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Chapter 1

Ants of the Nakanai Mountains, East New Britain Province, Papua New Guinea

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SUMMARY

We surveyed ants in the Nakanai Mountains of East New Britain Province, Papua New Guinea to assess their diversity and endemism at low, mid and high elevations (200 m, 900 m and 1,600 m). Leaf-litter sifting and hand-collecting produced 140 species of ants, of which approximately 40 appeared to be undescribed; nine of these have so far been confirmed as new to science. Species richness was similar at low and mid elevations, with 93 and 92 species respectively. Species composition at these elevations overlapped considerably, with approximately 60% of species shared (55 species). Species richness at high elevation was considerably lower with 22 species documented, of which ten were unique to the high-elevation site. Three species were found at both low and high sites; four at mid and high sites, and five species were found at all three elevations. Based on the high numbers of probably undescribed ant species encountered on this survey and the threats facing forest communities on Pacific Islands, we recommend that steps be taken to conserve the remaining intact tracts of rainforest at low, mid and high elevations in the Nakanai Mountains.

INTRODUCTION

Ants (Hymenoptera: Formicidae) represent the most successful radiation of social insects on Earth. They are a dominant component of terrestrial ecosystems across the globe with respect to taxonomic richness, abundance and biomass, and are absent only from the coldest and wettest environments (Hölldobler and Wilson 1990). Ants are well known for their beneficial roles as predators, scavengers, seed harvesters and pollinators, in addition to their harmful roles as invasive species (Lach et al. 2010). Their lifestyles include specialized symbioses with plants, fungi and other insects.

Because of their specialized life histories many ant species are also important subjects for biodiversity monitoring and in studies that evaluate environmental conditions (Agosti et al. 2000). Over 12,500 species of ants are known to science as named species (Bolton 2006), but researchers estimate that twice that many species may currently exist (Ward 2010). Approximately 800 ant species have been recorded from New Guinea (Janda 2010), with many more expected to be discovered.

The poorly-surveyed island of New Britain is likely to yield interesting discoveries of undescribed and endemic ant species. Prior to the recent expedition the most extensive survey of the Bismarck Archipelago ant fauna was conducted at the turn of the 19th century (Forel 1901). Of the approximately 38 species collected at that time, 30 were described as new. The remaining species are mostly known from material examined for scattered generic revisions of Pacific ants.

The great diversity of flora and fauna in New Guinea and its associated islands is due in large part to a complex biogeographic history. Mainland New Guinea is a collage of many terranes of various origins (Hall 2002). The southern part of New Guinea is part of the Australian plate and the northern part is a combination of 30 or more cratons stitched together from the Australian continent, the Asian continent, of oceanic origin or from ancient island arc complexes. In comparison New Britain (part of the Bismarck Archipelago, which also includes New Ireland) is part of an island arc that resulted from collision of the Pacific and Indo-Australian plates. Mainland New Guinea and the Bismarck Archipelago were never connected by land, so the biota must have arrived over water or by flight.

These different biogeographical histories have produced dramatic faunal differences between New Guinea and New Britain's terrestrial assemblages. For example monotremes and birds of paradise are present on mainland New Guinea but absent from the Bismarck Archipelago. The biogeography of Bismarck island insects is poorly understood; however studies have shown that terranes of northern New Guinea with similar geological histories to the Bismarck islands share some lineages. For example the aquatic Hemipteran genus *Tehtibates* (Gerridae) is only known from the Solomon Islands, New Britain and the Finisterre terrane of mainland New Guinea (Polhemus and Polhemus 1998). It is likely that some ant distributions follow a similar pattern, but current knowledge of ant distributions and diversity in the Bismarck Archipelago is sparse at best (Forel 1901, Wilson 1961, Janda 2010).

This survey of ants in the Nakanai mountains of New Britain was conducted to assess the diversity and endemism of taxa in this poorly known region. The results reported here contribute to a more complete understanding of historical biogeographic patterns in New Guinea ants, and more broadly to an understanding of the evolution of terrestrial biota in Melanesia and the Pacific islands.

METHODS

Ant diversity at low, mid and high elevations in the Nakanai Mountains of East New Britain, Papua New Guinea was investigated using two collecting methods: hand-collecting and Winkler Sampling. Hand collections involved searching for and collecting ants foraging on soil, leaf-litter, tree trunks and understory vegetation, as well as those nesting under stones, or under or inside decaying wood. Additionally, ultra-violet lights were erected to attract winged reproductive ants (males and queens) at night. Winkler sampling involved collecting ground-litter samples from 100m transects in different rainforest habitat types (along ridges, beside streams, at forest edges, etc.). Each sample was collected from a $1m^2$ quadrat of leaf litter placed at 5m intervals along each transect and subsequently sifted through mesh sieves (Agosti et al. 2000). Winkler extractor bags were used to passively collect ants from the sifted litter over a period of 48 hours.

Identifications were made to species level when possible based on comparison with museum material from the Philip S. Ward collection (PSWC), the Los Angeles County Museum of Natural History (LACM) and published literature. New species designations were assigned conservatively. We classified species as new to science only if they belonged to groups for which the taxonomy is well resolved in New Guinea. Beyond the species noted as new in this report, additional undescribed species are expected among less well-resolved groups (e.g. *Hypoponera, Monomorium, Pheidole, Vollenhovia*). The lack of revisionary work in these groups prevents ready recognition of named and unnamed species at this time.

STUDY SITES

Camp 1 (Lamas). From April 4-8, 2009 ants were surveyed in lowland rain forest at elevations ranging from 155-265 m. Vegetation was rather depauperate with *Pometia pinnata* (Sapindaceae) as one of the common tree species. Ants were collected using the Winkler method in understory areas where leaf litter had accumulated. Hand collections focussed on colonies that nest on the forest floor, with particular attention paid to rotten logs and standing dead stumps, as well as open areas such as tree-fall gaps where canopy-dwelling species often occur. Ants occurring in mud tunnels and under moss on standing trees were also collected.

Camp 2 (Vouvou). During the April 9-17, 2009 survey ants were surveyed using Winkler sampling and hand collecting in mid-elevation rain forest from 850-920 m. The environment differed considerably from Lamas with colder temperatures, greater water saturation of the leaf litter, soil and dead wood, and substantial amounts of moss present on live and dead wood. Bamboo became more common in the understory and *Castanopsis acuminatissima* (Fagaceae) was the dominant tree species.

Camp 3 (Tompoi). During the April 18-24, 2009 survey ants were surveyed in montane forests at elevations ranging from 1,550-1,660 m. The forest at Tompoi was less dense than the lower elevation forests seen at Vouvou. The site was colder and more water-saturated, and exposed surfaces were covered with thick moss-blankets. Bamboo was also prominent in the understory while *Castanopsis acuminatissima* and *Nothofagus* sp. (Nothofagaceae) were the dominant trees. The forest at Tompoi includes one of the remaining undamaged forest tracts in this area, as much of the primary forest on the Galowe Plateau was decimated in 1997 by severe drought and a cyclone. This forest is surrounded by recruiting secondary vegetation such as bamboo, vines, ferns and pioneer trees. Winkler sampling and hand collections were conducted only within the intact forest.

RESULTS AND DISCUSSION

Winkler sampling and hand-collecting recovered 140 species of ants; at least 9 of these species are new to science and we estimate 40 will be confirmed as undescribed species upon further studies. A preliminary list of the ant species found in the Nakanai Mountains is presented in Table 1.1. Ant species richness was similar at low (155-265 m) and mid (850-920 m) elevations, with 93 and 92 species, respectively. Species composition at these elevations overlapped considerably, with approximately 60% of species shared (55 species) between elevations. Richness at the highest elevation sampled (1,550-1,660 m) was considerably lower, with only 22 species. Of these, nearly half (ten species) were found only at the high elevation site. Twelve species were also found at other elevations: three species were found at both low and high sights, four at mid and high, and five species were found at all three elevations.

This pattern reflects a well-documented trend that ant diversity in the tropics generally declines with increasing elevation (Lach et al. 2010). All three sites surveyed contained habitat meeting nesting requirements of ants that nest in intact primary forest: undisturbed litter layer, canopy epiphytes, standing dead wood, fallen decomposing trees and broken branches and twigs on the forest floor.

As expected from previous surveys of ants in lowland tropical sites in Melanesia the forest at Lamas supports a

Table 1.1. List of ants collected during the 2009 RAP survey of the Nakanai Mountains in East New Britain Province, Papua New Guinea. Presence in each of the sites surveyed is denoted with an X. Asterisks (*) indicate species confirmed as new to science.

Subfamily	Genus	Species	Lamas (200 m)	Vouvou (900 m)	Tompoi (1,600 m)
Aenictinae	*Aenictus*	sp_EMS04	X	X	
Amblyoponinae	*Amblyopone*	sp_cf_*noonadan**			X
	Amblyopone	sp_cf_*papuana**	X		
Cerapachyinae	*Cerapachys*	sp_MB_A*	X		
	Cerapachys	*marginatus*	X	X	
	Cerapachys	cf_*inconspicuus*	X	X	
	Cerapachys	*desposyne*	X		
Dolichoderinae	*Philidris*	sp_EMS04		X	
	Philidris	sp_EMS06	X	X	
	Technomyrmex	*vitiensis*	X	X	
Ectatomminae	*Gnamptogenys*	sp_EMS04		X	
	Gnamptogenys	sp_EMS05		X	
	Rhytidoponera	sp_EMS02*	X	X	
Formicinae	*Acropyga*	*acutiventris*	X	X	
	Camponotus	*dorycus*	X		
	Camponotus	sp_EMS05	X		
	Camponotus	sp_EMS06		X	
	Camponotus	*vitreus*		X	
	Euprenolepis	*procera*		X	
	Oecophylla	*smaragdina*	X	X	
	Paratrechina	sp_cf_*minutula**			X
	Paratrechina	*glabrior*		X	X
	Paratrechina	*nuggeti*	X	X	
	Paratrechina	sp_EMS06	X		
	Paratrechina	sp_EMS11			X
	Polyrhachis	*bellicosa*	X		
	Polyrhachis	sp_EMS08	X		
	Polyrhachis	sp_EMS09		X	X
	Polyrhachis	sp_EMS10	X	X	
	Polyrhachis	sp_EMS11	X		

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Table 1.1. *continued*

Subfamily	Genus	Species	Lamas (200 m)	Vouvou (900 m)	Tompoi (1,600 m)
	Polyrhachis	sp_EMS12			X
	Polyrhachis	sp_EMS13	X	X	
	Polyrhachis	sp_EMS14		X	
	Polyrhachis	sp_EMS15		X	
	Polyrhachis	sp_EMS16		X	
	Polyrhachis	sp_EMS17		X	
	Polyrhachis	sp_EMS18			X
	Pseudolasius	sp_EMS03	X	X	X
Myrmicinae	*Cardiocondyla*	sp_EMS04	X		
	Cardiocondyla	sp_EMS03	X		
	Carebara	sp_EMS04	X	X	
	Crematogaster	sp_EMS06		X	
	Crematogaster	*weberi*		X	
	Crematogaster	*recurva*		X	
	Lordomyrma	sp_EMS05*	X		
	Lordomyrma	sp_EMS06*	X		
	Lordomyrma	*cryptocera*		X	
	Lordomyrma	*furcifera*	X		
	Lordomyrma	sp_cf_*furcifera**	X		
	Monomorium	sp_EMS01	X		
	Monomorium	sp_EMS02	X	X	
	Monomorium	sp_EMS03	X		
	Monomorium	sp_EMS04	X		
	Myrmecina	sp_EMS06	X	X	
	Myrmecina	sp_EMS07	X	X	X
	Pheidole	*oceanica*	X	X	
	Pheidole	sp_EMS01	X		
	Pheidole	sp_EMS04		X	
	Pheidole	sp_EMS11	X	X	
	Pheidole	sp_EMS21	X		
	Pheidole	sp_EMS27			X
	Pheidole	sp_EMS28			X
	Pheidole	sp_EMS29	X	X	X
	Pheidole	sp_EMS30		X	
	Pheidole	sp_EMS31	X		
	Pheidole	sp_EMS32	X	X	
	Pheidole	sp_EMS33	X	X	
	Pheidole	sp_EMS34	X		X
	Pheidole	sp_EMS35	X	X	
	Podomyrma	sp_EMS06			X
	Podomyrma	sp_EMS07		X	

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Table 1.1. *continued*

Subfamily	Genus	Species	Lamas (200 m)	Vouvou (900 m)	Tompoi (1,600 m)
	Prionopelta	sp_EMS01	X	X	
	Pristomyrmex	*brevispinosus*	X		
	Pristomyrmex	*coggii*	X	X	
	Rhoptromyrmex	*melleus*		X	
	Rogeria	*stigmatica*	X		
	Solenopsis	sp_EMS01	X		
	Tetramorium	*bicarinatum*		X	
	Tetramorium	*fulviceps*	X	X	
	Tetramorium	*gambogecum*	X	X	
	Tetramorium	*insolens*	X		
	Tetramorium	*ornatum*	X	X	
	Tetramorium	*pulchellum*	X	X	
	Tetramorium	sp_*undet*		X	
	Vollenhovia	sp_EMS12	X	X	
	Vollenhovia	sp_EMS13	X	X	
	Vollenhovia	sp_EMS14		X	
	Vollenhovia	sp_EMS15	X		
	Vollenhovia	sp_EMS16		X	
	Vollenhovia	sp_EMS17		X	
(tribe Dacetini)	*Eurhopalothrix*	sp_EMS04	X	X	
	Eurhopalothrix	sp_EMS05	X	X	
	Eurhopalothrix	sp_EMS06	X		X
	Pyramica	sp_EMS03	X		
	Pyramica	sp_EMS04		X	
	Pyramica	sp_EMS05		X	
	Pyramica	sp_EMS06	X		
	Strumigenys	*loriae*	X	X	X
	Strumigenys	sp_EMS17	X	X	
	Strumigenys	sp_EMS18		X	
	Strumigenys	sp_EMS19		X	X
	Strumigenys	sp_EMS20	X		
	Strumigenys	sp_EMS21	X		
	Strumigenys	sp_EMS22	X		
	Strumigenys	sp_EMS23		X	
	Strumigenys	sp_EMS24		X	
	Strumigenys	sp_EMS25	X	X	
Ponerinae	*Anochetus*	sp_EMS02	X	X	
	Anochetus	sp_EMS03	X		
	Cryptopone	sp_EMS02		X	
	Cryptopone	*testacea*		X	
	Cryptopone	sp_cf_*fusciceps**	X	X	

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Table 1.1. *continued*

Subfamily	Genus	Species	Lamas (200 m)	Vouvou (900 m)	Tompoi (1,600 m)
	Hypoponera	*pruinosa*	X	X	
	Hypoponera	*confinis*	X	X	
	Hypoponera	sp_EMS08	X	X	X
	Hypoponera	sp_EMS09		X	X
	Hypoponera	sp_EMS10	X	X	
	Hypoponera	sp_EMS11	X	X	
	Hypoponera	sp_EMS12			X
	Hypoponera	sp_EMS29			X
	Leptogenys	sp_EMS02	X	X	
	Myopias	*delta*		X	
	Myopias	sp_EMS07	X	X	
	Myopias	sp_EMS08	X	X	
	Myopias	sp_EMS09	X	X	
	Odontomachus	sp_EMS07	X	X	
	Odontomachus	sp_EMS08	X	X	
	Pachycondyla	*croceicornis*	X	X	
	Pachycondyla	sp_EMS05	X	X	
	Pachycondyla	sp_EMS06	X	X	
	Platythyrea	sp_EMS02	X		
	Ponera	*xenagos*	X	X	
	Ponera	*szaboi*		X	
	Ponera	sp_EMS06	X		X
	Ponera	sp_EMS10	X	X	
	Ponera	sp_EMS11	X		
Proceratiinae	*Discothyrea*	sp_EMS01	X	X	
	Discothyrea	sp_EMS02		X	
	Proceratium	sp_EMS01	X	X	
	Proceratium	sp_EMS02	X		
Described Species	34				
Undetermined Species	97				
Total Species	140		93	92	22
Confirmed Species new to science	9 (6%)		7 (8%)	2 (2%)	2 (9%)
Estimated Species new to science	40 (29%)				

high diversity of ants, although diversity was not as high as reported for sites on mainland New Guinea at similar elevations (Snelling 1998, Lucky et al. Chapter 10, this volume). The greatest ant diversity was found in the leaf litter with fewer species found in the understory or canopy. The leaf litter fauna included specialist predators on collembola (*Strumigenys* spp.), predators of other ants (*Cerapachys* spp., *Aenictus* spp.) as well as generalist predators (*Hypoponera* spp., *Odontomachus* spp.).

The forest floor around Vouvou was colder and wetter than that at the lower elevation site, but in general the ant community composition resembled that seen at Lamas. However approximately 60% of species occurring at Vouvou were found at both sites. Many trees, living and dead, were covered with either moss, ferns or other epiphytic vegetation and soil-nesting species in the genera *Pheidole*, *Tetramorium* and *Vollenhovia* were encountered in the soil at the interface of moss mats and tree trunks rather than on the ground. One major difference between ant communities at Vouvou and those at Lamas, was the presence of arboreally-nesting ants, including species in the genera *Crematogaster* and *Podomyrma,* foraging on the ground surface and leaf litter layer. Since we did not survey the arboreal strata, however, we cannot confirm the absence of these species from the lowest elevation site.

At Tompoi the abundance and diversity of ants (22 species) was lower than that observed at lower elevation sites, presumably because of the cold and wet climate. The vegetation in these forests becomes saturated with water during wet periods. Many ants were found nesting in sites that were protected against complete inundation with rainwater. The genera *Hypoponera, Paratrechina, Pheidole,* and *Ponera* were among those found nesting such sites, which included partially buried dead trees on the forest floor, dry bamboo internodes, hollow tree trunks and thick mats of roots, mosses, vines and epiphytes encircling tree trunks.

SPECIES OF CONSERVATION AND BIOGEOGRAPHIC INTEREST

The survey provides a wealth of useful information about the ant fauna of New Britain. Of the 34 described species identified from this study, 27 are new records for the Bismarck Archipelago. Nine species collected during this survey have already been confirmed as new to science, and further taxonomic reviews are expected to add an additional 20-30 new species to this list. The nine ants confirmed to be undescribed belong to six subfamilies and include three new species in the small genus *Lordomyrma,* which is only known from lowland wet forests on islands in the western Pacific. Two new species of the centipede-predator genus *Amblyopone* were found; one only at the lowest site and the other only at the high elevation site. One new species of *Cerapachys,* an army ant that is predatory on other ants, was found at the lowest elevation site. The other new species belong to the genera *Rhytidoponera, Paratrechina (Paraparatrechina)* and *Cryptopone*.

Three of the collected species (*Pheidole oceanica, Pristomyrmex brevispinosus, Technomyrmex vitiensis*) represent new records for Papua New Guinea. These species, along with another Pacific native species (*Tetramorium insolens*) are of biogeographic importance as they are widespread across other regions of the Pacific and their current geographic distributions are thought to be reflective of historic geotectonic events.

Of the described species, twenty are endemic to New Guinea, but none is endemic exclusively to the Bismark Archipelago. The lack of named New Britain endemics does not suggest low endemicity, but rather the opposite - the degree to which this island's ant fauna is poorly studied. The majority of ants encountered in this survey are probably undescribed species (6% confirmed new to science; 69% undetermined and at least 40 species likely undescribed), whereas only 24% of species can be associated with names. Further study of both the specimens collected on this survey and the broader Melanesian ant fauna will be necessary to determine what proportion of the New Britain ant fauna is endemic to the island.

Only one species encountered on this survey, the Penny Ant (*Tetramorium bicarinatum*) is potentially non-native. The pan-tropical distribution of this species is attributed to accidental human transport. However its native range is unknown, with the Indo-Pacific region considered the most likely source region (Wetterer 2009). The lack of other introduced ants in the Nakanai mountains is a notable discovery of this survey, as many Pacific Islands are suffering the destructive effects of invasive species. The absence of the highly invasive Little Fire Ant (*Wasmannia auropunctata*) from the New Britain study sites is of conservation significance, as this rapidly spreading species is inflicting severe damage to tropical ecosystems and local food security across the Pacific, including mainland New Guinea, the Solomon Islands, New Caledonia and Australia (Sarnat 2008).

Amongst the described species, no endemic ants were documented on this survey, which is likely the result of the poor state of knowledge of the ant fauna of this archipelago. Nevertheless, a high proportion of undescribed ant species encountered in New Britain suggests an island fauna that is poorly documented, and which may have considerable endemicity. Surveys of low (200 m), mid (900 m) and high (1,600 m) elevations produced nine species confirmed to be new to science thus far; an additional 20-30 new species are expected to be confirmed as new to science upon further study of this material. Many of the undescribed species are expected to come from diverse ground-dwelling genera such as *Hypoponera, Pheidole, Monomorium,* and *Vollenhovia*.

Unfortunately, the taxonomic resources available for identification of New Guinea ants is limited at this time. A taxonomic review of the major and minor islands has not yet been completed, and few taxonomic revisions have treated taxa with representatives in New Guinea. The results of this survey will to constitute a major step forward in our knowledge of the ant fauna of New Britain Island and more broadly, in New Guinea, one of the regions where ant diversity is thought to be amongst the highest on Earth.

Given the absence of destructive invasive ant species from the survey sites, and the threats posed by such introductions as well as logging, fire and habitat loss facing forest communities on Pacific Islands, we recommend that steps be taken to conserve the remaining intact tracts of rainforest at low, mid and high elevations in the Nakanai Mountains.

CONSERVATION RECOMMENDATIONS

The Nakanai Mountains of East New Britain are of high scientific and conservation value because they contain intact forest ecosystems that are both unique and vulnerable. New Britain's long isolation from mainland New Guinea and neighboring Solomon Islands has produced a unique community of flora and fauna. The threats to this biota include habitat loss due to human activities and the effects of invasive species, including invasive ants that may follow the logging road that runs from Marmar village on the east coast inland towards Muru. Many Pacific island animal communities have been devastated by such invaders, most notoriously *Wasmannia auropunctata,* and the resulting impact has had profound effects on ecosystem function (LeBreton et al. 2003, Jourdan 1997) as well as on local people and agriculture. Fire is also a concern in forests in karst areas, where prolonged dry spells may cause dieback. We recommend that authorities and local communities be adequately informed about the risks of uncontrolled fires and measures be taken to preserve the pristine forests of the Nakanai Mountains and to protect the unique ant communities that occur within them.

The high diversity of ants in the forests surveyed can be attributed primarily to species in leaf-litter or decomposing wood on the forest floor. The highest diversity of ants was found at low to mid elevations, where many ant species dwell in large, decomposing logs and in accumulations of leaf litter. Many of these taxa are expected to occur only in pristine habitats such as those encountered in the Nakanai Mountains. Microhabitats that foster rich communities of terrestrial arthropods are adversely affected by human activities such as logging, agriculture, mining, and the habitat alterations associated with increased population density, such as road-building.

Canopy-dwelling ants were not a focus of this survey and are likely under-represented in our samples, however, those that we did encounter were often found in association with ant-plants, species that provide nesting structures for ants within their living tissues. These inter-species symbioses are of conservation interest because they are especially susceptible to decoupling when threatened by environmental changes, be they human-induced or propelled by a changing climate. These co-evolutionary systems provide important models for the study of symbiosis, and are therefore of concern. In the Nakanai Mountains we also observed close relationships between ants and other insects, such as ants tending and feeding from scale insects (Hemiptera: Coccidae) and mealybugs (Hemiptera: Pseudococcidae). These close interactions often occur only in primary forests, and are therefore unlikely to survive habitat loss. The occurrence of closed canopy forest ant genera such as *Lordomyrma and Discothyrea* are a compelling indication of pristine forest. These and other ant species occur in the leaf litter and require closed canopy forest to maintain the appropriate microclimate they need. We recommend taking steps toward conserving unique forest tracts such as those sampled on East New Britain, at low, mid and high-elevations.

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