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Site fidelity and fluctuating asymmetry in males of *Libellula fulva* (Odonata: Libellulidae)

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Summary

During two seasons (2002-2003), a closed *Libellula fulva* (MÜLLER, 1764) population was studied along a small, canalized creek in Eastern Hungary. The territorial behaviour of males was observed with the mark-recapture method. A number of 169 males were marked in 2002, and 186 males in 2003. The movement of marked males was observed with binoculars, and was recorded along a 350 meter natural section of the stream that was marked every five meters with numbered sticks. The site fidelity of males was studied with the localisation index (LI) and site fidelity index (SFI). We found that the SFI of males that simultaneously defended three territories was high, while the LI was highest in the case of males that protected only one area. The purpose of the study was to see if male's site fidelity is related to wing asymmetry and body size. There was no correlation between male's site fidelity and the measure of wing asymmetry in 2002. In 2003, however, a significant correlation was found in the case of males which defended only one territory. There was no correlation between body size and SFI.

Rezumat

Fidelitate teritorială şi asimetrie fluctuală la masculii *Libellula fulva* (Odonata: Libellulidae)

În 2002 şi 2003 am studiat o populaţie izolată de *Libellula fulva* (MÜLLER, 1764) dealungul pârâului Kutas în partea estică a Ungariei. În cei doi ani de studiu am urmărit cu ajutorul metodei de capturare-recapturare comportamentul teritorial al masculilor. În 2002 au fost marcate 169, în 2003 186 masculi. Masculii au fost studiaţi dealungul unei secţii naturale de 350 m a pârâului, unde au fost montate din cinci în cinci metrii beţe marcate cu numere. Fidelitatea teritorială a masculilor a fost studiată cu ajutorul indexelor de localizare (LI) şi teritorialitate (SFI). Am constatat că, SFI a arătat cele mai mari valori în cazul masculilor care au protejat simultan trei teritorii, iar LI în cazul masculilor care au protejat un singur teritoriu. Am căutat corelaţii între fidelitatea teritorială a masculilor şi simetria aripilor, respectiv între fidelitatea teritorială şi mărimea corporală. Pe când în 2002 fidelitatea teritorială a masculilor şi simetria aripilor nu a corelat, în 2003 am găsit o corelaţie significantă.

Keywords: site fidelity, territoriality, fluctuating asymmetry, territorial behaviour, *Libellula fulva*

Introduction

Territoriality is a widespread behaviour in birds, mammals and social insects. It is poorly studied among non-social insects, but according to several authors it does exists in dragonflies where males show a strong territorial behaviour, mostly in the Anisoptera species (CORBET 1980). The site fidelity and territoriality of dragonfly males refers first of all to mating and oviposition sites, as forms of resource protection. The dragonfly male chooses its territory on the basis of habitat quality. Oviposition sites and sunny resting places are important in a single habitat in the case of percher species. Habitat quality is determined also by past reproductive success. Adherence of the male dragonfly to its territory was studied by SWITZER (1997) in *Perithemis tenera* (SAY, 1839). Natural oviposition sites were replaced with sticks, which were then removed after a male and a female dragonfly settled on them. In this way manipulated males were inhibited in mating. Switzer's study found that manipulated males left their territories with higher probability than non-manipulated ones.

The body size and wing asymmetry of males can influence their success in territory defence and mating. Several studies of territorial insects suggest that bigger body size is an advantage in occupying and defending the territory (ALCOCK 1981). The bigger size often can be connected with longer lifetime or mating success (ALCOCK 1996, THORNHILL and ALCOCK 1983). The smaller size can also be an advantage, because these individuals are more agile and manoeuvre more quickly (MCLACHLAN and

Cant 1995, Steele and Patridge 1988). The mating success can be influenced by the asymmetry or asymmetry of dragonfly wings. The asymmetry is caused by disturbing effects and perturbations during growth (Palmer 1994). There are three known forms of asymmetry: directional asymmetry, fluctuating asymmetry and antisymmetry. The value of the random deviation from the bilateral symmetry is fluctuating asymmetry (FA) (Sodhi 1996, Van Valen 1962). FA occurs due to accidental environmental or genetic effects, which change bilateral symmetry of morphological characters or body shape. Different characters are used for measuring the asymmetry in dragonflies: the wing length, the distance between *nodus* and *pterostigma* (Floate and Fox 2000).

Libellula fulva is a percher species, so it feeds and mates in the air. Individuals defend their territory by fly above it, and sometimes stand on a stick to see intruders. Presumably the wing asymmetry has a major impact on their fitness and success. From the studies of McLachlan (1997) and Balmford (1993), we know that asymmetry alters the frequency and increases the amplitude of wing-flapping. According Møller (1993), only the specimens with good fitness can develop symmetrical characters. They are more resistant in stressed conditions than less developed individuals. Territorial behaviour of the *Libellula fulva* species is poorly known, and there are only a few references on this subject (Szállassy et. al. 2003, Nagy et. al. 2003). The aim of our study was to answer questions regarding the territorial behaviour and the effect of FA on it. Our main questions were: (1) is there any difference between localisation index (LI) of males which defend one, two or three territories; (2) is there any difference between the site fidelity index (SFI) of the males which defend one, two or three territories; (3) is there a correlation between LI or SFI and wing asymmetry of males; (4) are males, which defend more than one territories, more symmetrical; (5) does abdomen size influence SFI of males?

Material and methods

We conducted our research, along the Kutas stream, near the Ártánd village in Eastern Hungary. Only 350 meters of this stream are in natural condition, the remaining portions are canalized, but are almost natural (Dévai et. al. 1998). The studied section is characterized by diverse vegetation (*Typha latifolia, Sium erectum, Mentha aquatica*, *Carex spp*.).

We studied an isolated population of *Libellula fulva* using the mark-recapture method. Males can be easily observed because they show strong territorial behaviour and they are percher types. Their mating time is relatively long (45-60 min.- pers. obs.). We marked 169 males in 2002 and 186 in 2003 with alcohol-pen on their right wings, and with at least double characters. Marking did not change the behaviour of males. After capturing, we measured the total length of the abdomen and the distance between *nodus* and *pterostigma* in the case of each wing to the nearest 0.1 mm using a digital calliper. We observed the marked specimens daily between 9^{00}-15^{00} using an 8x40 binocular, because the mating activity is the highest during this period. For each resighted specimen we noted its number, its position in the study area, its mating status (alone, coupled), its behaviour (fighting, patrolling, feeding) and the exact time of resighting.

On the first day of the study, we placed numbered sticks every five meters along the natural section of the stream. In this way, we could precisely follow the movement of marked males.

We applied the SFI to show that the site fidelity of males that simultaneously defend two or three territories is stronger than those that defend only one. On the other hand, the LI only shows the site fidelity for that territory for which the site fidelity is calculated. We used the localisation index (LI) as one measurement of site fidelity as used by Parr (1980). Site-fidelity is the period of time during which a male is adhered to certain territory. LI is a fraction of the number of cases when the specimen was seen on its territory, and of the number of all cases when the specimen was seen flying above the habitat. Values of LI are between 0 and 1. The specimen is more territorial when this value is closer to 1. LI was used by Parr on the males of an African libellulid, *Orthetrum julia* Kirby, 1900.

We calculated LI and SFI only for males that were seen at least three times on the same 15 meter long section. In previous studies we observed that the resident males defend their territory in a 15-20 meter long section.

LI and SFI were calculated for 26 males in 2002 and for 46 males in 2003. LI is obtained by dividing SFI with the number of defended territories (k). SFI is the sum of the numbers of resightings on a single territory (n_{Vi}) divided with the number of resightings on the whole study area (n_{SV}).

$$LI = \frac{\sum_{i=1}^{k} n_{Vi} / n_{SV}}{k} \quad (1)$$

$$SFI = \sum_{i=1}^{k} n_{Vi} / n_{SV} \quad (2)$$

Male wing asymmetry was calculated as the difference between left and right wing length.

SPSS for Windows (Release 11.5, SPSS Inc., 2002) statistical software package was used for data analysis. Normal distribution of data was tested with Kolmogorov-Smirnov test. We used F-test for examining deviation of variances. Values of LI and SFI of different male groups were compared with one-way ANOVA and Tukey-test. The relationship between values of SFI and asymmetry of wings was studied with parametric correlations.

Results

The differences between the LI of males that defend one, two or three territories

Values of LI had normal distribution in both years (Kolmogorov-Smirnov test). There was no difference between variances of data sets in 2002, but in 2003 variances were not homogenous (F-test). We found significant differences between LI values for males defending one, two and three territories in both years (one way ANOVA: 2002: F=5.9, $p<0.001$, df=2, n=26; 2003: F=14.17, $p<0.001$, df=2, n=46) (Figs. 1-2). Males defending three territories had significantly higher LI than those that defended only one (Tukey-test: 2002: mean difference=0.18, p=0.02), and those that defended two (Tukey-test: 2003: mean difference=0.16, p=0.02), or three territories (Tukey-test: 2003: mean difference=0.26, $p<0.001$)

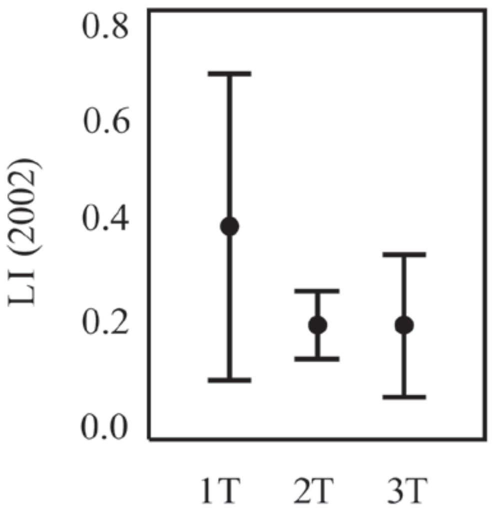

Fig. 1. Mean (±SD) of localisation index (LI) values, for males defending one (1T), two (2T) or three (3T) territories in 2002.

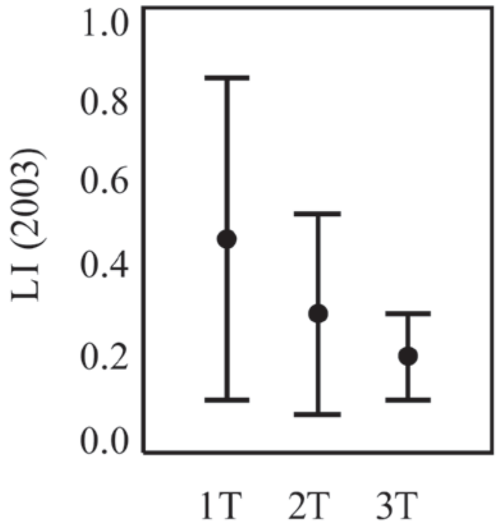

Fig. 2. Mean (±SD) of localisation index (LI) values, for males defending one (1T), two (2T), three (3T) territories in 2003.

The difference between the SFI of the males that defend one, two or three territories

SFI values showed normal distribution for data sets in both years (Kolmogorov-Smirnov test). We did not find differences between variances of the three groups (F-test). In both years there was a significant difference between the values of SFI for males defending one, two or three territories (one way ANOVA: 2002: F=5.47, df=2, n=26, p=0.01; 2003: F=5.63, df=2, n=46, $p<0.001$) (Figs. 3-4). SFI of males defending three territories was significantly higher than those which defended only one (Tukey-test: 2002: mean difference=0.19, $p<0.001$; 2003: mean difference=0.24, $p<0.001$).

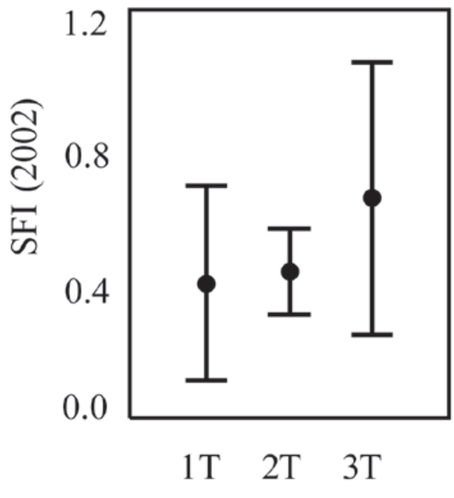

Fig. 3. Mean (±SD) of site fidelity index (SFI) values, for males defending one (1T), two (2T), three (3T) territories in 2002.

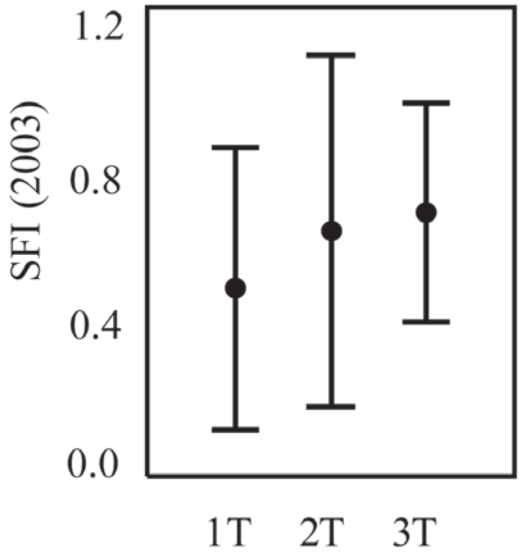

Fig. 4. Mean (±SD) of site fidelity index (SFI) values, for males defending one (1T), two (2T), three (3T) territories in 2003.

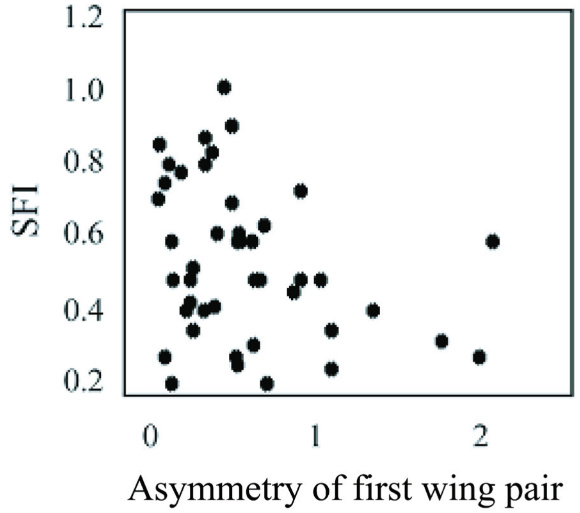

Fig. 5. Scatterplot of asymmetry of first wing pair of males on the basis of site fidelity index (SFI) values in 2003 (Pearson r=-0.3, p=0.04).

Correlations between LI or SFI and the wing asymmetry of males

There was no correlation between asymmetry and SFI in 2002. In the case of the data set from 2003, the asymmetry of the first wing-pair showed a negative correlation with values of SFI, when males were not categorized after the number of defended territories (Pearson r=-0.300, p=0.045) (Fig. 5). There was no significant correlation between asymmetry of hind wing-pair and SFI (Pearson r=-0.178, p=0.241). If males were categorized on the base of the number of defended territories, those that defended one territory showed correlation in the asymmetry of hind wing-pair and SFI (Pearson r=-0.424, p=0.031) (Fig. 6). There was no correlation between the asymmetry of first wing-pair (two territories: p=0.56; three territories: p=0.39) and SFI and between the asymmetry of hind ones (two territories: p=0.41; three territories: p=0.66) and SFI in case of males that defended two or three territories.

Wing asymmetry of males that defend more than one territory

There was no difference in the measure of asymmetry of wing-pairs between males defending one, two and three territories (one-way ANOVA) (Table 1).

Influence of abdomen size on the SFI of males

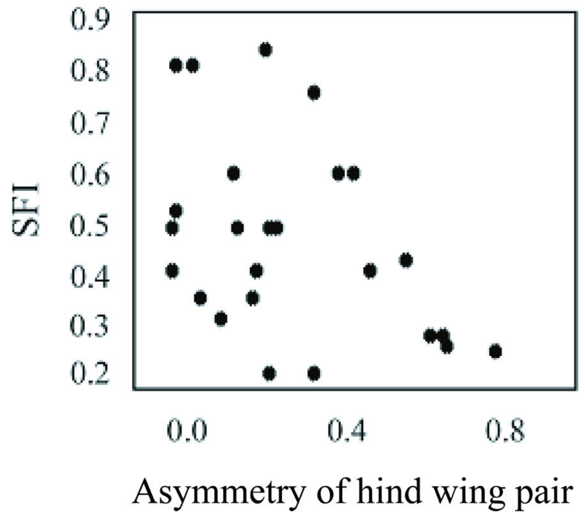

Fig. 6. Scatterplot of asymmetry of hind wing pair of males on the basis of site fidelity index (SFI) values in 2003 (Pearson r=-0.42, p=0.03).

Table 1.
Relationship between the asymmetry of wings and number of defended territories (results of the one-way ANOVA test, df1 – between groups; df2 – within groups).

	df1	df2	F	P
2002				
first wing-pair	2	23	1.87	0.17
hind wing-pair	2	23	0.75	0.48
2003				
first wing-pair	2	41	0.54	0.58
hind wing-pair	2	41	0.66	0.51

There was no relationship between abdomen length and SFI in 2002, neither considering number of defended territories, nor taken the males together. The abdomen length showed no difference between males defending different number of territories (one-way ANOVA: F=0.20, p=0.81). We found no relationship between abdomen length and SFI in 2003, but abdomen length was different between the three male groups (one-way ANOVA: df=43 F=3.61, p=0.036) (Fig. 7).

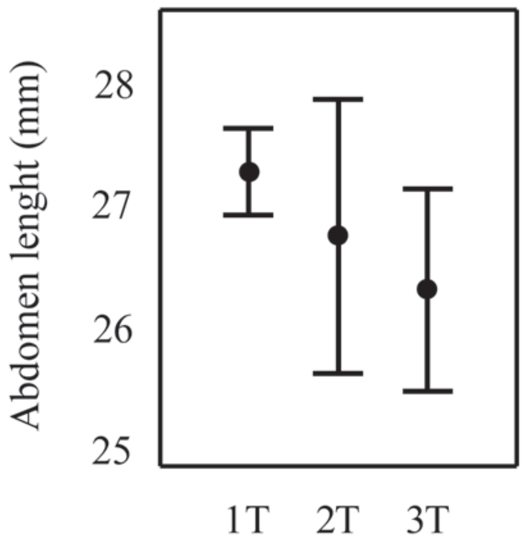

Fig. 7. Mean (±SD) of abdomen size, among male categories in 2003.

Discussion

As far as we can judge, the LI of males that defended only one territory was significantly higher than those that defended two or three territories. If we consider the SFI, the results indicated that the most loyal males were those that possessed three territories. This contradiction shows that males that defend more than one territory are not as devoted as the ones who defend only one. For a male with more territories, the time spent defending each of its separate territories is less than for those with only one. Those who have only one will repose all of their energy to that certain territory. Defending more than one territory might be an alternative mating strategy. It may be hypothesized that lesser quality males have to defend more territories because the ones with better fitness are spurning them away.

The wing asymmetry had no influence on SFI in 2002. Males with symmetric first wing pairs had bigger SFI than those with asymmetric wings in 2003. Furthermore, one territory males with more symmetric back-wing pairs had bigger SFI values in 2003. Both front and hind wing pairs play an important role in the battle for territory and in defence. Because the results were not quite clear, and the influence of the asymmetry was displayable only in 2003, we did not draw straight conclusions on whether or not wing asymmetry influences the fight for occupying and defending territories. The abdomen size did not influence the shape of SFI in those two years. As a result, it can be said that smaller males can successfully occupy and defend more territories as well. If neither wing asymmetry nor abdomen size is an influencing factor then this raises the question of which factors could be the influencing ones. We suppose that the temperature can be taken as an influencing factor, because it has a great impact on their behaviour. In those two seasons, mean temperature was significantly different. Weather was rainy and cloudy with low temperature values in 2002, while the weather was sunny and dry with higher temperature in 2003.

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