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FINAL REPORT
FOR ANT SURVEYS ON
DEFENSE FUEL SUPPORT POINT
SAN PEDRO, CALIFORNIA

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Executive Summary

We conducted checklist surveys for ants at the Defense Fuel Support Point because of the known mutualistic associations between ants and Palos Verdes blue butterfly. These results were combined with previous surveys to describe the distribution and diversity of ants across the installation. We documented eleven species in 2007, with an additional two species previously identified. Many of these species are potentially mutualistic with Palos Verdes blue butterfly. Four key conclusions result from these observations:

- Ant diversity at DFSP is substantial for its size, isolation, and disturbance history and should be considered in management actions.
- Invasive, exotic Argentine ants (*Linepithema humile*) are found throughout the property and although they can tend Palos Verdes blue butterfly larvae, their abundance is negatively associated with native arthropod diversity.
- The carpenter ant *Camponotus semitestaceus* tends Palos Verdes blue butterfly larvae and Palos Verdes blue butterfly adults are more frequently recorded in areas where it is present than areas where it is absent. The benefits of the mutualism between these species should be further investigated.
    - Benefits of tending by ants could be investigated by field studies on the wild population by observing females laying eggs and following development of larvae. This investigation could also be conducted by enclosing plants in areas with *Camponotus semitestaceus* or *Linepithema humile* and using captive females to provide eggs. Once females have died, the enclosures would be opened to the air to provide access for predators and parasitoids and survival tracked with tending of the two different species.
- Ant surveys should continue to improve understanding of the distribution and abundance of native and exotic species and their interaction with management actions.
    - Restoration actions such as supplemental irrigation and soil disturbance are associated with increased abundance of Argentine ants. For this reason, supplemental irrigation, especially any summer irrigation, should be terminated as quickly as possible at restoration sites.

1. Introduction

The Defense Fuel Support Point ("DFSP") in San Pedro, California has a long and varied history of military land uses, but large portions of the property still retain high biological values, as shown by the presence of two federally listed species. Overall biological diversity may increase ecosystem function through the many sets of complex interactions between species (Hector and Bagchi 2007). The distribution of ants is of particular interest at DFSP because they are recognized as indicators of habitat quality (Majer 1984, Andersen and Sparling 1997) and their known mutualistic association with the federally listed Palos Verdes blue butterfly, *Glaucopsyche lygdamus palosverdesensis* (Mattoni 1994, Mattoni et al. 2003). Aside from the report from Longcore (1999) little is known of the distribution of ant species at DFSP and their co-occurrence with Palos Verdes blue butterfly. In this report we document surveys of ants at DFSP during the spring of 2006 and synthesize these results with surveys reported by Longcore (1999).

Mutalistic interactions between lycaenid larvae and ants are well known, with a variety of benefits for larvae. In this interaction, the larva secretes honeydew from glands on the abdomen, which is consumed by attending ants. Different ant species may tend different larval instars (Peterson 1995) or even different ant species at the same instar (Axen 2000). Pierce and Easteal (1986) documented that ants (*Formica altipetens*) defend larvae of *Glaucopsyche lygdamus* from parasitoids and that larvae drop off of plants where ants are excluded. Ant-tended larvae were 12 times more likely to survive to pupation than non-tended larvae (Pierce and Easteal 1986). Fiedler and Saam (1994) showed that lycaenid larvae of several species grew larger when attended by two species of *Lasius* ants in an experimental setting. Invasive argentine ants, *Linepithema humile*, tend larvae of Palos Verdes blue butterflies in outdoor cages at DFSP (Mattoni et al. 2003). Larvae tended by ants in captivity had no fungal infections, which Mattoni et al. (2003) attributed to removal of all honeydew by ants. During surveys, Pratt (pers. comm.) observed *Camponotus* sp. associated with all Palos Verdes blue butterfly larvae he located in the field at DFSP and hypothesized that that of this ant may be a limiting factor in the distribution of the butterfly. The many studies of ant-butterfly symbioses indicate that it would not be unusual if Palos Verdes blue butterflies at the least were greatly benefited by associations with tending ants (e.g., Pierce and Easteal 1986, Weeks 2003).

The purpose of this investigation is to further document the distribution of ant species at DFSP and gain taxonomic certainty for specimens reported by Longcore (1999) as morphospecies (sensu Oliver and Beattie 1996) in preparation for further studies of ant-butterfly associations in the field.

2. Methods

Snelling conducted "checklist" surveys for ants across a range of habitats at DFSP on four dates in spring 2007 (see Appendix). Ants were collected with an aspirator, stored in alcohol, identified, and deposited at the Natural History Museum of Los Angeles County. Locations for all collections were recorded on an aerial photograph.

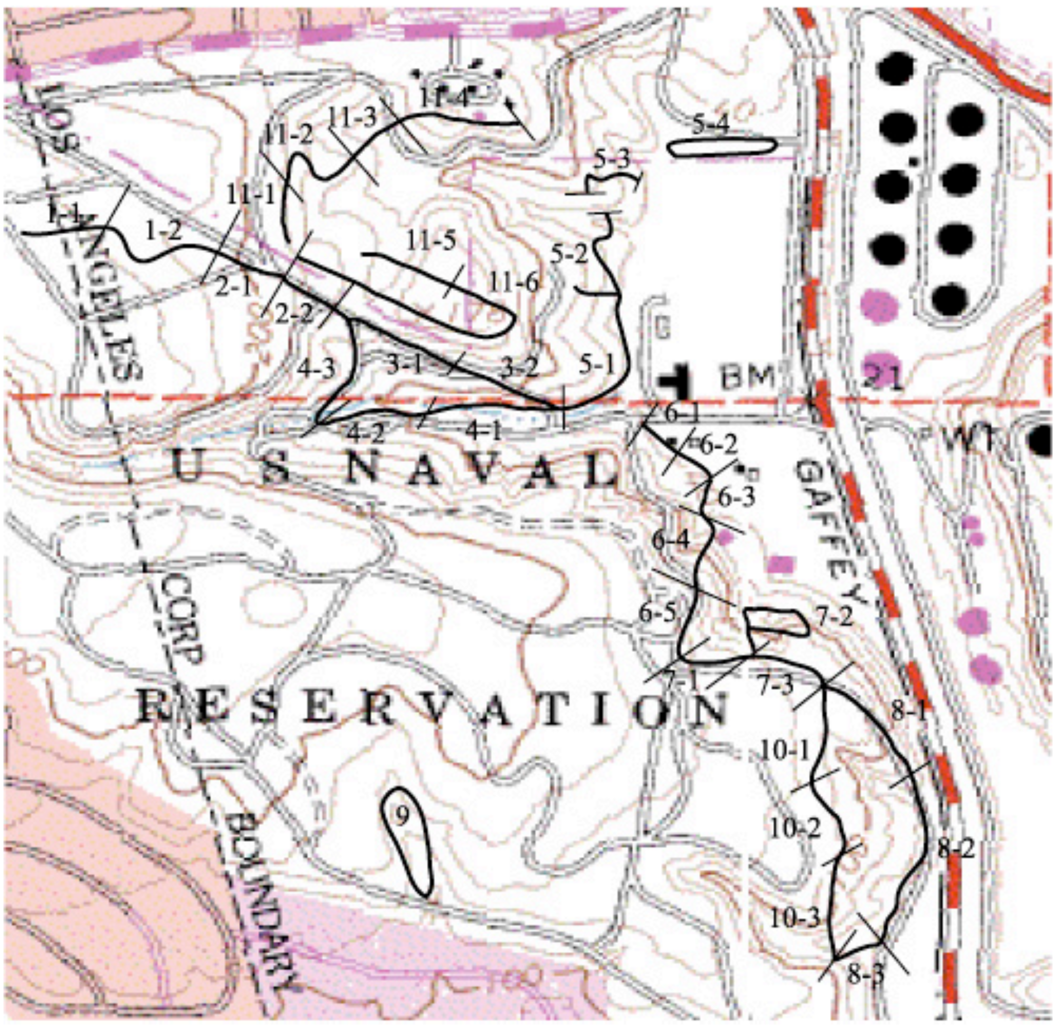

Figure 1. Location of Palos Verdes blue butterfly transect segments at DFSP (segments 1–10) and Palos Verdes housing (segment 11).

The data from DFSP reported by Longcore (1999) consisted of four years of pitfall trap collections at five locations that were directed by R. Mattoni and which were sorted and identified by R.

Rogers plus an additional year of surveys at these five locations plus a restoration site, which were collected by Longcore and sorted by R. Rogers. We retrieved the raw data for these collections for comparison with the results from the 2007 surveys but were unable to obtain the original specimens to confirm identifications.

To investigate the potential influence of ant species on butterfly distribution, we compared the percentage of years Palos Verdes blue butterflies occupied transects with and without ants of those genera found most often (see Figure 1).

3. Results

The spring 2007 surveys confirmed presence of 11 species of ants (Table 1). An additional two species were recorded by Longcore (1999) but vouchers are not available to confirm species determinations. The species, grouped by subfamily and including along with natural history information, follow below. Location of ants by transect segment is provided in Table 2.

Table 1. Ants found at DFSP and their potential to tend larvae of Palos Verdes blue butterfly, based on expert opinion (R.R. Snelling), observations (G. Pratt and J. Johnson), and Fiedler (2006).

Scientific name	*Common name*	*Status*	*Association with larvae*
Linepithema humile (Mayr)	Argentine ant	Exotic	tends larvae
Dorymyrmex bicolor Wheeler	bicolored pyramid ant	Native	possibly tends larvae
Dorymyrmex insanus (Buckley)	pyramid ant	Native	possibly tends larvae
Camponotus semitestaceus Snelling	carpenter ant	Native	tends larvae
Brachymyrmex depilis Emery	none	Native	possibly tends larvae
Prenolepis imparis (Say)	winter ant	Native	possibly tends larvae
Cardiocondyla mauritanica Forel	none	Exotic	unlikely to tend larvae
Messor andrei (Mayr)	harvester ant	Native	unlikely to tend larvae
Pheidole hyatti Emery	none	Native	unlikely to tend larvae
Pogonomyrmex californicus (Buckley)	California harvester ant	Native	unlikely to tend larvae
Solenopsis xyloni McCook	southern fire ant	Native	possibly tends larvae
Temnothorax probably *andrei* (Emery)	none	Native	possibly tends larvae
Crematogaster sp.	acrobat ant	Native	possibly tends larvae

Formicinae

Camponotus semitestaceus. Pratt (pers. comm.) has recorded this species tending Palos Verdes blue butterfly larvae. It is found throughout California at low to moderate elevations. The species is capable of displacing Argentine ants in competitive interactions at least some of the time (Human and Gordon 1996) but is far less abundant where Argentine ants are present (Human and Gordon 1997, Suarez et al. 1998).

Prenolepis imparis. Can coexist with Argentine ants (Ward 1987, Holway 1998), probably because of segregation in peak activity periods (Suarez et al. 1998). Although it has a wide distribution, it is somewhat surprising that this species persists at DFSP given its fragmented nature and the history of disturbance (R. Snelling, pers. obs.).

Brachymyrmex depilis. Possibly solicits larvae of Palos Verdes blue butterfly. Forages below ground (Suarez et al. 1998).

Dolichoderinae

Linepithema humile. The invasive Argentine ant is **a** well-known invasive pest in California. Abundance of this species is negatively correlated with diversity of native arthropods (Erickson 1971, Kennedy 1998, Suarez et al. 1998, Holway 1999, Longcore 2003). It displaces native ants and adversely affects seed mutualisms (Carney et al. 2003). Nevertheless, it may tend larvae of lycaenid butterflies and has been associated with Palos Verdes blue butterfly larvae in outdoor cages at DFSP (Mattoni et al. 2003). Some researchers have observed lycaenid larvae that seem to specialize on such invasive species (including *L. humile*), especially in the tropics, but it is unknown if the benefits of this mutualism to the larvae are equal to associations with native species (Fiedler 2006). Argentine ants are known to be egg predators (Way et al. 1992), but the potential impact of such behavior on Palos Verdes blue butterfly has not yet been investigated.

Dorymyrmex bicolor. Can persist with Argentine ants (Holway et al. 2002). Requires open, bare ground (Fisher 1997). Possibly solicits larvae of Palos Verdes blue butterfly (R. Snelling, pers. obs).

Dorymyrmex insanus. Requires open bare ground (Fisher 1997). Possibly solicits larvae of Palos Verdes blue butterfly (R. Snelling, pers. obs.). It is relatively insensitive to fragmentation and Argentine ant presence (Suarez et al. 1998).

Myrmicinae

Messor andrei. Is displaced at baits by Argentine ants about half of the time (Human and Gordon 1996) and tends not to be present with Argentine ants in surveys (Human and Gordon 1997, Suarez et al. 1998). Unlikely to solicit Palos Verdes blue butterfly larvae.

Pogonomyrmex californicus. These are harvester ants, which collect and disperse seeds (Arnett 1993). Unlikely to solicit Palos Verdes blue butterfly larvae. Very sensitive to Argentine ant presence (Suarez et al. 1998).

Pheidole hyatti. Unlikely to solicit Palos Verdes blue butterfly larvae (R. Snelling, pers. obs.) but genus can enter mutualisms with lycaenids (Fiedler 2006). The genus is moderately sensitive to habitat fragmentation (Suarez et al. 1998), but *P. hyatti* is more tolerant of disturbance and often persists in open lots in urban areas.

Crematogaster sp. Reported only by Longcore (1999). Specimens were not available for more complete identification; this species is likely to be either *C. californica* or *C. mormonum*. *C. californica* often co-occurs with *Solenopsis xyloni* (Suarez et al. 1998). Possibly tends lycaenid larvae (Fiedler 2006).

Solenopsis xyloni. These are mound-building fire ants, which can sting (Arnett 1993). Moderately sensitive to Argentine ant presence and fragmentation (Suarez et al. 1998). Possibly tends larvae of Palos Verdes blue butterfly (R. Snelling, pers. obs.).

Temnothorax probably *andrei*. Reported only by Longcore (1999**,** as *Leptothorax* sp.). Not influenced by presence of Argentine ants and tolerates fragmentation (Suarez et al. 1998). Very small ants that forage below ground (Ward 1987) or in surface litter. Not likely to tend lycaenid larvae (Fiedler 2006).

Cardiocondyla mauritanica. This very small species is introduced from Africa.

Table 2. Occurrence of ant species at Defense Fuel Support Point as reported by Longcore (1999) and in spring 2007 surveys. Reported by transect segment for Palos Verdes blue butterfly with percent of years butterflies were observed along each transect segment, 1994–2007. For Longcore records, segments without information were not surveyed. Snelling surveyed thoroughly but the dry weather in spring 2007 certainly depressed both abundance and detectibility of ants.

Segment	*% Years PVB Observed*	*Pitfall traps 1994–1998 (Longcore 1999)*	*Directed searches, Spring 2007*
1-1	21	106 collections at two traps 376 *Linepithema humile* 12 *Phiedole hyatti* 5 *Pogonomyrmex californicus* 1 *Temnothorax andrei*	site graded
1-2	14		*Linepithema humile*
2-1	0		*Linepithema humile*
2-2	21		*Linepithema humile*
3-1	64		*Linepithema humile* *Pogonomyrmex californicus*
3-2	71		*Linepithema humile*

Segment	*% Years PVB Observed*	*Pitfall traps 1994–1998 (Longcore 1999)*	*Directed searches, Spring 2007*
4-1	71	112 collections at two traps 433 *Linepithema humile* 7 *Pogonomyrmex californicus* 4 *Phiedole hyatti* 2 *Camponotus semitestaceus*	*Linepithema humile*
4-2	28		*Linepithema humile*
4-3	42		*Linepithema humile* *Cardiocondyla mauritanica Pogono-myrmex californicus*
5-1	42		*Linepithema humile*
5-2	57	96 collections at 2 traps 827 *Linepithema humile* 12 *Pogonomyrmex californicus* 6 *Camponotus semitestaceus* 4 *Pheidole hyatti* 1 *Temnothorax andrei*	*Linepithema humile*
5-3	42		*Linepithema humile*
5-4	100		*Linepithema humile*
6-1	83		*Linepithema humile*
6-2	50	36 collections at 3 traps 639 *Linepithema humile* 331 *Pogonomyrmex californicus* 184 *Crematogaster* sp. 4 *Camponotus semitestaceus*	*Linepithema humile*
6-3	33		*Linepithema humile*
7-1	50		*Linepithema humile*
7-2	100		*Linepithema humile* *Dorymyrmex insanus* *Camponotus semitestaceus* *Messor andrei*
7-3	50		*Linepithema humile*
8-1	57		*Linepithema humile* *Messor andrei*
8-2	14	94 collections at two traps 740 *Linepithema humile* 15 *Pogonomyrmex californicus*	*Linepithema humile*
8-3	42		*Linepithema humile*

Segment	*% Years PVB Observed*	*Pitfall traps 1994–1998 (Longcore 1999)*	*Directed searches, Spring 2007*
9	64	47 collections at two sites 290 *Camponotus semitestaceus* 151 *Linepithema humile* 150 *Pheidole hyatti* 31 *Messor andrei*	*Linepithema humile*
10-1	14		*Linepithema humile* *Dorymyrmex insanus* *Brachymyrmex depilis* *Cardiocondyla mauritanica* *Camponotus semitestaceus*
10-2	7		*Linepithema humile* *Dorymyrmex bicolor* *Pheidole hyatti*
10-3	7		*Linepithema humile* *Camponotus semitestaceus* *Prenolepis imparis* *Pheidole hyatti* *Pogonomyrmex californicus* *Solenopsis xyloni*

Table 3. Presence of Palos Verdes blue butterfly along transect segments with and without ant species.

Species (significance)	*Average % years butterfly observed when ant present (N)*	*Average % years butterfly observed when ant absent (N)*
Camponotus semitestaceus ($p<0.07$)	52 (7)	23 (7)
Messor andrei ($p<0.03$)	79 (2)	33 (13)
Pogonomyrmex californicus ($p<0.66$)	41 (8)	33 (6)
Pheidole hyatti ($p<0.97$)	38 (6)	37 (8)

Argentine ants are so widespread that their presence cannot be associated with frequency of detection of Palos Verdes blue butterflies on transect segments. The species that could be evaluated for association with butterflies were *Camponotus semitestaceus*, *Pogonomyrmex californicus*, *Messor andrei*, and *Pheidole hyatti* (Table 3). Palos Verdes blue butterflies are observed a greater percentage of years on transect segments with *C. semitestaceus* and *M. andrei* present than on segments with these ants absent.

M. andrei was found only on two segments so this association is far from conclusive. Probability of observing Palos Verdes blue butterflies on transect segments with the *Pogonomyrmex californicus* and *Pheidole hyatti* is not appreciably different with the ants either present or absent.

4. Discussion

The spring 2007 surveys extended the knowledge of distribution of ants at DFSP. The dry weather, however, likely decreased the abundance of active individuals and therefore also the number of species observed. Nevertheless, the list of species is respectable for a fragment with DFSP's disturbance history. Harvester ants (*Pogonomyrmex* and *Messor*) are sensitive to disturbance and persist at DFSP (Suarez et al. 1998). Suarez et al. (1998) identified army ants (*Neivamyrmex*) as the most sensitive to fragmentation and disturbance in southern California scrub habitats and no members of this genus have yet been found at DFSP.

The surveys documented presence of a series of species that could enter into mutualist interactions with larvae of Palos Verdes blue butterfly. Of these, *Camponotus semitestaceus* has been observed tending larvae in the field (G. Pratt, pers. comm.). Based on both the Longcore (1999) records and the current surveys, *C. semitestaceus* is found in most of the locations where Palos Verdes blue butterfly has been observed. It has notably not been recorded near transects 1-1, 1-2, 2-1, 2-2, 3-1, and 4-3. The positive association between presence of this ant species and frequency of observation of Palos Verdes blue butterfly is intriguing and suggests that further research might yield interesting results. This association may be an artifact of both species preferring the same habitat or the mutualistic interactions may aid survival of Palos Verdes blue butterfly larvae, increasing probability of observing adults.

The results are sufficient to also merit further investigation of the mutualistic interaction between Palos Verdes blue butterfly and other ant species in the field. It would be especially interesting to document tending by species other than *L. humile* and *C. semitestaceus*. Presence of a certain ant species does not seem to be a prerequisite for presence of Palos Verdes blue butterfly given the existing data, but it is certainly possible that these mutualistic interactions allow for increased reproductive success in particular areas (e.g., segments 6-2, 7-2, 9).

Figure 2. *Camponotus semitestaceus* and Palos Verdes blue butterfly at DFSP. Proportion of years Palos Verdes blue butterfly observed along transect segments represented by size of butterfly symbols. Presence of *Camponotus semitestaceus* indicated by ant symbols.

Snelling will continue surveys at DFSP in spring 2008, particularly if more winter rainfall is received than the 2006–2007 season. Continued surveys would be useful to conclusively determine the identity of those morphospecies recorded by Longcore (1999) for which specimens are missing. Continued investigation of the ant community could also confirm and extend existing knowledge about management actions and the distribution of native and exotic ants. Longcore (2003) reported a positive association between restoration actions and Argentine ant abundance at this and other local sites. If ant species other than Argentine ants are shown to be important to survival of Palos Verdes blue butterfly, this knowledge might lead to different restoration strategies that preserve native ant diversity.

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6. Appendix: Field Notes

26 February 2007

USA, Calif., Los Angeles Co.: San Pedro, Naval Fuel Depot (DFSP), 33.78ºN 118.31ºE, 70 m el. Highly disturbed open area.

07-001 *Linepithema humilis* (Mayr)
Foragers in field.

07-002 *Linepithema humilis* (Mayr)
Nest in soil under concrete block.

07-003 *Camponotus semitestaceus* Snelling
Nest in sandy soil, hillside above firing range.

07-004 *Messor andrei* (Mayr)
Nest in sandy soil in open flat area above firing range.

07-005 *Messor andrei* (Mayr)
Large nest in sandy soil, flat open area.

07-006 *Solenopsis xyloni* McCook
Nest in soil near 07-005.

07-007 *Dorymyrmex insanus* (Buckley)
Nest in sandy soil near 07-005

1 June 2007

USA, Calif., Los Angeles Co.: San Pedro, Naval Fuel Depot (DFSP), 33.78ºN 118.31ºE, 70 m el. Highly disturbed open area.

07-107 *Pogonomyrmex californicus* (Buckley)
Foragers on ground.

07-108 Debris from chaff pile of *Messor andrei* (Mayr): no additional ant species found.

07-109 Sifted litter beneath oak trees along road: no ants present.

07-110 *Prenolepis imparis* (Say)
Two stray workers on ground near *Helianthus*.

8 June 2007

USA, Calif., Los Angeles Co.: San Pedro, Naval Fuel Depot (DFSP), 33.78ºN 118.31ºE, 70 m el. Highly disturbed open area.

07-111 *Dorymyrmex insanus* (Buckley)
Nest in loose sand.

07-112 At *Chamaesyce* mat:
a. *Brachymyrmex depilis* Emery
b. *Cardiocondyla mauritanica* Forel

07-113 Debris from chaff pile of *Pogonomyrmex californicus* (Buckley):

16 July 2007

07-126 *Pogonomyrmex californicus* (Buckley)
Nest in soil on hillside

07-127 *Cardiocondyla mauritanica* Forel
Nest in cracks in asphalt road; foragers at and under *Chamaesyce* mats, some visiting blossoms, others picking up fragments of dead arthropods.