A Survey of *Odontomachus* (Hymenoptera: Formicidae) and Observations of Nesting Preferences in the Commonwealth of Dominica, Lesser Antilles

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Abstract: Localities in the Commonwealth of Dominica, an island in the Lesser Antilles, were surveyed for *Odontomachus* spp. (Hymenoptera: Formicidae) in June 2015. *Odontomachus* ants, commonly known as trap-jaw ants, have elongated mandibles which they use for capturing prey. Some species within the genus are invasive in the United States, however, little is known about their biology or nesting preferences in the Commonwealth of Dominica. Specimens were collected in nest series and details nesting locality, substrate, and co-habitation with termites (Blattodea: Termitidae) and other formicids were recorded. Two species of *Odontomachus* were found, most prominently *O. bauri* Emery, 1892 and, in a single sample, *O. ruginodis* Smith, 1937. Many *Odontomachus* colonies were found to be co-habitating in terrestrial termite mounds or rotting wood along with their termitid inhabitants. No *Odontomachus* spp. were found at elevations higher than 1686 ft above sea level. High resolution images of each species collected are included. The specimens of *O. ruginodis* that were collected are new records for the Commonwealth of Dominica. Our study provides implications for further biological and ecological studies on *Odontomachus,* particularly their relationships with other ant species and termites, as well as their distribution throughout the Commonwealth of Dominica and the Caribbean.

Keywords: trap-jaw ants, Termitidae, Caribbean, new record, invasive species

Within Formicidae (Hymenoptera) there is a multitude of diverse adaptations and morphological modifications that permit members of the family to live in habitats around the globe. For example, ants in the genus *Cephalotes* (Hymenoptera: Formicidae) have expanded and flattened heads which allow them to seal entrances to their colonies (Powell 2008). Another example of morphological adaptation within Formicidae are the repletes found in the genus *Myrmecocystus* (Hymenoptera: Formicidae) (Wheeler 1912). Repleates are specialized worker ants with abdomens that can swell to many times their original size to store food (Wheeler 1912).

Within the subfamily Ponerinae (Hymenoptera: Formicidae), the genus *Odontomachus* bears a distinguishing adaption concerning its mandibles. Commonly known as trap-jaw ants, these ponerines have elongate and narrow mandibles that lock open at a near 180° angle (Carlin and Gladstein 1989; Schmidt 2009). Most, but not all, trap-jawed species also possess one or two pairs of prominent, long sensory hairs which point forward when the mandibles are held fully open (Carlin and Gladstein 1989). Stimulating these so called trigger hairs releases closure of the mandibles, accompanied in larger species by an audible click (Carlin and Gladstein 1989). This clicking sound has led to the use of the word "tac-tac" in the Creole culture and language to describe ants in the genus *Odontomachus* (Winer 2008). It has been recorded that this jaw snapping movement completes from start to finish in 0.33 to 1.00 milliseconds, making it the fastest known animal action (Gronenberg 1993). This snapping action can be used to capture prey, attack rivals, defend from predators, and generate a means of escape. It has been observed that *Odontomachus* will utilize the force of the jaw snapping action to propel themselves away from a threat or even to launch a threat away from themselves (Patton 1984).

Odontomachus ants are social insects and colonies consist of distinctive castes: reproductive females known as queens, males, and non-reproductive female workers (Schmidt 2009). Worker ants can be found in leaf litter foraging for prey items and tend to avoid a noticeable presence as they stalk over the surface of the ground (Deyrup and Cover 2004). The size of *Odontomachus* colonies varies between species, ranging from as few as 18 workers to as many as 10,000 workers, but often averaging several hundred workers (Schmidt 2009). Members of this genus have become invasive in the gulf regions of the United States of America, ranging from South Texas to Florida (Deyrup et al. 2000; MacGown et al. 2014).

While *O. bauri* Emery, 1892 (Hymenoptera: Formicidae) is known from the Commonwealth of Dominica, no studies on the distribution, biology, natural history, and nesting preferences of ants in the genus in Dominica have been published (AntWeb 2015; Deyrup et al. 2000; Schmidt 2009). This study aimed to collect and identify specimens of *Odontomachus* throughout the island in order to contribute to the existing literature related to the genus as well as to provide background for answering future questions about *Odontomachus* in Dominica and members of the genus that are invasive in other regions.

Materials and Methods

Survey Dates and Localities

Collecting was conducted throughout the Commonwealth of Dominica between the dates of 2-VI-15 and 15-VI-15 (Table 1; Fig. 1). Specifically, 14 localities from across the island were surveyed (Table 1; Fig. 1). Based on known *Odontomachus* nesting preferences, areas with leaf litter, damp soil, rotting wood, and termites were targeted for sampling within each locality (MacGown et al. 2014; Schmidt 2009).

Table 1. Locality data and dates surveyed for *Odontomachus* in the Commonwealth of Dominica, Lesser Antilles

Locality	GPS Coordinates	Elevation (ft)	Forest Type	Date Surveyed
Syndicate Nature Trail	15°31'31.06”N, 61°25'1.90”W	1830	Primary Montane Forest	2-VI-15

Locality	GPS Coordinates	Elevation (ft)	Forest Type	Date Surveyed
Kalinago Territory	15°29'18.9"N, 61°15'10.2"W	512	Disturbed Atlantic Forest	5-VI-15
St. David's Bay	15°25'54.06"N, 61°15'19.83"W	25	Non-Forest	5-VI-15
ATREC[a]	15°20'46.1"N, 61°22'09.0"W	984	Secondary Rain Forest	7-VI-15
ATREC[a]	15°20'48.3"N, 61°22'08.6"W	1171	Secondary Rain Forest	7-VI-15
Lake Letang	15°20'27.66"N, 61°18'34.30"W	2550	Primary Elfin Forest	9-VI-15
Lake Boeri	15°21'4.44"N, 61°19'15.18"W	2870	Primary Elfin Forest	9-VI-15
Roseau Botanical Gardens	15°17'58.6"N, 61°22'53.3"W	167	Non-Forest	10-VI-15
ATREC[a]	15°21'03.0"N, 61°21'47.9"W	1594	Secondary Rain Forest	11-VI-15
ATREC[a]	15°21'01.9"N, 61°21'47.9"W	1604	Secondary Rain Forest	11-VI-15
ATREC[a]	15°20'59.2"N, 61°21'48.8"W	1611	Secondary Rain Forest	11-VI-15

Locality	GPS Coordinates	Elevation (ft)	Forest Type	Date Surveyed
Emerald Pool Trail	15°23'51.4"N, 61°18'44.9"W	1155	Primary Rain Forest	11-VI-15
Boiling Lake Trail	15°19'45.0"N, 61°19'29.3"W	1686	Primary Rain Forest	12-VI-15
Cabrits National Park Trail	15°35'06.7"N, 61°28'19.8"W	200	Dry Forest	15-VI-15

[a] Archbold Tropical Research and Education Center.

Fig. 1. A satellite image map of the Commonwealth of Dominica showing all localities visited to collect *Odontomachus* spp. Localities marked in red indicate locations where *Odontomachus* spp. were found and yellow markers indicate where *Odontomachus* spp. were not found. The map is oriented from North to South when being read from left to right.

Collecting Procedures

Ants were collected as nest series in which as many ants representing each caste found in a single nest were captured (AntWiki 2015a). Individual *Odontomachus* specimens were captured using wide tip featherweight forceps

(Bioqup, Rancho Dominguez, CA) and a manual insect aspirator (Bioquip, Rancho Dominguez, CA). All ant specimens were placed in eith six dram vials (Bioquip, Rancho Dominguez, CA) or eight dram vials (Bioquip, Rancho Dominguez, CA) which were filled with 95% ethanol, obtained locally, to kill specimens.

Following collection, the coordinates, elevation, date, and notes about each colony sampled were recorded on an Aspire cell phone (Samsung, Seoul, South Korea) using the application GPS Essentials (Schollmeyer Software Engineering 2009).

Specimen Preservation, Identification, and Imaging

Specimens from each nest series were sorted by caste and counted by placing the contents of each vial in a small sorting tray (Rose Entomology, Benson, AZ) and examining them with a Leica GZ4 stereo microscope (Leica Microsystems, Wetzlar, Germany).

Species identification was completed using the *Key to Odontomachus of the New World* (AntWiki 2015b), the *Key to Odontomachus Species in the Southeastern United States* (MacGown 2004), and *A New Species of Odontomachus Ant (Hymenoptera: Formicidae) from the Inland Ridges of Florida, with a Key to the Odontomachus of the United States* (Deyrup and Cover 2004). AntWeb (2015) images were compared with images taken of collected specimens from the field as described below to refine species identifications. Distribution maps of *Odontomachus* in the Lesser Antilles from AntWeb (2015) were also studied to determine records of *Odontomachus* species on Dominica and other Caribbean islands.

Individual specimens of each caste were point-mounted and imaged using a Nikon D300 12.3 MP Digital SLR camera (Nikon Corporation, Tokyo, Japan), four Nikon SB-R 200 Slave Flashes (Nikon Corporation, Tokyo, Japan), a mylar ring, a bolt ring LED for focusing, a table top tripod, a ball head, a focusing ball, and several lens extensions. The computer software used for processing the images was Adobe Photoshop Lightroom (Adobe, San Jose, CA). All other specimens were preserved in 95% ethanol. All specimens collected were deposited in the Texas A&M University Insect Collection (TAMUIC) under voucher number 724.

Results

A total of 408 specimens representing two species of *Odontomachus* were collected. Four hundred and six specimens of *O. bauri* were idendified from material in 10 different nest series. *Odontomachus ruginodis* Smith, 1937 (Hymenoptera: Formicidae) was represented by two specimens collected in a single nest series at the Roseau Botanical Gardens.

Each caste of *O. bauri* was collected (Fig. 2; Fig. 3; Fig. 4; Fig. 5). Two castes of *O. ruginodis*, a queen and a worker, were also identified (Fig. 6; Fig. 7). Out of all the specimens, 2.7% were either males, alate queens, or queens, the reproductive castes (Fig. 8). Alates were only found in large colonies.

The localities that yielded specimens were Kalinago Territory, Archbold Tropical Research and Education Center (ATREC), Mount Joy, Roseau Botanical Gardens, Emerald Pool Trail, Boiling Lake Trail, and Cabrits National Park Trail (Table 1; Fig. 1). There were four localities that did not yield *Odontomachus* specimens: Syndicate Nature Trail, St. David's Bay, Lake Letang, and Lake Boeri (Table 1; Fig. 1).

Three *Odontmachus* queens were found at the Roseau Botanical Gardens, each within a few feet of each other and under leaf litter.

Fig. 2. Anterior and lateral views of an *Odontomachus bauri* worker are presented.

Fig. 3. A dorsal view of the head as well as a lateral view of a male *Odontomachus bauri* are presented.

Fig. 4. A dorsal view of the head as well as a lateral view of a *Odontomachus bauri* queen are presented.

The smaller, differently colored queen was identified as *O. ruginodis* while the other queens were *O. bauri*. Within a few feet of these three queens, a colony of *O. bauri* was discovered inside a small log in the leaf litter. Additionally, one *O. ruginodis* worker was found while collecting from this *O. bauri* colony at the Roseau Botanical Gardens. The locality that yielded the greatest number of ants was Mount Joy. The colony was located under a termite mound about 20 inches in diameter. Another colony, collected from underneath a termite mound that was about 3 ft wide by 4 ft high, at ATREC yielded significantly fewer ants.

The *O. bauri* collected at Emerald Pool Trail were collected in a log which was roughly partitioned into three territories. One of these territories contained with termites, another

Fig. 5. A dorsal view of the head as well as a lateral view of an alate *Odontomachus bauri* queen are presented.

Fig. 6. A dorsal view of the head as well as a lateral view of a *Odontomachus ruginodis* worker are presented.

Fig. 7. A dorsal view of the head as well as a lateral view of a *Odontomachus ruginodis* queen are presented.

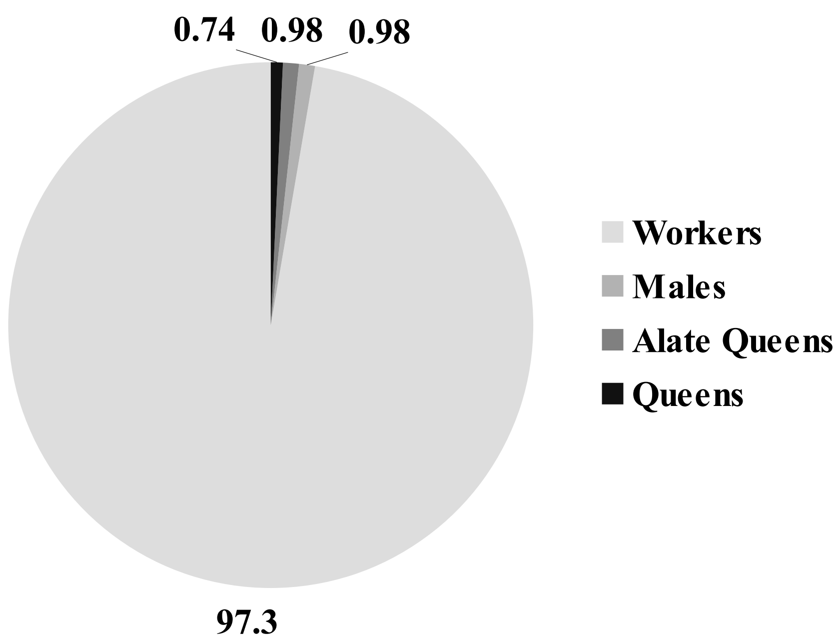

Fig. 8. The distribution of caste members within the total *Odontomachus* specimens collected are shown as percentages.

contained ants in a different genus of Formicidae, and the third territory contained *O. bauri.*

A colony of *O. bauri* was collected at Cabrits National Park Trail, from the side of the trail between Fort Shirley and the Fort Commandant's Quarters. This area had leaf litter at least 3 or 4 inches deep with fallen tree limbs, logs, and other woods scattered around it. Other formicid colonies as well as termites were also observed in the wood at this site.

The lowest elevation surveyed that yielded *Odontomachus* was for both *O. bauri* and *O. ruginodis* at the Roseau Botanical Gardens, 167 ft above sea level (Fig. 9). The highest elevation recorded for either species collected was for *O. bauri* at 1686 ft above sea level, on the Boiling Lake Trail (Fig. 9). The highest elevation where *Odontomachus* did not occur was 2870 ft above sea level at Lake Boeri (Fig. 10). The lowest elevation where *Odontomachus* was not collected occurred at St. David's Bay, 25 ft above sea level (Fig. 10).

Of the colonies surveyed, 33.3% of them were found in or around leaf litter and in damp soil (Fig. 11). Another 11.11% of the observed colonies were found in live terrestrial termite mounds (Fig. 11). In 50% of the nest series, *Odontomachus* was found co-habitating with termitids and, in 30% of the nest series, with other formicids (Fig. 12). No *Odontomachus* colonies were found inside of termite mounds that were in trees and above the ground. Additionally, no *Odontomachus* workers were observed to forage in trees.

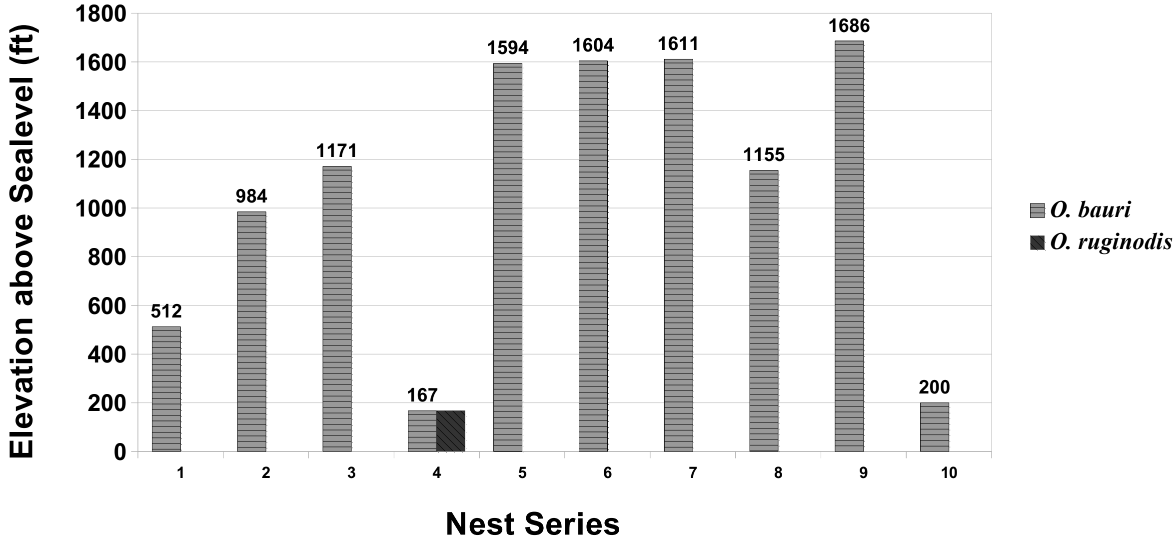

Fig. 9. The distribution of *Odontomachus bauri* and *Odontomachus ruginodis* specimens collected are shown by elevation (in feet).

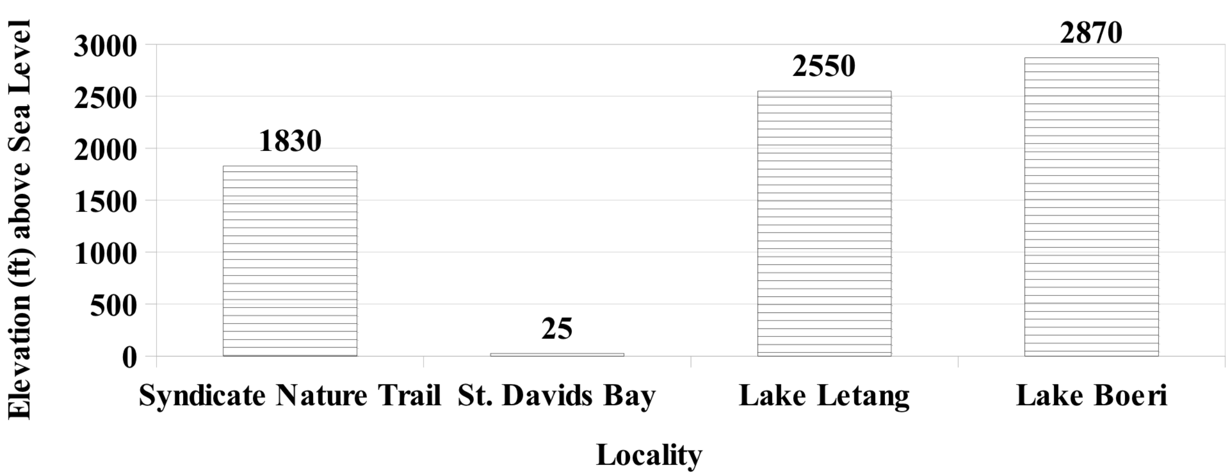

Fig. 10. The localities and their respective elevations where where *Odontomachus* spp. were not found are shown.

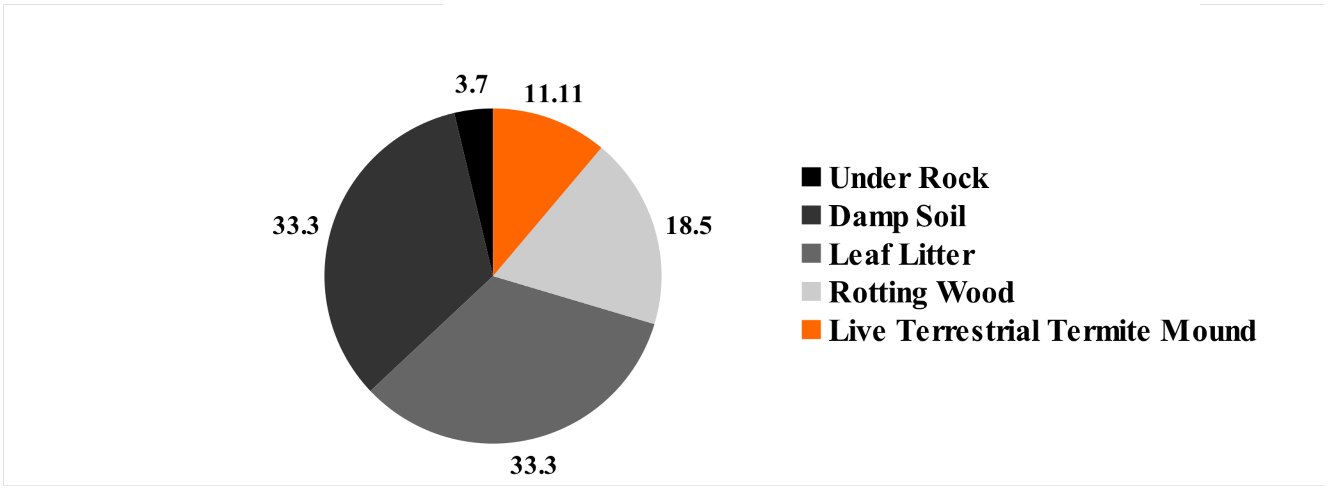

Fig. 11. The nesting attributes (under rock, damp soil, leaf litter, rotting wood, and live terrestrial termite mound) associated with each of the sampled *Odontomachus* colonies are shown as percentage distribution.

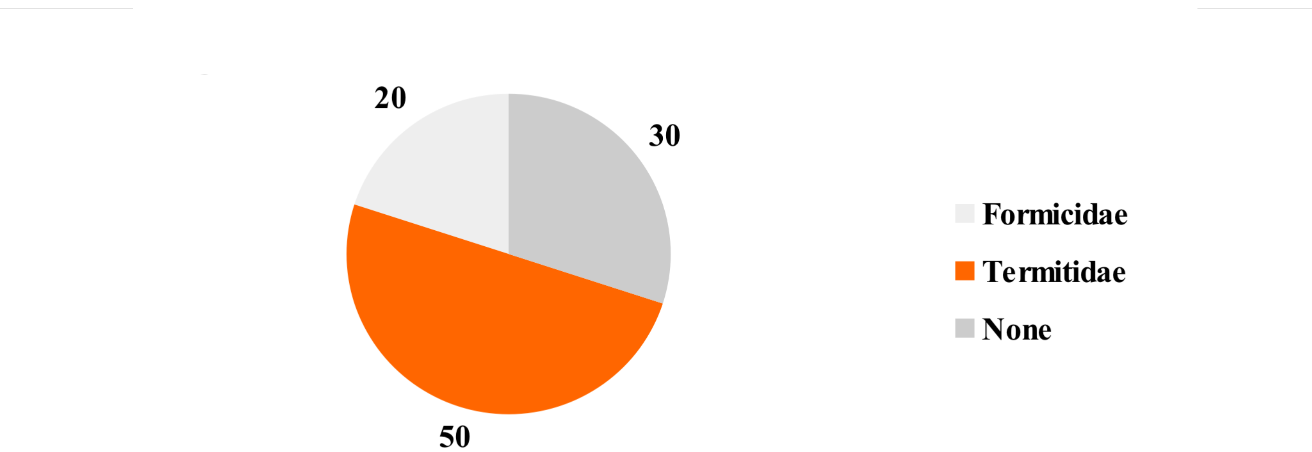

Fig. 12. The percentage of the sampled *Odontomachus* colonies that did or did not have observed co-habitation with termitids or other formicids in their nesting substrates is shown.

Discussion

The Commonwealth of Dominica, like other islands in the Lesser Antillies, has an established population of *Odontomachus* spp. (Deyrup et al. 2000). The specimens collected at the Botanical Gardens remain some of the most interesting as this was the only locality where both species of *Odontomachus* were collected during this study. This is also the first known record of *O. ruginodis* in the Commonwealth of Dominica. Since this is the only locality at which *O. ruginodis* was collected on the island, it is possible that *O. ruginodis* was introduced to Dominica in imported plants or other shipments from nearby islands. Guadeloupe, an island just north of Dominica, has many collecting records of *O. ruginodis* (AntWeb 2015). It is also possible that the species had not yet been reported from Dominica due to undersampling of taxa in the region.

Since no thriving colonies of *O. ruginodis* were found, no males or alate queens could be imaged. The representatives of *O. ruginodis* that were imaged were the only two specimens found (Fig. 6; Fig. 7). The male caste is the most extreme when it comes to morphological differences among the castes in the genus. The trigger hairs that, when stimulated, cause the unlocking and snapping shut of the mandibles are shown (Fig. 2). On all specimens of *Odontomachus*, it can also be seen that the mesoplueron does not have setae or striations, being relatively bare and even glossy (Fig. 2; Fig. 3; Fig. 4; Fig. 5; Fig. 6; Fig. 7).

Since the procedures for collecting *Odontomachus* in all of the study locations were identical, it is possible that *Odontomachus* cannot become established at certain elevations above sea level, despite all of the available moisture, leaf litter, and decaying tree matter since three of the four locations where *Odontomachus* was not found at high elevations (Table 1; Fig. 1; Fig. 10). Additionally, no termite mounds were found at these four locations, which were a commonly observed nesting site of *O. bauri* (Fig. 11). The elevations that *Odontomachus* were found at varied from just above sea level to nearly 1700 ft above sea level (Table 1; Fig. 1; Fig. 9). It should be noted that it is possible that *Odontomachus* spp. can be found on the island at elevations above 1700 ft, but they were simply not uncovered the locations searched in (Table 1; Fig. 1; Fig. 9; Fig. 10). However, on a hike to Middleham Falls (2000-2300 ft) not a single colony or forager of *Odontomachus* was found on the trail. Fallen logs and leaf litter were checked periodically to no avail and no terrestrial or arboreal termite mounds were found either. It is possible that these elevations are inhospitable for *Odontomachus*, however such a notion would need to be further investigated by attempting to collect in multiple areas on the island at these high elevations. Additionally, this suggests that the presence of termites are an important part of *Odontomachus* biology and their establishment across the island. Future research should be conducted to look specifically and extensively at this relationship.

Odontomachus spp. were found in different types of nesting substrates (Fig. 11). It would appear that some *Odontomachus* spp. favor, when available, the ground-level portions of terrestrial termite mounds since three nest series followed this trend (Fig. 11; Fig. 12). It is likely that this comes from a combination of potential benefits that can be advantageous for *Odontomachus*. Firstly, the termites themselves are a common source of nutrition for *Odontomachus* which they will actively hunt (Schmidt 2009). Secondly, termites are known for their ability to efficiently control the internal climate of their mounds (Korb and Linsenmair 2000). It is possible that the area of substrate where the mound meets the ground is ideal for nesting conditions and rearing of young in *Odontomachus* spp. While collecting, it was observed that the termites avoided contact with the *Odontomachus*. When terrestrial-based termite mounds were lifted up to see under them, the areas that contained *Odontomachus* individuals were completely clear of termites. Lastly, the termite mound could provide defense for the *Odontomachus* colonly. The mud material of the mounds is hard and provides a shield against attacks from animals or undesired external conditions such as rain, wind, or temperature shifts. *Odontomachus* are known as leaf litter ants, remaining primarily hidden while hunting for prey items (Deyrup and Cover 2004). The combination of a hidden nesting site, a steady supply of nutrition within the mound, climate control, and defensive benefits make nesting inside of a termite colony seem ideal.

The differences in the size of *Odontomachus* colonies found associated with termite mounds at Mount Joy and ATREC is of interest as the size of the termite mound was inversely proportional to the number of ants in the colony. It is possible that the larger termite colony at Mount Joy had only recently been invaded by *Odontomachus*. Another possibility is that the larger size of the termite mound and its relative population were large enough to keep the *Odontomachus* within a small portion of the nest and resist their attempts at invading the colony. In comparison, the smaller termite mound at ATREC may have been overwhelmed by the *Odontomachus* population upon invasion or the ants may have been living within the mound for a longer period of time.

The observations made at Emeral Pool Trail are of interest due to the inhabitants of the log which were present with the *Odontomachus* ants. What exactly was occurring between these organisms is a question that future research could answer to help understand the kinds of relationships that can occur between social insects of different species inhabiting the same substrate. Once again, it would appear there is a connection between *Odontomachus* nesting preference and termites.

The specimens that were collected at Cabrits were the most difficult to find overall. It was expected that *Odontomachus* would not be found at this locality due to the nature of dry forests and the fact that the ants favor damp conditions (Van Pelt Jr. 1958). It had been stated by local residents as well as others familiar with the site with that Cabrits had been drier than usual, therefore it could be that the timing of collecting was not favorable as *Odontomachus* colonies were likely not flourishing.

While collecting, the goal was to obtain as many specimens from the colony as possible, even until none remained. It is known that *Odontomachus* spp., like other Ponerines, have smaller colony populations than most other Formicidae (Schmidt 2009). Instead of thousands of colony members, *Odontomachus* spp. Colonies tend to have a few hundred or less workers, even in a strong and thriving colony (Schmidt 2009). No fertile, egg-laying queens from a nest were actually captured and the only queens captured were alone, founding new nests. With queens being close in size to that of the worker caste, it can be difficult to distinguish them in the field while scanning through a disturbed colony. Both male and female alates were few (Fig. 3; Fig. 5). The time of year or other factors inside individual colonies possibly contributed to this finding as well as the fact that only larger colonies contained these potentially reproductive individuals.

Common themes at the sites where *Odontomachus* spp. were collected included damp leaf litter, rotting logs, terrestrial based termite mounds, and elevations between 200 ft and 1686 ft (Fig. 9; Fig. 10; Fig. 11; Fig. 12). Knowledge of *Odontomachus* biology, such as their preferences for damp and hidden sites for nesting. Would lead one to expect some of these results (MacGown et al. 2014; Schmidt 2009). However, their preference for terrestrial termite colonies and the elevation preferences observed need to be investigated through further research. *Odontmachus* spp. have been known to inhabit abandoned termite mounds, however, this infestation of active termite colonies seems to be not a well known or recorded occurrence (Schmidt 2009). Additionally, some of the localities that were surveyed were within close proximity of each other, namely the collecting events within the extensive land property of the Springfield Research Station. Future research could focus on generating larger sample sizes from a wider distribution of locations across the island. This effort would potentially result in sufficient data to support conclusions about nesting site tolerance levels of *Odontomachus* in the Commonwealth of Dominica.

Odontomachus bauri seems well established on the island of Dominica and should be researched further to answer questions about their relationship with termites and why certain nesting preferences are favored over others. *Odontomachus ruginodis* could have extensive populations that were simply not found, or it could be that they are not yet established enough for their presence to be noticed. Because it was only found at the Roseau Botanical Gardens, it is possible that *O. ruginodis* is an invasive species on the island and additional research is required to determine its distribution within the island and ecological status. *Odontomachus bauri* was found at nearly any locality on the island that had leaf litter, rotting logs, terrestrial-based termite mounds, or other suitable nesting substrates with the exception of high elevations. Research focusing on potential relationships between the ants, termites, elevations, and distributions will need to be conducted to explore what factors may have contributed to *Odontomachus* spp. being found at some localities, but not at others. Other surveys throughout the Carribean islands may also contribute information about the overall geographic distribution of *Odontomachus* spp.

Acknowledgments

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