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Badge Size and Arrival Time Predict Mating Success of Red-breasted Flycatcher *Ficedula parva* Males

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Older red-breasted flycatcher males (after the second year) have an orange patch on the throat and breast. To date, the occurrence of this ornament has been explained in terms of male-male interactions. In this paper, we show that badge size also influences the mating success of red-breasted-flycatcher males. In addition to the size of the ornament, arrival time was a second factor related to the males' mating success, but no effects of body parameters such as wing length, tarsus length, and body mass were observed. Mated males arrived significantly earlier than unmated ones. The arrival time of males was negatively correlated to body mass and positively correlated to tarsus length but no relation to wing length or badge size was observed. No correlations between badge size and body parameters were observed. This ornament was evolved through sexual selection, with both male-male interaction and selection pressure arising from female preference for males with larger badges.

Key words: ornaments, color, male characteristic, spring settlement, female preferences

INTRODUCTION

In many bird species, males have conspicuous, colored ornaments which can be evolved in two ways related to sexual selection: female choice and male-male competition. Some studies have shown that the size and color of ornaments play a role in mating success or in male-male relations, e.g. competition (reviewed Andersson, 1994). The size of ornaments can be an indicator for various traits in males or females like age (Veiga, 1993), social status (Rohwer, 1975; Senar, 2006; Nakagawa et al., 2007b) and body condition of the owner (Veiga and Puerta, 1996; Roulin and Dijkstra, 2003). The females may gain direct and indirect benefits from pairing with highly ornamented males. Males with larger ornaments may provide direct gains, such as high quality territories (Studd and Robertson, 1985; Maynard and Harper, 1988; Møller, 1988; Keyser and Hill, 2000; van Dongen and Mulder, 2007) and better parental care (Trivers, 1972; Kirkpatrick and Ryan, 1991; Siefferman and Hill, 2003). Indirect gains may provide the female's offspring with good genes and greater fitness. In addition to ornaments, body size, condition, and characteristics of the territory can be used as indicators of male quality. In migrating species, arrival time can also act as such an indicator. Individuals that arrive earlier may obtain higher quality territories (Potti and Montalvo, 1991; Aebischer et al., 1996; Johnson, 1997; Smith and Moore, 2005a) and can increase their probability of mating success (Møller, 1994; Lozano et

al., 1996; Kokko, 1999).

The red-breasted flycatcher *Ficedula parva* is a small, insectivorous, migratory bird, and males exhibit delayed plumage maturation; older males (after-second year) have an orange badge on the throat and breast, while young males (second year) exhibit female-like plumage coloration, without an orange badge. After arrival, males try to attract females by singing and defending territories. Most of them are socially monogamous; to date, only one case of polygyny has been recorded (Mitrus and Soćko, 2005). The earliest males arrive in the Białowieża Forest in late April to early May (Mitrus et al., 2005), older males arrive significantly earlier (Mitrus, 2007b). The red-breasted flycatchers breed solitarily in natural tree cavities (Mitrus and Soćko, 2004) in deciduous or mixed stands, in low densities of up to 2.0 pairs/10 ha (Wesołowski et al., 2002, 2006, 2010).

Earlier observations showed that existing ornaments in this species may play a role in male-male interactions, as males are less aggressive against models displaying sub-adult plumage coloration (Mitrus, 2007a). Previous studies showed also that age, which is related to the presence of the orange badge on the breast, is important for females in mate choice. Males of both age groups can attract a mate, however, older males (with an orange badge) achieve higher mating success (Mitrus, 2006). Nevertheless, no evidence that the size of males' badges has an influence on mating success in this species has been reported to date.

Our goal in this study was to determine if the size of the ornament i.e. the orange badge on the throat of male, other biometric parameters and/or arrival time were related to male mating success.

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MATERIALS AND METHODS

Observations were carried out from 2002 to 2009 in old-growth Białowieża Forest (NE Poland—52°41'N, 23°52'E) from the beginning of May to the end of June. During the time of the arrival (usually three weeks in May), one or two persons per study plot searched for newly arriving males every day, by listening for the songs of individual red-breasted flycatchers. Singing males were searched for in three study plots (total area 79.5 ha) covered by old-growth lime-oak-hornbeam *Tilio Quercus-Carpinetum* stands (Tomiałojć, 1991; Wesolowski et al., 2002, 2006) and along roads leading to those plots. Territories were considered occupied if males were observed for three or more days. In the statistical analyses, in each year, we used the arrival date of the first male to arrive as day 1. After arrival, territories were checked every day to determine mating success and to observe breeding behaviour. Mating success was defined as success in acquiring a female and in the case of the red-breasted flycatcher, a male was designated as mated when it was seen to have stopped singing, seen copulating, seen to be assisted in nest building by a female, or by possession of an active nest.

Males were captured using a concealed tape-recorder that broadcasted conspecific song to lure birds into a mist net (mesh: 16 mm; dimensions: 6 × 25 m) within a male's territory. All birds were aged based on plumage coloration: older males (after-second year) exhibit an orange badge of feathers extending from the throat to the breast, bluish feathers under the eye and on the neck, while young males (second year) exhibit female-like plumage coloration; the throat and breast lack orange plumage and there is no blue plumage on the face (Svensson, 1992). Only older males were included in the analyses. The following measurements were taken: wing length (maximum wing chord in mm, Kelm, 1970), body mass with a Pesola spring balance, 30-g (to the nearest 0.25 g), and tarsus length with sliding callipers (to the nearest 0.1 mm, Svensson, 1992). Males were uniquely marked using a combination of aluminum and color-coded rings. To measure the size of the ornament a method similar to that used by Pilastro et al. (2002, 2003) was used. For each old male, the circumference of the badge was drawn on transparent foil; the piece of foil was put on the breast and the drawing made using felt-tip pen. The badge area, comprising orange feathers, was calculated using the computer program "Autocad." All measurements were made by one person, C. Mitrus. For calculations, all males were used only once.

To determine factors affecting mating success, logistic regression models were constructed, using arrival time, wing length, tarsus length, body mass, and badge size as independent factors. All statistical analyses were performed using Statistica for Windows v.6.0.

RESULTS

Mating success was determined for 97 marked males; 62.9% of them gained a mate. The badge size (logistic regression, $\chi^2 = 4.04$, $P = 0.04$) and arrival time (logistic regression, $\chi^2 = 8.17$, $P = 0.004$, Fig. 2) were the most important factors influencing mating success of the red-breasted-flycatcher males (logistic regression model, $\chi^2 = 19.51$, $P = 0.001$). On average, males with larger badges on the breast (Fig. 1) and arriving earlier mated more frequently (Fig. 2). No effects of wing length (logistic regression, $\chi^2 = 1.26$, $P = 0.26$), tarsus length (logistic regression, $\chi^2 = 0.50$, $P = 0.48$) or body mass (logistic regression, $\chi^2 = 0.93$, $P = 0.33$) were observed. Heavier males and with shorter tarsi arrived significantly earlier ($r_s = -0.24$, $P < 0.01$, $n = 113$, 0.20 , $P = 0.05$, $n = 122$ respectively) but no relation of the arrival time to wing length ($r_s = -0.10$, $P = 0.24$, $n = 123$) or

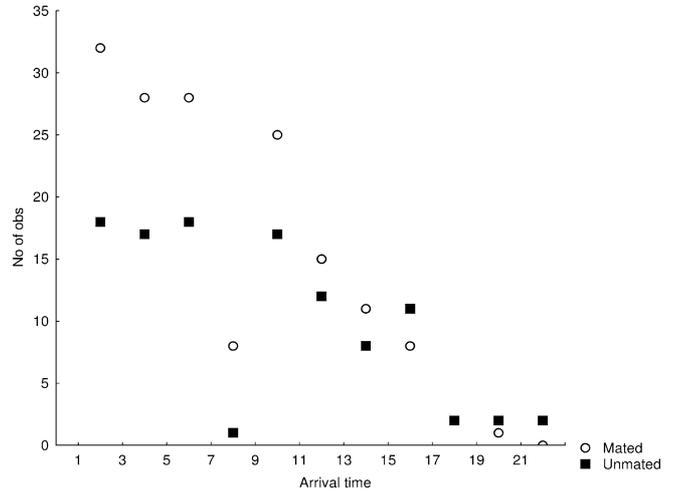


Fig. 1. Badge sizes of mated and unmated red-breasted flycatcher males.

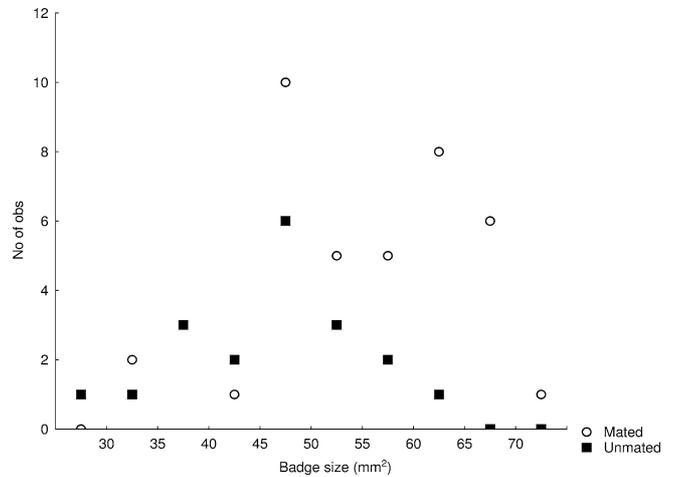


Fig. 2. Relative arrival times of mated and unmated red-breasted flycatcher males.

badge size ($r = -0.17$, $P = 0.22$, $n = 54$) was observed.

No correlations between badge size and wing length ($r = 0.07$, $P = 0.56$, $n = 69$), tarsus length ($r = 0.09$, $P = 0.48$, $n = 69$) or body mass ($r = 0.19$, $P = 0.12$, $n = 66$) were observed.

DISCUSSION

Our observations revealed that badge size and arrival time of male red-breasted flycatchers were associated with female mate choice. Mated males had larger ornaments and arrived significantly earlier than unmated males. In the red-breasted flycatcher, delayed plumage maturation is observed and the absence or occurrence of the orange badge is a determinant of male age. This signal is probably recognized by both males and females. Earlier studies showed that badge presence on the breast in this species can play a role in male-male interactions (Mitrus, 2007a) and mate choice (Mitrus, 2006). The results of this paper indicate that the size of the ornament (orange badge) can also be used by females for mate choice.

The size of the ornament can be an indicator for females of the age and/or quality of the male. The orange badge in males of the red-breasted flycatcher appears in the third year of life (Svensson, 1992). We have known that the badge appears in the third year of life, but we have no direct observations that the size of this ornament changes with age, although this pattern is observed in other bird species (Otter and Ratcliffe, 1999; Hahn and Hans-Ulrich, 2003; Nakagawa et al., 2007a; Kingma et al., 2008). It is well known in the red-breasted flycatcher and other species, that older males arrive earlier on the breeding areas (Hill, 1989; Thompson and Hale, 1991; Lozano et al., 1996; Morbey and Ydenberg, 2001; Mitrus, 2004, 2006). In this way, they also have the opportunity to occupy a good quality territory (Potti and Montalvo, 1991; Lundberg and Alatalo, 1992; Johnson, 1997). In the case of the red-breasted flycatcher, territories of older males differed significantly in some features in comparison with those of young males (Mitrus et al., 2006). In addition to better territories, older males can also offer other advantages to females, such as high feeding rates during incubation and/or increased parental care, as is observed in other species (Forslund and Part, 1995; Preault et al., 2005).

The mating success of male red-breasted flycatchers also depended on arrival time. A similar pattern has been observed in other species (Møller, 1994; Lozano et al., 1996; Møller et al., 2009; Choi et al., 2010). Earlier arrivals have the opportunity to obtain a better territory and to make an earlier start to breeding, and in consequence can achieve higher breeding success (Aebischer et al., 1996; Lozano et al., 1996; Smith and Moore, 2005a). Such males are also often older, more experienced, in good condition, and of good quality (Kokko, 1999; Smith and Moore, 2005b; Choi et al., 2010) providing advantages for females mating with them.

Many papers have shown that ornaments are costly, especially those based on carotenoids (Hill, 1991, 1996a, b, 1999; Lozano, 2001) and that they can be good indicators of male quality. The characteristics of the spectral-reflectance profile (using UV-VIS spectrophotometry) of feathers from the badges of some individuals (unpublished data) indicated melanin rather than carotenoid pigmentation in this species. The role of melanin-based ornaments is rather related to social interactions, aggressive behaviour, nest defense, hormones and immune response, and these are not condition-dependent traits (Gonzalez et al., 1999; McGraw and Hill, 2000; Buchanan et al., 2001; McGraw et al., 2002; Siefferman and Hill, 2005; Nakagawa et al., 2007b; Quesada and Senar, 2007; Ducrest et al., 2010; Klvanova et al., 2011). However, other papers have reported that melanin-based plumage can be honest indicators of condition, parental effort and mate quality, for example, in the eastern bluebird *Sialia sialis* (Siefferman and Hill, 2003), Kentucky warbler *Oporornis formosus* (Parker et al., 2003) and penduline tit *Remiz pendulinus* (Kingma et al., 2008). High-quality individuals show higher survival rates (Jennions et al., 2001) and offer females good genes, high feeding rates during incubation, and increased parental care (Siefferman and Hill, 2003, 2005). Thus male badge size in the red-breasted flycatcher may be an indicator not only of aggressiveness and fighting ability with intruders, but also a

signal for females of other traits of the male. In this species, males select the territory, feed the female during incubation, and participate in parental care of nestlings (Mitrus et al., 2006, 2010), thus choice of a good partner should be an important factor of female life strategy. On the other hand, investment in sexual ornaments is costly and ornament expression could have a negative influence on survival (Brooks, 2000; Hunt et al., 2004), and this can affect variation in trait expression within individuals (Gil et al., 2001).

In conclusion, our study and earlier observations provide evidence that the size of the orange badge of male red-breasted flycatchers has an influence on mating success and that this trait was evolved through sexual selection, with both male-male interaction and selection pressure arising from female preference for males with larger badges.

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