Ants of the leaf litter of two plateaus in Eastern Suriname

Author: Sosa-Calvo, Jeffrey

Source: RAP Bulletin of Biological Assessment: A Rapid Biological Assessment of the Lely and Nassau Plateaus, Suriname (with additional information on the Brownsberg Plateau): 92

Published By: Conservation International

URL: https://doi.org/10.1896/1-881173-98-4.92

Chapter 5

Ants of the leaf litter of two plateaus in Eastern Suriname

Jeffrey Sosa-Calvo

INTRODUCTION

Due to rapidly declining diversity and disappearing habitats worldwide, systematists and ecologists have created a series of protocols to rapidly explore, understand, and catalogue our planet's extensive living resources. Invertebrates are an important component of the trophic structure of every ecosystem. Among all the invertebrates that live in the forest, ants possess numerous qualities that make them a cornerstone element for conservation planning. Ants are: 1) dominant constituents of most terrestrial environments, 2) easily sampled in sufficiently statistical numbers in short periods of time (Agosti et al 2000), 3) sensitive to environmental change (Kaspari and Majer 2000), and 4) indicators of ecosystem health and of the presence of other organisms, due to their obligate symbioses with plants and animals (Alonso 2000). For these reasons ant taxonomists, ecologists, and behaviorists created the Ants of the Leaf Litter protocol (A.L.L) (Agosti and Alonso 2000). A.L.L is a standardized methodology that can be easily repeated in different habitats at different times of the year (Agosti et al. 2000). Under this protocol different datasets can be combined and analyzed at a larger scale.

The ant fauna of Suriname remains unknown. Borgmeier (1934) reported 36 ant species from a study of the ants in coffee plantations in Paramaribo; Kempf (1961) studied the ant fauna of the soil from collections made by der Drift from April to October of 1959. In his study Kempf found 171 ant species belonging to 59 genera. In that survey, der Drift used pitfall traps, leaf-litter samples using Berlese funnels, and soil samples from primary forest, agricultural fields, and pastures. Previous censuses of the Neotropical ant fauna by Kempf (1972), Brandao (1991), and Fernandez and Sendoya (2004) recognize 290 species for Suriname. The new world tropics is known to contain one of the richest ant faunas in the world, with more than 3000 described species (Fernandez and Sendoya 2004), As sampling becomes more exhaustive, this number continues to increase. The La Selva Biological Station provides an instructive example. As a result of more than ten years of continuous sampling, La Selva accounts for almost 450 species (Longino et al. 2002).

Suriname's position within the Guiana Shield, considered the largest undisturbed region of tropical forest in the world, makes it one of the most important places for tropical forest conservation and sustainable development. The most important and urgent threats faced by Suriname are: 1) large-scale (bauxite and gold) mining, 2) small-scale gold mining, 3) large-scale logging, and 4) hunting. As pointed out by Haden (1999) the principal cause of deforestation and pollution is mining at both large and small scales. The extraction of gold is associated with water poisoning due to the large quantities of mercury or cyanide used. Common techniques to extract gold (i.e., suction-dredge placer and hydraulic) are responsible for erosion, siltation, and water turbidity (Haden 1999). This increasing pressure from mining and other resource-extraction industries threatens the pristine nature not only of Suriname but of the entire Guiana Shield.

I present the results of a rapid assessment program survey of the ant fauna that inhabit the leaf litter, hoping that the information presented here will inform critical conservation decisions by mining companies, governments, and individuals.

MATERIALS AND METHODS

Study sites

The Lely and Nassau plateaus are located in eastern Suriname on the Guiana Shield near the border with French Guiana and east of the man-made Lake Brokopondo, created in 1864 and swamping about 580 square miles of virgin rainforest.

The Lely Mountains comprise a series of plateaus with a maximum altitude of 700 m. A preliminary plant survey of the Lely Mountains (ter Steege et al. 2004) showed two types of forest. The first is a high mesophytic rain forest characterized by relatively well-drained soil and high (25 – 50 m) closed canopy. This type of forest is dominated by tree-species within the genera *Eschweilera, Couratari, Lecythis, Sloanea, Hymenaea, Virola,* and *Qualea*.

The second type of forest, a mountain savannah forest, is characterized by very low tree diversity. The mountain savannah forest was divided into three subcategories by ter Steege et al. (2004): 1) a dry forest dominated by *Croton* sp., *Micrandra brownsbergensis, Vriesea splendes*, and large numbers of species within the family Myrtaceae; 2) a humid type dominated by *Vriesea* spp., mosses, and epiphytes; and 3) a low moss forest with all tree trunks covered by dark brown mosses.

The Nassau Mountains comprise four plateaus ranging from 500 to 570 m. Nassau plateaus include primary and secondary rain forest, 'berg savannah' dominated by *Hevea guianensis, Micrandra* sp., and several Myrtaceae species (Banki et al. 2003), and limited patches of *Euterpe oleracea,* a palm found on the plateau in swamp-like areas. Nassau is also characterized by rocky soils and some cleared areas (roads and an overgrown airstrip).

Data collecting

The sampling method carried out is a modified version of the A.L.L. protocol as described in Agosti et al. (2000). Two hundred-meter linear transects were delimited at each locality (Lely= 2 transects, Nassau= 1 transect). A 1 x 1-m quadrat was set up every 10 m. The leaf-litter, rotten twigs, and first layer of soil present in the quadrat were shaken for about a minute using a wire sieve of 1-cm^2 mesh size. The sifted leaf litter was then placed in a mini-Winkler sack and allowed to run for 48 hours. (For further information and discussion of this technique, see Agosti et al. 2000: p. 133.) The alcohol-preserved samples were sorted to morphospecies in the laboratory using a Leica MZ16 stereomicroscope. Specimens of each morphospecies were mounted and identified to named species whenever allowed by current ant taxonomy.

Data analysis

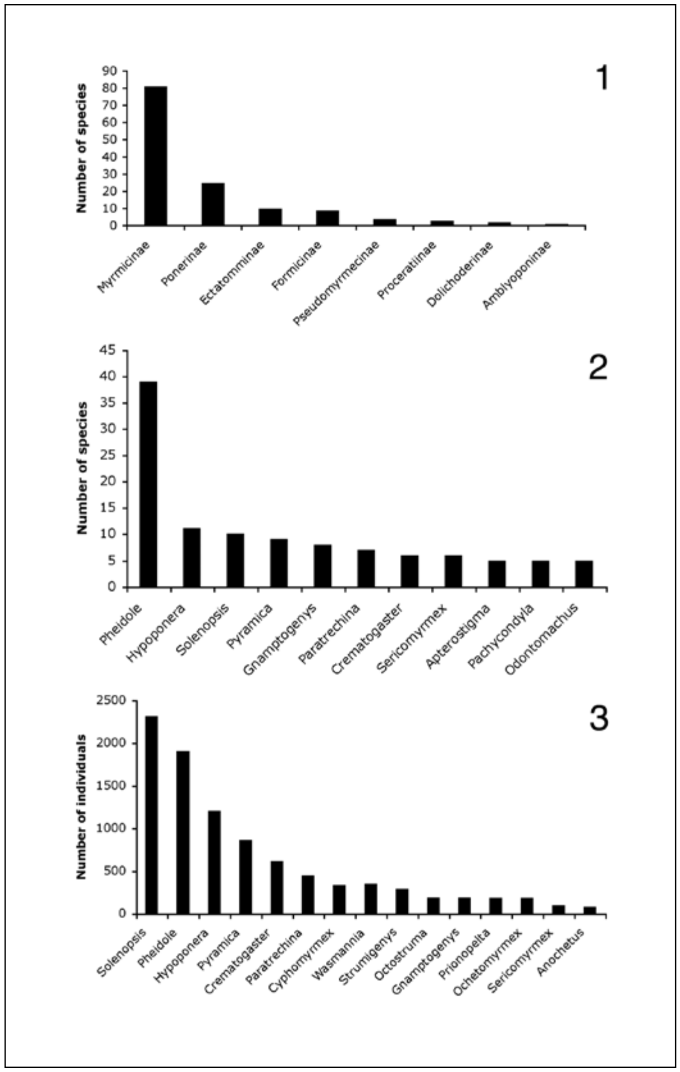
The computer program EstimateS (version 7.5 for Mac) (Colwell 2005) was used to calculate species accumulation curves. Curve-smoothing was accomplished by randomizing sample order 100 times (Toti et al. 2000; Colwell & Coddington 1994). EstimateS was also used to compute the mean of the non-parametric species richness estimator, ICE (incidence-based coverage estimator), which relies on incidence data to quantify rarity (i.e., the number of uniques and duplicates). To compare the taxonomic composition of both sites, two similarity indexes were used. The first was the Sorensen index of similarity:

$$S = 2c/(a+b)$$

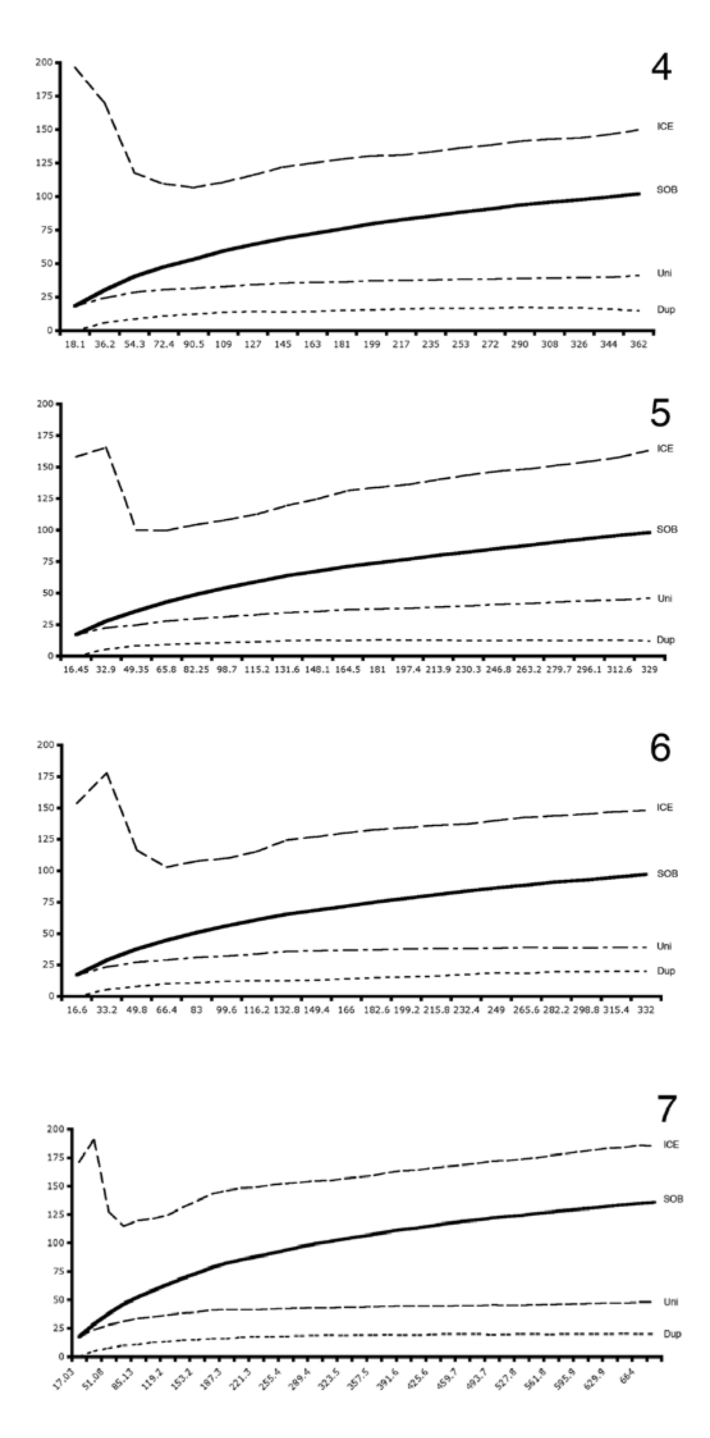
where, a= number of species in site A, b= number of species in site B, and c= number of shared species in sites A and B. This index is considered as one of the most effective presence/absence similarity measures (Magurran 2003). The second index employed was the Jaccard classic index:

$$Sj= c/a+b-c$$

where, a= total number of species in sample A, b= total number of species in sample B, c= number of common species to sample A and B (Wilson and Shmida 1982).



Figures 5.1 – 5.3. Taxonomic composition of the survey: 1) Total number of ant species in the different subfamilies collected at both sites. 2) The eleven most speciose ant genera collected at both sites. 3) The fifteen most individual rich genera collected at both sites.



Figures 5.4 – 5.7. Assessment of the leaf litter ant inventory for each site. 4) Lely transect 1; 5) Lely transect 2; 6) Nassau; 7) Combined Lely transects. The species accumulation curve plots the number of species (Y-axis) and the number of samples (X-axis). Abbreviations: Uni= uniques, Dup= duplicates, SOB= species observed, ICE= incidence-based coverage estimator.

RESULTS

A total of 9838 individual ants was collected. Of those 9838 individuals, 9651 worker specimens, representing 36 genera and 169 species, were collected from 600 m^2 of leaf-litter samples (Appendix 6). Of those 169 species, the combined transects at Lely accounted for 136 species while Nassau accounted for 97 species. The subfamily Myrmicinae (Figure 5.1) was represented by the largest number of species with 81 species, followed by the Ponerinae with 25 species (48% and 15% of the total species, respectively). The most speciose genus (Figure 5.2) was *Pheidole* with 39 species (23% of the total) followed by the genera *Hypoponera* (11 species), *Solenopsis* (10 species), *Pyramica* (9 species), and *Gnamptogenys* (8 species), the four genera together accounting for 21.9% of the total. The ranking of the genera changes with respect to the number of individuals collected (Figure 5.3) with *Solenopsis* ranking first (2316 individuals, 24% of total), followed by the genera *Pheidole, Hypoponera,* and *Pyramica* (1904 [19.7%], 1201 [12.4%], and 862 [8.9%] individuals, respectively). Among species, *Solenopsis* sp. 001 accounted for the largest number of individuals with 797 specimens collected, followed by *Pyramica denticulata* (667 individuals), and *Pheidole* sp. 006 (463 individuals). See photo pages for images of several of the ant species.

Species richness estimates

For none of the three transects (Lely = 2 and Nassau = 1) individually, nor for the combined Lely transects, does the mean, randomized, or observed species accumulation curve reach an asymptote (Figures 5.4 – 5.7). The number of uniques (species detected in only one quadrat) and duplicates (species detected in only two quadrats) for Lely tend to reach a plateau or to slightly decrease. In Nassau, however, the number of uniques has stabilized, while the number of duplicates is increasing. When both Lely transects are combined, the number of uniques and duplicates reaches a plateau. The species estimator, ICE, for the combined Lely transects presents a slightly tendency to decrease and to approach the observed species accumulation curve. However, for each of the individual transects the species estimator continues increasing, suggesting that more sampling is needed. Lely, with 136 species, possessed the richest ant fauna of the survey. In only one transect, 102 species were collected. For Nassau 97 species were recorded from a single transect. Although, this could be an artifact of collection intensity (two entire 200 m transects of leaf litter samples were collected at Lely while a unique entire 200 m transect was carried out at Nassau), previous studies of the diversity of the flora for both sites shown have shown that Lely present a higher diversity while Nassau presented the lowest (including Brownsberg National Park).

Richness estimates and other summary values for each transect, including the combined Lely leaf-litter sample, are given in Table 5.1. Each richness estimate is represented by the mean of 100 randomized iterations of sample order.

Community structure

Values of the Sorensen similarity index and the Jaccard classic index (Table 5.2) show that the two communities (Lely vs. Nassau) differ slightly in ant species composition. Both transects at Lely share 64 species, while comparisons between transects 1 and 2 with Nassau showed a lower number of species shared (54 each). When both Lely transects are combined and compared with Nassau, the number of shared species shared between Lely and Nassau increases to 66. However, the similarity value of each index shows slightly low complementarity between both sites. Based on the values of the indices none of them approach to 1, with exception of Lely 1 to Lely 2 (Sorensen=0.637; Jaccard= 0.467).

DISCUSSION

According to the censuses of Neotropical ants by Kempf (1972) and Fernandez and Sendoya (2004), Suriname possesses about 290 species. There have been few attempts to study the ant fauna of Suriname. Borgmeier (1934) reported 36 ant species in coffee plantations in Paramaribo, while Kempf (1961) reported the presence of 171 species (54 genera) from primary forest, plantations, and pastures. Most of the ant collections in the interior in Suriname occurred sporadically from 1938 – 1958, mainly by G. Geyskes in Paramaribo and Brownsberg Nature Park. This survey conducted in the eastern part of Suriname recorded 169 ant species and morphospecies from three 200-m leaf litter samples. Species richness estimators (Figures 5.4 – 5.7) suggest a much higher ant diversity for Suriname than suggested by any of the aforementioned studies. More leaf litter samples from different localities within the country are needed to properly estimate Suriname ant diversity and address future conservation strategies. Suriname's central position within the Guyana Shield, an ancient rock massif dating back to the Pre-Cambrian (~ 2.5 billion years ago) (Gibbs and Barron 1993), recommends it for biological resource conservation and sustainable development.

This dataset contains a high number of unnamed morphospecies, making it difficult to quantify the number of species that were not recorded by Kempf (1972) or Fernandez and Sendoya (2004), but perhaps half of the species in this study constitute new records for Suriname. Of all ecological communities, tropical rain forests are thought to have the greatest species diversity. In Costa Rica, for example, Longino et al. (2002) reported about 450 ant species in an area no greater than 1500 ha (La Selva Biological Station). LaPolla et al. (in press) recorded 230 species in eight localities in Guyana and estimated a much higher ant diversity than the 330 species previously known for that country. Other surveys conducted in Borneo (Brühl et al. 1998) and Madagascar (Fisher 1999, 2005), with extensive field sampling over several years, have shown that the number of ant species is usually undersampled. Based on these studies, extensive fieldwork will undoubtedly increase the number of ant species in Suriname.

The absence of some ants that are known to be typical leaf-litter inhabitants, but that were uncommon in this data-

Table 5.1. Richness estimates and other summary values for each locality.

	Lely	Lely 2	Nassau	Lely (combined)
Observed richness	102	98	97	136
Number of samples	20	20	20	40
Number of adult workers	2384	2392	4425	5226
Number of uniques	41	46	39	48
Number of duplicates	15	12	20	20
ICE	149.82	163.14	147.96	185.42
Chao 1	153.25	177.62	132.29	189.71
Chao 2	150.69	173.63	130.52	188.37
Jacknife	140.95	141.7	134.05	182.8
Bootstrap Mean	119.14	116.45	113.93	156.74
MM Mean	130.77	127.16	126.51	159.36

Table 5.2. Number of shared species and values of similarity indices for the two sites (three transects) in Suriname. See text for definition of indices.

	Lely to Lely 2	Lely to Nassau	Lely 2 to Nassau	Lely total to Nassau
Number of shared species	64	54	54	66
Sorensen's similarity index	0.637	0.545	0.554	0.564
Jaccard's similarity index	0.467	0.375	0.383	0.392

set, may be due to an artifact of the sampling method used. For example, at Lely, the genera *Pheidole* and *Camponotus* were found everywhere in high numbers by hand collecting. However, the genus *Camponotus* was not collected in any of the 60 quadrats sampled, perhaps due to their rapid escape response and to the fact that they nest in trees and in rotten logs rather than in the soil or litter. The species *Daceton armigerum* and *Gigantiops destructor* were hand collected in Lely and Nassau, respectively. Again, neither of these was present in the Winkler samples. *Daceton armigerum* is known to be arboreal, so its capture in leaf litter sampling is unlikely. *Gigantiops destructor*, on the other hand, is a typical inhabitant of the leaf litter. Their big eyes give them a highly visual ability, which combined with their quick speed and jumping ability, make their capture in leaf litter quadrats unlikely.

The species *Wasmannia auropunctata* can be abundant in either primary forest or young second growth, although it is perhaps most abundant in disturbed habitats. This species is known to be an important agricultural pest in several regions of the tropics because of its strong sting. The species *Wasmannia scrobifera* while infrequently collected, is known to be more typical of mature lowland rainforest.

The genus *Pheidole* is the most speciose genus at both sites. *Pheidole* represents 23% of total ant species collected in this survey (with 39 species), while the genera *Hypoponera*, *Solenopsis*, *Pyramica*, and *Gnamptogenys* together counted for almost 22% of total species collected (with 11, 10, 9, and 8 species, respectively) (Figure 5.2). The taxonomic dominance of *Pheidole* in most tropical forests is well known (Ward 2000, Wilson 2003). Nonetheless, in terms of the number of individuals collected per genera, *Pheidole* drops to second place with 1904 individuals. The genus *Solenopsis* ranked first with 2316 individuals collected. The genus includes the famous invasive species *S. geminata* and *S. invicta* (fire ants), of great economic importance in the United States. In spite of its widespread distribution, the genus has not been taxonomically revised and the biology of many of its species remain unknown. Another ecologically dominant genus in Neotropical rain forests is *Hypoponera*, a prime candidate for conservation planning and long-term monitoring. However, the number of species recorded here is perhaps underestimated due to the lack of a synoptic revision.

The tribe Dacetini, which was recently revised by Bolton (2000), is represented in Suriname by four genera, *Acanthognathus, Daceton, Pyramica,* and *Strumigenys*. According to Kempf (1972), Bolton (2000), and Fernadez and Sendoya (2004) this represents the first record of the genus *Acanthognathus* for Suriname. Within the genus *Pyramica*, there are five species that are recorded for the first time for Suriname: *P. auctidens* (known previously from French Guiana), *P. beebei* (known from Colombia and Brazil), *P. cincinnata* (known from Brazil), *P. crassicornis* (known from Trinidad and Tobago to Paraguay), and *P. halosis* (known previously from Venezuela). Within the genus *Strumigenys*, two species were recorded for the first time: *S. cosmostela* (known from Mexico to Peru, including Brazil) and *S. trinidadensis* (known previously from Costa Rica to Brazil). A possible new species within the genus *Pyramica* was also collected. Members of the Dacetini tribe are good tools for biodiversity planning. Their biology is relatively well- known, their taxonomy has been recently revised, and their diet is restricted to arthropods that inhabit the soil.

The recently described genus *Cryptomyrmex* Fernandez (Myrmicinae: Adelomyrmicini), known from only two species from Brazil and Paraguay, was collected in Nassau. The species, *Cryptomyrmex longinodus*, was originally described from Brazil from soil samples (see photo pages). Here, the distribution of the species and genus is extended. The biology of this intriguing ant remains unknown. The genus can easily be confused with *Adelomyrmex*, but close examination of the specimen reveals differences in the petiole and eyes, visible under light stereomicroscope, but not visible under Scanning Electron Micrography (SEM) (Fernando Fernandez, personal communication).

Lely contained the most ant species in this survey. The combined transects produced a total of 136 species, while in Nassau 97 species were recorded. This difference could be due to the number of transects and samples collected (2 transects, 40 samples for Lely vs. 1 transect, 20 samples for Nassau). However, the level of disturbance seems to be lower in Lely than Nassau, where open roads, camps, mining, and hunting activities have resulted in a low animal population (ter Steege et al. 2005). The results of this survey with those of ter Steege et al (2004, 2005) and Bánki et al. (2003), which compared the plant diversity of three areas, including Brownsberg Nature Park (BNP), Lely, and Nassau. Those studies concluded that Nassau has the lowest plant diversity of the three, while Lely is the most diverse.

Similarity indices (Jaccard and Sorensen), although low, showed that the two samples within Lely are more similar than either one is to Nassau (Table 5.2). When the combined Lely samples are compared to Nassau, the number of shared species between the two increases to 66, but the indices still suggest a low similarity.

CONSERVATION RECOMMENDATIONS

With most of its landscape still intact, the time for Suriname to take action is now, before deforestation and mining become more widespread. Although the extraction of some natural resources is certain to happen, the rich fauna and flora of Suriname can be preserved with planning and with the creation of protected areas, such as the Central Suriname Nature Reserve. As demonstrated by Agosti et al. (2000), ants of the leaf litter are important tools for conservation planning. The impact of logging, mining, and hunting on the physical environment and on the ant community is severe. Ants are known to respond negatively to the loss of plant diversity and to changes in soil microclimate resulting from deforestation (Underwood and Fisher 2006). Although deforestation is not yet widespread at Lely or Nassau, I recommend the maintenance of large areas of intact primary forest to serve as reservoirs of keystone species.

As pointed out by ter Steege (2005), the constant pressure from mining activities in the surrounding areas of Nassau has resulted in a very low animal population. Hunting accompanies small-scale mining. As seen in Lely, the pressure of such activity on mammals and birds is shocking. It is imperative that local people be educated to properly use their natural resources. The impact that only a few people can have on the environment was evidenced in Lely, where small mammals, birds, and monkeys, among others, where found dead near the trails used by the local airstrip work crew.

The conservation of these still healthy forests should be a principal goal for the government, the mining companies, and the Surinamese people. One of the largest and richest remnants of pristine forest in the world is still intact within Suriname's borders, but it is largely threatened by uncontrolled logging, hunting, and mining. Thus, the application of high environmental standards to resource extraction companies and strong sanctions on illegal resource exploitation are needed in order to help to preserve the great diversity of the Guiana Shield in Suriname.

REFERENCES CITED

Agosti, D. and Alonso, L. E. 2000. The ALL protocol: a standard protocol for the collection of ground-dwelling ants. *In:* D. Agosti, J. Majer, L. E. Alonso and T. R. Schultz (eds.). Ants, Standard Methods for Measuring and Monitoring Biodiversity. Washington, D.C.: Smithsonian Institution Press. Pp. 204-206.

Agosti, D., J. D. Majer, L.E. Alonso, and T. R. Schultz (eds.). 2000. Ants: Standard Methods for Measuring and Monitoring Biodiversity. Smithsonian Institution Press. Washington, D.C.

Alonso, L.E. 2000. Ants as indicators of diversity. *In:* D. Agosti, J. Majer, L. E. Alonso and T. R. Schultz (eds.). Ants: Standard Methods for Measuring and Monitoring Biodiversity. Washington, D.C.: Smithsonian Institution Press. Pp. 80-88.

Bánki, O. S., ter Steege, H., Jansen-Jacobs, M. J., and Raghoenandan, U.P.D. 2003. Plant diversity of the Nassau Mountains Report of the 2003 expedition. Internal report. NHN-Utrecht, BBS-Paramaribo. Utrecht, Netherlands. Paramaribo, Suriname.

Bolton, B. 2000. The ant tribe Dacetini, with a revision of the *Strumigenys* species of the Malagasy Region by Brian L. Fisher, and a revision of the Austral epopostrumiform genera by Steven O. Shattuck. Memoirs of the American Entomological Institute. 65: 1 – 1028.

Borgmeier, T. 1934. Contribuição para o conhecimento da fauna mirmecólogica dos cafezais de Paramaribo, Guiana Holandesa (Hym. Formicidae). Arquivos do Instituto de Biología Vegetal. 1: 93 – 113.

Brandão, C.R.F. 1991. Adendos ao catálogo abreviado das formigas da região Neotropical (Hymenoptera: Formicidae). Revista Brasileira de Entomologia. 35: 319-412.

Brühl, C.A., M. Mohamed, and K.E. Linsenmair. 1998. Altitudinal distribution of leaf litter ants along a transect in primary forests on Mount Kinabalu, Sabah, Malaysia. Journal of Tropical Ecology. 15: 265 – 177.

Colwell, R.K., J.A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society (Series B). 345: 101-118.

Colwell, R. K. 2005. EstimateS: Statistical estimation of species richness and shared species from samples. Version 7.5. User's Guide and application published at: http://purl.oclc.org/estimates.

Fernandez, F. and S. Sendoya. 2004. List of Neotropical ants (Hymenoptera: Formicidae). Biota Colombiana. 5: 3 – 93.

Fisher, B.L. 1999. Improving inventory efficiency: A case study of leaf litter ant diversity in Madagascar. Ecological Applications. 9: 714 – 731.

Fisher, B.L. 2005. A model for a global inventory of Ants: A case study in Madagascar. Proceedings of the California Academy of Sciences. 56: 86 – 97.

Gibbs, A.K. and C.N. Barron. 1993. The Geology of the Guyana Shield. Oxford University Press. Oxford, UK.

Haden, P. 1999. Forestry issues in the Guyana Shield region: A perspective on Guyana and Suriname. European Union Tropical Forestry. Overseas Development Institute. London, UK.

Kaspari, M. and J.D. Majer. 2000. Using ants to monitor environmental change. *In:* D. Agosti, J. Majer, L. E. Alonso and T. R. Schultz (eds.). Ants: Standard Methods for Measuring and Monitoring Biodiversity. Smithsonian Institution Press. Washington, D.C.

Kempf, W.W. 1961. A Survey of the ants of the soil fauna in Surinam (Hymenoptera: Formicidae). Studia Entomologica. 4: 481 – 524.

Kempf, W.W. 1972. Catalogo abreviado das formigas da região Neotropical (Hymenoptera: Formicidae). Studia Entomologica. 15: 3 – 344.

LaPolla, J.S., T. Suman, J. Sosa-Calvo, and T.R. Schultz. In press. Leaf litter ant diversity in Guyana. Biodiversity and Conservation.

Longino, J.T., J. Coddington, and R.K. Colwell. 2002. The ant fauna of a tropical rain forest: Estimating species richness three different ways. Ecology 83: 689 – 702.

Magurran, A.E. 2004. *Measuring biological diversity*. Blackwell, Publishing. Oxford, UK.

ter Steege, H., O.S. Bánki, T.R. van Andel, J. Behari-Ramdas and G. Ramharakh. 2004. Plant diversity of the Brownsberg Nature Park, Suriname. Report of the Nov-Dec 2003 Expedition. NHN-Utrecht Branch, Utrecht University. Utrecht, Netherlands.

ter Steege, H., O.S Bánki, M.J. Jansen-Jacobs, S. Ramharakh, and K. Tjon. 2005. Plant diversity of the Lely Mts, Report of the 2004 expedition. Internal report.

NHN-Utrecht, BBS-Paramaribo, CELOS-Paramaribo. Utrecht, Netherlands. Paramaribo, Suriname.

Toti, D.S., F.A. Coyle, and J. A. Miller. 2000. A structured inventory of Appalachian grass bald and heath bald spider assemblages and a test of species richness estimator performance. The Journal of Arachnology. 28: 329 – 345.

Underwood, E.C. and B. Fisher. 2006. The role of ants in conservation monitoring: If, when, and how. Biological Conservation. 132: 166 – 182.

Ward, P.S. 2000. Broad-scale patterns of diversity in leaf litter ant communities. *In:* D. Agosti, J. Majer, L.E. Alonso and T.R. Schultz (eds.). Ants: Standard Methods for Measuring and Monitoring Biodiversity. Smithsonian Institution Press. Washington, D.C. Pp. 99-121.

Wilson, M.V. and A. Shmida. 1984. Measuring beta diversity with presence- absent data. Journal of Ecology. 72: 1055 – 1064.

Wilson, E.O. 2003. *Pheidole* in the New World. Harvard University Press. Cambridge, MA.

Appendix 6

List of ant species and number of individuals collected on three transects during the RAP survey.

Jeffrey Sosa-Calvo

Species	Lely transect 1	Lely transect 2	Nassau
Acanthognathus lentus	2		
Acanthognathus ocellatus	4		
Acromyrmex sp. 001	1	1	
Acromyrmex sp. 002	8		
Acropyga guianensis			14
Anochetus horridus	4	1	7
Anochetus inermis	20	33	
Anochetus mayri	2		1
Anochetus targionii	11		
Apterostigma pilosum sp. 001		7	
Apterostigma pilosum sp. 002	4		
Apterostigma pilosum sp. 003			1
Apterostigma pilosum sp. 004	24		1
Apterostigma pilosum sp. 005			3
Brachymyrmex sp. 001	7	5	24
Brachymyrmex sp. 002		1	
Brachymyrmex sp. 003	2		
Carebara sp. 001	1		
Carebara sp. 002	3		5
Carebara reticulata	20		2
Carebara urichi	6		18
Crematogaster sp. 001		52	207
Crematogaster sp. 002	28		
Crematogaster sp. 003	99	4	1
Crematogaster limata	18	5	
Crematogaster sotobosque	54	83	61
Crematogaster tenuicula		3	
Cryptomyrmex longinodus			4
Cyphomyrmex cf. *peltatus*	25	21	66

Species	Lely transect 1	Lely transect 2	Nassau
Cyphomyrmex rimosus	48	124	49
Discothyrea denticulata	5		3
Discothyrea sexarticulata		1	
Discothyrea sp. 001			3
Dolichoderus imitator	3		
Dolichoderus sp. 001			51
Ectatomma lugens			1
Ectatomma tuberculatum	1		
Gnamptogenys horni	13	6	13
Gnamptogenys interrupta	1	4	
Gnamptogenys moelleri	1	5	9
Gnamptogenys pleurodon	59	1	17
Gnamptogenys relicta			45
Gnamptogenys sulcata	15		
Gnamptogenys tortulosa	1		
Gnamptogenys sp. 001	1		
Hylomyrma sp. 001	1	13	
Hylomyrma sp. 002			20
Hylomyrma sp. 003			19
Hypoponera nitidula	92		58
Hypoponera sp. 001	121	1	33
Hypoponera sp. 002	25		23
Hypoponera sp. 003	3		2
Hypoponera sp. 004	44	64	3
Hypoponera sp. 005	29	4	1
Hypoponera sp. 006	37	28	143
Hypoponera sp. 007	33		
Hypoponera sp. 008	21	4	52
Hypoponera sp. 009	97	108	174
Hypoponera sp. 010	1		
Leptogenys sp. 001	1		
Megalomyrmex sp. 001	3		5
Megalomyrmex sp. 002			1
Myrmelachista cf. *mexicana*			1
Ochetomyrmex sp. 001	93	39	52
Octostruma balzani	35	61	72
Octostruma iheringi	6		
Octostruma sp. 001		8	1
Octostruma sp. 002	1	7	
Odontomachus brunneus	2	3	17
Odontomachus hastatus			1

Species	Lely transect 1	Lely transect 2	Nassau
Odontomachus laticeps			1
Odontomachus scalptus			1
Odontomachus sp. 001	3	1	
Pachycondyla constricta	1	1	6
Pachycondyla harpax	6	9	
Pachycondyla pergandei	4		
Pachycondyla stigma		1	
Pachycondyla unidentata			9
Paratrechina sp. 001			10
Paratrechina sp. 002			70
Paratrechina sp. 003	27	98	137
Paratrechina sp. 004	7		
Paratrechina sp. 005	20		76
Paratrechina sp. 006			4
Paratrechina sp. 007	1	1	
Pheidole sp. 001	11	8	19
Pheidole sp. 002		5	
Pheidole sp. 003		1	
Pheidole sp. 004		2	
Pheidole sp. 005	133	81	178
Pheidole sp. 006	29	173	261
Pheidole sp. 007		5	
Pheidole sp. 008		4	1
Pheidole sp. 009		2	
Pheidole sp. 010		2	
Pheidole sp. 011		3	
Pheidole sp. 012	12	8	
Pheidole sp. 013	16		2
Pheidole sp. 014	16	5	
Pheidole sp. 015	3	10	
Pheidole sp. 016		9	26
Pheidole sp. 017	74	19	
Pheidole sp. 018	2	12	
Pheidole sp. 019		5	
Pheidole sp. 020	27	6	2
Pheidole sp. 021	97	136	215
Pheidole sp. 022		24	
Pheidole sp. 023	22	6	94
Pheidole sp. 024		18	
Pheidole sp. 025	11	3	
Pheidole sp. 026			5

Species	Lely transect 1	Lely transect 2	Nassau
Pheidole sp. 027	1	1	
Pheidole sp. 028	1		
Pheidole sp. 029	16	2	
Pheidole sp. 030		1	14
Pheidole sp. 031	1	1	5
Pheidole sp. 032		2	15
Pheidole sp. 033	5	11	21
Pheidole sp. 034	1		
Pheidole sp. 035			1
Pheidole sp. 036		1	
Pheidole sp. 037			1
Pheidole sp. 038	1		
Pheidole sp. 039			1
Prionopelta amabilis	81	1	103
Pseudomyrmex sp. 001			3
Pseudomyrmex sp. 002			2
Pseudomyrmex sp. 003		1	
Pseudomyrmex sp. 004		1	
Pyramica auctidens	1	18	16
Pyramica beebei		10	
Pyramica cincinnata		11	
Pyramica crassicornis		1	
Pyramica denticulata	189	98	480
Pyramica halosis		3	5
Pyramica subedentata			22
Pyramica sp. 001	1	6	
Pyramica sp. 002		1	
Rogeria blanda			2
Rogeria curvipubens			11
Rogeria innotabilis	1		
Rogeria micromma		1	1
Sericomyrmex beniensis	4	7	
Sericomyrmex harekulli arawakensis	3		
Sericomyrmex impexus		10	1
Sericomyrmex myersi	7	1	
Sericomyrmex zacapanus	1	52	7
Sericomyrmex sp. 001			1
Solenopsis sp. 001	229	198	370
Solenopsis sp. 002	49	171	3
Solenopsis sp. 003	14	60	388
Solenopsis sp. 004	172	27	98

Species	Lely transect 1	Lely transect 2	Nassau
Solenopsis sp. 005	17	88	244
Solenopsis sp. 006		47	23
Solenopsis sp. 007	17	24	15
Solenopsis sp. 008	31	27	
Solenopsis sp. 009	3		
Solenopsis sp. 010		1	
Strumigenys cosmostela		4	
Strumigenys elongata	18	17	18
Strumigenys perparva	114	61	49
Strumigenys trinidadensis	1	1	2
Thaumatomyrmex ferox	4		
Trachymyrmex cf. *bugnioni*			17
Trachymyrmex sp. 001	3		
Tranopelta gilva			1
Wasmannia auropunctata	189	59	83
Wasmannia rochai			3
Wasmannia scrobifera	1	11	
Total Number of Species	**103**	**98**	**97**