An Accurate Bell Curve Discovered in Intraspecific Body Mass Distribution of 1k Beetles

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Abstract

While the normal distribution is often termed "normal," it is uncommon to encounter precise bell curves in biological measurements. In this study, we discovered an accurate normal distribution in the intraspecific body mass distribution of the Scarab Beetle *Anomala albopilosa*. We captured over thousands of beetles and measured their weight, and we also conducted a Mark-Release-Recapture study.

Introduction

Many biological variables are believed to fit the normal distribution quite well (McDonald, 2012). However, actual histograms of biological measurement often do not show well-balanced, well-shaped bell curves (A'Hearn, Peracchi and Vecchi, 2009; Gouws, Gaston and Chown, 2011; Zhu *et al.*, 2016; Chen *et al.*, 2022); Many histograms skewed or exhibit platykurtic or leptokurtic shapes. The absence of a smooth bell shoulder may simply result from small sample sizes. The central limit theorem assumes randomness, but biological phenomena are usually not random. The biological background may influence the shape of histograms. For instance, a previous study found that the intraspecific body mass distribution of non-social insects tends to follow a normal distribution. Invasive species tend to have low genetic diversity (Hagenblad *et al.*, 2015) and may have not so complex biological background. We hypothesized that we could obtain an accurate bell curve in an intraspecific body mass distribution if we measure over 1000 individuals of invasive species.

The scarab beetle *Anomala albopilosa* is a major agricultural pest insect in the southern region of Japan. In Okinawa prefecture, the insect is managed using UV-LED traps (Aragaki, 2016). The insect was not major in the northern region of Japan and has been increasing the population in those areas such as the Kanto region since around 2000 AD (Nakano, 2020).

In this study, we captured thousands of the scarab beetles in the Kanto region, measured their weight and drew a histogram and Q-Q plot. We also performed a mark-release-recapture study to estimate beetle population. We compared the body mass of captured insects with the mark and without the mark to survey affection of the marking. The weight loss of the insects when they were starved was measured to estimate agricultural damage.

Materials and Methods

Insects were captured using a 120 W 365-405nm UV LED light (Sunpie, Saitama, Japan) at 7 p.m. to 9 p.m. on 9-15, 17 Aug 2024 in the seven face mountain, Kawasaki city, Kanagawa prefecture, Japan (N35°60.43', E139°60.46'). The light was blocked by houses and reached about 40 meters at a 5 degree angle. Insects body mass was measured using an analytical balance LA-JT1003D(LA) (Lachoi Scientific Instruments Co. Ltd., Zhejiang, China). Insect marking was performed using a liquid whiteout EZL21-W (Pentel Co. Ltd., Tokyo, Japan). We marked 88 insects captured and released on 9 Aug 2024. Beetle starvation was performed in a plastic box (approximately 3L) at room temperature.

Results and Discussions

We captured 88, 142 (12), 126 (2), 121 (1), 80 (1), 163 (0), 91 (0), 46 (0), 100 (0), 35 (0) and 38 (0) insects on 9-15, 17-20 Aug 2024, respectively (Numbers in parentheses indicate number of marked insects). The histogram of the body mass distribution of 1014 insects showed an accurate bell curve (Figure 1). In the first 24 hours, the density of marked insects was 0.0845. Estimated population of the insects in our survey area is 1041 (88/(0.0845)). The rate of recaptured insects with marks in total captured insects decreased immediately. Most of the insects within the study area would be replaced by insects from outside the area within a few days. Recaptured insects (with marks) body mass on 10 Aug 2024 were 0.825, 0.885, 0.652, 0.525, 0.628, 0.708, 0.714, 0.698, 0.567, 0.654, 0.6 ,0.729, 0.751 ,0.855 ,0.669 and 0.599 (mean 0.691). Those were not different from whole captured insects (mean 0.689, $p = 0.94$ in t-test). The whiteout marking would not disturb the wildlife of the insects. After 48 hours from release, marked insects were captured little. It would be explainable by insects moving. The lifespan of this insect after emergence is thought to be 15 to 25 days (Hokyou and Nagamine, 1978). The mean weight loss of the insects when they were starved for 2 days were 0.13 g (40/120 dead) and that of 3 days were 0.16 g (88/120 dead). The insects in this area would damage approximately 100 g of agricultural leaves every night.

The previous studies representing metrics and/or histogram did not deposit raw data. A small p-value from the Shapiro-Wilks test only rejects the null hypothesis that the data is not normally distributed; it does not actively assess the fit to a normal distribution. It is crucial to deposit and share raw data to advance studies on intraspecific body mass distribution (Supplemental Data 1).

The invention paid attention since entire fields of biology are connected to the question of how a species breaks away from its previous modes of adaptation, expands its range, flourishes, and then disintegrates (Matsuda, Suzuki and Ogata, 2020). Our data suggests a new site of invasive species.

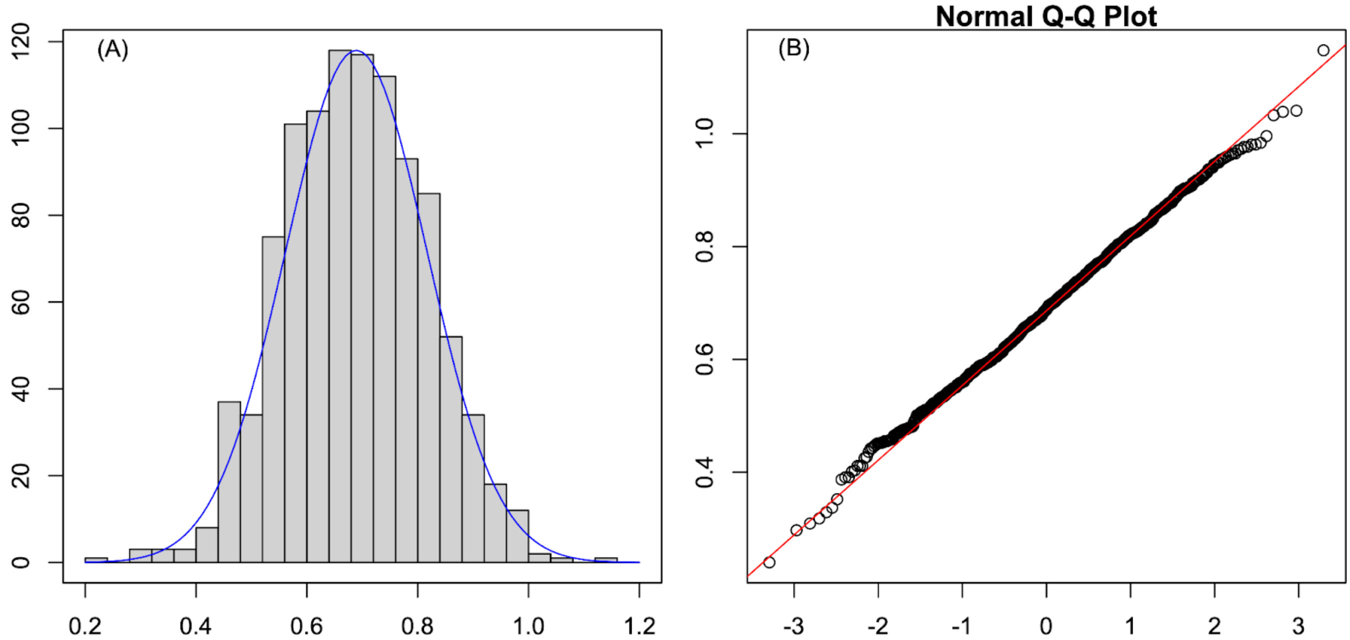

Figure 1. Intraspecific Body Mass Distribution of Beetles.

(A) Histogram of intraspecific body mass distribution of 1014 scarab beetles *Anomala albopilosa*. Blue line is a theoretical distribution having the same mean and the same standard variance with data. (B) Q-Q plot of intraspecific body mass distribution of beetles. x axis is normal theoretical quantiles and y axis is normal data quantiles.

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Supplemental Data 1

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