal if it had the possibility to express its ecological potential.

All tramp species collected on Floreana in early expeditions (see Tables 2 and 3), namely *Monomorium floricola*, *T. simillimum*, and *Paratrechina longicornis*, are now distributed all over the island. *Odontomachus bauri* and *Solenopsis geminata* show the same patterns (*S. geminata* is only absent in the natural arid zone).

Restricted distribution of some species may indicate a recent introduction (e.g., *M. destructor*, see below).

Supposed Introduction Sites

The presence of a species exclusively at a possible introduction site could be an indicator for a recent introduction, which has still not had the time for colonizing other areas.

This is the case of *M. destructor*, *T. lanuginosum*, and *Pheidole* sp. A, which were found only in or near the village Puerto Velasco Ibarra, where ships regularly bring all supplies. *Pheidole* sp. B was only found at Punta Cormorant, which is a highly visited tourist site .

Moreover, since many goods arriving by ship are transported directly to the highlands, it is necessary to consider this area as an additional introduction site for new species. This way of introducing new species may play a major role for those species which would not have been able to survive and establish themselves in the littoral or arid zones. Possible examples of such introductions are *S. louisianae*, *Q. emmae*, and *W. auropunctata*, which were collected in the humid zone only.

Tetramorium bicarinatum is a particularly good example for demonstrating the importance of introduction sites. It was found only at human-impacted littoral sites and in the highland cultivated zone. This is probably not dependent on environmental conditions, since it is recorded in the arid zone of other islands (Clark *et al.* 1982).

Dispersal

Once species have established themselves on the island, the question is whether or not these species will spread into adjacent areas. There are three different ways for ants to reach and colonize new areas: nuptial flight, budding, and passive transport.

By way of nuptial flight, alate sexuals normally leave the nest and mate. Afterwards mated queens can found new colonies several meters or even kilometers away, especially with the help of wind. We observed this type of dispersal by *C. macilentus* and *O. bauri*.

By budding, workers and mated queens leave the nest on foot and establish themselves few meters away. This form of spreading is slower and does not allow colonization of distant areas, but it is more thorough (Passera 1994). As indicated, several tramp species do not have a nuptial flight and disperse solely by budding (Passera 1994). Workers together with dealate females of *T. simillimum* and *Cardiocondyla emeryi* were collected with pitfall traps (*T. simillimum* with bait as well). This perhaps indicates the presence of budding behavior.

Peck (1994a, 1994b) studied aerial dispersal and sea surface transport of insects between islands in the archipelago. He collected 6 or more species belonging to the genera *Paratrechina*, *Cardiocondyla*, *Monomorium*, *Pheidole*, *Hypoponera* and *Camponotus*, either using aerial dispersal or sea-surface transport. These two modes of colonization could be of great importance for ants, especially if female sexuals (i.e., mated queens) reach a new island. A comparison of ant diversity between inhabited, visited and unvisited, and uninhabited islands will be decisive to adjust the importance of these types of colonization.

The last means of dispersal in Galápagos is passive, due to humans. Passive transport represents the only way for long-range dispersal. Humans are responsible for dispersing tramp species within Floreana, e.g., from littoral sites to humid cultivated areas in the highlands (transport of goods between these areas is quite frequent) or within a single zone, which could be the case with *W. auropunctata*. In comparison with Lubin (1985), we found another population of *W. auropunctata* in the cultivated area, probably displaced by humans (the previous population is located around the most important fresh water source of the island and transports to and from this site are frequent).

Environmental Pressure

We suppose that the extreme conditions prevailing in the arid zone (aridity and high temperatures) may be a limiting factor for some introduced species, or at least a factor which prevents them from dominating. Our observations and measurements at the sampling sites of the natural area show that the situation there is quite close to an "original natural picture," with *C. macilentus*, *C. planus*, and *S. globularia* subsp. *pacifica* as dominant species. Since their arrival to the Archipelago a long time ago, these species have had time to adapt to the harsh conditions prevailing in the arid zone.

S. geminata and *C. nuda*, which did not occur in the natural arid zone, were found in the corresponding human-impacted area, where humidity was present (e.g., sprinkling, water sources).

The lability of man-made environments could be a possible explanation for the observation that these habi-

tats were often not dominated by a single species, as in natural zones, but that several species were quite abundant. Disturbance could therefore partially be interpreted as a factor which "resets" conditions to their starting point each time, thereby preventing the best-adapted species from dominating.

Finally, fluctuating weather patterns might also be of great importance. Wet years may increase dispersal, as already shown by Lubin (1985).

Assessment of Collecting Methods

From our results, it can be seen that pitfall traps represent a valid collecting method for deriving an index of diversity, in this case species richness (but see Seifert 1990). Indeed, among the 24 ant species collected on Floreana, 21 were collected with pitfall traps. The exposure time of two weeks should not be shortened, as sometimes only a few ants were collected, with some species represented by a single specimen.

The aim of the study is to obtain a more detailed picture of the area (i.e., information on distribution, activity, and dominance of a single species), so baiting methods must be used in combination with pitfall traps. The applied methods permitted us, with a relatively small effort, to learn what is happening among ants on Floreana.

The best bait was honey, which, in spite of being less attractive than tuna in oil to most of the species, recorded the larger number of ant species. Also, time expenditure was smaller for honey, both in preparing the bait and in analyzing the collected ants.

A shorter exposure time than we used (17 hours) is recommended for future investigations. In fact, confirmed by controls, a shorter exposure time of 6 to 8 hours would still allow ants to colonize the bait, but would avoid the bait being emptied.

A division of the baiting procedure into diurnal and nocturnal parts would be worthwhile, especially in the arid zone, where dominant ant species vary from day to night. Baiting in the daytime should end at dusk, whereas bait for the nocturnal trapping should be collected well before sunrise.

The sample sites were relatively small in size, but may be representative due to a certain uniformity of the chosen natural zones. This is not necessarily true for the man-impacted sites, where the heterogeneity of the habitats was considerable. The sites were nonetheless useful for obtaining an idea of how human-made environments can influence the ant fauna.

CONCLUSION

Our investigation shows that most of the introduced ant species occupy natural zones of Floreana.

In comparison, the case of the Hawaiian Islands is a dramatic example. The ant fauna, composed entirely of alien ants, has had a devastating effect on the native ter-

restrial fauna (Reimer 1994) (directly or indirectly, by symbiotic relationship with Homoptera). *W. auropunctata* is already an example of an aggressive tramp species that was recently introduced to Galápagos and has had a big impact on the native arthropod fauna (Lubin 1984). The absence of the endemic *Camponotus planus* in Puerto Velasco Ibarra is probably the consequence of the aggressive nature of *M. destructor*, whose future development should be closely investigated.

The methods applied in this study resulted in both qualitative and quantitative data, allowing us, with relatively little effort, to obtain a reasonable picture of the processes on one island. Until now, only a few studies using comparable methods have been conducted on the insect fauna of Galápagos, and our study may be a first step in the development of standardized methods for further investigation of ants in the Galápagos Islands.

It will now be necessary to follow future developments in the ant fauna on Floreana (e.g., *M. destructor, T. lanuginosum*, and *Q. emmae*).

The next step should definitively compare other islands, inhabited as well as uninhabited ones, in order to obtain data which allow a prediction of ant population dynamics. Recent groups of arthropods may act as good indicators for predicting medium-term consequences and possible further developments of an ecosystem, since they react rapidly to small disturbances.

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SCAVENGING BEHAVIOR OF THE WAVED ALBATROSS IN GALÁPAGOS: A POTENTIAL PROBLEM WITH INCREASING LONGLINING?

By: Godfrey Merlen (reprinted from Pacific Seabirds[1])

In 1994, the population of waved albatross *(Diomedea irrorata)* was estimated at 15,000 breeding pairs (Anderson 1995a). Well over 99% of their breeding activity is confined to Española Island in the Galápagos Archipelago. By attaching satellite transmitters to breeding birds during the incubation period, Anderson (1995b) was able to show that his sample (n=5) foraged over the continental shelf off Peru. However, the present report of a census carried out later in the same year shows that scavenging near the Galápagos Archipelago may also be an important part of waved albatross feeding. The proposed introduction of new fishing techniques (longlining and squid fishing) near the islands could result in a new conservation problem in an already beleaguered archipelago.

An unpublished report by the author on the occurrence and feeding activities of the waved albatross suggested that the birds are, to a greater or lesser extent, scavengers when in the waters near the archipelago during the breeding season. An excellent opportunity to further these observations on the distribution and scavenging behavior of waved albatross came when the author was asked by David Parer and Elizabeth Parer-Cook, of the Australian Broadcasting Corporation, to accompany them on a reconnaissance trip to the western part of the archipelago, aboard the motor yacht *Samba* between 1 and 14 September 1995. We maintained a dawn-to-dusk survey on nine full days. On the other days, the *Samba* was anchored or made short journeys. Observations were made on these short trips also. The survey was carried out mainly by two observers (G. Merlen and David Day), using 8x binoculars, but additional help was provided by the crew of the *Samba*, Naturalist Guide Mauricio Garcia, and by D. Parer and E. Parer-Cook. There was an excel-

lent observation platform in the form of the flying bridge 3.5 m above sea level.

During the mostly calm weather, the distinctive white heads and necks of the waved albatross facilitated observation on the sea. Higher winds caused the birds to soar above the horizon, which aided the count in more adverse conditions. We avoided counting birds twice by only searching ahead of the boat. Whenever the boat stopped, circled, or made other maneuvers, the census was ended. The average speed of travel was 8 knots and all positions were plotted by GPS.

Where large concentrations of albatross were encountered, several counts were made by independent observers. After leaving such an area, no counts were made for half an hour. The average speed of travel was 8 knots and all positions were plotted by GPS.

Albatross in flight were usually alone, although a few to many were often in the same area. On the water small groups (1-3) were common.

By far the greatest concentrations were found where blue-footed boobies *(Sula nebouxii)* were or had recently been feeding. On one occasion, 389 albatross were closely associated with several other species in a feeding frenzy. Such activities were frequent offshore in deep water, when magnificent frigatebirds *(Fregata magnificens)*, common dolphins *(Delphinus delphis)*, blue-footed boobies, masked boobies *(Sula dactylatra)*, waved albatross, white-vented storm petrels *(Oceanites gracilis)*, wedge-rumped storm petrels *(Oceanodroma tethys)*, and Galápagos sea lions *(Zalophus californianus)* were present. Inshore (in shallower water or between the central islands) bottle-nose dolphins *(Tursiops truncatus)* may replace common dolphins. Feeding frenzies are associated with concentrations of fish, which include tunas, sardines, jacks and sharks (pers obs.).