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Biometry indicates sexual differences in spring migration strategy in Ringed Plovers *Charadrius hiaticula tundrae* captured in the southern Belarus

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Abstract. Biometric data on 161 adult males and 166 adult females of the Ringed Plover *Charadrius hiaticula* captured in the southern Belarus in spring between 2002 and 2014 were analysed. In males, a significant decrease in total head length and wing length occurred from April to May, while there was no such trend in females. As individuals of the *C. h. tundrae* subspecies are generally smaller than birds of the nominate subspecies, this indicates that mainly *C. h. tundrae* males migrated through the study area in May. A possible explanation of the lack (or very low number) of *tundrae* females is that the sexes differ in migration strategy, such that one sex may skip some staging areas and make longer flights, leading to an unequal proportion of males and females at some stopover sites. Low body mass indices of males in May and a very low number of retrapped birds suggested that these birds arrived to the study area with low energy reserves and have to use additional stopover sites to reach their breeding areas.

Key words: Ringed Plover, measurements, spring migration, body mass index, migration strategy

Introduction

The Ringed Plover *Charadrius hiaticula* nests in the Arctic and northern temperate zone. The breeding distribution is largely restricted to coastal areas but in Eastern Europe the species breeds along some of the major river systems of Poland, Belarus and Ukraine (Davidson & Scott 2009). Three subspecies are recognized (Davidson & Scott 2009) and two of them occurring in Central and Eastern Europe differ greatly in migratory distances. The nominate subspecies *C. h. hiaticula* winters in Europe and breeds in the area from the British Isles to the Baltic and around the Scandinavian coast, and in inland areas in Central and Eastern Europe. In contrast, the subspecies *C. h. tundrae* inhabits the northern parts of Eurasia from the Scandinavian mountain range to the Chukotka peninsula. This subspecies is a long-distance migrant with wintering grounds mainly in sub-Saharan Africa (Davidson & Scott 2009). The two subspecies differ in biometry (*tundrae* is smaller than *hiaticula*, Engelmoer and Roselaar 1998) and in timing of autumn migration. In the Wadden Sea *C. h. hiaticula* departs about mid-August, while *tundrae* passes this area during August-September and even October (Meltofte et al. 1994). A similar pattern was found along the Iberian Atlantic coast (Hortas & Cuenca 2000). This migration schedule was confirmed by biometrical analysis of birds captured in the southern Baltic Sea (Meissner 2007).

Data on spring migration phenology of this species are sparse. Two migration waves were reported in the southern Baltic (Meissner & Sikora 1995) and in eastern Austria (Winkler & Herzig-Straschil 1981). During spring in the Eastern Mediterranean the number of these plovers peaks in May, probably mainly due to the passage of the *tundrae* subspecies (Onmuş & Siki 2011). Differentiated migration of the subspecies may be aided by analysing data on biometrical variability of Ringed Plovers, but such data are rarely reported in spring (Meissner 2007). Only Clapham (1978) showed the overall mean wing length for birds migrating in NW England but without reporting on the temporal variation.

We captured Ringed Plovers during the spring migration period in the Pripyat floodplain, southern Belarus, and collected basic biometrical data to explore the possibility that birds migrating in different time periods belong to different subspecies. We predicted that early arrivals were larger birds from nominate subspecies and later ones might be *tundrae*, because the breeding season in Siberian Arctic begins later than in temperate zone. Special emphasis was put on possible differences in migration strategy between sexes, as in migratory birds, males tend to precede females during spring migration, except in sex-role reversed species

(Morbey & Ydenberg 2001, Kokko et al. 2006). This may lead to differences in stopover strategy between sexes (Farmer & Weins 1999, Bishop et al. 2004).

Methods

Studies were conducted in the floodplain meadows of the Pripyat River in the vicinity of Turov, Gomel Region, Belarus (N 52°04', E 27°44') (Fig.1). This is an important stopover site for waders during seasonal migrations (Pinchuk et al. 2005, Meissner et al. 2011). According to recent estimates, every year nearly half a million of waders use these meadows as stopover site during spring migration (PP, NK – unpublished data). The south-eastern border of the breeding range of the *hiaticula* subspecies runs through this part of Belarus (Davidson & Scott 2009) and most of the local population concentrates in the floodplain meadows of the middle Pripyat River (Pinchuk et al. 2014).

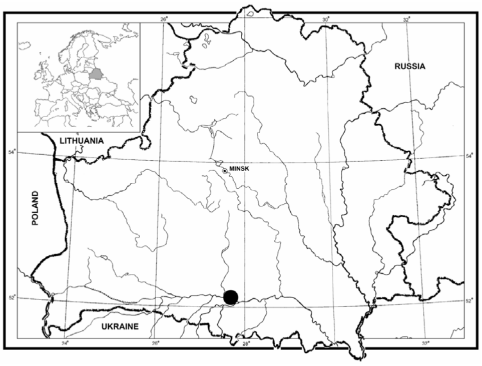

Figure 1. Localization of the study area (black dot) in the southern Belarus.

The field studies were conducted over 13 spring seasons, from 2002 to 2014. Each year, the fieldwork was carried out from the end of March or beginning of April to the beginning of June. This period covered almost the entire spring migration and also most of the breeding season for Ringed Plovers in the area (Pinchuk et al. 2002).

The majority (about 90%) of birds were captured with walk-in traps (Meissner 1998) and the rest with mist nets. All birds were weighed on an electronic balance to an accuracy of 0.1 g and the following morphometrics were recorded: wing length (maximum chord method, Evans 1986), total head length (Green 1980), bill length (from tip of bill to the base of feathers, Prater et al. 1977), and tarsus length (Svensson 1992). The wing was measured with a stopped ruler to 1 mm accuracy. Dial callipers were used for the other linear measurements (accuracy 0.1 mm). Every year the accuracy and repeatability of measurements taken by different ringers were checked as described by Busse and Meissner (2015). More than 90% of all captured birds were measured by two authors (PP and NK). To separate aspects of body mass that are due to structural size from those that reflect amount of energy reserves, a body mass index was calculated as the ratio between body mass and wing length (e.g., Whitfield et al. 1999). Ageing of birds was based on the presence of juvenile inner medians and amount of wear of primaries. Sexing was made according to coloration of the head markings, breast band and the eye-ring (Meissner et al. 2010). As ageing of second-year *tundrae* is difficult, some of these birds might be included in a group of adults. However, differences in mean measurements between adult and second-year birds, are usually small or does not exist (Meissner & Krupa 2009, Pinchuk et al. 2016) hence it was assumed that including second-year *tundrae* would have no influence on obtained results. In some individuals we were able to identify second-year birds according to plumage characteristics, but finally they were excluded from the analysis due to small sample size (22 males and 26 females). Data on 34 males and 51 females caught on nests, i.e., breeding in the study area, were included to show biometrical characteristics of local Ringed Plovers.

To check for biometrical differences among birds migrating earlier and later in the season, we analysed data with respect to birds captured in five successive periods. The first one covered March, while the others were the four subsequent half-month periods of April and May. Due to a small sample size (n=5), females captured in March were excluded from the analyses. In total, data on 161 adult males and 166 adult females were analysed in this study. One-way ANOVA and the Newman-Keuls post-hoc test were used to check differences in mean measurements of birds caught in subsequent time periods. The sample sizes differ slightly between analyses since not all measurements were taken on all birds. Statistical tests were done in STATISTICA 10 (StatSoft Inc. 2011).

Results

Males arrived earlier than females, but the number of Ringed Plover caught in this months was low (Fig. 3). Later, in April and May the proportion of males and females caught in subsequent five-day periods did not differ significantly (G-test; G=7.99; p=0.714). However it should be noted that due to irregular catching the number of caught birds cannot be a proxy of migration dynamics.

Adult males captured in May had significantly shorter heads (ANOVA; $F_{(4,157)}$=5.29; p=0.001) and tarsi (ANOVA; $F_{(4,156)}$=3.30; p=0.013) than males caught in March and April (Fig. 2). The mean wing length of males slightly decreased in the second half of April and the first half of May (ANOVA; $F_{(4,156)}$=3.95; p=0.004) (Fig. 3). The mean total head length and tarsus length of males caught in March and April were similar to the values obtained for birds from local breeding population caught on

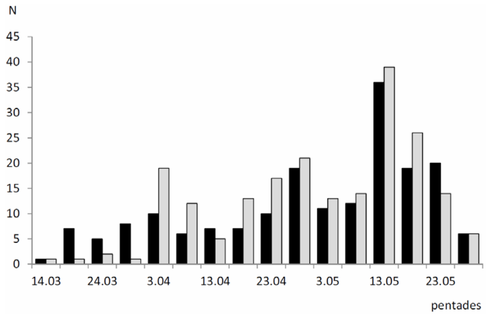

Figure 2. Number of males (black bars) and females (grey bars) caught at subsequent five-day periods (pentades) during spring 2002–2014 (all years combined).

the nests; an exception was mean wing length, which was lower in breeding birds (Fig. 3). There were no significant differences in mean bill length among adult males from different time periods (ANOVA; $F_{(4,151)}$=0.57; p=0.688), nor in all linear measurements of adult females (ANOVA p>0.10 in all cases) (Fig. 4). The body condition indices of both sexes were highly variable. In males, the body mass index decreased from the second half of April to the end of May (ANOVA; $F_{(4,155)}$=7.08; p<0.001 and Newman-Keuls post-hoc test, p<0.05), while in females these indices were significantly higher in the second half of April compared to May (ANOVA; $F_{(3,165)}$=4.80; p=0.003 and Newman-Keuls post-hoc test, p <0.05) (Fig. 4).

Discussion

The total head and tarsus lengths of males caught in March and in April were similar to those recorded for birds from local breeding population. This and a significant decrease of general male body size with the progress of spring migration indicated that Ringed Plovers of the northern *tundrae* subspecies migrated through the study area mostly in May. Such timing coincides with the period of migration of several other waders breeding in the Arctic, which pass through the southern Belarus, e.g., the Dunlin *Calidris alpina*, Curlew Sandpiper *Calidris ferruginea* and Temminck`s Stint

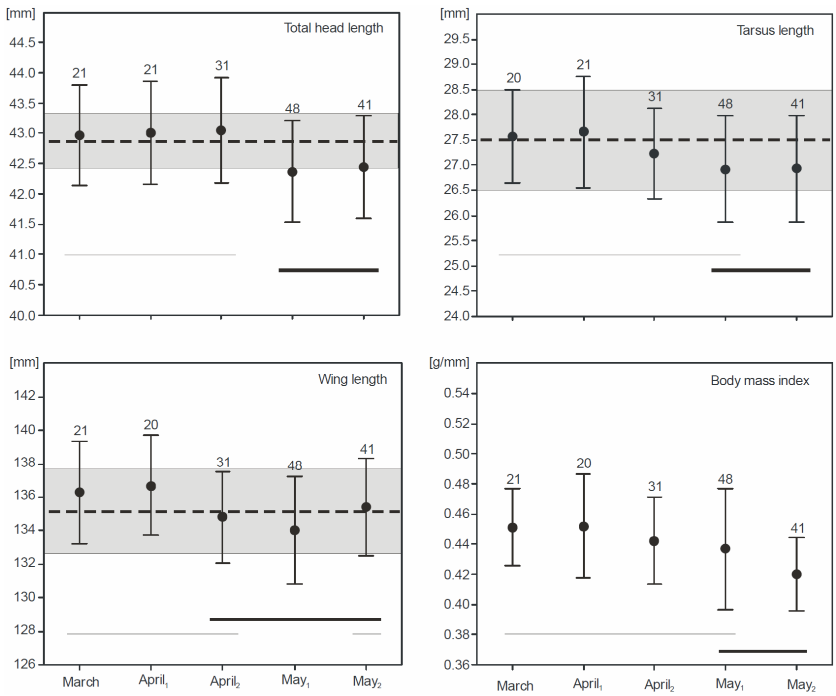

Figure 3. Variability of measurements and body mass indices of the Ringed Plover males in different time periods from March through May. Dots show mean values, vertical lines show standard deviation. Dashed line and shaded area show mean and standard deviation of the measurements taken from 34 birds caught on nests. Sample sizes are given above whiskers. Horizontal lines of a given width denote homogeneous groups of means, which did not differ significantly according Newman-Keuls post-hoc test at p>0.05.

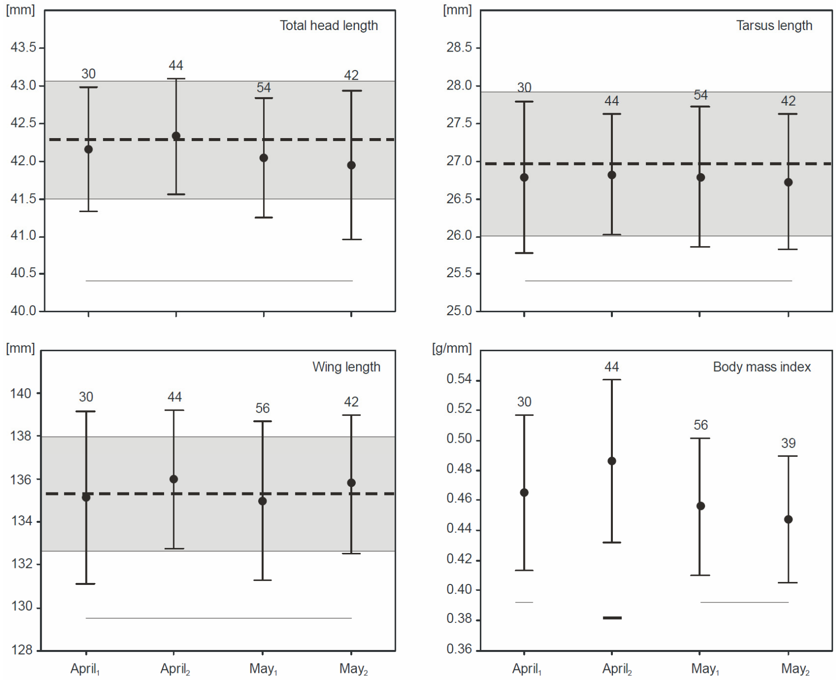

Figure 4. Variability of measurements and body mass indices of the Ringed Plover females in different time periods from March through May. Dots show mean values, vertical lines show standard deviation. Dashed line and shaded area show mean and standard deviation of the measurements taken from 51 birds caught on nests. Sample sizes are given above whiskers. Horizontal lines of a given width denote homogeneous groups of means, which did not differ significantly according Newman-Keuls post hoc test at $p>0.05$.

Calidris temminckii (Pinchuk & Karlionova 2011). It also fits the timing of the second wave of the Ringed Plover passing through eastern Turkey (Onmuş & Siki 2011). No strong passage of *hiaticula* through the study area is expected in spring since this site is localised near the extreme south-eastern part of this subspecies' breeding range (Davidson & Scott 2009). Hence, all Ringed Plovers captured in March and the vast majority captured in the first half of April are likely to represent local breeding populations. Among birds caught in May there was a mixture of both subspecies, because migrating *tundrae* stopped-over in the breeding site of the local population of *hiaticula*. However only in males expected decrease in time in mean measurements was found. The lack of decrease in the size of adult females during spring suggests that females of *tundrae* subspecies do not stay in significant number in the Pripyat floodplain during spring migration.

Female Ringed Plovers have longer wings, legs and bills than males (Glutz von Blotzheim et al. 1975) and in wader species with sexual dimorphism in bill size, sexual differences in foraging niche might lead to spatial segregation of males and females (Both et al. 2003, Nebel 2005). However, in the case of the Ringed Plover, differences between sexes in bill and tarsus lengths are very small (Glutz von Blotzheim et al. 1975) and it is unlikely that resource partitioning could be a reason of observed strong bias in biometry related to sex in *tundrae* subspecies. In a closely related species, the Semipalmated Plover *Charadrius semipalmatus*, there were no significant differences in habitat use between sexes (Smith and Nol 2000). Moreover, plovers typically use visual cues in foraging and they forage almost exclusively outside shallow water (Pienkowski 1983). In the study area walk-in traps were set such that the leadline fences crossed the entire area utilized by waders for foraging, from dry ground to deeper water. Hence, possible differences in habitat selection cannot be a reason of the lack or low number of females among captured Ringed Plovers of *tundrae* subspecies. Another possible explanation of the lack (or very low number) of *tundrae* females is that sexes differ in migration strategy such that one sex may skip some staging areas by making longer flights. This may lead to an unequal proportion of males and females in subsequent stopover sites, which was found in Siberian Knots, *Calidris canutus canutus,* (Nebel et al. 2000, Meissner 2005) and Dunlins (Meissner 2015) in the southern Baltic coast. If so, *tundrae* females probably migrate longer distances than males and pass over the Pripyat floodplain.

Body mass indices of males and females showed the lowest values in May. The majority of females were from the local breeding population and this decrease reflected egg laying, which continues in the southern Belarus from the mid-April till early May (Pinchuk et al. 2002). The low body mass indices of males in May indicated that males from *tundrae* subspecies arrived in the study area with low energy reserves. During spring migration late migrating waders usually accumulate more energy reserves than early migrants at a given stopover site (Goede et al. 1990, Lyons & Haig 1995, Krapu et al. 2006, Meissner et al. 2011, Pinchuk et al. 2016). This may be due to an improvement in feeding conditions as spring progresses (Meissner et al. 2011) and/or differences in migration strategy and distance to cover between early and late migrants (Goede et al. 1990). Large energy stores allow following time minimising strategy and reaching destination in one flight, and faster than birds following energy minimising strategy and migrating with low reserves in short steps (Alerstam & Lindström 1990). The closest breeding grounds of *tundrae* subspecies are localised about 2500 km from the Pripyat floodplain (Lappo et al. 2012). Hence, the males needed time for refuelling or employed an energy minimization strategy (Alerstam & Lindström 1990) (short distance flight with low energy reserves) and used additional stopover sites to reach their breeding areas. However, the lack of data from other stopover sites localised along this migratory route causes that the hypothesis on sex difference in the length of migration bouts cannot be fully supported.

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