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1 **Change in migration phenology and biometrics of two sister *Sylvia***
2 **species in Hungary**

3
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6
7 **Concise title:** Change of migration phenology of *Sylvia spp.*

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21 **ABSTRACT**

22 The distribution area and the timing of migration of many bird species have changed recently,
23 presumably due to climatic factors. In our study we estimated the effect of climate change on
24 migration phenology and biometrics of two sister *Sylvia* species: the medium distance migrant
25 Blackcap (*Sylvia atricapilla*) and the long distance migrant garden warbler (*Sylvia borin*). We
26 used the data of 52 440 Blackcaps and 6 943 Garden Warblers caught and ringed at the Ócsa
27 Bird Ringing Station (47°15'N, 19°15'E) in Hungary between 1984 and 2008. The age and in
28 case of blackcaps the sex groups were handled separately. The timing of the spring migration
29 of garden warblers shifted earlier, whereas it did not change in blackcaps during the study
30 period. We presume- in accordance with other observations concerning blackcaps in West-
31 Europe- that it probably has changed earlier than the 80's. The timing of autumn migration
32 shifted about two weeks later in all age and sex groups of blackcaps. We found significant
33 correlation in the timing of autumn migration of sex groups, the sign of the differences
34 between the timing of males and females changed. Juvenile garden warblers shifted their
35 autumn migration 13 days later, but adults did not. Mean body mass decreased while mean
36 wing length increased suggesting a change in the composition of the trans-migrant population.
37 We hypothesise that due to climate change the breeding range of these species expanded
38 northwards, producing an increased ratio of long-winged northern individuals in the trans-
39 migrant populations.

40

41 **KEY WORDS:** garden warbler, blackcap, climate change, migration phenology, biometrics

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43

44 **Zusammenfassung**

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46 **Veränderungen in Zugphänologie und Biometrie zweier Grasmückenarten in Ungarn**

47

48 Bei vielen Vogelarten haben sich jüngerer Zeit Verbreitung und Zugphänologie verändert,
49 vermutlich als Folge des Klimawandels. In dieser Studie untersuchten wir die Wirkung von
50 klimatischen Veränderungen auf die Phänologie und Biometrie der Zuges zweier
51 Grasmückenarten, nämlich des Mittelstreckenziehers Mönchsgrasmücke (*Sylvia atricapilla*)
52 und des Langstreckenziehers Gartengrasmücke (*Sylvia borin*). Wir untersuchten 52.440
53 Mönchsgrasmücken und 6.943 Gartengrasmücken, die von der Beringungsstation Ócsa
54 (47°15'N, 19°15'E) zwischen 1984 und 2008 gefangen und beringt wurden. Altersgruppen
55 und bei Mönchsgrasmücken zusätzlich Geschlechtsgruppen wurden unabhängig behandelt.
56 Der Zeitraum des Frühlingszuges der Gartengrasmücke verschob sich nach vorne, während er
57 sich bei der Mönchsgrasmücke im Verlauf der Studie nicht änderte. Wir nehmen an,
58 unterstützt durch andere Beobachtungen von Mönchsgrasmücken in Westeuropa, dass bei
59 ihnen diese zeitliche Verschiebung schon vor den 1980er Jahren erfolgte. Der Zeitpunkt des
60 Herbstzuges verschob sich bei der Mönchsgrasmücke in allen Alters- und
61 Geschlechtsgruppen um etwa zwei Wochen nach hinten. Wir fanden signifikante
62 Veränderungen im Zeitpunkt des Herbstzuges, wobei die Vorzeichen der Veränderung bei
63 Männchen und Weibchen verschieden waren. Junge Gartengrasmücken verschoben ihren
64 Herbstzug um 13 Tage nach hinten, Altvögel hingegen nicht. Ihre mittlere Körpermasse
65 verringerte sich, während sich die mittlere Flügellänge erhöhte, was auf eine Änderung in der
66 Zusammensetzung der durchziehenden Population hindeutet. Wir nehmen an, dass sich die
67 Brutgebiete dieser Arten auf Grund des Klimawandels nach Norden verschoben haben,
68 wodurch mehr nördliche, langflügelige Individuen auftreten.

69

70

71 **INTRODUCTION**

72 One of the most intriguing questions is to what extent living organisms are able to adapt to
73 rapid environmental changes (Berteaux et al. 2004). Global and regional warming play an
74 important role in distribution shifts in many taxa including birds (Root et al. 2003; Gordo
75 2007). In birds specifically, climate change may alter the geographic distribution of species
76 (Huntley et al. 2007), influence the timing and phenology of migration (Lehikoinen et al.
77 2004, Tøttrup et al. 2006; Zalakevicius et al. 2006), moult (e.g. Pulido and Coppack 2004)
78 and breeding (e.g. Crick and Sparks 1999; Charmantier et al. 2008). The rate and direction of
79 changes may differ among species and between populations of the same species (Bearhop et
80 al. 2005; Catry et al. 2006). Even age and sex groups may react differently (Catry et al. 2007).

81 In case of European birds, climate change may cause northward shifts in the breeding
82 areas (Huntley et al. 2007). These changes depend on the migration strategy of the species
83 concerned. The migration of long distance migrants is predominantly under genetic control
84 (Gwinner and Wiltschko 1978) allowing a slower adaptation to rapid changes compared to
85 residents, short-range or facultative migrants (Both and Visser 2001). Spring migration
86 shifted earlier, in particular in species with more generalized diet, shorter migration distance,
87 more broods per year, and less extensive prenuptial moult (Végvári et al. 2009).

88 The prediction is obvious for spring migration due to the advantages of early breeding
89 (Crick and Sparks 1999; Dunn 2004). The timing of spring migration shifted earlier at most of
90 the examined species. In case of good weather conditions earlier arrival is beneficial, since
91 earlier birds can occupy better territories and can raise their reproductive success (Forstmeier
92 2002).

93 In autumn, the causes of the shifts are more complicated as birds generally optimize for
94 survival and could use different strategies to adapt to the changing environment. Departures
95 may occur earlier under a warming climate if nesting is completed earlier, or even later if the

96 extended season encourages additional nesting attempts (Jenni and Kéry 2003). Advanced
97 spring migration and delayed autumn migration of several passerine species have been
98 detected at our study site (Miholcsa et al. 2009).

99 Blackcaps have a large Palearctic distribution area. The southern populations are
100 resident, the northern and eastern populations of European blackcaps are long-range migrants
101 while the Central European populations are partial or medium-distance migrants (Cramp and
102 Brooks 1992). Blackcaps breeding in Hungary are medium-distance migrants, their main
103 wintering range covers the Eastern Mediterranean Basin, but birds may overwinter in any part
104 of the Mediterranean region. Cross migrant blackcaps at our study site originate from northern
105 populations, thus are long-distance migrants (Csörgő and Gyurácz 2009 a). In Western
106 Europe the spring arrival of blackcaps shifted earlier according to the studies of Lungberg and
107 Endholm (1982) and Tøttrup et al. (2006), similar shift have been observed in Central Eurasia
108 by Askayev et al. (2009), while the timing of autumn migration is delayed (Nowakowski
109 1999).

110 Garden warbler has the most northern distribution area in the Palearctic region amongst
111 the Sylvidae warblers (Cramp and Brooks 1992). According to ring recovery data, birds from
112 our study area migrate through the Apennine Peninsula towards Africa (Csörgő and Gyurácz
113 2009 b). Their wintering grounds cover the Sahel region south from the Sahara (Cramp and
114 Brooks 1992; Grattarola 1999). In Northern and Western Europe and Central Eurasia the
115 timing of spring migration of the garden warblers shifted earlier (Hüppopp and Hüppopp 2003;
116 Jonzén et al. 2006; Sparks et al. 2007, Askayev et al. 2009), the timing of autumn migration
117 did not change in Denmark (Tøttrup et al. 2006) and in Switzerland (Jenni & Kéry 2003).

118 In our study we analyzed the changes in timing of migration of two *Sylvia* warbler
119 species at an Eastern European stopover site. We hypothesize that birds shift their migration
120 earlier in spring and later in autumn. We suppose it can be a possible effect of recent climate
121 change. We propose that the changes depend on age and moulting strategy in autumn.

122 Furthermore, we analyzed the change in differences in migration peaks of the two sex groups
123 of blackcaps as we hypothesize that the two sex groups may use different migration strategy.
124 Additionally, we used wing length and body mass in order to examine how these biometric
125 parameters have changed during the last 25 years. In our view the biometric changes could be
126 explained by the changes in the composition of populations passing through the area, thus
127 indirectly showing the possible effects of climate change.

128

129 **2. MATERIALS AND METHODS**

130

131 **1.1. Location and data**

132

133 Data were collected in Central Hungary (47°15'N, 19°15'E) at the Ócsa Bird Ringing
134 Station. The station is situated within the Ócsa Landscape Protection Area, a coherent part of
135 the Danube-Ipoly National Park. The site is at the edge of a postglacial peatbog. The
136 surrounding is highly variable comprising all habitat types from reedbeds to closed forests.
137 The study area has a typical continental climate with cold winters and warm summers. Our
138 bird ringing database contains data of 25 years (1984–2008). Mist-netting and ringing were
139 conducted at the same locations, using the methodology of Szentendrey et al. (1979)
140 throughout the whole study period. We used the records of 13 049 adult and 39 391 juvenile
141 blackcaps (*Sylvia atricapilla*) trapped and ringed between February-November and 1 968
142 adult and 4 975 juvenile garden warblers (*Sylvia borin*) ringed between April-October within
143 the study period. Only data from first captures were used. We distinguished two age groups
144 by features published by Svensson (1992). 1st calendar year birds are referred to as juveniles,
145 older birds as adults. In blackcaps we could determine the sex of birds by cap colorization
146 (Svensson 1992). All birds were measured by a few experts who follow the same
147 methodology (Szentendrey et al. 1979) to eliminate inter-observer bias. The right wing length

148 (to the nearest millimetre using the ruler) and the body mass (to nearest 0.1 g using a digital
149 balance) were measured for each individuals. Visual fat scores were estimated following the
150 scale of Kaiser (1993), ranging from zero (no visible fat) to eight (whole belly covered with
151 fat). We used the data of birds whose fat scores fall into the linear range of the Kaiser scale in
152 biometric analysis.

153 **1.2. Statistical analysis**

154

155 Bird migration phenology has been traditionally described by measures of central
156 tendency (mean, median and mode) and spread (first and last observations, or 5% and 95%
157 percentiles). We defined arrival times as the day of the year when the birds were caught at the
158 first time and characterized the annual timing of migration by the location of the peak of the
159 kernel smoothed arrival distribution curves (Fig. 1). Kernel smoothing was used to reduce the
160 effects of missing observations (Silverman 1986; Knudsen et al. 2007).

161 Peaks of smoothed curves were identified separately for each species by season and age
162 group and in blackcaps also by sex. To detect a shift in the timing of annual peaks during the
163 study period, we applied linear regression analysis. The estimated shift in timing was
164 calculated from the regression equations as the number of years times the estimated per year
165 change (regression coefficient). Shift was regarded as significant if the corresponding linear
166 regression was significant.

167 Quantile regression (Cade and Noon 2003) was used to estimate trends in 10%, 25%,
168 50%, 75% and 90% percentiles of the distribution of arrival times from 1984 to 2008. As
169 different quantiles may represent different population segments which may have different
170 responses to the changing environment, quantile regression can provide an insight to different
171 trends of migration timing of early and late arrivals. Shift in timing and significance was
172 determined same as for linear regression.

173 We analysed the relationship between migration peaks of the two species and of the two
174 age groups of blackcap by Spearman's rank correlation (Hollander and Wolfe 1973).
175 Furthermore we tested the changes in differences between migration peaks of male and
176 female blackcaps by linear regression.

177 Concerning changes in body condition, we first applied a linear model to estimate body
178 mass from fat score and wing length. We used wing length to control for body size. Extra
179 deposited fat was defined as the difference between actual (observed) body mass and body
180 mass belonging to 0 fat score estimated from the linear model. Changes in average extra
181 deposited fat from 1984 to 2008 were estimated by linear regression weighted by sample size.

182 The changes in average wing length were determined by linear regression. Additionally
183 in case of garden warblers we used quantile regression to explore changes in the annual
184 distribution of this parameter. To see the differences between an early (1984–1990) and a late
185 (2002–2008) period smoothed density plots were applied.

186 All statistical analyses were made by the R 2.9.2 program (R Development Core Team
187 2007).

188

189

190 **3. RESULTS**

191

192 **3.1. Changes in timing of migration**

193

194 No significant shift was found in spring migration peak of blackcaps ($p = 0.5$ and
195 $p = 0.08$ for males and females, respectively). Peak of spring migration of garden warblers
196 shifted 9 days earlier ($p = 0.016$). Quantile regression detected a shift of 8 days at the
197 beginning of the migration period (10% and 25% quantiles) while the median passage date
198 (50% quantile) changed by 6.5 days. For late arrivals (75 and 90% quantiles) the changes

199 were not significant (Table 1 and Fig. 2a). In the timing of autumn migration of blackcaps the
200 largest delay was detected in adult males (17 days, $p = 0.02$), whereas the smallest occurred in
201 juvenile males (11.5 days, $p = 0.02$). Females of both age groups shifted their peak time 14
202 days later on average (adults: $p = 0.035$; juveniles: $p = 0.025$). We found similar results by
203 quantile regression for all groups (Table 2). In autumn the time of peak migration of garden
204 warblers did not change significantly in adults ($p = 0.1$), whereas it shifted 14 days later ($p =$
205 0.05) in juveniles. Juvenile garden warblers migrated later than adults in the whole study
206 period. Therefore the difference of median passage dates between the two age groups
207 increased from 2 to 14 days from 1984 to 2008. In juveniles about the same delay was found
208 for all quantiles in autumn (Table 1).

209 There was no significant correlation in the peak of migration of the two species neither
210 in spring, nor in autumn. Migration peaks of male and female blackcaps correlated
211 significantly in autumn (adults: $r = 0.55$ $p = 0.028$, juveniles: $r = 0.81$ $p < 0.0001$). In autumn
212 the differences between migration peak of adult male and female blackcaps increased
213 significantly between 1984-2008: estimated differences between males and females were -5
214 days for 1984 and 7.6 days for 2008 ($p = 0.006$).

215

216

217 **3.2. Changes in biometrics**

218

219 The extra deposited fat decreased significantly from 1984 to 2008 in each age and sex
220 group of both species in autumn (Table 3), however it did not change in spring. The average
221 wing length of adult blackcaps and garden warblers showed a significant increase in both
222 seasons (0.04 mm/year, $p = 0.05$ for blackcap males in both season and 0.03 mm/year, $p =$
223 0.05 for blackcap females in both season, 0.05 mm/year, $p = 0.01$ for garden warblers in
224 spring and 0.06 mm/year, $p = 0.005$ for garden warblers in autumn). Although median wing

225 length of adult garden warblers did not change significantly, wing length distribution shifted
226 toward larger wing lengths (Table 4, Fig. 3, 4). We have not observed remarkable size
227 differences between sexes.

228 **4. DISCUSSION**

229

230

231 The distribution area and the timing of migration of many bird species has changed
232 recently, presumably due to climatic factors (Gordo 2007). In our study we pointed out some
233 possible consequences of climate change on the migrating populations of blackcaps and
234 garden warblers caught at the Ócsa Bird Ringing Station in Hungary.

235 The timing of spring migration of many long and medium distance migrants shifted
236 earlier (e.g. Gordo and Sanz 2005, Sparks and Tryjanowski 2007). The reason of this
237 changing trend could be the optimization to reproduction. In spring birds benefit from the
238 early arrival and could increase their reproductive success in case of favourable spring
239 weather conditions (Forstmeier 2002; Dunn 2004). In spite of the possibility of prosperous
240 consequences of advanced spring migration neither sex groups of blackcaps altered their
241 spring arrival timing significantly during our study period. The reason may be that this
242 species migrates very early in spring and earlier arrival could be non-adaptive as local
243 weather is highly unfavourable preceding the observed arrival dates. In Hungary the first
244 blackcaps arrive in late February, however a handful of recent observations of overwintering
245 birds suggest that a minor fraction of the population may have become sedentary (Csörgő and
246 Gyurácz. 2009 a). Nevertheless in early spring (late February, early March) the weather in
247 Hungary can be very cold sub-zero temperatures and snow is often characteristic of this
248 period. If these unfavourable circumstances occur permanently, the survival rate of birds is
249 very low. We presume - similarly to the observations in Western Europe - that the spring

250 migration of blackcaps has already shifted earlier before our study period in the previous
251 decades. According to the observations in Northern and Western Europe e. g. in Sweden the
252 timing of spring migration of blackcaps shifted on average 5 days earlier between 1965–1979
253 compared to the 1941–1950 period (Lundberg and Endholm 1982). A Danish study pointed
254 out that the median of arrival dates of blackcaps showed greater shift than those of its related
255 species between 1976 and 1997 (Trottrup et al 2006). In Central Eurasia a study reported on 6
256 days earlier shift in first arrival date of blackcaps between 1957-2008 (Askeyev et al. 2009).
257 The first garden warblers arrive to Hungary in the second half of April, the peak of migration
258 is in the middle of May (Csörgő and Gyurácz 2009 b). We found that the spring migration of
259 garden warblers shifted 6.5 days earlier in Ócsa. Similarly to our results, Jonzén et. al. (2006)
260 showed a 7 days average shift of spring migration of garden warblers in Sweden (Falsterbo,
261 Ottenby) between 1980–2004. In Germany (Helgoland) the mostly Scandinavian originated
262 cross migrant garden warblers shifted their spring migration on average 7.4 days earlier
263 between 1960 and 2000 (Hüpopf and Hüpopf 2003). In England (Sussex) the first arrival
264 date of garden warblers occurred on average 16.8 days earlier during 42 years long study
265 period (Sparks et al. 2007), however, it only shifted 4 days earlier during 51 years in Central
266 Eurasia (Kazan) (Askeyev et al. 2009) and did not change significantly in Lithuania (Vilnius)
267 between 1971–2004 (Zalakevicius et al. 2006).

268 Contrary to the observations in Central Eurasia (Askeyev et al. 2007, Askeyev et al.
269 2009), there was no significant correlation in the peak of migration of the two sister species
270 neither in spring, nor in autumn at our study site. However, the lack of correlation in our data
271 is not surprising as blackcaps in Central Eurasian are long-distance migrants, while they are
272 medium distance migrants in Eastern Europe. Blackcaps in Central Eurasia arrive on average
273 at the same time with garden warblers (Askeyev et al. 2009), while there is a marked
274 difference in arrival dates in Europe.

275 After the dispersion period of early August the autumn migration of blackcaps starts in
276 late August and the peak of migration is in the first half of September at our study site
277 (Csörgő and Gyurácz. 2009 a). The autumn passage of blackcaps takes two months, thus the
278 detected approximately two weeks shift is remarkable in all sex and age groups.

279 Both species alter their foraging strategy before autumn migration, they switch from
280 insects to fruits e.g. elderberry at our study site. The change of main food source may cause
281 inexperienced juveniles to spend more time with food deposition than adults. Adult blackcaps
282 – contrary to juveniles and garden warblers – have postnuptial moult, therefore they stay
283 longer, like the inexperienced juveniles. Presumably this is the reason of the approximately
284 two weeks shift in both age groups. Another observation on the timing of autumn migration of
285 blackcaps was a 3 days delay in North Poland in the period between 1985–1998 (Nowakowski
286 1999). Blackcaps favour late migration as a consequence of increasing temperature and
287 improved food availability on the breeding grounds (Coppack et al. 2001).

288 In small bird species, energy-demanding life cycle stages, such as breeding, moult and
289 migration are separated in time. Thus, there is a strong correlation between the timing of
290 postjuvenile moult and migration of blackcaps (Pulido and Coppack 2004). The longer
291 stopover time may be beneficial as it provides sufficient time to complete life cycle
292 components such as moult and allows to prepare for migration (Pulido and Coppack 2004).

293 We found significant correlation between autumn migration peaks of the two sexes. We
294 hypothesize that it may be due to similar responses of the sexes to annual changes of climatic
295 parameters. Interestingly, the sign of the differences between the timing of autumn passage of
296 adult males and females changed significantly. It means that in the early years of study period
297 the males had earlier migration peaks compared to females and recently females leave earlier
298 the study site and males staying longer. These results may imply that the two sex groups of
299 blackcaps could use slightly different migration and refuelling strategies. Possibly, females
300 place more importance on energy-maximization, in order to ensure successful reproduction

301 (Tryjanowski et al. 2004). On the other hand males are the territory defenders and that they
302 generally arrive ahead of females to the breeding territories (Izhazi 1998, Gustin 1999). Catry
303 et al. (2007) have presented convincing evidence on differential distance migration of sexes in
304 chiffchaffs, with females moving further than males. In blackcaps was found a significantly
305 larger proportion of females in samples of British birds that wintered in Africa (Catry et al.
306 2006). If this sexual difference in sex-ratios on wintering grounds occurs, males can leave the
307 breeding ground later, than females. In case weather is highly favourable on stopover site
308 males can stay even longer and the differences between sexes increase.

309 In contrast to blackcaps, winter moulting adult garden warblers must fit this highly
310 energy consuming life-cycle component into a relatively short winter, hindering delayed
311 departure from the breeding grounds (Hedenström et al. 2007). They gain weight faster and
312 hence migrate earlier than juveniles. In this species, the timing of autumn migration of adults
313 did not change during the past 25 years, while juveniles shifted their timing 13 days later. The
314 autumn migration commences in early August at our study site. The peak of autumn passage
315 is in early September and the last individuals leave the ringing site at the beginning of
316 October (Csörgő and Gyurácz 2009 b). Considering that the duration of autumn passage of
317 garden warblers at our study site is two months, our results of a 13 day shift in the migration
318 peak of juvenile garden warblers are non-negligible.

319 In contrast to our results the passage times of the last 5% of garden warblers in autumn
320 shifted earlier in Denmark (Christiansø) (Tøttrup et al. 2006). The last passage date also
321 shifted earlier in England (Oxfordshire) between 1971–2000 (Cotton 2003). However these
322 studies cannot be compared with our results, as they have not handled the age groups
323 separately during their analysis, while we have found large differences in the timing of adults
324 and juveniles.

325 Both species deposit large amounts of fat before autumn migration. The average body
326 mass of blackcaps is 18.7 grams in Sweden and 21 grams on Cyprus (Fransson et al. 2006).

327 Around 16% of body mass of garden warblers from South Sweden consist of deposited fat
328 (Ellergren and Fransson 1992). In Greece the average body mass of juveniles is approximately
329 20 grams (Fransson et al. 2008), while south from the Sahara it is around 17 grams (Ottosson
330 2005).

331 As the published data shows that there could be large differences in mean body mass
332 and in average deposited fat -depending on the distances between two stopover sites and the
333 distance between their current stopover site and the wintering grounds- among migrating
334 populations. On the other hand the pattern of refueling is strictly defined in a population.
335 Therefore, the change in average deposited fat of species at a stopover site could indicate the
336 changes in population composition of cross migrating birds. Remarkable decrease was found
337 in extra deposited fat in all age and sex groups of blackcaps and in adult and juvenile garden
338 warblers at the Ócsa stopover site (Table 3). This decrease could mean a drop with more than
339 one fat score on average. As we have only analysed the first capture data of every individual,
340 and as arriving migrants are predominantly caught shortly after arrival, our data represents the
341 condition of newly arrived birds. Additionally the amount and availability of food for these
342 species could not have changed in this rate at our study area between 1984-2008, thus, it
343 signifies a change in the population composition of cross migrating birds.

344 A correlation was observed between length of migration route and wing length and
345 wing morphology of migrating birds (Lockwood et al. 1998). The wing of northern breeders
346 having longer migration route until the wintering ground is longer and more pointed than that
347 of southern breeders with shorter migration route. This theory is supported by the data of
348 blackcaps on the Iberian Peninsula, where the wing length of cross migrants is larger on
349 average than that of residents (Perez-Tris 2001). According to the data of Western
350 Mediterranean ringing stations there are differences in wing length and body mass among
351 garden warbler populations (Grattarola 1999). Our study indicates that the wing length of
352 blackcaps increased on average and the distribution of wing length shifted toward longer

353 winged birds regarding garden warblers (Table 4, Fig 3, Fig 4). We detected a large change in
354 wing length (average shift of 0.8-1.3 mm), which cannot be explained by local adaptations.
355 There are many studies, which have been reported morphological changes hypothesised as
356 related to climatic variables (Kaňuščák et al. 2004, Tryjanowski et al. 2004). In accordance
357 with our results long-term decrease in body weight and increase in wing length was found for
358 ringed blackcaps in Britain between 1968 and 2003 (Yom-Tov et al. 2006).

359 We detected that the average body mass decreased and the average wing length
360 increased in the migrating population during the study period. In our view this is explained by
361 the change in the composition of individuals originating from different populations, by the
362 increasing rate of northern originated birds among the trapped birds. Therefore a northward
363 shift in the distribution or a larger reproductive success of these species in northern breeding
364 territories, as the effect of climate change, is probable (Huntley et al. 2007). Our theory is
365 supported by the positive correlation between warming weather conditions and the
366 reproductive success in the populations of other northern breeder species (Møller 2002). The
367 population sizes in northern breeding grounds of blackcaps and garden warblers have
368 increased in the previous decades (Jiguet et al. 2010). According to our results there is a
369 remarkable shift in the timing of migration in autumn and spring in case of two species.
370 Garden warblers advanced their spring migration and the autumn migration of garden warbler
371 juveniles and blackcaps was delayed.

372 In addition, our results may indirectly show the effects of climate change on extending
373 breeding range northwards as on the predicted distribution map for blackcaps in the Climatic
374 Atlas of European Breeding Birds, or effects on increasing reproductive success in northern
375 breeding territories like in case of the prediction for garden warblers (Huntley et al. 2007).

376

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378

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382

383 **References**

384

385 Askeyev OV, Sparks TH, Askeyev IV, Tryjanowski P (2007) Is earlier spring migration of
386 Tatarstan warblers expected under climate warming? *Int. J. Biomet.* 51:459-463.

387 Askeyev OV, Sparks TH, Askeyev IV, Tryjanowski P (2009) Spring migration timing of
388 *Sylvia* warblers in Tatarstan (Russia) 1957-2008. *Central European Journal of Biology*
389 4:595-602.

390 Bearhop S, Fiedler W, Furness RW, Votier SC, Waldorn S, Newton J, Bowen GJ, Berthold P,
391 Farnsworth K (2005) Assortative mating as a mechanism for rapid evolution of a
392 migratory divide. *Science* 310:502.

393 Berteaux D, Réale D, McAdam AG, Boutin S (2004) Keeping pace with fast climate change:
394 can arctic life count on evolution? *Integr Comp Biol* 44: 140-151.

395 Both C, Visser ME (2001) Adjustment to climate change is constrained by arrival date in a
396 long-distance migrant bird. *Nature* 411:296-298.

397 Cade BS, Noon BR (2003) A gentle introduction to quantile regression for ecologists. *Front*
398 *Ecol Environ* 1:412-420.

399 Catry P, Bearhop S, Lecoq M (2007) Sex differences in settlement behaviour and condition of
400 Chiffchaffs *Phylloscopus collybita* at a wintering site in Portugal. Are females doing
401 better? *J Ornithol* 148:241-249.

402 Catry P, Lecoq M, Conway G, Felgueiras M, King JMB, Hamidi S (2006) Are blackcaps
403 *Sylvia atricapilla* differential distance migrants by sex? *Ardeola* 53(1):31-38.

404 Charmantier A, McCleery RH, Cole LR, Perrins C, Kruuk LEB, Sheldon BC (2008) Adaptive
405 phenotypic plasticity in response to climate change in a wild bird population. *Science*
406 320(5877):800-803.

407 Coppack T, Pulido F, Berthold P (2001) Photoperiodic response to early hatching in a
408 migratory bird species. *Oecologia* 128:181-186.

409 Cotton PA (2003) Avian migratory phenology and global climate change. *Proc Natl Acad Sci*
410 USA 100(21):12219-12222.

411 Cramp P, Brook DJ (1992) The birds of western Palearctic vol. 6. Oxford University Press,
412 Oxford.

413 Crick HQP, Sparks TH (1999) Climate change related to egg-laying trends. *Nature* 399:423-
414 424.

415 Csörgő T, Gyurácz J. (2009 a) Blackcap in Csörgő T, Karcza Zs, Halmos G, Magyar G,
416 Gyurácz J, Szép T, Bankovics A, Schmidt A, Schmidt E (eds) (2009) Hungarian Bird
417 Migration Atlas. Kossuth Kiadó Zrt. Budapest. (in Hungarian with English summary)

418 Csörgő T, Gyurácz J. (2009 b) Garden warbler in Csörgő T, Karcza Zs, Halmos G, Magyar G,
419 Gyurácz J, Szép T, Bankovics A, Schmidt A, Schmidt E (eds) (2009) Magyar
420 madárvonulási atlasz. Kossuth Kiadó Zrt. Budapest. (in Hungarian with English
421 summary)

422 Dunn PO (2004) Breeding dates and reproductive performance. *Adv Ecol Res* 35:69-87.

423 Ellegren H, Fransson T (1992) Fat loads and estimated flight-ranges in four *Sylvia* species
424 analysed during autumn migration at Gotland, South-East Sweden. *Ring Migr* 13:1-12.

425 Fransson T, Barboutis C, Mellroth R, Akriotis T (2008) When and where to fuel before
426 crossing the Sahara desert-extended stopover and migratory fuelling in first-year
427 garden warblers *Sylvia borin*. *J Avian Biol* 39(2):133.

428 Fransson T, Jakobsson S, Kullberg C, Mellroth R, Pettersson T (2006) Fuelling in front of the
429 Sahara desert in autumn – an overview of Swedish field studies of migratory birds in the
430 eastern Mediterranean. *Orn Svec* 16:74-83.

431 Forstmeier W (2002) Benefits of early arrival at breeding grounds vary between males. *J*
432 *Anim Ecol* 71:1-9.

433 Gordo O (2007) Why are bird migration dates shifting? A review of weather and climate
434 effects on avian migratory phenology. *Clim Res* 35:37-58.

435 Gordo O, Sanz JJ (2005) Phenology and climate change: a long-term study in a
436 Mediterranean locality. *Oecologia* 146:484-495.

437 Grattarola A, Spina F, Pilastro A (1999): Spring migration of the garden warbler (*Sylvia*
438 *borin*) across the Mediterranean Sea. *J Ornithol* 140:419-430.

439 Gustin M, Pizzari T, Capizzi D (1999) Relationship between biometry and migration time
440 among blackcaps (*Sylvia atricapilla*) in Central Italy. *Die Vogelwarte* 40: 88-97.

441 Gwinner, E., Wiltschko, W. (1978) Endogenously controlled changes in migratory direction
442 of garden warbler, *Sylvia borin*. *J Comp Physiol* 125:267-273.

443 Hedenström A, Barta Z, Helm B, Houston AI, McNamara JM, Jonzén N (2007) Migration
444 speed and scheduling of annual events by migrating birds in relation to climate change.
445 *Clim Res* 35:79-91.

446 Hollander M, Wolfe DA (1973), *Nonparametric Statistical Methods*. New York: John Wiley
447 & Sons. pp 185-194.

448 Huntley B, Green R, Collingham Y, Willis SA (2007) *Climatic Atlas of European Breeding*
449 *Birds*. Durham University, The RSPB and Lynx Edicions. Barcelona.

450 Hüppopp O, Hüppopp K (2003) North Atlantic Oscillation and timing of spring migration in
451 birds. *Proc R Soc Lond B Biol Sci* 270:233-240.

452 Izhaki I, Maitav A (1998) Blackcaps (*Sylvia atricapilla*) stopping over at the desert edge:
453 inter- and intra-sexual differences in spring and autumn migration. *Ibis* 140:234-243.

454 Jenni L, Kéry M (2003) Timing of autumn bird migration under climate change: advances in
455 long-distance migrants, delays in short-distance migrants. *Proc R Soc Lond B*
456 270:1467-1471.

457 Jonzén N, Lindén A, Ergon T, Knudsen E, Vik JO, Rubolini D, Piacentini D, Brinch C, Spina
458 F, Karlsson L, Stervander M, Andersson A, Waldenström J, Lehikoinen A, Edvardsen,

459 E, Solvang R, Stenseth NR (2006) Rapid advance of spring arrival dates in long-
460 distance migratory birds. *Science* 312:1959-1961.

461 Jiguet F, Devictor V, Ottvall R, Van Turnhout C, Van der Jeugd H, Lindström Å (2010) Bird
462 population trends are linearly affected by climate change along species thermal ranges.
463 *Proc R Soc B* doi:10.1098/rspb.2010.0796

464 Kaiser A (1993) A New Multi-Category Classification of Subcutaneous Fat Deposits of
465 Songbirds. *J Field Ornithol* 64(2):246-255.

466 Kaňuščák P, Hromada M, Sparks TH, Tryjanowski P (2004) Does climate at different scales
467 influence the phenology and phenotype of the River Warbler *Locustella fluviatilis*?
468 *Oecologia* 141:158-163.

469 Knudsen E, Lindén A, Ergon T, Jonzén N, Vik J, Knape J, Røer J, Stenseth N (2007)
470 Characterizing bird migration phenology using data from standardized monitoring at
471 bird observatories. *Clim Res* 35:59-77.

472 Lehikoinen E, Sparks TH, Zalakevicius M (2004) Arrival and departure dates. *Adv Ecol Res*
473 35:1-31.

474 Lockwood R, Swaddle JP & Rayner JMV (1998) Avian wing shape reconsidered: wingtip
475 shape indices and morphological adaptation to migration. *J Avian Biol* 29:273-292.

476 Lundberg A, Edholm M (1982) Earlier and later arrival of migrants in central Sweden. *British*
477 *Birds* 75:583-585.

478 Miholcsa T, Tóth A, Csörgő T (2009) Change of timing of autumn migration in *Acrocephalus*
479 and *Locustella* genus *Acta Zool Acad Scient Hung* 55 (2):175-185.

480 Møller AP (2002) North Atlantic Oscillation (NAO) effects of climate on the relative
481 importance of first and second clutches in a migratory passerine bird. *Ecology* 71:201-
482 210.

483 Nowakowski JK (1999) Terms of autumn migration of the genus *Sylvia* in Central Poland.
484 *Ring* 21 (2):3-13.

485 Ottosson U, Waldenstöm J, Hjort C, McGregor R (2005): Garden warbler *Sylvia borin*
486 migration in sub-Saharan West Africa: phenology and body mass changes. *Ibis*
487 147:750-757.

488 Perez-Tris J, Telleria L (2001) Age-related variation in wing shape of migratory and
489 sedentary blackcaps *Sylvia atricapilla*. *J Avian Biol* 32:207-213.

490 Pulido F, Coppack T (2004) Correlation between timing of juvenile moult and onset of
491 migration in the blackcap, *Sylvia atricapilla*. *Anim Behav* 68 (1):167-173.

492 R Development Core Team (2007) R: A language and environment for statistical computing.
493 R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL
494 www.R-project.org.

495 Root TL, Price JT, Hall KR, Schneider SH, Rosenzweig C, Pounds JA (2003) Fingerprints of
496 global warming on wild animals and plants. *Nature* 421:57-60.

497 Silverman BW (1986) Density estimation for statistics and data analysis. In: Cox DR, Hinkley
498 DV, Keiding N, Reid N, Rubin DB, Silverman BW (eds) *Monographs on statistics and*
499 *applied probability*, 26. Chapman & Hall/CRC, London.

500 Sparks TH, Huber K, Bland RL, Crick HQP, Croxton PJ, Flood J, Loxton RG, Mason CF,
501 Newnham JA, Tryjanowski P (2007) How consistent are trends in arrival (and
502 departure) dates of migrant birds in the UK? *J Ornithol* 148:503-511.

503 Sparks T, Tryjanowski P (2007) Patterns of spring arrival dates differ in two hirundines.
504 *Clim. Res.* 35:159-164.

505 Svensson L (1992) *Identification guide to European Passerines*. 4th ed. Stockholm/Ugga.

506 Szentendrey G, Lövei G, & Kállay Gy (1979) Methods applied at the Actio Hungarica
507 Ringing Scheme. *Állattani Közl* 66: 161-166. (in Hungarian with English summary)

508 Tøttrup AP, Thorup K, Rahbek C (2006) Changes in timing of autumn migration in North
509 European songbird populations. *Ardea* 94:527-536.

510 Tryjanowski P, Sparks TH, Kuczyński L, Kuźniak S. (2004) Should avian egg increase as a
511 result of global warming? A case study using the red-backed shrike (*Lanius collurio*). J
512 Ornithol 145:264-268.

513 Végvári Z, Bókony V, Barta Z, Kovács G (2009) Life history predicts advancement of avian
514 spring migration in response to climate change. Glob Change Biol 2009: 1365-2486.

515 Yom-Tov Y, Yom-Tov S, Wright J, Thorne CJR, Du Feu R (2006) Recent changes in body
516 weight and wing length among some British passerine birds. Oikos 112(1):91-101.

517 Zalakevicius M, Bartkeviciene G, Raudonikis L, Januaitis J (2006) Spring arrival response to
518 climate change in birds: a case study from Eastern Europe. J Ornithol 147:326-343.

519

520

521 **Tables**

522 Table 1: Shift in timing of migration of garden warblers (*Sylvia borin*) estimated by quantile
 523 regression. Estimated number of shifted days (d) from 1984 to 2008 and p-values (p) are
 524 represented. Negative numbers represent earlier arrivals.

525

526

quantiles	spring		autumn adult		autumn juvenile	
	d	p	d	p	d	p
10%	-8.0*	0.005	8	<0.001	16	<0.001
25%	-8.0	0.001	3	0.311	9	<0.001
50%	-6.5	0.096	1	0.142	13	<0.001
75%	-7.5	0.052	0	0.922	16	<0.001
90%	1.5	1.000	2	0.901	7	<0.001

527

528 *e.g. -8.0 (upper left cell in the table) means that the shift of the 10% quantile of the distribution was 8 days
 529 earlier on average in 2008 than in 1984.

530

531 Table 2: Shift in timing of migration of blackcaps (*Sylvia atricapilla*) estimated by quantile
 532 regression. Number of days shifted (d) from 1984 to 2008 and p-values (p) are represented.

533

534

quantiles	autumn adult				autumn juvenile			
	male		female		male		female	
	d	p	d	p	d	p	d	p
10%	17.0	<0.001	12.5	<0.001	10.5	<0.001	8.0	<0.001
25%	13.5	<0.001	12.5	<0.001	9.5	<0.001	7.5	<0.001
50%	12.5	<0.001	14.0	<0.001	11.5	<0.001	12.5	<0.001
75%	12.5	<0.001	12.5	<0.001	11.0	<0.001	15.5	<0.001
90%	9.0	<0.001	14.5	<0.001	10.0	<0.001	16.0	<0.001

541

542 Table 3: Change in annual average extra deposited fat in autumn in each group of garden
 543 warblers (*Sylvia borin*) and blackcaps (*Sylvia atricapilla*) from 1984 to 2008 estimated by
 544 linear regression. The changes in grams, slopes (grams/year) and p-values are represented.
 545

	garden warbler		blackcap			
	autumn	autumn	autumn adult		autumn juvenile	
	adult	juvenile	male	female	male	female
change (g)	-1.5	-1.1	-0.7	-0.8	-1.0	-0.9
slope	-0.061*	-0.046	-0.029	-0.032	-0.042	-0.036
p-value	<0.001	0.026	0.006	<0.001	<0.001	<0.001

546
 547 *e.g. -0.061 in the table means that the decrease of extra deposited fat was 0.061 per year on average from 1984
 548 to 2008.

549
 550 Table 4: Changes (d) of wing length (mm) of adult garden warblers (*Sylvia borin*) from 1984
 551 to 2008 in spring and in autumn estimated by quantile regression. The changes (mm), slopes
 552 (mm/year) and p-values are represented.

quantiles	spring adult			autumn adult		
	slope	d	p-value	slope	d	p-value
10%	0.08	2.0	0.012	0.07	1.8	<0.001
25%	0.05	1.3	0.024	0.06	1.5	<0.001
50%	0.00	0.0	1.000	0.00	1.0	1.000
75%	0.00	0.0	1.000	0.06	1.5	<0.001
90%	0.06	1.5	0.037	0.06	1.5	<0.001

561

562 **Figures**

563

564 **Fig. 1** The daily number of mist-netted juvenile garden warblers (*Sylvia borin*) caught in 2008
565 and the smoothed line fitted by kernel smoothing

566

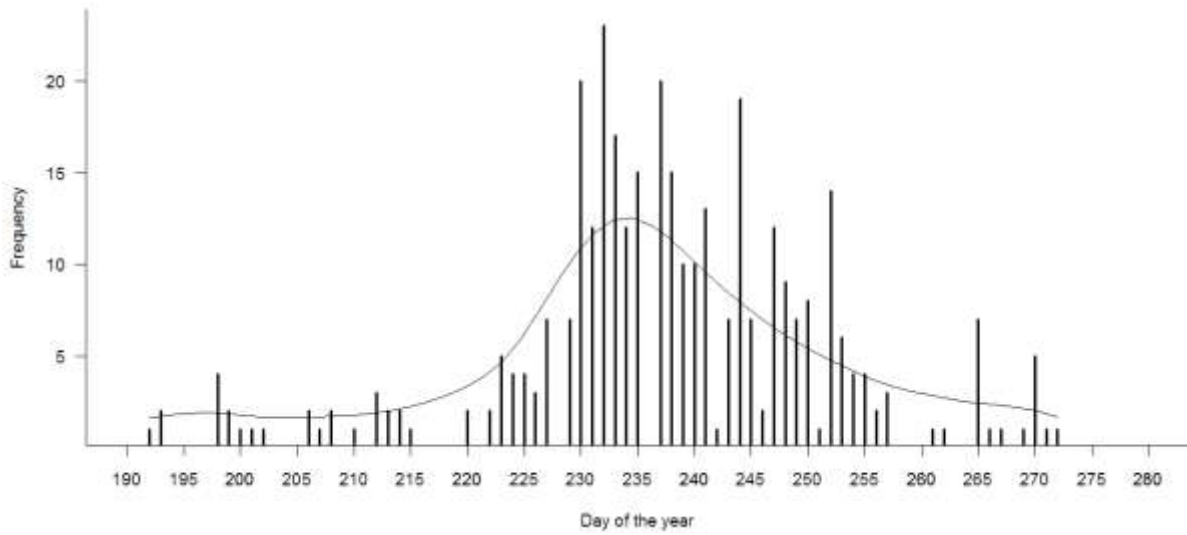
567 **Fig. 2** Scatter plot of capture times (day of the year) vs. year. Lines were fitted by quantile
568 regression (10, 25, 50, 75, 90%; significant – solid lines, non-significant - broken lines) to the
569 arrival times of spring migration of adult (a) and autumn migration of juvenile garden
570 warblers (*Sylvia borin*) (b)

571

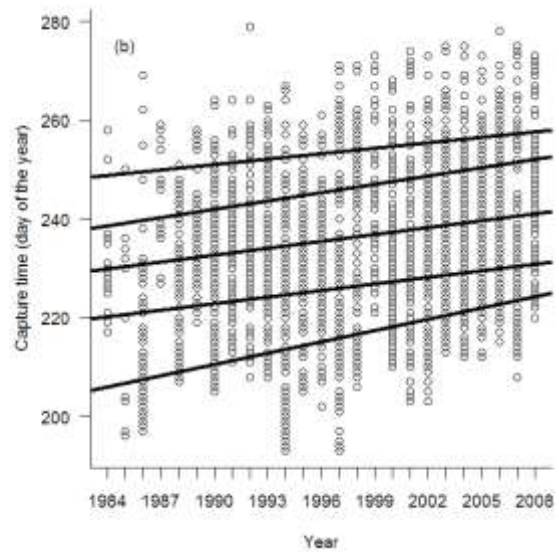
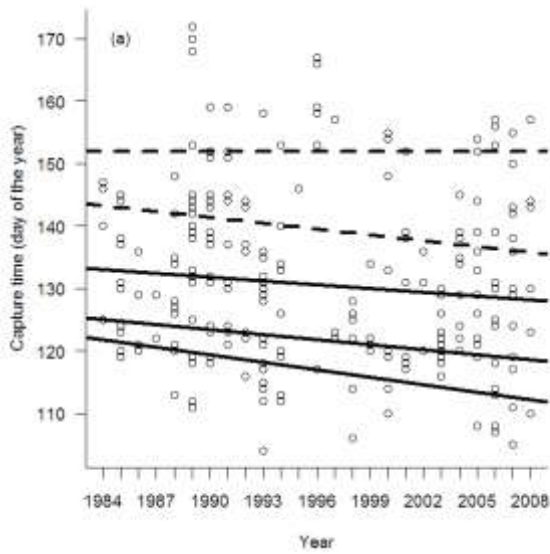
572 **Fig. 3** Wing length (mm) changes of adult garden warblers (*Sylvia borin*) captured in spring
573 (a) and in autumn (b) and fitted lines (quantile regression 10, 25, 50, 75, 90%; significant –
574 solid lines, non-significant – broken lines). Data points are jittered

575

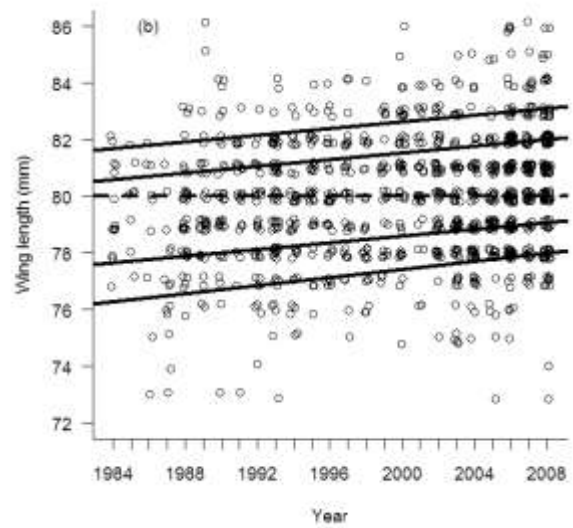
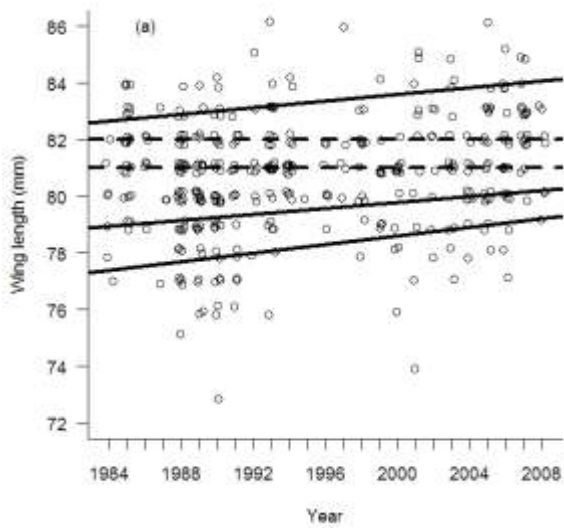
576 **Fig. 4** Smoothed density distributions of wing length (mm) of adult garden warblers (*Sylvia*
577 *borin*) captured between 1984 and 1990 (solid lines) and between 2002 and 2008 (broken
578 lines) in spring (a) and in autumn (b)



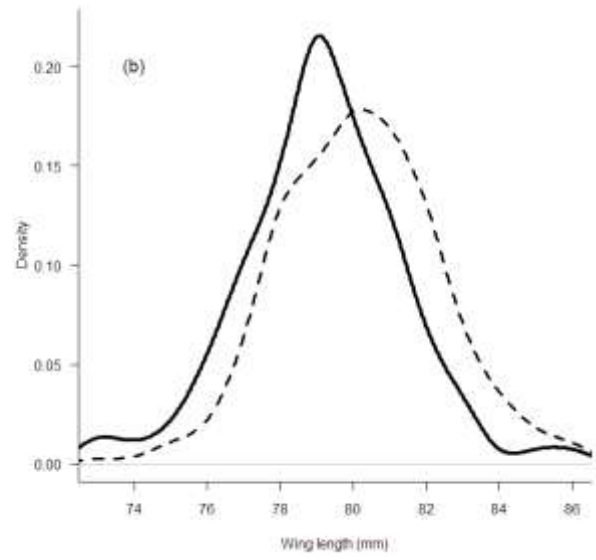
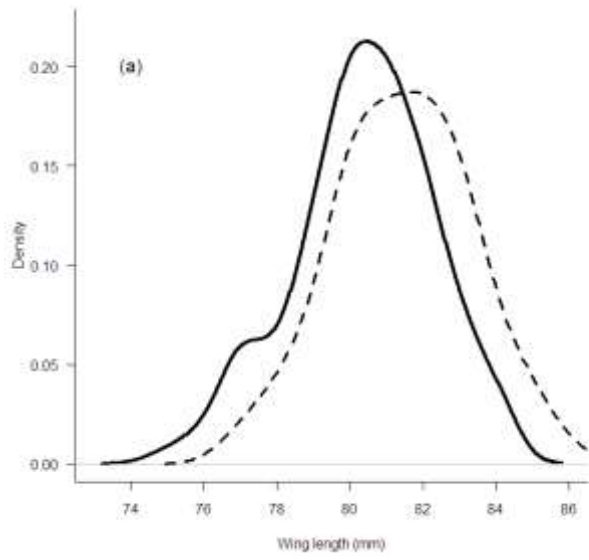
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