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CROP PROTECTION

RESEARCH NOTE

Changes in wing length in the pollinator *Bombus dahlbomii* occurring with the fragmentation of the Maulino forest, Chile

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Abstract

M.M. Murúa, A.A. Grez, and J.A. Simonetti. 2011. Changes in wing length in the pollinator *Bombus dahlbomii* occurring with the fragmentation of the Maulino forest, Chile. Cien. Inv. Agr. 38(3): 391-396. Habitat fragmentation can affect the morphological design of flying insects in different ways through changes in the costs and benefits of dispersal patterns. Larger wings should be favored if necessary resources are scattered across a fragmented landscape. The purpose of this research is to test this prediction in *Bombus dahlbomii* (Guérin), a native Chilean pollinator associated with the fragmented Maulino forest. We used hanging traps to collect individuals in the continuous native forest, in four small forest remnants and in two *Pinus radiata* plantations (matrix). We measured the body size (mm) and the length of the first and the second pairs of wings (mm) of each individual collected. In all, 280 individuals were captured. The body size and the length of both the first and the second pairs of wings were higher in the forest fragments and the matrix than in the continuous forest. A significant positive relationship between wing length and body size was observed for all habitats, but the percentage of variance explained was lower in the continuous forest than in the fragments and the matrix. These results suggest that the fragmentation of the Maulino forest would favor phenotypes with larger wings. It is probable that these phenotypes would be best at flying and obtaining scarce resources during foraging.

Key words: Bumblebees, habitat fragmentation, morphometric changes.

Introduction

Habitat fragmentation might affect the morphological design of flying insects through changes in the cost/benefit balance of altered movement patterns (Olivieri *et al*., 1995; Van Dyck and Matthysen, 1999). The success of movements often depends on morphological traits related to flight. Characters related to body size, such as thorax size and wing length, could be under selection pressure (Hill *et al.,* 1999; Van Dyck and Matthysen, 1999). Fragmented landscapes might require that foraging individuals be more mobile if food resources are scattered relative to their original distribution in a continuous forest (Van Dyck and Matthysen, 1999; Gathmann and Tscharntke, 2002; Tscharntke *et al.,* 2005). Therefore, insects in forest fragments should have larger wings to allow longer-distance foraging flights. Evidence from butterflies and damselflies supports

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this hypothesis (Taylor and Merriam, 1995; Hill *et al.,* 1999; Berwaerts *et al.,* 2002; Merckx and Van Dyck, 2006). For example, the wings of the forest damselfly *Calopteryx maculata* are longer and wider in fragmented landscapes, where sites for foraging and reproduction are more widely separated, than in continuous landscapes (Taylor and Merriam, 1995). Similarly, in calcareous grasslands in England, fragmented populations of the butterfly *Hesperia comma* showed an increase in wing and thorax size (Hill *et al.,* 1999). However, whether hymenopteran species also show changes in response to changed landscape configurations remains to be assessed (Dydham *et al.,* 1996).

Here, we study the wing length of *Bombus dahlbomii* Guérin (Hymenoptera: Apidae), a native Chilean bumblebee that thrives in the fragmented Maulino forest, a unique temperate ecosystem in central Chile between 35º55' S and 37º20' S in one of the 25 global biodiversity hotspots (Myers *et al*., 2000). *Nothofagus glauca* (Fagaceae), the dominant species in this forest, coexists with many endangered endemic species, such as *Nothofagus alessandrii* (Fagaceae), *Pitavia punctata* (Rutaceae) and *Gomortega keule* (Gomortegaceae). Since the end of the nineteenth century, the Maulino forest has been intensively deforested and fragmented. It persists as a mosaic of different-sized fragments surrounded by a matrix of introduced Monterey pine (*Pinus radiata*) plantations (Grez *et al*., 1998; Echeverría *et al.,* 2006, see Henríquez *et al.,* 2009 for a map of the area). *Bombus dahlbomii* is an important pollinator of different plant species in the Maulino forest, such as *Lapageria rosea* (Ruiz *et* Pav., Philesiaceae), an endemic vine that depends primarily on this insect for successful reproduction. The flowers of *L. rosea* are 1.4 times less abundant in forest remnants than in the continuous forest (Henríquez, 2004; Valdivia *et al.,* 2006), and they are almost absent from the pine matrix (unpublished data). Hence, it is expected that individuals of *B. dahlbomii* will have shorter wings, relative to body size, in the continuous forest than in small fragments or in the pine matrix.

Materials and methods

From 2003 through 2006, we studied *B. dalhbomii* populations in the Maulino forest in Tregualemu. The individuals were collected in hanging traps, an adaptation of Japanese beetle traps. The traps consisted of a pair of crossed walls that served to intercept the insects and a 250-cc vial filled with water, formalin and detergent underneath the walls. These traps were suspended from *Aristotelia chilensis* trees at a height of 1.5 m. The trees were separated by a distance of at least 10 m. A total of 120 traps were placed in the continuous forest (Los Queules National Reserve and neighboring lands, with a total area of 600 ha) (UTM WGS 84: 708083 6015323), in four small fragments of native forest occupying between 2 and 5 ha (F1: 707637 6014306; F2: 708702 6014772; F3: 706462 6015611; F4: 708095 6013014), and in two *P. radiata* plantations (P1: 707451 6015006; P2: 706715 6015505) (Henríquez, 2004; Valdivia *et al.,* 2006). Forty traps were placed in each habitat type and sampled monthly during the spring and summer of each year.

Each individual collected was taken to the laboratory, where the body size (mm) and the length of the first and the second pairs of wings (mm) of the specimen were measured. Body size was measured with a digital caliper (precision 0.01 mm). The lengths of the pairs of wings were measured twice under a stereoscope (10 x). In the analysis, we used one measurement of body length and the average lengths of the first and second wings. The data were analyzed with an ANCOVA for unbalanced samples (Type IV model) with the habitat of the population as a fixed effect, the length of the wing as a response variable and the body size as a covariate. Even though the sample sizes in the three habitats were highly unbalanced (see Results below), the results of the ANCOVA are equally robust for both low and high sample sizes (see Underwood, 1997). A Tukey test was used for multiple comparisons.

Results

Of the 280 individuals captured, 19 were collected in the continuous forest, 142 in the small fragments and 119 in the pine matrix. Queens (large individuals) were generally recorded early in the season, whereas workers (small individuals) were found later in the season, in accordance with the activity pattern of this species (Estay, 2007). On average, the lengths of both the first and the second pairs of wings were greater in the fragments (mean ± standard error: 14.57 ± 0.22; 10.31 ± 0.15, for the first and the second pairs, respectively) and in the pine matrix (14.23 ± 0.18; 10.31 ± 0.15) than in the continuous forest (13.83 ± 0.34; 9.83 ± 0.26). A significant positive relationship between the length of wings and the body size was observed for all habitats, but the fraction of variance explained was lower for the continuous forest (R^2=0.39, P=0.005; R^2 = 0.30, P=0.02 for the first and the second pairs of wings, respectively) than for the fragments (R^2=0.75, P≤0.0001; R^2 = 0.73, P≤0.001) and the pine matrix (R^2=0.52, P≤0.0001; R^2=0.56, P≤0.0001) (Figure 1). The lengths of both pairs of wings differed significantly between habitats (ANCOVA, $F_{2, 279}$ = 8.42, P=0.0003; $F_{2, 279}$ = 8.10, P=0.0004 for the first and the second pairs of wings, respectively). Individuals from the small fragments and pine matrix had longer wings in relation to body size than those from the continuous forest (Tukey test, P≤0.05).

Discussion

Morphologically, *B. dahlbomii* differs across habitats. The largest individuals (female queens) were only captured in fragments and the pine matrix, whereas small individuals (male workers) were captured in all three habitats. In forest fragments and pine plantations, individuals have longer wings relative to body size than in the continuous forest. This pattern is unrelated to a queen-biased sex ratio in forest fragments and pine plantations. The relationship between body size and wing length is statistically significant (ANCOVA, $F_{2, 261}$ = 6.55, P=0.0001; $F_{2, 261}$ = 6.22, P=0.0002 for the first and the second pairs of wings, respectively) even after removing females from the analysis. The significant relationship between wing length and body size might result from changes in resource availability across habitats. *Lapageria rosea*, one of the principal nectar sources for *B. dahlbomii* at the Maulino forest, is scarce in the pine plantations and the small fragments compared with the continuous forest (Valdivia *et al.,* 2006). Because individuals in those habitats would therefore need to travel long distances to acquire resources, those with larger wings would be favored, as previously demonstrated in some species of Lepidoptera and Odonata (Taylor and Merriam, 1995; Thomas *et al.,* 1998; Hill *et al.,* 1999; Berwaerts *et al.,* 2002; Merckx and Van Dyck, 2006). In forest fragments, at least, *B. dahlbomii* faces a more demanding flight

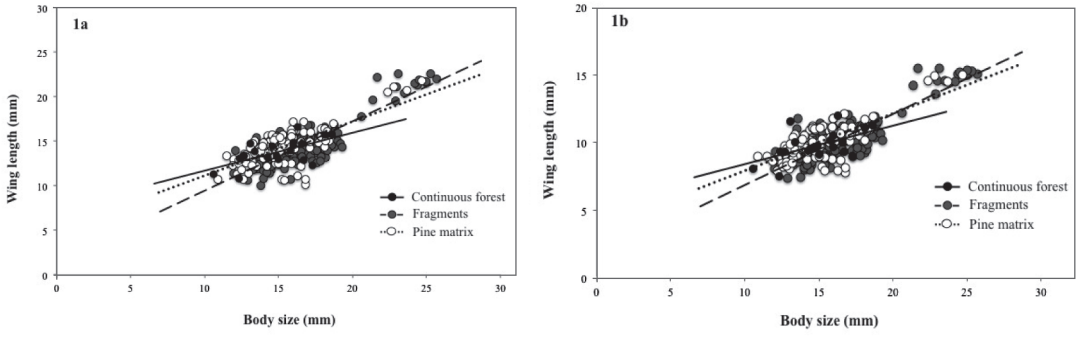

Figure 1. Relationship between the length of a) the first and b) the second pairs of wings (mm) and body size (mm) of individuals of *Bombus dahlbomii* in three different habitats in the Maulino forest.

environment than that of the continuous forest. Gust speeds are 10% greater in forest fragments (*e.g.*, average gust speed during January is 1.15 m/s in fragments and 1.05 in continuous forest, authors' unpublished data).

A difference in wing length would be particularly important for species of *Bombus* that have a short-distance foraging pattern and fly relatively close to the nesting site (Hedtke and Schricker, 1996; Walker-Hellwing and Franks, 2000; Goverde *et al*., 2002; Kreyer *et al.,* 2004). The putative higher mobility of *B. dahlbomii* in small fragments and pine plantations at the Maulino forest might explain the higher capture rates in these two habitats, compared with the continuous forest. Individuals would need to fly longer distances in the forest fragments and pine plantations to track the relatively scarce nectar sources. Their capture would thus be more probable. In contrast, in the continuous forest, with its higher resource availability, individuals would tend to forage closer to their nest. Investing more time and energy in flying in forest fragments and in pine plantations might imply a reduction in fitness. Such consequences remain to be assessed. At Tregualemu, individuals of *Ceroglossus chilensis* (Carabidae) from the center of forest fragments are smaller than those from the center of the continuous forest. This difference is a result of lower habitat quality (Henríquez *et al*., 2009). Therefore, more detailed studies related to morphological changes associated with flight function are needed because they may offer important insights on the colonization and extinction tendencies of the populations (*e.g.*, Colas *et al.,* 2004, Henríquez *et al.,* 2009, Valdovinos *et al.,* 2009) and thus provide valuable information for the conservation and restoration of populations living in fragmented landscapes. As indicated by the findings cited above for *B. dahlbomii* and *C. chilensis*, habitat fragmentation can impact not only the size of the remaining populations but also the morphological features of the surviving individuals.

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Resumen

M.M. Murúa, A.A. Grez y J.A. Simonetti. 2011. Cambios en el largo alar del polinizador *Bombus dahlbomii*, con la fragmentación del bosque Maulino, Chile. Cien. Inv. Agr. 38(3): 391-396. La fragmentación del hábitat puede afectar el diseño morfológico de los insectos voladores de distintas maneras, a través de cambios en los costos y beneficios de los patrones de dispersión. Como resultado, es probable que alas más grandes puedan ser favorecidas cuando los recursos necesarios se encuentren dispersos a lo largo del paisaje fragmentado. En esta investigación se puso a prueba esta predicción en *Bombus dahlbomii* (Guérin), un polinizador nativo de Chile asociado al bosque Maulino fragmentado. Mediante trampas colgantes, se capturaron individuos en el bosque nativo continuo, en cuatro pequeños fragmentos y en dos plantaciones de *Pinus radiata* (matriz). A cada individuo colectado se le midió su tamaño corporal (mm) y el largo de su primer y segundo par de alas (mm). En total, fueron capturados 280 individuos. El tamaño corporal y el largo de ambos pares de alas fue mayor en los fragmentos y en la matriz, en comparación con el bosque continuo. Además, se observó una relación positiva y significativa entre la longitud de las alas y el tamaño corporal en todos

los hábitats, sin embargo, la varianza explicada fue menor en el bosque continuo que en los fragmentos y la matriz. Estos resultados sugieren que la fragmentación del bosque Maulino podría favorecer fenotipos con alas más grandes, probablemente con mayores capacidades de vuelo para la búsqueda de recursos escasos durante el forrajeo.

Palabras clave: Abejorros, hábitat fragmentado, cambios morfológicos.

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