The effects of anthropogenic disturbance and seasonality on the ant communities of Lang Tengah Island (#82713)

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The effects of anthropogenic disturbance and seasonality on the ant communities of Lang Tengah Island

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Anthropogenic disturbances and seasonal changes significantly impact diversity and community composition, but their effects are often intertwined. We investigated these drivers on Lang Tengah Island, a location with a pronounced monsoon season and three resorts that close during this period. We surveyed four sites, two disturbed and two undisturbed, before and after the monsoon season, using pitfall traps to sample epigaeic ant communities. Undisturbed habitats had higher species diversity, but both habitats (undisturbed and disturbed sites) have a high proportion of ants with characteristics of being encroached by generalist and invasive/tramp ant species. Seasonal changes, such as monsoonal rains, can temporarily alter ant interactions and resource distribution, potentially maintaining diversity. Future studies should validate these findings for ant communities under similar pressures, using ant composition and functional roles for conservation and management purposes.

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Abstract

Anthropogenic disturbances and seasonal changes significantly impact diversity and community composition, but their effects are often intertwined. We investigated these drivers on Lang Tengah Island, a location with a pronounced monsoon season and three resorts that close during this period. We surveyed four sites, two disturbed and two undisturbed, before and after the monsoon season, using pitfall traps to sample epigaeic ant communities. Undisturbed habitats had higher species diversity, but both habitats (undisturbed and disturbed sites) have a high proportion of ants with characteristics of being encroached by generalist and invasive/tramp ant species. Seasonal changes, such as monsoonal rains, can temporarily alter ant interactions and resource distribution, potentially maintaining diversity. Future studies should validate these findings for ant communities under similar pressures, using ant composition and functional roles for conservation and management purposes.

Keywords

Island ant composition; pitfall traps; monsoon; invasive ants; tramp ants; Malaysia; Hill numbers; Rarefaction curves; generalist; specialist

Introduction

Ants (Hymenoptera: Formicidae) are globally distributed insects that play vital ecological roles as decomposers, soil aerators, seed dispersers, and key members of food webs (*Hölldobler & Wilson, 1990*). Ants They are excellent ecological indicators due to their impact on resource availability through physical and chemical changes in their environment (*Jones et al., 1994*), ease of consistent sampling from their stationary colonies, and ecological importance (*Hölldobler & Wilson, 1990*). Changes in ant diversity, composition, and functional roles in response to environmental triggers have been extensively studied, particularly in restoration ecology (*Majer & Nichols, 1998; Bisevac & Majer, 1999; Casimiro, Sansevero & Queiroz, 2019*). Previous studies have explored ant responses to restoration efforts, including the effects of habitat fragmentation, invasive species, and changes in land use (*Majer & Nichols, 1998; Bisevac & Majer, 1999; Casimiro, Sansevero & Queiroz, 2019*).

Ant distributions and their community composition response to seasonality are well known (*Parr & Andersen, 2008; Linksvayer & Janssen, 2009*; *Gibb et al., 2015; Paolucci et al., 2017; Andersen, 2019*). Epigaeic (*i.e.*, ground surface-dwelling including leaf-litter) ants inhabiting environments with seasonal flooding typically experience short-term species diversity reduction and changes in community composition (*Mertl et al., 2009*; *Vasconcelos et al., 2010*). However, some epigaeic species have adapted to seasonal flooding, increasing survivability (*Purcell et al., 2014*; *Kolay & Annagiri, 2015*; *Hertzog et al., 2016*), leading to the combination of ill- and well-adapted epigaeic ant species to alter species composition and the population dynamics in the given area (*Vasconcelos et al., 2010*). Sentences are long.

Ant distribution and community composition response to anthropogenic disturbances have also been extensively studied (*Andersen, 1995; Andersen, 2019; Philpott et al., 2010*), with varying findings. Some studies report a decline in species richness due to human disturbance (*Yamaguchi, 2004*; *Lessard & Buddle, 2005*), while others did not observe such decline (*Gibb & Hochuli, 2003*). Urbanization is known to lead to a decrease in species richness (*Lessard & Buddle, 2005*), with opportunistic or non-native species persisting in changed landscapes, leading to changes in ant composition (*Carpintero, Reyes-Lopez & de Reyna, 2003; Gibb & Hochuli, 2003; Holway & Suarez, 2006*). Exotic, invasive and tramp ant species are often found in anthropogenically disturbed environments (*Brassard et al., 2021*), impacting the native ants community (*Human & Gordon, 1996; Holway et al., 2002; Holway, 2005*), non-ant invertebrates (*Gerlach, 2004*) and plant communities (*Ness & Bronstein, 2004*), ultimately disrupting ecosystem services (*O'Dowd, Green & Lake, 2003*). Sentences rather long. They become confusing.

Ant communities' response to disturbance can be studied by classifying them into functional groups based on their broad behavior at biogeographical scales (*Hoffmann & Andersen, 2003*). This classification is sometimes preferred as it allows for easier comparison between studies and general understanding of disturbance impacts (*Andersen, 2019*). Seven functional groups are recommended for ant community comparison studies (*Andersen, 2000*), and they can be broadly categorized into generalist or specialist functional groups based on their behavior (*Hoffmann & Andersen, 2003*). Studies that investigate the effect of disturbance on ant communities commonly use this functional group classification, as it is easier to classify ants at higher taxonomic levels, such as genera and species-groups (*Andersen, 2019*).

Ant communities vary in functional group composition across different habitats, with dominant generalist functional groups such as Dominant Dolichoderinae (DD), Generalized Myrmicinae (GM), and Opportunists (OPP) being more common than specialist functional groups such as Hot Climate Specialists (HCS), Specialist Predator (SP) and Cryptic Species

(CRY) (*Leal et al., 2012*; *Arnan et al., 2018*; *Triyogo et al., 2020*). While the original functional group classification was based on Australian forest ant communities (*Andersen, 1995*), it has been adapted for other landscapes, including tropical forests in Brazil and Indonesia (*Leal et al., 2012*; *Triyogo et al., 2020*). Regardless of the habitat type, generalist functional groups typically make up more than 80% of the ant community, with the remainder being specialist functional groups (*Andersen, 1995*; *Andersen, 2000*; *Triyogo et al., 2020*). However, ant communities in pristine forest fragments have a higher proportion of specialist functional groups (~38%) (*Leal et al., 2012*) than those in anthropogenically disturbed environments, indicating a permanent alteration of ants composition in disturbed landscapes (*Carpintero, Reyes-Lopez & de Reyna, 2003; Gibb & Hochuli, 2003; Holway & Suarez, 2006*).

With increasing anthropogenic presence globally, it is imperative to understand how different types of disturbances affect species richness, community composition and identity of species present to prevent further biodiversity loss (*Allen et al., 2001*; *Luck, 2007*). This study aims to understand the impact of anthropogenic disturbance and seasonality on the epigaeic ant fauna of Lang Tengah Island, located off the East Coast of Peninsular Malaysia. The study uses pitfall trapping to collect data and analyze the changes in species richness, diversity indexes, rarefaction curves, and the composition of functional groups and status (native, tramp, or invasive) of ant species in different habitat types.

Materials & Methods

Study Area

This study was conducted at four sites on Lang Tengah Island, which is located in the state of Terengganu off the east coast of Peninsular Malaysia and has an area of approximately 125 hectares. There are only three resorts on the island (Sari Pacifica, Summerbay, and D'Coconut). Sari Pacifica and Summerbay are located adjacent to each other. Due to the island's small size and landscape structure, only the western part of the island and a few southern parts are accessible, while the eastern part of the island consists of rocky outcrops with no anthropogenic activities present except for occasional hiking trails scattered around this area (*Fig. 1*; *Google Maps, 2022*).

To examine the effect of anthropogenic disturbance, we selected all the sites based on their accessibility by foot. We designated Sari Pacifica-Summerbay resort (SP, 5°47'32.64"N 102°53'36.09"E) and D'Coconut resort (DC, 5°47'22.56"N 102°53'56.21"E) as anthropogenically disturbed sites due to resort construction, resulting in landscape changes and human presence. Batu Kuching (BK, 5°47'21.73"N 102°54'8.31"E) and Turtle Bay forest (TB, 5°47'22.34"N 102°54'1.66"E) were designated as undisturbed sites due to their relatively pristine conditions and limited accessibility to tourists. These sites have hiking trails leading to lookout points on the island and consist of relatively open forest habitat (*Fig. 1*; *Google Maps, 2022*). Field experiments were approved by Resorts Operators and Lang Tengah Turtle Watch (NGO) on Lang Tengah Island. This island experiences a pronounced monsoon period, resulting in dry and rainy seasons. There are no indigenous human settlements on this island. Due to the harsh weather during the monsoon period, the island is closed to tourists for six months, and all resort staff are evacuated from ~~the months of~~ October to March. To examine the effect of seasonality, we sampled the four sites twice, once post-monsoon from 2nd to 9th March 2020, right after the island reopened to tourists, and pre-monsoon sampling was carried out from 26th September to 3rd October 2020, before the island was closed for the monsoon period. Although the pre-monsoon sampling was carried out during the early period of the global COVID-19 pandemic, daily cases in Malaysia were low during this period (*DG of Health, 2020*), and the government had just relaxed domestic travel restrictions, contributing to a period of heightened tourist activity during this time (*BERNAMA, 2020a; BERNAMA, 2020b*).

[**Figure 1 insert here]**

Sampling of the epigaeic ant fauna

Ants' diversity studies typically focus on three different vertical strata: canopy, arboreal and epigaeic or ground-dwelling (*Hashimoto et al., 2006*). While canopy and epigaeic ant communities have been found to show little overlap (*Itino & Yamane, 1995; Brühl et al., 1998; Yanoviak & Kaspari, 2000*), arboreal ants can often be detected using epigaeic sampling methods as they come down to the ground to forage (*Wilson, 1959; Hahn & Wheeler, 2002*). In this study, due to the absence of canopy trees at the disturbed sites, epigaeic sampling methods were used to study the diversity of ground-dwelling ants. Although the pitfall methods used may capture some arboreal ant communities, including specific arboreal sampling methods such as baits placed on trees may increase ant diversity and community composition. However, this can introduce sampling bias and lead to inconsistencies in the representation of ant communities, as not all arboreal ants are attracted to the same baits.

For each study site and pre-/post-monsoonal season sampling, we installed traps to collect the epigaeic ant fauna. We used pitfall traps adapted from *Hashimoto (2003)* with 200 ml of 75% ethanol. A total of 20 traps were installed at each site, spaced about 1 m apart, resulting in 160 sampling points (4 sites x 20 repetitions x 2 pre-/post monsoonal seasons). *Eguchi, Bui & Yamane* (2004) found that the majority of epigaiec ants' foraging range does not exceed one meter, although some predatory raiding ants such as *Leptogenys* spp. might have a larger foraging range (*Maschwitz et al., 1989*). We chose the distance between the traps as 1 m because the ground surface at the resort sites was mostly concrete, limiting suitable trap placement to available ground surfaces consisting of soil and vegetation. This spacing was also used at the undisturbed sites for consistency, even though there was more surface area for trap placement. Most ant diversity studies using pitfall traps typically use a spacing range of five to 10 meters (*Yek et al., 2009*).

The traps were kept in the field for five days and checked daily for any evaporation of the 75% ethanol. After five days, the traps were removed, and securely packed in waterproof bags for transport to the Monash University Malaysia laboratory for subsequent sorting. In the laboratory, the sorted ants were identified to the genus level following *Hashimoto (2003)* and *Bolton (1994)* by TSP and SHY. Species identification was carried out by comparing the specimens with the ant collections at the Institute for Tropical Biology and Conservation (ITBC), University Malaysia Sabah (UMS). Morphospecies codes were assigned to unidentified species, which apply only to this study. A full set of specimens with voucher specimen numbers HYM0003796-HYM0003826 is deposited at ITBC, UMS (*Supplementary Table S1 raw data*).

Data analysis

The study first assessed ant species richness using Hill numbers, which included species richness, Shannon diversity and Simpson diversity (*Colwell et al., 2012*). To represent a site/season, 20 traps were combined due to their close spacing (1 meter). Ant species incidence frequencies were used as input to compute Hill numbers, and species occurrences per sample were used as proxy for relative ant abundance to avoid bias from sampling near nests and trails

(*Longino*, 2000; *Yek et al., 2009*). To examine sample coverage completeness, rarefaction curves and species richness estimators (Chao1 and ACE) were computed. The *iNext* and *vegan* package (*Chao et al., 2014*; *Hsieh et al., 2020*) in R Statistical Software (v4.1.1; *R Core Team, 2022*) were used to calculate the Hill numbers, species richness estimators, and rarefaction curves.

In the second set of assessments, we analyzed the changes in ant composition, including their community identity and functional groups. To ensure accuracy, we used several databases to categorize the ant species. We first checked the Global Invasive Species Database (GISD 2023) and the IUCN worst 100 list (*Lowe et al., 2004*) and then cross-referenced each identified species with AntWiki (*Janicki et al., 2016; Guénard et al., 2017*) for distributional and ecological information. The final assignment followed the terminology from AntWiki for native, tramp, and invasive species. Tramp status was used for species with uncertain biogeographic origins, but that have established populations in non-native habitats (*Brassard et al., 2021*).

The ant species were classified into seven functional groups based on *Andersen (2000)*. Four generalist functional groups exhibit broad foraging behaviour, while three specialist functional groups exhibit narrow foraging behaviour *(Andersen, 2000*; *Brandão et al., 2012*). The generalist functional groups are Dominant Dolichoderinae (DD), Generalized Myrmicinae (GM), Opportunists (OPP) and Subordinate Camponotini (SC). The specialist functional groups are Cryptic Species (CRY), Hot Climate Specialists (HCS) and Specialist Predators (SP).

Results

A total of 2,084 individual ants, identified to 30 morphospecies, were collected at four sampling sites across pre-and post-monsoon seasons (*Supplementary Table S1 raw data*). In general, undisturbed sites (TB and BK) presented higher species richness and diversity indexes compared to disturbed sites (SP and DC). Moreover, post-monsoon at disturbed sites also yielded an increase in species richness and diversity but not at undisturbed sites (*Table 1*).

[Table 1 insert here]

The species diversity estimators (Chao1 and ACE; *Table 1*) and rarefaction curves (*Fig. 2*) indicate that all sites were generally adequately sampled. Post-monsoon sampling of undisturbed
yielded
sites yields the highest species richness (Observed = 23 species, Estimated = 24-26 species) with the pre-monsoon sampling of disturbed habitats yielding the lowest species richness (Observed = 9 species, Estimated = 12-13 species) (*Table 1*). When assessing the species richness from each sampling unit, TB - an undisturbed site, yielded the highest species richness pre-monsoon (Observed = 17 species, Estimated = 21 species), whereas DC - a disturbed site, yielded the lowest species richness post-monsoon (Observed = 5 species, Estimated = 6 species) (*Supplementary Table S2*).

[Figure 2 insert here]

We assigned epigaeic ants to their community identity status. Most of the identification was carried out at the morphospecies level, hence conservatively we assigned the unidentified species to native species (24 native species; *Table 2*). Six ant species were either tramp or
were
invasive species (*Table 2*). At undisturbed sites, 25% of ant species found here are categorized as
were
tramp/invasive species. At disturbed sites, 17% of ant species found here are categorized as

tramp/invasive species, suggesting that undisturbed sites harbor a higher proportion of tramp/invasive species on this island (*Fig. 3*). Same tenses should be in the same paragraph.

Ant communities were categorized into four generalist and three specialist functional groups (*Table 2*). Both disturbed and undisturbed sites have relatively high proportions of generalist species, making up to >80% of the ant community (*Fig. 4*). Generalized Myrmicinae (GM) and Opportunist (OPP) dominate in the undisturbed sites whereas OPP and Subordinate
were
Camponotini (SC) generalist groups are only found in disturbed sites (*Fig. 4*). The relative proportion of generalist groups increased slightly post-monsoon for both disturbed and undisturbed sites (*Table 2*; *Fig. 4*).

[Table 2 insert here]

[Figure 3 insert here]

[Figure 4 insert here]

Discussion

assessed
This study assesses changes in epigaeic ant fauna changes in response to seasonality and anthropogenic disturbance. Both habitat type and seasonality were found to affect ant species richness, with higher richness observed in undisturbed habitats (BK and TB) and before the monsoon. The species diversity estimators and rarefaction curves (*Fig. 2*) suggest that all sites were adequately sampled. Disturbed and undisturbed sites were found to have similar proportions of tramp/invasive species (*Fig. 3*) and generalist species (*Fig. 4*). However, undisturbed sites harbor a relatively higher proportion of tramp/invasive ant species (25% at

undisturbed *versus* 17% at disturbed sites) (*Fig. 3*). The relative proportion of generalist groups slightly increased post-monsoon for both disturbed and undisturbed sites (*Table 2*; *Fig. 4*).

The results of our study indicate that undisturbed habitats have higher ant species richness (*Table 1*), which is consistent with most ant bioindicator studies (*Uno et al., 2010*; *Buczkowski & Richmond, 2012*). Surprisingly, undisturbed habitats also haboured harbour more tramp/invasive ant species (*Fig. 3*). On the other hand, disturbed sites have more generalist functional groups, as reported in other studies (*Garcia-Martinez et al., 2015*), whereas specialist ant groups are more sensitive to anthropogenic disturbance (*Leal et al., 2012*) (*Fig. 4*). We believe that the findings of tramp/invasive and generalist ant species in both habitats reflect the altered landscape that favours these species. Abundant anthropogenic resources, such as food waste, relax resource competition and may support an increased number of tramp and generalist ant species, but decrease the number of native and specialist ant species (*Rocha & Fellowes, 2020*).

Anthropogenic activities can lead to an increase in invasive and tramp ant species due to the creation of new ecological niches that these ants can exploit (*Shimoji et al., 2022*). In small islands, as in many urban environments, the constant influx of merchandise and human traffic through the jetty can make them an ideal gateway for exotic species introduction (*Russell et al., 2017*). Another possible transmission route for exotic species is through marine debris, which accumulates on the beaches, particularly after the monsoon season (*Fauziah et al., 2021*; *Tan et al., 2022*; *Fig. 1*). Although regular beach clean-up activities are carried out during the tourist seasons by workers of the resorts or volunteers from NGOs (*Yi & Kannan, 2016*), many tramp/invasive ant species could still occupy undisturbed sites (*Fig. 3*). It is also possible that hikers transport ants them from disturbed areas. Regardless of the means of transport, ~~their~~ the dominance and presence on the undisturbed sites could explain the overall low species richness of epigaeic ants sampled at Lang Tengah Island.

The annual monsoonal rains, in short terms, introduce heterogeneity to the environment through microclimate (*Bátori et al., 2019*), habitat structure (*Lassau & Hochuli, 2004*), resource availability (*Souza et al., 2015*; *Silveira et al., 2016*) and competitive interactions (*Rowles & O'Dowd, 2007*), which may have caused the observed changes in species composition (*Table 1*; *Fig. 4*). The impact of seasonality, such as the monsoonal rains, can significantly affect epigaeic ant abundance by causing nest flooding and increasing mortality rates (*Mertl et al., 2009*; *LeBrun et al., 2011*). Indirectly, it can reset ant-ant interactions for resource utilization, leading to short-term changes in species composition (*Gray et al., 2018*), which is consistent with the observed changes in functional group composition (*Fig. 4*).

In both disturbed and undisturbed habitats, generalist species dominate over specialist species due to their ability to flexibly exploit different resources and expand their colonies rapidly, leading to their ecological dominance (*Brandão et al., 2012*). They can also coexist with other generalist species by exploiting different unoccupied niches (*Parr & Gibb, 2012*). Although the composition and identity of these groups of ants remained largely unchanged, large-scale monsoonal rains caused a slight increase in their abundance in both habitats (*Table 2*; *Fig. 3; Fig. 4*; *Tchoudjin et al., 2020*).

Conclusions

In conclusion, our study reveals revealed two ant composition patterns on Lang Tengah: (1) prevalent tramp/invasive at both habitat types, higher at undisturbed sites due to the constant flux of new propagules through marine debris and anthropogenic activity encroaching into these sites, and

(2) seasonality such as monsoonal rains resets ant-ant interactions and resources distribution in the short-term, potentially maintaining diversity. Future studies should validate the findings of this study across different ant communities under similar pressure. We propose the use of ant composition status and functional roles in future studies as these categorizations are more relevant for biodiversity conservation and management plans than the species richness/diversity indexes.

Well written.

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Table 1(on next page)

The results of species richness, Shannon diversity and Simpson diversity index on habitat types (undisturbed *versus* disturbed) and seasonality (pre-/post-monsoon).

Two species richness estimators (Chao1 and ACE) were computed to examine the completeness of the sampling effort.

Habitat Types	Disturbed		Undisturbed	
Seasonality	**Pre-Monsoon**	**Post-Monsoon**	**Pre-Monsoon**	**Post-Monsoon**
Species richness	9	11	13	23
Shannon Index	1.12	1.47	2.18	2.00
Simpson Index	0.54	0.71	0.87	0.80
Chao1 Estimate	12	11	13	24
SE Chao1	4.48	1.28	0.24	1.84
ACE Estimator	13	13	13	26
SE ACE	1.46	1.68	1.67	2.44

Table 2(on next page)

Incidence of epigaeic ant morphospecies at each habitat type across pre-/post-monsoon season.

The ants are grouped to their status (column 1) following Global Invasive Species Database (2023), IUCN worst 100 list (*Lowe et al., 2004*) and finally checked against the map distribution in AntWiki (*Janicki et al., 2016; Guénard et al., 2017*). Functional groups assignment is further classified into generalist and specialist functional groups with the code as follows: DD = Dominant Dolichoderinae, GM = Generalized Myrmicinae, OPP = Opportunist, SC = Subordinate Camponotini, CRY = Cryptic Species, HCS = Hot Climate Species, SP = Specialist Predator.

Status	Behaviour Functional group	Species	Habitat type			
			Disturbed		Undisturbed	
			Pre monsoon	Post monsoon	Pre monsoon	Post monsoon
Native	Generalist (DD)	*Dolichoderus* sp.	0	1	0	7
Tramp	Generalist (GM)	*Monomorium floricola*	0	2	0	0
Invasive		*Monomorium pharaonis*	6	13	0	0
Native		*Monomorium* sp. I	12	10	0	1
Native		*Pheidole* sp. I	0	1	0	0
Native		*Pheidole* sp. II	2	11	0	0
Native		*Pheidole* sp. III	5	18	0	0
Native		*Pheidole* sp. IV	0	1	0	0
Invasive	Generalist (OPP)	*Anoplolepis gracilipes*	9	4	0	0
Native		*Aphaenogaster* sp.	0	1	0	0
Native		*Cardiocondyla kagutsuchi*	0	1	0	0
Native		*Cardiocondyla* sp.	4	0	0	0
Native		*Cardiocondyla tjibodana*	2	1	0	0
Native		*Paraparatrechina* sp.	5	13	0	0
Invasive		*Paratrechina longicornis*	3	2	20	34
Native		*Paratrechina* sp.	0	1	0	0
Tramp		*Tapinoma indicum*	16	28	0	0
Invasive		*Tetramorium insolens*	0	2	6	9

Native		*Tetramorium* sp. I	3	2	10	8
Native		*Tetramorium* sp. II	0	0	0	5
Native		*Tetramorium* sp. III	0	0	12	17
Native	Generalist (SC)	*Camponotus* sp.	0	0	1	1
Native	Specialist (HCS)	*Meranoplus bicolor*	15	8	0	0
Native	Specialist (SP)	*Amblyopone* sp.	0	0	1	1
Native		*Leptogenys* sp.	0	0	4	0
Native	Specialist (CRY)	*Carebara* sp. I	0	0	1	3
Native		*Carebara* sp. II	0	1	0	0
Native		*Hypoponera* sp. I	1	3	0	0
Native		*Hypoponera* sp. II	0	1	0	0
Native		*Plagiolepis* sp.	0	3	3	0

Figure 1

Map of four sampling sites on Lang Tengah island.

Lang Tengah island is located on the east coast of Peninsular Malaysia. Sari Pacifica (SP) resort and D'Coconut (DC) resort were designated as disturbed sites while Batu Kuching (BK) and Turtle Bay forest (TB) were designated as undisturbed sites. Map data @ 2022 Imagery @ 2022 CNES/Airbus, Landsat/Copernicus, Maxar Technologies.

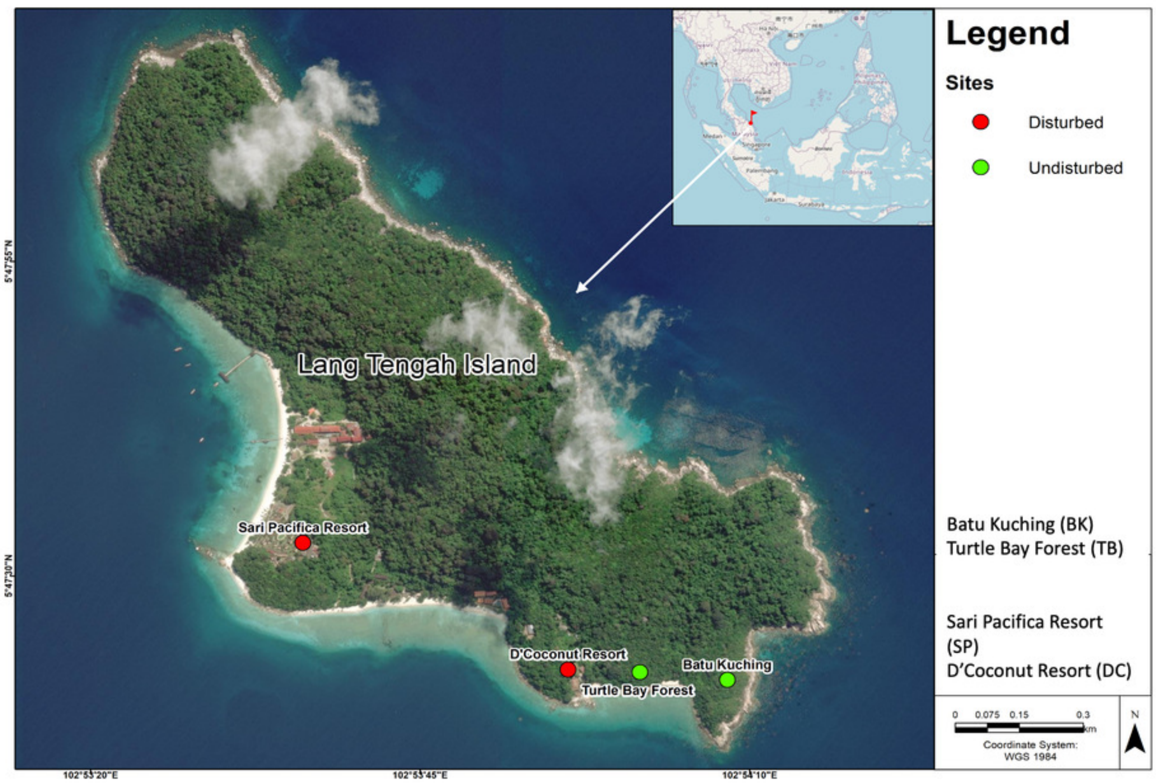

Figure 2

The number of epigaeic ant species sampled at two different habitat types (Undisturbed *versus* disturbed) and across seasonality (pre- *versus* post-monsoon).

The sample-based interpolation (solid coloured lines) represents the species diversity from the actual number of pitfall traps and sample-based extrapolation (dashed coloured lines) indicates sampling completeness and the estimated species diversity if sampling effort (*i.e.* number of traps) were to increase.

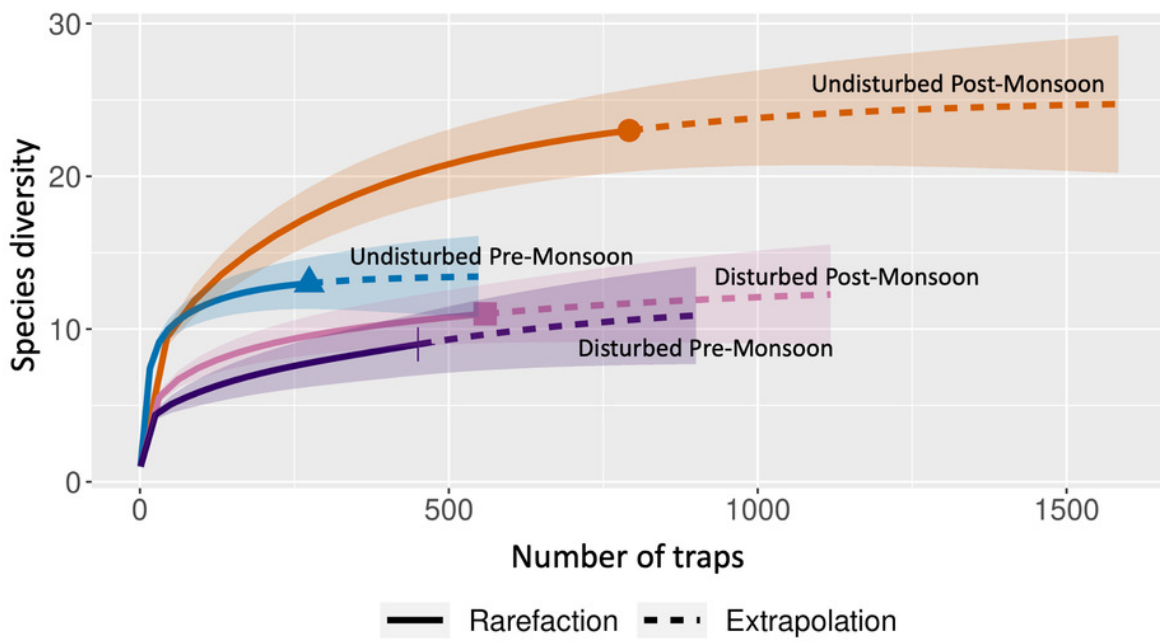

Figure 3

The relative proportion of native *versus* tramp/invasive ant species across undisturbed and disturbed habitat types.

There are 24 ant species in the undisturbed habitat sites and 12 ant species in the disturbed habitat sites. At undisturbed sites, 25% of ant species found here are categorized as tramp/invasive species. At disturbed sites, 17% of ant species found here are categorized as tramp/invasive species.

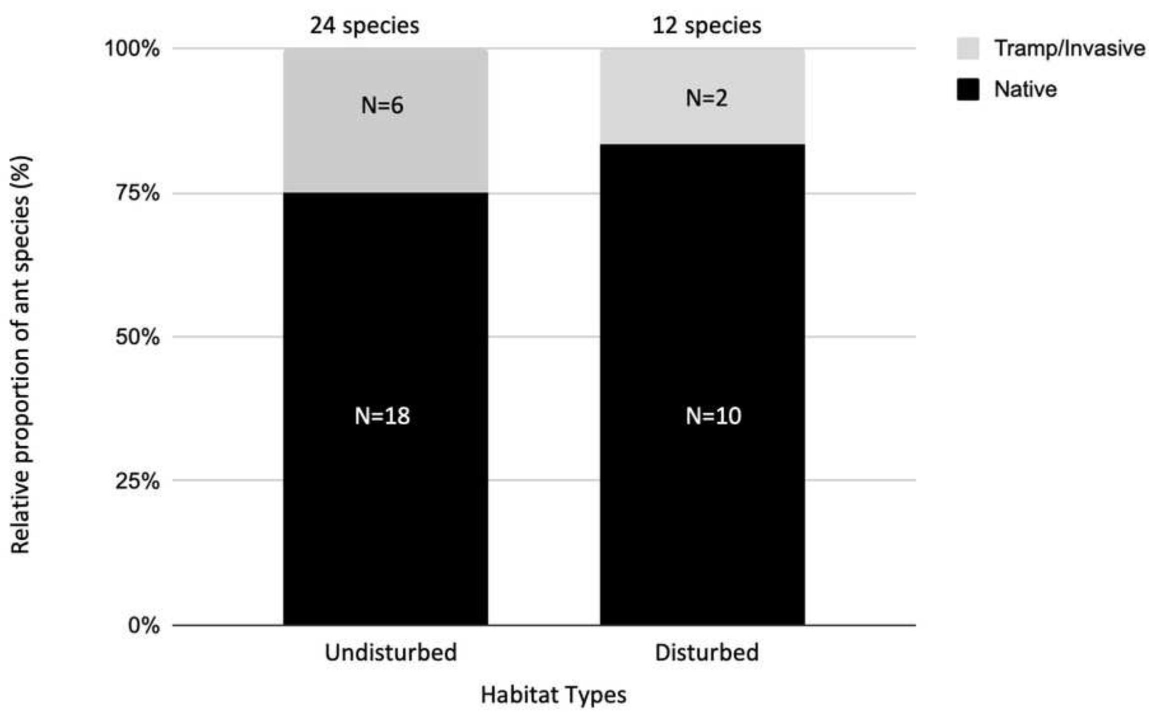

Figure 4

The relative incidence of epigaeic ant morphospecies classified into functional groups for habitat type and pre-/post-monsoon season.

The top three patterned-filled bars represent specialist functional groups – Cryptic Species (CS), Hot Climate Specialists (HCS) and Specialist Predators (SP), and the bottom solid colour-filled represents the generalist functional groups – Opportunists (OPP), Generalized Myrmicinae (GM), Dominant Dolichoderinae (DD) and Subordinate Camponotini (SC).