No evidence for offspring sex ratio adjustment in Marsh Tits *Poecile palustris* breeding in a primeval forest

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**Abstract.** When production costs or fitness returns vary between sons and daughters, selection is expected to favor females that adjust sex ratios accordingly. However, to what extent birds can do so remains debatable. Here we analyze the secondary offspring sex ratios in Marsh Tits *Poecile palustris* breeding in the primeval, strictly protected, part of Białowieża National Park (north-eastern Poland). We collected data on parent birds (age), their breeding performance (laying dates, clutch size, nesting success), and the offspring sex ratio in two types of old growth habitats over three years. The individual broods varied from all male to all female, but no significant deviation from parity was detected at the population level. The inter-brood variation could be accounted for neither by environmental (season, habitat) nor parental (female age, laying dates, clutch size, and brood size) variables analyzed. The primary sex ratios (at laying) did not differ from the secondary (brood) sex ratios. Thus, there was no indication of post-hatching sex ratio adjustments, either. Together, our results do not support the hypothesis of adaptive sex ratio adjustments in the studied Marsh Tit population. We suggest that possible fitness benefits could be insufficient to exceed the costs conferred by sex ratio manipulation in this species.

**Key words:** Marsh Tit, primeval forest, *Poecile palustris*, sex ratio, sex allocation

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**INTRODUCTION**

Fisher (1930) postulated that, if offspring of different sex require equal level of investment, natural selection should favor 1:1 sex ratio at conception. If, however, parents gain fitness benefits by overproducing offspring of one sex, sex ratio is expected to differ from parity (Trivers & Willard 1973, Charnov 1982, Frank 1990). Several hypotheses explaining adaptive value of sex ratio adjustment in birds and mammals have been suggested (reviewed by Cockburn et al. 2002, Hasselquist & Kempenaers 2002). According to them, females in good condition (Trivers & Willard 1973), in high quality habitats (Stauss et al. 2005) or mated with an attractive male (Charnov 1982), are expected to overproduce males, while those in poor condition or paired with an unattractive male should overproduce females. Furthermore, females should bias the sex ratio towards the dispersive sex to decrease competition between the relatives in the future but the opposite situation would be expected if the presence of philopatric descendants is desirable in terms of reproductive success (Clark 1978), and produce more young of the rarer sex (Werner 1965, Bensch et al. 1999).

Despite constraints posed by chromosomal sex determination in birds, several studies have provided evidence that female birds can adjust the sex ratio of their offspring in relation to different ecological conditions or parents’ characteristics (reviews in Cockburn et al. 2002, Hasselquist & Kempenaers 2002, Alonso-Alvarez 2006, but see Krackow 1999, 2002). The sex of nestlings was found to vary with the female’s age (Blank & Nolan 1983, Sheldon et al. 1999, Saino et al. 2002, Husby et al. 2006), laying date (e.g. Krebs et al. 2002, Andersson et al. 2003, Rosivall et al. 2004, review in Cordero et al. 2001 and Hasselquist & Kempenaers 2002), clutch size (e.g. Dijkstra et al. 2001 and Hasselquist & Kempenaers 2002).
1990, Gowaty 1993, Lessels et al. 1996, Saino et al. 2002), or habitat/territory quality (Dhondt 1970, Komdeur 1998, Suorsa et al. 2003, Stauss et al. 2005, Hjernquist et al. 2009). However, the patterns found in individual studies were often difficult to replicate or there was a lack of consistency between a given factor and the brood sex ratio skew across studies (Bensch et al. 1999, Krackow 1999, Palmer 2000, Cockburn et al. 2002, Hasselquist & Kempenaers 2002).

As a part of ongoing long-term study of this species in BNP, we collected data on parent birds (age), their breeding performance (laying dates, clutch size, and nesting success), and their offspring sex ratio in two old growth habitats (riverine forest and oak-lime-hornbeam forest) over three years. Due to a plethora of, often inconsistent, results and of theoretical expectations (Cockburn et al. 2002, Hasselquist & Kempenaers 2002, Alonso-Alvarez 2006) it was difficult to make firm predictions on Marsh Tits sex ratios to be observed. We expected, though, that if any bias from even sex ratios did occur, it should be an overproduction of daughters. More females should be reared because they are smaller (i.e. presumably less costly to rear), more dispersive, and are the rarer sex. The latter was shown by regular observations of bachelor territorial males in the spring, whereas no observations of non-breeding females were made (PR and TW, unpubl. data). As food availability and timing of breeding were similar in the two studied habitats (Wesolowski 1998 and unpubl. data) we did not expect to find between-habitat differences in the sex ratios. Similarly, sex ratios should not differ between the seasons, since three years in which we conducted the study fell on high folivorous caterpillar abundance (Wesolowski & Rówiński 2008). Females of some species were found to allocate offspring sex according to the laying order (Kilner 1998, Cichoń et al. 2003), we thus expected small broods to be more female-biased, since females should reduce competitive disparity between larger male and smaller female offspring by producing daughters from eggs early in the laying sequence. Younger, inexperienced females were expected to produce more female-biased (less costly to rear) broods.

**STUDY AREA AND METHODS**

The Białowieża Forest complex is situated at the Polish–Belarussian border; the western part (613 km², c. 45% of its total area) belongs to Poland. The forest represents a remnant of the vast lowland forests that once covered large parts of temperate Europe. Its present unique features result from its considerable size and an exceptionally good state of preservation (Tomiałojć & Wesolowski 1990, 2005). Management encompasses the majority of the Polish part, except a 47.7 km² block of the best preserved primeval old-growth stands strictly protected within the Białowieża National Park. The primeval stands preserved in BNP are distinguishable by an array of features: they are multi-story, mixed-species, uneven-aged, contain many oversized trees, and a large amount of dead timber and uprooted trees (for detailed descriptions and photographs see Tomiałojć & Wesolowski 1990, 2005, Wesolowski 2007, Wesolowski et al. 2010).

**Field data collection**

Data were gathered in the strictly protected part of BNP, in four large (33–50 ha) sample plots, 1–2 km apart. Three of them (plots C, M, and W) were situated in oak-lime-hornbeam stands composed mostly of hornbeam *Carpinus betulus*, lime *Tilia cordata*, pedunculate oak *Quercus robur*, spruce
Picea abies, and continental maple Acer platanoides. The fourth one (plot K) was located in a swampy riverine forest made up mainly by alder Alnus glutinosa, ash Fraxinus excelsior, and spruce (see Wesołowski 1996, 1998, Wesołowski et al. 2010 for detailed descriptions). Natural holes were in excess in all the plots (Walankiewicz 1991, Wesołowski 1996, 2001).

Intensive observations of Marsh Tit pairs, aimed at mapping the distribution of territories and finding the holes of all breeding pairs, were made in 2003–2005. Each season, in the prebreeding period (end of March–first half of April), the birds were followed and their consecutive song posts/places of conflict with neighbors marked on large scale maps of the plots. This procedure was repeated every few days in each plot, all observations were combined on cumulative maps and borders of territories of individual pairs were delineated on them.

To gather data on the course of breeding, clutch size, number of young, and fate of broods the holes were regularly checked throughout the nesting cycle, mostly from the ground. Inspections of the nest contents (using a small bulb on a bendable wire and a small mirror) allowed evaluation of clutch size, number of hatched eggs, nestling age and number of young. First egg dates were only infrequently directly recorded in the field. This was mostly due to the fact that it was quite difficult to ascertain whether laying had already commenced; nest cups around the laying period were filled with wool, and one often could not see if they contained eggs or not (Wesołowski 1998). Clutch size amounted to the number of eggs recorded in a nest during incubation. Around the expected fledgling dates, the holes were observed from a distance every c. 24 h, up to the day on which no parents were observed bringing food to the hole. If on the previous day, young were at least 18 days old (the youngest age of fledging of undisturbed broods; Wesołowski 2000, 2001) and no signs of attempted robbing were detectable, the nest was considered to be successful. If no feeding was observed at a hole containing young about to fledge (16–17 days old), we searched for parent birds (most of them color-ringed) to check whether they were collecting food for prematurely fledged young. If they did, the nest was classified as successful. All other cases of premature cessation of parental activity (no signs of parent presence during an hour observation session) were treated as nest failure (Wesołowski 2002).

Adults carrying food for nestlings were caught in door-traps or mist-nets placed at the hole entrance when the nestlings were 10–14 days old, and color-ringed. To minimize disturbance no measurements of adults were taken. Nestlings were removed from holes and ringed when 13–14 days old. From each nestling, a single outer rectrix was collected and preserved in a vial with 96% ethyl alcohol. It was stored, along with information on location of the brood, date of feather collection, and nestling identity (ring number) for further analysis. The samples were kept in a refrigerator, at 5–8°C.

**Sex determination**

We determined the sex of nestlings by polymerase chain reaction (PCR) amplification of the CHD-W and CHD-Z genes using P2 and P8 primers (Griffiths et al. 1998). DNA was extracted from feathers with the use of GeneMatrix Tissue DNA Purification Kit (Eurx) following the manufacturer’s protocol designed for hairs. We performed PCR amplification in a final volume of 10 μl using 1× PCR buffer (10 × Pol Buffer A, Eurx), 2.0 mM MgCl₂, 0.2 mM of each dNTP, 0.25 U polymerase (Yellow OptiTaq DNA Polymerase, 1U/μl, Eurx), 0.4 μM of each primer, and about 50 ng of DNA. PCRs condition was as follows: initial denaturation at 94°C for 2 min, then 40 cycles of denaturation at 94°C for 45 s, annealing at 48°C for 45 s and extension at 72°C for 45 s, followed by a final extension at 72°C for 5 min. PCR products were separated on 3% agarose gels stained with ethidium bromide, and visualized under UV light. We sexed the nestlings according to the presence of two bands for females and one band for males.

**Data processing and statistical analysis**

First egg dates were usually back calculated from the field notes, following the rules given in Wesołowski (2001). They were calculated firstly as absolute dates, then (to account for inter year variation) transformed to relative dates. The latter were expressed as deviations of individual laying dates (number of days) from median absolute laying dates (= day 0) of respective years. Similarly, clutch and brood sizes were transformed to their relative values, deviations of the number of eggs/nestlings from median absolute values (= 0) of respective years. The broods were classified as “complete” when number of nestlings equaled the number of eggs in a clutch, or “reduced” if they contained fewer nestlings than the number of eggs laid.
The exact age of unringed birds when first caught at breeding holes was unknown but we treated them as first time breeders (second calendar year of life) in the analysis. This is justified because over 90% (19/21) of females of known age (ringed as nestlings and locally recruited), were caught by us in their first breeding season, the remaining two birds, in their second year (T. Wesołowski unpubl. data).

We were able to sex 98% of nestling feathers collected (n = 484). Sex ratios represent the proportion of males per brood at nestling stage (i.e. secondary sex ratio, hereafter “sex ratio”). The dataset comprised 426 nestlings sexed from 66 broods born to 50 different females over three consecutive breeding seasons. We included only those broods for which we were able to sex all nestlings present in the nest during ringing (four nests removed) and only those for which we had data for all the analyzed variables (four additional nests removed). Statistical analyses were performed using R 2.13.1 (R Development Core Team 2011). Null hypotheses were rejected when p < 0.05.

We performed exact binomial tests to determine whether the sex ratio deviated from parity. We analyzed deviations of sex ratio variation from binomial expectation using James’ procedure described by Krackow et al. (2002). The power analysis for binomial tests was carried out with the pwr package (Champely 2009). We calculate the repeatability in brood sex ratio between years for females that bred more than once using the rptR package (Nakagawa & Schielzeth 2010). The variation in brood sex ratio was analyzed with generalized linear mixed model (GLMM) with binomial error and logit link function, using the lme4 package (Bates et al. 2011). Sex ratio was set as the response variable, with brood size as the binomial denominator, using command cbind (Crawley 2007). The initial model included all available variables i.e. laying date of the first egg (standardized in relation to the median date within a year), number of eggs, number of nestlings, female’s age, habitat type, year of study, and brood completeness. Since we used multiple broods from some females, female identity was introduced as a random factor. The model was backward selected by removing statistically nonsignificant terms, starting with the variable with the highest p value. Tests for the significance of the fixed effects in the model were performed via the Wald statistic.

RESULTS

At the population level the proportion of males to females among nestlings did not deviate from parity in any of the studied years (binomial test, all p > 0.2, Table 1). Variance in the sex ratio was not significantly different from binomial expectation (z = 0, p = 0.5). There was a considerable brood sex ratio variation, and broods ranged from ones with exclusively males to exclusively females (Fig. 1). The offspring sex ratio was not repeatable between consecutive clutches of the same females (r = 0.001, 95% CI = 0–0.09, n = 14), in an extreme case, a female produced six daughters and two sons in one year, while next year seven sons and two daughters. There was no difference between primary (complete) and secondary (reduced broods) sex ratios (Table 1, 2). Sex ratio did not differ either between breeding seasons, habitats, nor was it related to the date of first egg laying, clutch size, brood size, or female’s age (Table 2). None of the variables had a significant effect on sex ratios, presented results pertain to the last model that contained given variable (i.e. before it was removed from the model during the backward selection).

DISCUSSION

Though individual Marsh Tit broods varied from all males to all females, we found no significant deviations from parity in the sex ratios of Marsh Tit broods in BNP at the population level.
Offspring sex ratio in Marsh Tits

In 2002, this phenomenon could be actually more widespread than the picture suggests. Lack of sex ratio manipulation could result from constraints, Marsh Tits being unable to regulate the sex ratio of their clutch at laying, or from lack of fitness benefits from making adjustments. Facultative manipulation of nestling sex ratio might not confer sufficient fitness benefit to exceed the costs. Evenness of primary sex ratios is

Contrary to our expectations, females were even slightly less numerous than the males. The interbrood variation could be accounted for neither by environmental (season or habitat) nor parental (female age, laying dates, clutch size, or brood size) variables analyzed. The primary sex ratios (at laying) did not differ from the secondary (brood) sex ratios, either. Thus, we found no evidence of sex ratio adjustments in the studied population. This might mean that Marsh Tit females did not manipulate sex ratio, or that the adjustments were so weak, that they remained undetectable with our sample size. We may also not exclude that such manipulation in Marsh Tits is possible in relation to other factors e.g parental characteristics, which were not studied here.

Our study thus adds to a growing number of avian studies reporting no bias in brood sex ratios (Dietrich-Bischoff et al. 2006, van Dijk et al. 2008, Dyrcz & Cichoń 2009, Kingma et al. 2011, review in Hasselquist & Kempenaers 2002, and Budden & Beissinger 2004). As such data are probably underrepresented in the published literature (Palmer 2000, Hasselquist & Kempenaers 2002, Krackow 2002), this phenomenon could be actually more widespread than the picture suggests.

Lack of sex ratio manipulation could result from constraints, Marsh Tits being unable to regulate the sex ratio of their clutch at laying, or from lack of fitness benefits from making adjustments. Facultative manipulation of nestling sex ratio might not confer sufficient fitness benefit to exceed the costs. Evenness of primary sex ratios is

Table 1. Secondary sex ratio (n males/n nestlings) and mean brood sex ratio (proportion of males) in relation to the measured variables. Laying dates: medium — median ± 1 d, early — < median -1, late — > median +1. Clutch and brood size: small — < median, large — ≥ median. * — detecting a skew as small as 0.60 sons to 0.40 daughters.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex ratio</th>
<th>Mean brood sex ratio</th>
<th>No. of broods</th>
<th>p (binomial test)</th>
<th>Power*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brood reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0.52 (112/214)</td>
<td>0.52</td>
<td>29</td>
<td>0.54</td>
<td>0.84</td>
</tr>
<tr>
<td>Reduced</td>
<td>0.53 (112/212)</td>
<td>0.51</td>
<td>37</td>
<td>0.45</td>
<td>0.83</td>
</tr>
<tr>
<td>First egg date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early</td>
<td>0.50 (57/115)</td>
<td>0.49</td>
<td>17</td>
<td>1</td>
<td>0.58</td>
</tr>
<tr>
<td>Medium</td>
<td>0.54 (128/237)</td>
<td>0.53</td>
<td>36</td>
<td>0.24</td>
<td>0.87</td>
</tr>
<tr>
<td>Late</td>
<td>0.53 (39/74)</td>
<td>0.52</td>
<td>13</td>
<td>0.73</td>
<td>0.41</td>
</tr>
<tr>
<td>Female’s age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young (second year)</td>
<td>0.54 (120/223)</td>
<td>0.53</td>
<td>35</td>
<td>0.28</td>
<td>0.85</td>
</tr>
<tr>
<td>Old</td>
<td>0.51 (104/203)</td>
<td>0.50</td>
<td>31</td>
<td>0.78</td>
<td>0.82</td>
</tr>
<tr>
<td>Habitat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riverine forest</td>
<td>0.47 (34/72)</td>
<td>0.45</td>
<td>11</td>
<td>0.72</td>
<td>0.40</td>
</tr>
<tr>
<td>Oak-lime-hornbeam forest</td>
<td>0.54 (190/354)</td>
<td>0.53</td>
<td>55</td>
<td>0.18</td>
<td>0.97</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>0.55 (93/169)</td>
<td>0.54</td>
<td>23</td>
<td>0.22</td>
<td>0.74</td>
</tr>
<tr>
<td>2004</td>
<td>0.55 (68/123)</td>
<td>0.54</td>
<td>22</td>
<td>0.27</td>
<td>0.61</td>
</tr>
<tr>
<td>2005</td>
<td>0.47 (63/134)</td>
<td>0.47</td>
<td>21</td>
<td>0.67</td>
<td>0.64</td>
</tr>
<tr>
<td>Clutch size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>0.54 (69/127)</td>
<td>0.52</td>
<td>23</td>
<td>0.38</td>
<td>0.62</td>
</tr>
<tr>
<td>Large</td>
<td>0.52 (155/299)</td>
<td>0.51</td>
<td>43</td>
<td>0.56</td>
<td>0.94</td>
</tr>
<tr>
<td>Brood size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>0.48 (51/118)</td>
<td>0.47</td>
<td>23</td>
<td>0.78</td>
<td>0.59</td>
</tr>
<tr>
<td>Large</td>
<td>0.54 (167/308)</td>
<td>0.54</td>
<td>43</td>
<td>0.15</td>
<td>0.94</td>
</tr>
<tr>
<td>All data</td>
<td>0.53 (224/426)</td>
<td>0.52</td>
<td>66</td>
<td>0.31</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Table 2. Brood sex ratio in relation to analyzed variables. The sequence corresponds to order of removal of non-significant effects. Female identity was a random factor in the model. Shown are fixed effects from a GLMM. Significance was assessed with the Wald statistic ($\chi^2$).

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female’s age</td>
<td>0.25</td>
<td>1</td>
<td>0.62</td>
</tr>
<tr>
<td>Date of the first egg</td>
<td>0.29</td>
<td>1</td>
<td>0.59</td>
</tr>
<tr>
<td>Habitat</td>
<td>0.88</td>
<td>1</td>
<td>0.35</td>
</tr>
<tr>
<td>Clutch size</td>
<td>1.49</td>
<td>1</td>
<td>0.22</td>
</tr>
<tr>
<td>Brood reduction</td>
<td>0.45</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>Year</td>
<td>3.74</td>
<td>2</td>
<td>0.15</td>
</tr>
<tr>
<td>Brood size</td>
<td>0.86</td>
<td>1</td>
<td>0.35</td>
</tr>
</tbody>
</table>
expected to be optimal from the gametic point of view, thus the chromosomal sex determination mechanisms would produce equal primary sex ratios and lack of parental manipulation would be the most parsimonious explanation of the equal sex ratios (Krackow 1999, 2002). However, it has been demonstrated that the sex ratios could vary with varying environmental or social conditions (reviews in Cockburn et al. 2002, Hasselquist & Kempenaers 2002, Alonso-Alvarez 2006). It has been shown as well, that brood (secondary) sex ratios can be further adjusted by sex-related hatching failures (Cichoń et al. 2005) or nestling mortality (Heinsohn et al. 2011, reviews in Hasselquist & Kempenaers 2002, Alonso-Alvarez 2006). Therefore, the birds are apparently not forced to invariably follow the results of gametic processes. Lack of repeatability of sex ratios in consecutive clutches laid by individual Marsh Tits in BNP demonstrates as well, that the sex ratios of their broods were not a fixed feature. Moreover, facultative sex ratio adjustments were found in other tit species (Parus major, e.g. Kölliker et al. 1999, Stauss et al. 2005, Cyanistes caeruleus, e.g. Svensson & Nilsson 1996, Sheldon et al. 1999, Griffith et al. 2003, Dreiss et al. 2006). Therefore, it is conceivable that Marsh Tits would also be able to manipulate sex ratios of their broods if this was advantageous for them.

Marsh Tits in this study apparently did not use these possibilities. This could be because the costs of eventual adjustments could in their case exceed possible fitness gains. Krackow (1999, 2002) and Pen et al. (1999) indicated that the costs of pre-laying sex ratio control could be substantial and the post-laying sex ratio adjustment, via embryo mortality or infanticide, which reduces the overall number of young reared, is very costly as well. Thus, the gains should be very substantial, to offset the costs. It seems, though, that in the case of Marsh Tit, these benefits would be rather small. Overproduction of females could increase their reproduction via daughters. However, if sons could sire additional young via extra-pair fertilizations (no data concerning this point), a son could possibly produce more grandchildren than a daughter. In such situation, the lower proportion of sons could be offset by their higher productivity. Due to small differences in body size (males less than 10% larger than females, Cramp & Perrins 1993, Glutz von Blotzheim & Bauer 1993) the savings from rearing a brood of seven (mean number in BNP, Wesolowski 2001) daughters instead of seven sons, would probably make less difference than the reduction of a brood by one nestling. Moreover, Marsh Tits in BNP were not energetically limited in their reproduction; no reproduction cost was detectable in unusually heavily investing birds (Wesolowski & Rowiński 2006). A short, very synchronized breeding season (90% of birds commencing laying within 10 days, Wesolowski 1998, 2001) would not probably produce a gradient of environmental conditions steep enough that would allow any sex-related seasonal differences to become visible. Besides, Nilsson (1988, 1989) and Nilsson & Smith (1988) demonstrated that the post-fledging survival of young Marsh Tits was independent of sex, but strongly affected by their fledging dates. Birds that left nests earlier than the others in a local population had a higher chance of settlement and survival; delay of just a few days resulted in significant decreases. Because of this selection pressure, birds bred early and the late laying birds used several time-saving mechanisms to compensate for the initial delay (Wesolowski 1998, 2001). The young Marsh Tits move away from their natal territories soon after gaining independence, disperse in random directions, and settle in territories of strangers (Nilsson 1989, Amann 1997, Broughton et al. 2010). With such a pattern of dispersal and settlement, the chance of young competing with parents or siblings competing with one another are close to nil, so any manipulation of sex ratios could not bring any additional benefits, as well.

Summing up, it seems that the possible fitness benefits from the sex ratio adjustment in Marsh Tits would be too small to overcompensate the costs of such manipulations. This phenomenon could be much more widespread. We contend that species with life histories resembling that of Marsh Tit would rather not show sex ratio adjustments.

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STRESZCZENIE

[Brak dowodów na dostosowywanie proporcji płci potomstwa przez sikory ubogie gnieżdżace się w lesie pierwotnym]

W sytuacji, gdy koszty i zyski z posiadania synów i córek są różne, powinny być faworyzowane te samice, które będą w stanie odpowiednio dostosować procent swojego potomstwa. W ostatnich latach wykazano, że samice niektórych gatunków ptaków różnicowały proporcję płci w legu w zależności od czynników środowiskowych lub cech swoich i partnera. Wiele badań nie potwierdziło jednak tego zjawiska. W pracy przeanalizowano proporcję płci w legach sikor ubogich, gnieżdżących się w pierwotnym lesie, w ściśle chronionej części Białowieskiego Parku Narodowego. Badania terenowe prowadzono w latach 2003–2005. Dane dotyczące wieku samicy, fenologii legów, wielkości zniesienia oraz udanego legów zbierano w dwóch typach lasu (gat. i leg) zlokalizowanych na czterech powierzchniach badawczych. Poszczególne legi różniły się proporcją samców (Fig. 1), a nie poziomie populacyjnym proporcja płci wśród piskląt nie odbiegała od 1:1 (Tab. 1). Nie stwierdziliśmy, aby samice dostosowywały proporcję płci do przebadanych czynników środowiskowych (sezon, typ siedliska) ani też rodzicielskich (wiek samicy, fenologia legu, wielkość zniesienia oraz liczba piskląt w legu) (Tab. 2). Pierwotna proporcja płci w legach, w których pisklęta wykluły się ze wszystkich złożonych jaj nie różniła się od proporcji w legach zredukowanych (liczba piskląt < liczba jaj), nie stwierdzono zatem większej śmieritelnosti piskląt/embrionów jednej z płci (Tab. 1 i 2).