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# Invasive ants of tropical origin at mid-high altitude and latitude: adaptation and invasiveness

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## Abstract

Recent discovery of longhorn crazy ant (*Paratrechina longicornis*) at mid-high altitude and latitude raises a series of ecological and evolutionary issues as this invasive ant, although reportedly originated from tropical regions, seems to be able to survive through cold environments. We thus are interested in understanding if colonization of longhorn crazy ant into these areas involves thermal adaptation, and if such adaptive potential results from behavioral/physiological plasticity or strong genetic basis. Here we reported some preliminary data and also presented future research framework of my laboratory on dissecting the adaptive mechanisms of this invasive ant. Results are expected to serve baseline information for development of management strategy on ant invasion under different temperature regimes.

## Introduction

Tropical regions have been regarded as one of the top ‘‘source population’’ hotspots for quite a few invasive ants. These ant species include *Paratrechina longicornis* (longhorn crazy ant, LCA), *Anoplolepis gracilipes* (yellow crazy ant, YCA), *Solenopsis geminata* (tropical fire ant, TFA), *Pheidole megacephala* (African big-headed ant, ABA) and *Monomorium destructor* (Singapore ant, SA), all of which have been transported around the world from the tropics where they are native and have become major ecological, agricultural, and/or household pests in most of areas they were introduced into [1].

Taking LCA as an example, most of LCA samples were collected in low-elevation areas including cities and suburbs where human activities are generally intense (Fig. 1). Such distributional pattern not only is in perfect agreement with the prediction that this ant has originated from the tropics but also verifies the preference of warmer habitats by LCA. However, recent collection efforts of our lab revealed a surprising finding that a handful of LCA samples were discovered in mountain areas with mid-high elevation (600-1200 m) in northern Taiwan (Fig. 1), leading us to hypothesize that colonization of mid-high elevation by LCA may have involved adaptation to cold environments. Hence, this study represents a first attempt to test if such thermal adaptation exists for LCA.

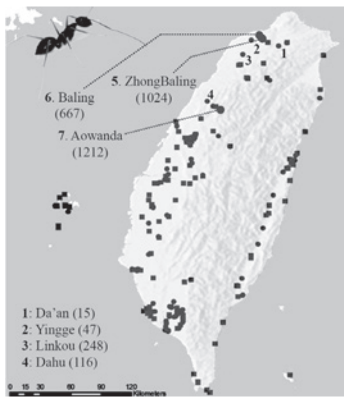


Figure 1. Map showing various collection sites of LCA in Taiwan. Nests used in the chill coma recovery experiments were collected from Site 1~7. Number in parenthesis indicates the elevation (m) of a given LCA nest was collected.

## Materials and methods

We collected a total of seven LCA nests at different elevations and maintained in the lab under normal conditions (28±2°C, RH 55±5%). To test thermal adaptation at physiological and behavioral levels, two sets of chill coma recovery experiments were conducted including short-term (4°C for 30 minutes) and long-term (4°C for 15 hours), where LCA workers from each nest were divided into two groups with one exposed to 4°C for 30 minutes and the other one to 4°C for 15 hours, followed by dislocation to normal conditions for recovery. Noted that both experiments were carried out for the LCA workers within three

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days after the nests were collected to avoid artifacts associated with prolonged acclimation period under laboratory conditions. Recovery patterns of 30 LCA foragers per nest from both experimental settings were recorded: in short-term treatment time required for all foragers recovering was recorded, while in long-term treatment we recorded the number of recovering foragers every 30 minutes as well as accumulated mortality. For both treatments, behavior of antenna cleaning serves as an index to define recovery of individual ant from frozen stupor. Significance of recovery patterns was tested using Welch ANOVA and Games-Howell test for short-term treatment but not long term one as the number of workers is insufficient to complete at least three replicates in the latter one. Hence, we observed the trend of the recovery patterns for the long term treatment only.

**Results and discussion**

Results of short-term chill coma recovery revealed a negligible correlation between recovery time and elevations as considerable variations of recovery time are observed among individuals from different populations (Fig. 2). In long-term treatment, however, most of individuals from nests collected from mid-high elevations generally are characterized by faster recovery time as well as lower mortality compared to those from lowland (Fig. 3), suggesting that cold tolerance likely have been developed and operated during colonization into mid-high elevations by LCA. Nevertheless, results presented here are based on a limited number of LCA nests; greater sample size therefore is required to test if such trend remains significant.

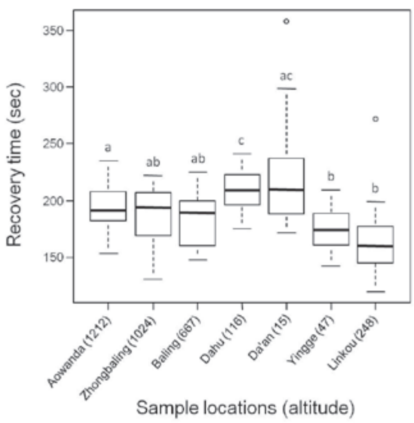


Figure 2. The recovery time of LCA workers after short-term cold treatment. Box-plots with the same letter are not significantly different. Open circles denote outlier data point.

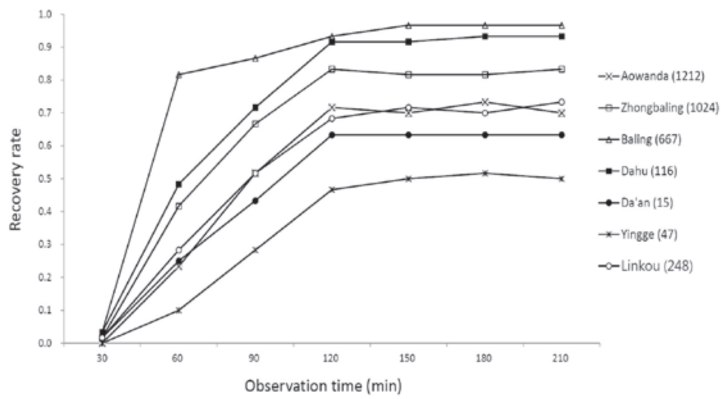


Figure 3. The recovery rate and accumulated mortality of LCA workers after long-term cold treatment (accumulated mortality = 1- recovery rate).

**Outlook on future research**

It is believed that LCA was introduced into Japan in early 20$^{th}$ century (with the earliest known record dated back to 1924) and have spread across entire Okinawa Islands and southern Kyushu area (ex. Kagoshima Prefecture) since then [2]. In addition, populations of LCA can be found sporadically in other areas of mainland Japan where appear to be non-preferable environment for LCA especially during the winter. Together with the finding of successful colonization of LCA into mid-high elevation in Taiwan, LCA serves as a rare yet excellent system to understand how invasive ants of tropical origin overcome environmental stresses at both high latitude and altitude.

My laboratory therefore aims to use a multidisciplinary approach combining genetics, genomics, physiology and behavior to study the mechanisms underlying latitudinal and altitudinal adaptation of LCA. Firstly, extensive survey is expected to conduct in Kagoshima Prefecture, and distribution of LCA will be accordingly mapped out. Genetic markers are developed and subsequently employed to confirm long-term population persistence for LCA using pedigree/kinship analyses. Cold tolerance, chill coma recovery and

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supercooling point are assayed to understand if such adaptive potential results from behavioral or physiological plasticity. If such plasticity exists, we attempt to pinpoint the genomic region associated with thermal regulation by mining the functional genomic database that was previously established. Results are expected to serve as baseline information for development of management strategy on ant invasion under different temperature regimes. Several collaborators are included in this study: Tsuyoshi Yoshimura at RISH, Chow-Yang Lee at Universiti Sains Malaysia, Alexander Mikheyev at Okinawa Institute of Science and Technology and DeWayne Shoemaker at University of Tennessee at Knoxville.

**References**

[1] Wetterer J. 2015. Geographic origin and spread of cosmopolitan ants (Hymenoptera: Formicidae). *Halteres* 6: 66-78.

[2] Wetterer J. 2008. Worldwide spread of the longhorn crazy ant, *Paratrechina longicornis* (Hymenoptera: Formicidae). *Myrmecological News* 11: 137-149.