

SPECIAL FEATURE

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Idea paper: Airport ecology, an environment without predation pressure drives evolution

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Abstract

Evolutionary changes in organisms are directly observable, and they can occur rapidly in the presence of strong natural selection. Here, we present the “airport ecology” to describe the rapid evolution of animals. The pygmy grasshopper *Tetrix japonica* exhibits significant variations in pronotum color and markings and is a good model organism for “airport ecology.” There are trade-offs in black-spot markings in the pygmy grasshoppers; although it helps in camouflaging and reducing predation pressure, it stimulates overheating, resulting in a reduction in mating opportunities and foraging success under high solar irradiance. Therefore, the frequency of black-spotted morphs is lower at lower latitudes than at higher latitudes along a latitudinal cline. However, in an airport where predation pressure is reduced by the removal of predatory bird populations, we predict that the frequency of black-spotted morphs of *T. japonica* will be lower in habitats without predators than in those with predators at the same latitude; this demonstrates the anthropogenic effect on *T. japonica* polymorphism. As suggested here, predator-free environments such as airports are valuable for illustrating the effects of anthropogenic activity on animal evolution. These findings can be extended to several other species that are found around airports and are potentially preferred by avian predators in terms of not only rapid evolution of color polymorphism but also evolution of various life-history traits.

KEYWORDS

anthropogenic effect, evolution, latitudinal cline, observation, polymorphism

1 | RESEARCH QUESTION

Rapid evolution in response to natural selection is one of the attractive issues for evolutionary ecologists to illustrate and visualize the evolutionary processes on an observable time scale. To elucidate how anthropogenic activities affect the rapid evolution of animal phenotypes such as morphological, behavioral and life

history traits, we suggest airports as a new research field.

2 | VALUE

Since the first flight by Wright Brothers in 1903, broad airports have been developed, and they often provide a

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FIGURE 1 Various color patterns of the pygmy grasshoppers *Tetrix japonica* collected in Tsukuba City, Ibaraki, Japan (36.0130°N, 140.1136°E) [Color figure can be viewed at wileyonlinelibrary.com]

wide area of grassland habitats to various organisms (e.g., Kutschbach-Brohl, Washburn, Bernhardt, Chipman, & Francoeur, 2010; Narita International Airport Co., Ltd., 2018). They are also highly attractive areas for birds as they provide a suitable habitat for roosting, feeding and breeding. However, bird strikes cause aircraft accidents, which result in direct economic losses to the civil aviation industry by disturbing flight schedules; the economic loss associated with aircraft bird strikes exceeds 1.2–1.5 billion USD annually (Allan, 2006). To mitigate this, various deterrents (e.g., lasers, blank shootings and acoustic disturbances) are regularly assessed in airports to manage and drive birds away (Soldatini, Georgalas, Torricelli, & Albores-Barajas, 2010). This in turn reduces predation pressure on insects living in the surrounding environments, thereby offering a predator-free environment for the insects inhabiting airports. The removal of predators will have a significant effect on the local ecosystems as demonstrated in a classic experiment by Paine (1966). In this study, we focused on the coloration and polymorphism in the pygmy grasshopper *Tetrix japonica* as an example of “airport ecology,” and this idea can be applied to various organisms inhabiting airport fields.

3 | RELEVANT HYPOTHESIS

The pygmy grasshoppers are highly polymorphic with variable black spot markings on the pronotum (Figure 1), providing camouflage and reducing predation pressure (Tsurui, Honma, & Nishida, 2010). On the contrary, the black coloration negatively affects thermoregulation in a related species *T. undulata* (Forsman, Ringblom, Civantos, & Ahnesjö, 2002), especially at low-latitude areas. Therefore, under high solar irradiance, darker morphs of pygmy grasshoppers are likely subject to overheating, which restricts their activity, resulting in a state of poor nutrition and limited mating opportunities. The cost of overheating always exists within the area of distribution of *T. japonica*, although the cost will reduce at higher latitudes. Thus, polymorphism in the pygmy grasshopper is likely maintained by trade-offs between predation pressure and reproductive success. The frequency of black-marking morphs was increased at high latitude areas, and this was demonstrated as a latitudinal cline (Tsurui & Nishida, 2010). Additional data collected in 2019 also supported this latitudinal cline (Figure 2).

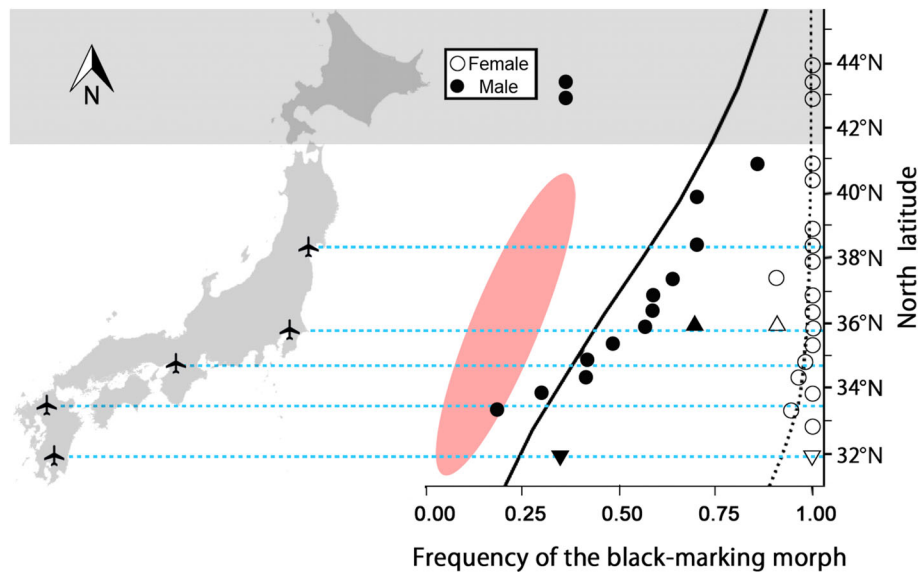


FIGURE 2 Latitudinal ratio of color patterns in *Tetrax japonica*, with a greater proportion of black-spotted morphs occurring in northern Japan, except in the Hokkaido Island (north latitude 41.5° <, shaded area). The solid line represents a logistic regression of frequency of the black-marking morph in males and the dotted line represents that in females. The regression curve of males was estimated after excluding samples from Hokkaido Island. Datasets including <5 samples were omitted. This figure is modified from Tsurui and Nishida (2010), with additional records included from Tsukuba City (Ibaraki prefecture, upper triangles) and Akune City (Kagoshima prefecture, lower triangles). Latitudinal locations of major airports (Sendai, Narita, Osaka, Fukuoka, and Kagoshima) are indicated in blue dot lines. We predict that in major airports, the frequency of the non-marking males will not adhere to the latitudinal cline and that rapid evolution will be visualized in the area indicated with the reddish circle [Color figure can be viewed at wileyonlinelibrary.com]

4 | NEW RESEARCH IDEA

Based on previous studies, the camouflage advantages of spotted markings should be diminished when predation is eliminated under high solar irradiance. This may stimulate the rapid evolution of body color in *T. japonica*. Here, we suggest the “airport ecology” to describe the rapid evolution of animals. We hypothesize that the body color ratio of *T. japonica* in airports will not show the latitudinal cline as demonstrated by Tsurui and Nishida (2010), because the advantages of black spots for the camouflage effect would be lost or reduced in such a situation. Light body color allows increased mating and foraging opportunities rather than natural condition. This altered body-color morph ratio demonstrates an anthropogenic effect on *T. japonica* polymorphism in airports.

5 | HOW TO SOLVE THE QUESTION THROUGH THE NEW IDEA

Arguably, the most famous example of rapid evolution is industrial melanism in the peppered moth (Majerus, 2009). This example provides key evidence for natural selection

and demonstrates the importance of a greater understanding of ways in which anthropogenic activity influences animal phenotypes. Other cases of rapid evolution are detected in islands or regions where accidental disturbances have occurred via invasion of alien species (e.g., Grant & Grant, 2014; Katoh, Tatsuta, & Tsuji, 2017; Stuart et al., 2014). Wind farm environments deter raptors, resulting in minimal predation on the fan-throated lizard (*Sarada superba*) and leading to cascading effects including dull dewlap coloration, increased population density and declined body condition (Thaker, Zambre, & Bhosale, 2018). In an urban heat island area, Kerstes, Breeschoten, Kalkman, and Schilthuizen (2019) showed that snails are more likely to be yellow than pink due to thermal selection. As cited here, several studies have been conducted on the rapid evolution of animals, but they have focused on a single species; the “airport ecology” may illustrate the rapid evolution for various organisms inhabiting airports.

To demonstrate anthropogenic effects on rapid evolution, we suggest sampling in or near major airports. Several organisms including *T. japonica* were observed in a research on airport fauna (Narita International Airport Co., Ltd., 2018), but because no voucher specimens were preserved, this idea cannot be directly validated. As an example, we predict that the frequency of black-spotted morphs of *T. japonica* will be lower in habitats without

predators than in those with predators at the same latitudes (Figure 2). It is difficult to obtain permission for insect collection in major airports; however, we can conduct sampling in the grassland near and outside the airports. In addition, we also expect that the “airport ecology” will demonstrate the rapid evolution of the life-history traits on various organisms.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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