

Ecomorphology in dragonfly *Neurothemis fluctuans* (Fabricius, 1973)

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Abstract. The 'bigger is better' hypothesis is examined on dragonflies by using an ecomorphological approach. Preliminary evidence indicate that optimum fitness, as measured by the survivorship and resource holding potential, favours medium-sized males. Population differences in body parts measurements were not obvious but size sexual dimorphism was negatively correlated.

Abstrak. Hipotesis 'besar itu lebih baik' ialah persoalan yang dikaji di sini dengan menggunakan pendekatan ekomorfologi. Bukti dari penemuan peringkat awal menunjukkan bahawa ketegapan optima yang diukur sebagai jangkamasa hayat dan pembolotan sumber, ialah cenderung kepada saiz jantan pertengahan. Perbezaan populasi dalam ukuran bahagian badan tidak ketara tetapi dimorfisme seks bagi saiz berkorelasi negatif.

Introduction

Dragonflies (of the order Odonata) are a much studied creature worldwide. They have also been well examined locally [1-4]. Besides inventorization and updating of species, aspects of behavioural ecology constitute an interesting subject [5], and one of these is ecomorphology, whose basis unites the ecological and morphological approaches [6]. More precise morphological measurements enable a better estimate of the associated ecological parameters. For example, the morphometric differences in comparable features are related to ecological and behavioural differences, and the relationships are analysed at all levels and for diverse species. Ecomorphological results can be applied to ecological problems such as diet, habitat selection and coexistence of species.

Population biologists have traditionally viewed an animal's ecology from its morphology [7]. Body size has been correlated to niche expansion in iguanas [8] and the sizes of eyes to the activity heights of gecko species; other body parts measurements have been taken as indicators of diet [9]. In crabs, the chelae length and weight determine the victor in agonistic encounters [10]. In flies, resource holding

potentials for mating successes [11]; on the other hand, the ability to hold higher ranking territories is believed to be related to body size in dragonflies [12]. *Neurothemis fluctuans* is a suitable species for study; dragonflies are known for their intricate distribution pattern and high population numbers [13].

Experimental

In the year-long study in the botanical garden of the University of Malaya (3°7' N, 101°39'E) beginning July 1995, a population of *N. fluctuans* was captured, marked, sexed and measured for the fore-wing (FW), hind-wing (HW) and abdomen(AL). The marked individuals were released on site for subsequent detailed behavioural observations (reported elsewhere). Captured individuals were male biased over water bodies, where females only made intermittent visits for egg-laying purposes [5]. The females were not arked for the purpose of data gathering on reproductive behaviour. For population comparisons, morphometric data obtained from a second locality, Tasek Bera, Pahang (3°5' N, 102°38' E), were used.

Three forms of parameters that fulfil the criteria of individual fitness were scored. These

were Dayspan (the total duration of stay measured in days), Site Fidelity (or territoriality, which is the number of days males were consistently guarding specific space) and Total Territories (where shifting of territories was scored). The results were analysed with the statistical package STATISTICA version 5.0.

Results and Discussion

Morphometrics of monospecific population and sexual dimorphism

Two hundred and fifty males and 14 females were marked and measured from Rimba Ilmu whereas 50 males were measured from Tasek Bera. Body measurements were plotted separately for males (Figure 1). Both wing parameters were highly correlated between each other (Spearman's Rank Correlation: FW-HW, $R = 0.9806, p < 0.05$) and with the body length in the males (Spearman's R.C.: AL-FW, $R = 0.6759, p < 0.05$ and AL-HW, $R = 0.6846, p < 0.05$). For the females, with the exception of correlated wing measurements, other interactions were not significant (Spearman's R.C.: FW-HW, $R = 0.9283, p < 0.05$; AL-HW, $R = 0.1567, NS$; AL-FW, $R = 0.2351, NS$).

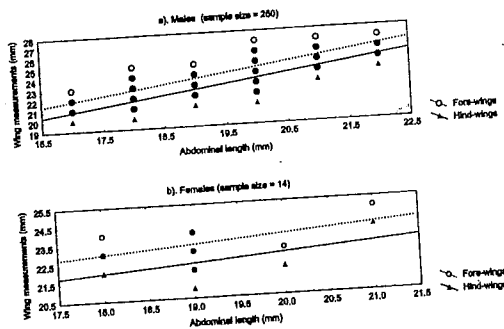


Figure 1. Fore- and hind-wing measurements against abdominal length for male and female populations in Rimba Ilmu, University of Malaya.

The morphological values were then subjected to analyses for sex differences. The outcome showed a significant difference between male and female fore-wings (t-test: $t = 2.3493, p = 0.04$) but not for other features (t-test: HW, $t = 1.4712, NS$; AL, $t = 1.5048, NS$). Interestingly, the overall mean of males (22.28) was

significantly higher (21.45) (t-test: $t = 7.7609, p = 0.02$).

Conspecific population comparisons

As fore- and hind-wings are correlated across population level, only hind-wing and abdomen measurements are considered here. Populations from 2 different habitats displayed normal distribution patterns (Shapiro-Wilk test: HW-Rimba, $W = 0.9182, p < 0.001$; AL-Rimba, $W = 0.8979, p < 0.001$; HW-Tasek Bera, $W = 0.9195, p = 0.004$; AL-Tasek Bera, $W = 0.9227, p = 0.003$). There are no apparent differences in body structures between the two populations (Wilcoxon test: HW, $Z = 0.4745, p = NS$; AL, $Z = 1.0334, p = NS$). The wing lengths of some individuals in Tasek Bera exceeded the maximum of 26 mm found in Rimba Ilmu.

Ecomorphological correlates

Site Fidelity seemed to be an obvious trait associated with body size (Multiple Regression test: FW, $b = 1.19, p = 0.011$; HW, $b = 1.70, p = 0.003$; AL, $b = 0.177, p = NS$). There is some indication to suggest that body size is correlated to the Dayspan (Multiple Regression: FW, $p = 0.90, p = 0.091$; HW, $b = 1.10, p = 0.074$; AL, $b = 0.09, p = NS$); the relationship of total number of territories with morphometrics is less clear. The abdominal length appears to be inversely correlated to the territories held.

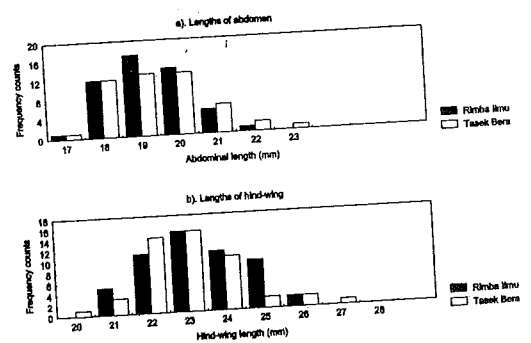


Figure 2. Frequency counts for morphometrics of population comparison from Rimba Ilmu and Tasek Bera.

Figure 3 shows that the medium-sized dragonflies obtained higher scores for Dayspan and Site Fidelity. When the body structures data

were pooled for comparisons between scores in means against other sizes, they were found to be highly significant (t-test: Site Fidelity, $t = 3.9001$, $p = 0.05$; Dayspan, $t = 4.5826$, $p = 0.04$).

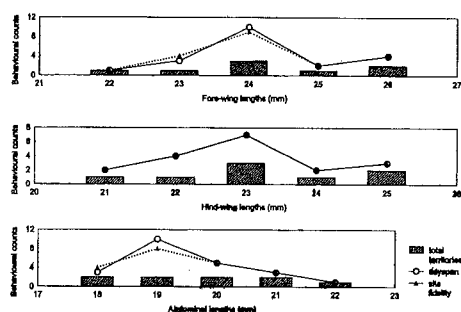


Figure 3. Behavioural counts that measure fitness of individuals with three morphological parameters.

Body measurements are typically reported in taxonomic or biological studies of animals. In odonates, wing and abdominal measurements were often cited which are attributed to positive allometry with body mass [14]. Females were more variable in body measurements, which could arise from a small sample size or a possible influence in width rather than length, which governs the capacity for carrying reproductive materials. The study of size sexual dimorphism has produced a substantial body of literature, which suggests that females are larger than males in most invertebrates, including dragonflies [5,14,15]. However, such a trend is not shown here. This anomaly may be attributed to the manner females were marked to exclude those in the act of reproductive display (data reported elsewhere); females involved in such reproductive behaviour were presumably fertile and larger.

Morphological parameters are commonly used for analysing well-being or fitness in studies on fish, and among the indices used, the most popular index [16] is used for comparing monospecific populations living under apparently different situations [17]. In contrast to studies [18] on damselflies in pasture and forest areas, the present survey on two localities revealed no evidence of morphological

variability except for a skew to the right for the Tasek Bera population. The bigger specimens in Tasek Bera can be explained by the richer biomass sustained in the protected habitat [18].

The present morphological dimensions point to fitness correlation; fitness, as measured, comprise survivorship and resource holding capacity. The number of days of male presence over a month period is considered a good indication of individual's lifespan. The number of days a male is able to defend a specific space (territoriality) would then give a measure of the fitness of an individual. The hypothesis that 'bigger is better' has been supported in many studies on odonate species [5,12,19, 0]. Despite some similarities with previous reports, this study has shown that even though such trends persist, optimum performance was achieved by the medium-sized individuals.

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