**Title**

Catch a free ride with me: A report on ant hitchhiking on vehicles in Taiwan and its ecological implications

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**Abstract**

Species hitchhiking on human transportation objects can facilitate long-distance dispersal of organisms, allowing them to colonize new areas and thus increasing the probability of biological invasions. In Taiwan, there have been observations of active species hitchhiking on mobile vehicles by ants, yet no study has examined this behavior. Here, we provide the first report on ant hitchhiking using citizen science data. In total, 45 cases of ant hitchhiking on cars (*n* = 39) and scooters (*n* = 6) were collected between 2017 and 2023. Among the eight hitchhiking species, six were exotic and seven were arboreal. One species, the black cocoa ant (*Dolichoderus thoracicus*), constituted over half of the reported cases (*n* = 26). The parking duration of the vehicles on which the ants hitchhiked ranged from several hours to over a month, with around 65% (*n* = 28) of the cases occurring within a day. Moreover, there were more cases reported in spring and summer compared to fall and winter. We encourage future studies to examine the behavioral, morphological, physiological, and ecological traits of ants that underlie the success of hitchhiking events to better predict the spread of exotic ants and to develop management strategies for preventing their biological invasions.

**Keywords**

arboreal and ground-dwelling ants, biological invasions, citizen science, exotic species, human-mediated long-distance dispersal, species hitchhiking, transportation

**Introduction**

The increases in human transportation activities over the past few decades have had a wide range of impacts on human societies, living organisms, and the environment (Hulme 2009, Banks et al. 2015). One of the various ecological consequences of human transportation is the transfer of organisms to a new area through mobile vehicles. Such “hitchhiking” can lead to long-distance dispersal of species beyond their natural ranges and potentially facilitate biological invasions (Ward et al. 2006, Von der Lippe and Kowarik 2007, Wilson et al. 2009, Auffret et al. 2014, Gippet et al. 2019).

Various terrestrial organisms have been documented to hitchhike on vehicles. For example, plant seeds can disperse to new places by attaching to car and tire surface (Von der Lippe and Kowarik 2007, Ansong and Pickering 2013), and the seeds can retain on the vehicles for hundreds of kilometers under certain conditions (Taylor et al. 2012). Exotic earthworms have been introduced into the boreal forests of western Canada through vehicle transportation (Cameron et al. 2007). Many insects also hitchhike on vehicles. For instance, gypsy moth (*Lymantria dispar*) may lay eggs on the surface of shipping containers and trucks, and later arrive at the destination as larvae (Gray 2017, Meurisse et al. 2019). The tiger mosquito (*Aedes albopictus*) can travel in cars and move across provinces (Eritja et al. 2017).

In recent years, there have been observations of active hitchhiking on vehicles by ants in Taiwan, a subtropical country located off the coast of Eastern Asia (Fig. 1). These observations have shown that exotic ants seemed to hitchhike frequently, which could facilitate their spread to new areas. To better understand such an active hitchhiking behavior, in this study we examined the spatial and temporal patterns of ant hitchhiking in Taiwan using citizen science data. Our aim is to provide the first report on ant hitchhiking on vehicles and discuss its ecological implications.

**Materials and Methods**

*Data collection*

Cases of ant hitchhiking on vehicles were collected on a social media platform Facebook by distributing relevant information to the users. When an observer reported, we asked the person for the parking date and location of the vehicles, the parking duration, and vehicle type, the weather conditions and surrounding environment, the intended destination, and a photo of the ants for species identification. The ant species were classified as “arboreal”, “ground-dwelling”, or “both” based on their nesting sites and foraging habits. The number of reported cases in the four seasons (spring: March–May; summer: June–August; fall: September–November; winter: December–February) was tested using a Pearson's chi-square test. All recorded cases and the associated variables were provided in the Supplementary Data.

**Results**

In total, we collected 45 cases of ant hitchhiking on cars (*n* = 39) and scooters (*n* = 6) between 2017 and 2023, with the majority of them from central and northern Taiwan (Fig. 1). Eight species were recorded, among which two were native and six were exotic (Table 1). Seven species were arboreal ants (Table 1). One species, the black cocoa ant (*Dolichoderus thoracicus*), constituted over half of the reported cases (*n* = 26). The parking duration of the vehicles on which the ants hitchhiked ranged from several hours to over a month, with around 65% (*n* = 28) of the cases occurring within a day. There were more cases reported in spring and summer compared to fall and winter (χ2 = 16.78, *df* = 3, *P* < 0.001; Fig. 2).

**Discussion**

Ant hitchhiking on vehicles can be a potential pathway for the spread of exotic species (Table 1). In some cases, the travel distance between the parking location and the intended destination can be as long as a few hundred kilometers (from Nantou County in central Taiwan to PingTung County in southern Taiwan), which largely exceeds the dispersal distance achievable through natural movements. Furthermore, hitchhiking events can take place within several hours, during which the workers would carry the queen, the eggs, and the larvae to the vehicles, suggesting that such hitchhiking is not a foraging behavior but rather a colonization attempt, potentially driven by high population pressure. In fact, the most reported hitchhiking species, the black cocoa ant (*D*. *thoracicus*), has high local densities, which may stimulate their dispersal and colonization of artificial structures.

Various factors determine a successful ant hitchhiking event (Fig. 3). First, ants need to encounter vehicles, which depends largely on their searching behavior. Ants are generally more active under warmer conditions (Parr and Bishop 2022), potentially leading to more hitchhiking cases in spring and summer compared to fall and winter (Fig. 2). Moreover, species with different habitat associations may differ in the probability of encountering vehicles. Tree canopies are often drier and resource-limited (particularly nitrogen), facilitating the searching activities of arboreal ants on the ground (Yanoviak and Kaspari 2000, Hahn and Wheeler 2002, Hashimoto et al. 2010). As a result, they are more likely to encounter vehicles compared to ground-dwelling ants. Interestingly, rubber odor could be an important chemical cue for ants to locate vehicles since the tires are the only part of the vehicles directly connected to the ground.

Second, ants need to climb onto the vehicles after locating them. The metallic paint of vehicle surface could present a slippery barrier to ants, and only species with good climbing abilities are able to overcome this hurdle. The climbing performance of ants is determined by the morphological characteristics of the leg segments (Beutel et al. 2020). For instance, the fine hair arrays on the tarsus can increase the friction for vertical climbing (Endlein and Federle 2015). Arboreal ants have hooked pretarsal claws, well-developed adhesive pads, and fine tarsal hairs, allowing them to walk on smooth vertical substrates. On the other hand, ground-dwelling ants have straight pretarsal claws and lack adhesive pads as well as tarsal hairs, and therefore they are less capable of moving on smooth vertical surfaces (Orivel et al. 2001, Billen et al. 2017).

Third, ants need to be capable of colonizing the vehicles after moving onto them. The thermal tolerance of species plays a critical role in this because ants have to tolerate the high temperature of the vehicle surface and interior before arriving at the destination and dispersing to new areas. Arboreal ants are generally more heat- and drought-tolerant compared to ground-dwelling ants (Hood and Tschinkel 1990, Bujan et al. 2016, Leahy et al. 2022), and therefore they are more likely to utilize artificial structures and hitchhike on vehicles. Furthermore, car color may influence the ants’ colonization attempt and success as it affects the temperature of the vehicles, particularly under sunlight exposure.

To our knowledge, this is the first report on ant hitchhiking on vehicles via citizen science. Despite limited reported cases, our study nonetheless reveals interesting patterns in ant hitchhiking, and we have endeavored to engage the wider community in citizen science efforts as a cost-efficient method for hitchhiking data collection. We encourage future studies to examine the behavioral, morphological, physiological, and ecological traits of exotic species versus their native relatives to better understand the determinants underlying the success of hitchhiking events. Hopefully, this can help predict the spread of exotic ants and develop management strategies for preventing their biological invasions.

**Acknowledgements**

We thank XXX for the constructive comments on the early draft of this manuscript.

This study was funded by (grant number YYY).

**Conflict of interest**

The authors declare no conflict of interest regarding this manuscript.

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**Tables and Figures**

Table 1. The status, habitat association, and the number of reported hitchhiking cases of the ant species in this study

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Status | Habitat association | Cases |
| *Polyrhachis dives* | Native | Arboreal | 2 |
| *Nylanderia* sp. | Native | Ground-dwelling | 1 |
| *Dolichoderus thoracicus* | Exotic | Arboreal | 26 |
| *Tapinoma melanocephalum* | Exotic | Both | 5 |
| *Paratrechina longicornis* | Exotic | Both | 4 |
| *Technomyrmex albipes* | Exotic | Arboreal | 4 |
| *Technomyrmex brunneus* | Exotic | Arboreal | 2 |
| *Anoplolepis gracilipes* | Exotic | Both | 1 |

Figure 1. (a) A map of the ant hitchhiking cases in Taiwan and (b–c) example photos of ant hitchhiking on vehicles.

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Season_barplot

Figure 2. The number of ant hitchhiking cases in each season (spring: March–May; summer: June–August; fall: September–November; winter: December–February).

Illustration

Figure 3. The determinants of a successful ant hitchhiking event. See *Discussion* for more details.