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Seasonal age differences in weight and biometrics of migratory Dunlins (*Calidris alpina*) at Eilat, Israel

Reuven Yosef[1] and Wlodzimierz Meissner[2]

[1] *International Birding and Research Centre in Eilat, PO Box 774, Eilat 88000, Israel*
[2] *Avian Ecophysiology Unit, Department of Vertebrate Ecology and Zoology, University of Gdansk, al Legionow 9, 80-441 Gdansk, Poland*
Corresponding author email: ryosef@eilatcity.co.il

This study was undertaken to understand the migratory strategies of the Dunlins (*Calidris alpina*) caught in Eilat, Israel, before and after they accomplish the crossing of the combined ecological barrier of the Sinai, Sahara and Sahel deserts. Between 1999–2001, a total of 410 adults and 342 juveniles were banded. The significant difference in mean wing length between birds caught in autumn and spring reflects the degree of abrasion of the outer primaries during over-wintering in Africa. Dunlins caught in Eilat in autumn and early winter had a mean wing length 1.4–1.9mm longer than in the spring. The rate of body mass increase was comparatively high and the mean body mass of the heaviest 10% of Dunlin at Eilat was 56.2g (SE ± 0.6, N = 80). The heaviest birds from Eilat carried on average about 10g of fat with a lipid index (fat mass as a percentage of total body mass) of 18%. These reserves allow a flight of approximately 1 000km, which is probably sufficient for continued migration to more southerly wintering grounds.

Introduction

Studies of shorebird migration across continental Europe and the Mediterranean Sea (cf Gromadzka 1987), the westernmost flyways of the Western Palaearctic (e.g. Sandberg and Holmquist 1998, Tibor and Gergo 2000) and on their wintering grounds in Africa (e.g. Pienkowski and Dick 1975, Wymenga *et al.* 1990, van der Have *et al.* 1997) have been carried out for decades. Conversely, the eastern flyways of the Western Palaearctic remain largely unstudied. Studies conducted on shorebirds on the circum-Mediterranean flyway of the Middle East are very limited (Serra *et al.* 1998) and much remains to be understood about the migratory habits and requirements of the group while in transition south to the wintering grounds in autumn, or north to the breeding areas in spring.

This study was undertaken to investigate the migratory strategies of Dunlins (*Calidris alpina*) caught in Eilat, southern Israel. Further, we hoped to elucidate the status of the different subspecies that migrate through the region and which have not been studied to date. To answer these questions, we analysed the trapping and banding data of the International Birding and Research Center in Eilat (IBRCE).

Material and methods

Birds were trapped in walk-in traps on the salinas of the IBRCE, at the southern tip of Israel, on the Red Sea (29°33N 34°57E). For this study, we analysed the data on Dunlin caught in 1999–2001. Shorebirds were trapped on a daily basis in spring (1 March–30 August) and autumn (1 September–31 December). A total of 410 adults and 342 juveniles were banded during the study period. The sample size of the Dunlin trapped in all the other months was too small for statistical procedures and was excluded from our analyses.

Each bird trapped was banded, sexed and aged (Prater *et al.* 1977). We classified the birds into four age classes: juvenile and adult in autumn, and immature (in the second calendar year) and adult in the spring. Flattened maximum wing cord was measured to the nearest millimetre (Evans 1986), body mass was determined with a Pesola 100g spring balance to the nearest 1g (Svensson 1992), total head length (back of head to tip of beak) was measured with a vernier caliper (Green 1980) and tarsus plus toe length was measured with a bent wing ruler (Piersma 1984). All measurements were rounded to the nearest millimetre (mm). Difference in body mass between first and last capture of each bird was used to calculate average daily mass changes of juveniles and adults in subsequent months and for the whole season. For calculation of the average changes in body mass, those individuals re-trapped on a daily basis were omitted because shorebirds are known to lose body mass on the first day after capture (Masher 1966, Page and Middleton 1972, Meissner 1998, Meissner and Koziróg 2001). We chose to use the median instead of the mean length of stay because the distribution of intervals between the first and the last capture was not normal for adults (Kolmogorov-Smirnov test, d = 0.23, P < 0.05) and juveniles (d = 0.19, P < 0.05). In order to compare the length of stay of re-trapped Dunlins we used the median test, because the majority were caught within a few days of the initial capture (StatSoft 1997).

Unless otherwise specified, all data are presented with mean ± SD, sample size (N) and range. We chose P < 0.05 as the minimum acceptable level of significance.

Results

The age structure of the Dunlin caught in subsequent months, from September to December, differed significantly (G-test, G = 78.89, P < 0.001) and the relative percentage of the juveniles increased progressively from 19% in September up to 77% in December (Figure 1).

There were no significant differences in total head length (ANOVA, $F_{3,711}$ = 2.03, P = 0.109), tarsus–toe length

(ANOVA, $F_{3,703}$ = 0.57, P = 0.636), tail length (ANOVA, $F_{3,740}$ = 0.46, P = 0.710), or in body mass (ANOVA, $F_{3,716}$ = 0.52, P = 0.670) amongst all age classes (distribution of measurements, Figure 2). Only mean wing length was significantly shorter (ANOVA, $F_{3,741}$ = 5.82, P = 0.0006; Table 1). Results of Newman-Keulis post hoc tests showed that juveniles and adults caught in autumn had, on average, longer wings than birds measured in spring (Table 1, Figure 3).

The number of re-traps in autumn was greater than in spring. Between September and December, we re-trapped 48% of the juveniles and 55% of the adults. In contrast, in spring, only 11% and 17%, respectively, were re-trapped. In autumn, the median minimum length of stay of re-trapped Dunlin did not differ significantly between juveniles (4.9, N = 83) and adults (4.5, N = 78)(median test, Chi-square = 0.01, P = 0.92).

Average body mass increased in 51% of the juveniles and in 53% of the adults between the first and the last capture (Figure 4). There was no significant difference in the number of birds that gained or lost body mass in October and November, both in juveniles (Fisher exact test, P = 0.223) and adults (Fisher exact test, P = 0.288). The average daily body mass change ranged from –2.4 to 3.0g/day in juveniles and from –4.0 to 4.0g/day in adults. On average, between September and December, the mean daily body mass changes were 0.3 ± 0.35g/day (N = 60) and 0.4 ± 1.29g/day (N = 67) in juveniles and in adults, respectively, and did not differ between these two age classes (t-test for independent means, t = 0.59, P = 0.558). When taking into account only
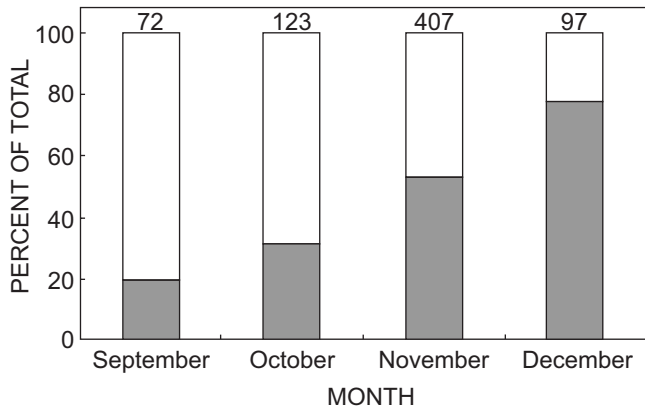

Figure 1: Changes in age structure of Dunlins (*Calidris alpina*) caught in Eilat, Israel (1999–2000), by month. The grey portion represents the relative proportion of juveniles in the population. Numbers above bars denote sample size
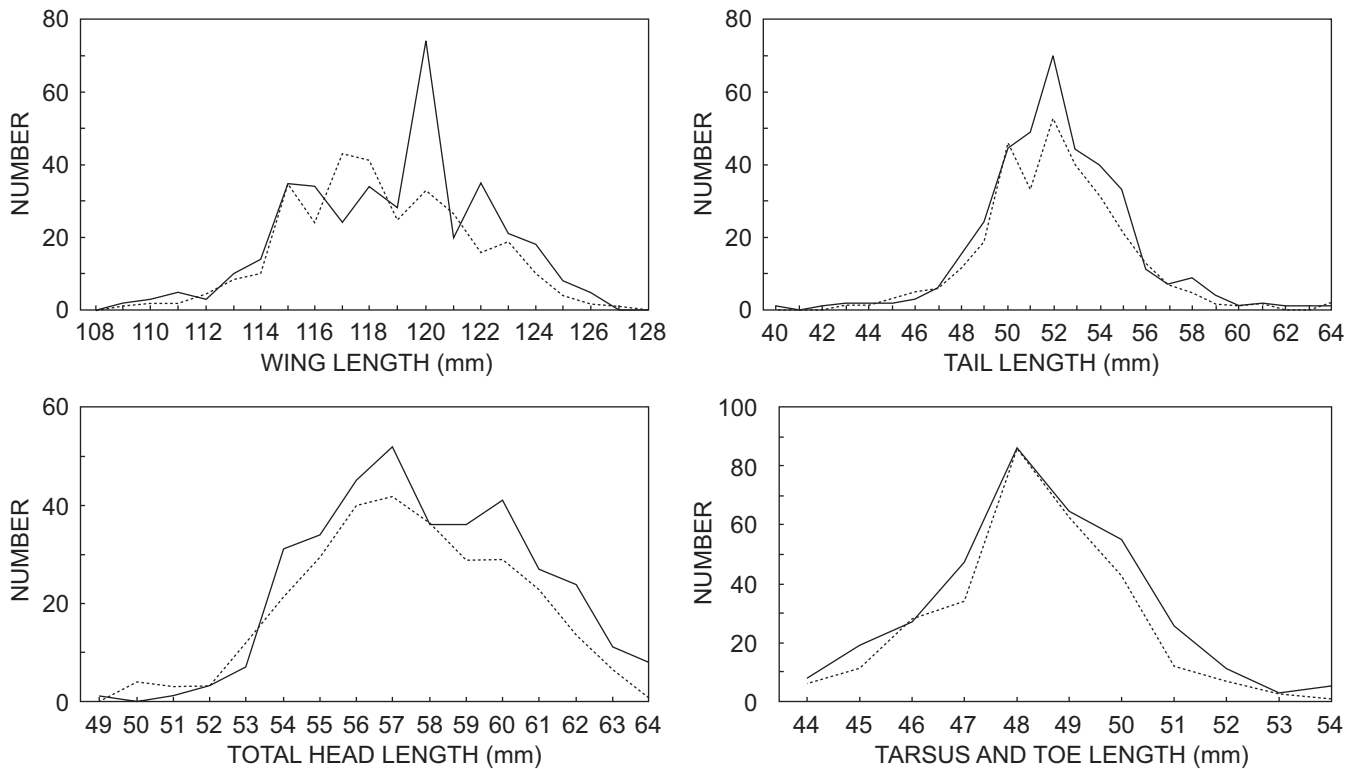

Figure 2: Distribution of measurements of adult (solid line) and juvenile (dashed line) Dunlins (*Calidris alpina*) caught between September and December in Eilat, Israel (2000–2001)

Table 1: Mean measurements of Dunlins (*Calidris alpina*) caught in Eilat, Israel, in autumn and spring 2000–2001

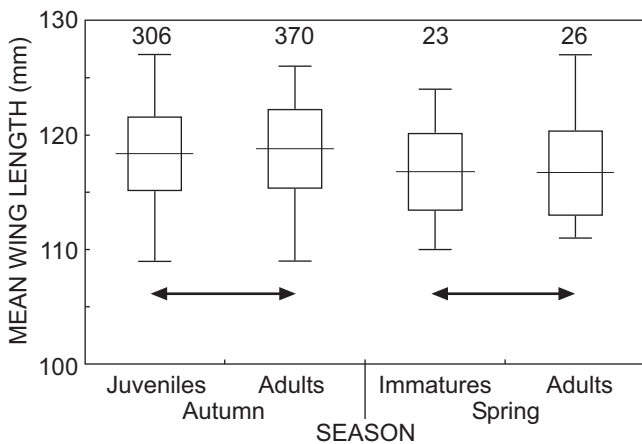|		Autumn		Spring	
		Juvenile	Adult	Immature	Adult
Wing length	Mean	118.4	118.8	117.0	116.9
	SD	3.2	3.4	3.4	3.5
	N	306	373	29	37
Total head length	Mean	57.4	57.9	57.0	57.5
	SD	2.8	2.8	3.0	3.4
	N	294	357	28	36
Tarsus plus toe length	Mean	48.3	48.4	48.7	48.3
	SD	1.7	2.0	2.3	2.1
	N	293	352	26	36
Tail length	Mean	52.0	52.2	51.6	51.7
	SD	3.1	3.1	3.2	3.6
	N	305	373	29	37
Body mass	Mean	44.7	44.7	43.2	44.1
	SD	5.8	5.8	6.8	8.1
	N	306	367	13	19

Figure 3: Comparison of the mean wing length of Dunlins (*Calidris alpina*) caught in autumn and in spring. Horizontal line = the average; rectangle = standard deviation; vertical line = range. Number above each box indicates the sample size. Arrows join groups that do not differ statistically (ANOVA and Neuman-Keulis post hoc test)

birds that gained weight between the first and last capture, the average body mass increase was 1.3g/day in adults and 1.1g/day in juveniles, but the difference remained insignificant (t-test, t = 0.74, P = 0.46).

Discussion

Dunlins were first caught in Eilat on autumn passage in late August. The proportion of trapped juveniles progressively increased towards December. This suggests that first-year Dunlins arrived at Eilat later than adults. Similar results were obtained in Bahrain, where adults were most abundant in September and the first juveniles were trapped in early October (Hirschfeld *et al.* 1992). In the western Mediterranean, Dunlins were most numerous in late July and in August and juveniles comprised over 20% of the migrants (Fuchs 1973, Pienkowski and Dick 1975). The comparatively
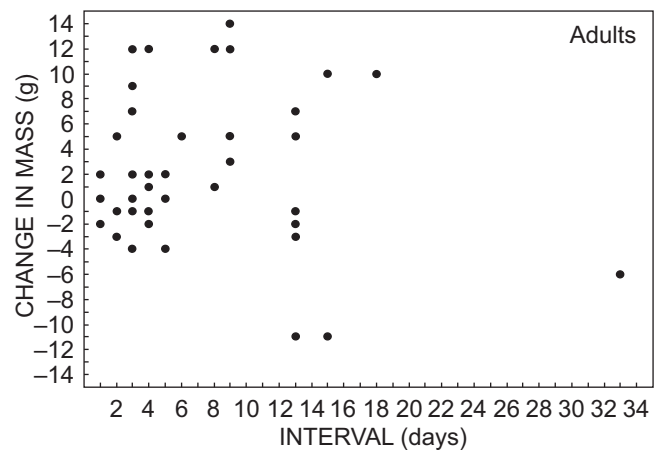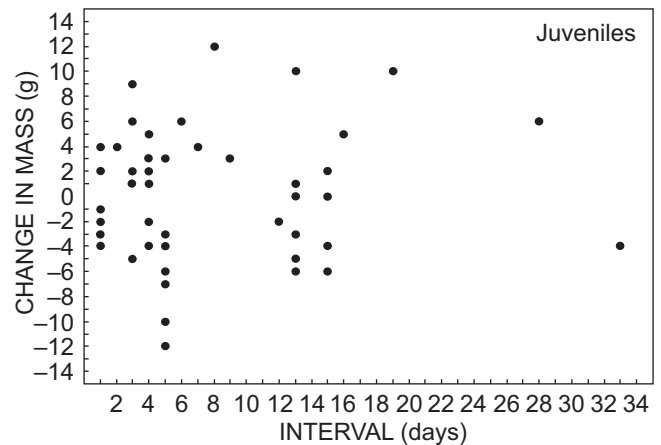

Figure 4: Body mass changes between first and last capture in juvenile and adult Dunlins (*Calidris alpina*) caught in Eilat, Israel, in autumn of 2000–2001

late arrival of Dunlin in Israel suggests a more easterly origin of these birds. Kozlova (1961) reported that juvenile *C. a. centralis* departed from the breeding grounds in early
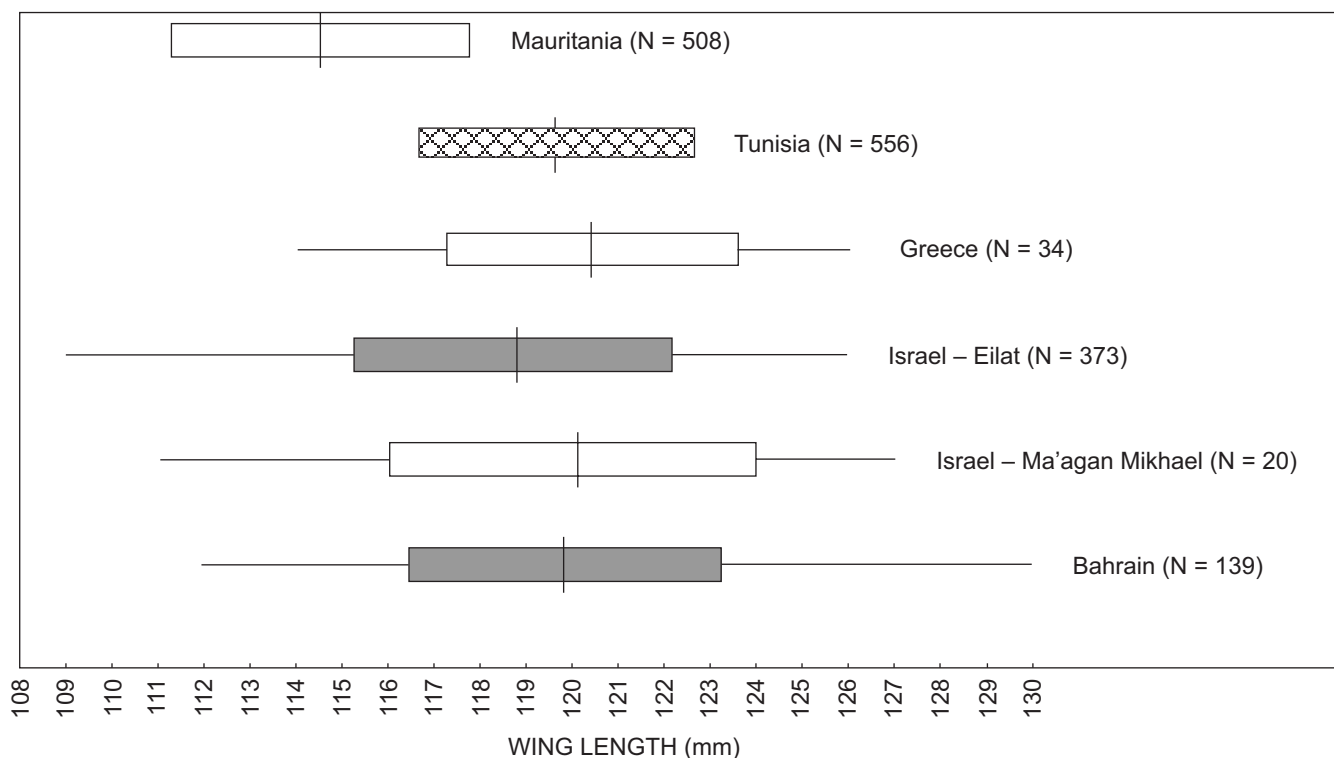
Figure 5: Comparison of wing length of adult Dunlins (*Calidris alpina*) caught at different sites. Vertical line = mean; rectangle = standard deviation; horizontal line = range. Grey rectangles = data from autumn and early winter; hatched rectangle = data from winter; white rectangles = data from spring. Data from sites other than Eilat after Meininger *et al.* (1987), Wymenga *et al.* (1990), Hirschfeld *et al.* (1992), Keijl *et al.* (1992) and van der Have *et al.* (1997)

August, whereas juvenile *C. a. alpina* departed from the west Siberian tundra approximately one month earlier. On the Baltic coast, peak abundance of adult Dunlin occurred in July or early August, and of juveniles in September (Meissner and Sikora 1995).

The mean wing length of adults caught in autumn and early winter in Eilat was longer than reported in Mauritania and closer to values from other sites located on the more easterly flyways (Figure 5). The majority of the Dunlin wintering in western Africa belong to the subspecies *C. a. shinzii*, one of the smallest of the Dunlins (Pienkowski and Dick 1975, Wymenga *et al.* 1990). Although the occurrence of *C. a. shinzii* in Israel seems unlikely (Greenwood 1984), the smallest individuals caught appear to belong to this subspecies. Gromadzka (1989) mentioned 12 direct recoveries of Dunlins banded on the Polish Baltic coast and recovered in the Black Sea region and the eastern part of Mediterranean. Among them, one certainly was a *shinzii* banded as a nestling. According to measurements of different Dunlin subspecies given by Engelmoer and Roselaar (1998), the mean wing lengths of birds from Israel, Bahrain and Greece fit those of *C. a. alpina* and *C. a. centralis*, and are marginally smaller than the average wing length of *C. a. sakhalina*. However, one must also take into account that the average wing length of adult Dunlins at Eilat may be under-estimated, due to the presence of individuals with an old or not fully grown outermost (longest) primary. Trapping in Eilat started earlier in the season than in other sites

mentioned in Figure 5, and the probability of occurrence of such birds is higher than in the other locations.

The average body mass of Dunlin in autumn in Eilat is higher than those caught during the same period in north-west Africa (Dick and Pienkowski 1978), but birds from Israel are larger than the individuals from Mauritania and Morocco (Figure 5) and this difference can be attributed to structural size, not fat reserves.

The moult score was not recorded in Eilat, but the mean wing length of adults and juveniles in autumn is almost the same, which suggests that the majority of the measured adults had new, full-grown primaries. After the breeding season, adult Dunlin have significantly shorter wings than full-grown juveniles, owing to wear of the longest primary, and this difference disappears after completion of the primary moult by the adults (Fuchs 1973, Pienkowski and Minton 1973). Dunlins breeding in central and eastern Siberia are known to moult their primaries before autumn migration and birds from more western origins start their autumn migration with old outer primaries (Gromadzka 1987, Engelmoer and Roselaar 1998). This supports the hypothesis of a more easterly origin of the Dunlins caught in Eilat, in comparison to those birds from the western Mediterranean, where the majority of the adults had finished their primary moult in November (Pienkowski and Dick 1975).

The significant difference in mean wing length between birds caught in autumn and spring may reflect the degree of

abrasion of the outer primaries during over-wintering in Africa. In Knots (*C. canutus*) and Sanderlings (*C. alba*), the average decrease in wing length ranged from 0.30mm–0.68mm per month (Pienkowski and Minton 1973). Dunlin caught in Eilat in autumn and early winter had a mean wing length which was longer by 1.4–1.9mm than that in the spring (Figure 3), which suggests a similar abrasion rate per month.

The median length of stay of Dunlin in the Baltic region was about 1.5–1.7 days in adults and about 3.0–4.2 days in juveniles (Meissner 1998). The rather long periods of stay of the Dunlin at Eilat and the lack of body mass increase after several days in some individuals suggest that some may over-winter in the Eilat region. Others probably continue their southward migration to wintering grounds located along the Red Sea coast of sub-Saharan Africa (Hayman *et al.* 1986). The rate of body mass increase calculated only for Dunlins that amassed weight was comparatively high (Goede *et al.* 1990). The mean body mass of 10% of the heaviest Dunlin at Eilat was 56.2g (SE 0.6, N = 80). When we compare this value with data on the lean mass of Dunlins from NW Africa (see Piersma and van Brederode 1990), it appears that the heaviest birds from Eilat carried, on average, about 10g of fat, with a lipid index of about 18% (fat mass as a percentage of total body mass), which is probably sufficient for further migration towards the more southerly wintering grounds in Africa.

It remains unclear whether Dunlin over fly deserts, as has been reported for passerines and raptors (e.g. Yosef and Tryjanowski 2002, Yosef *et al*. 2002). It is possible that Dunlin, and other shorebirds, follow the Gulf of Aqaba/Eilat and Red Sea coasts to the Indian Ocean, in order to reach the farthest wintering sites along the eastern coastline of Africa and to have many opportunities to feed in tidal areas en route i.e. the shorebirds could adopt an energy and time-minimising strategy (Alerstam and Lindström 1990). This will allow them to shorten the time spent at staging areas, reduce the predator risk factor (Dekker 2003) and not have to gain disadvantageous levels of body mass (e.g. Gosler *et al.* 1995), while supplementing energy shortfalls at almost any point along the route.

The possibility that shorebirds, and possibly other avian groups, depend extensively on staging habitats in the region has not previously been considered and requires further study. The low conservation priority afforded to these habitats in Middle Eastern and other countries spanning the Syrio-African Rift Valley could endanger migratory species stopping over in this region. It is important to identify, at the earliest, those areas that are important as staging or wintering areas for the Palearctic migratory avian fauna and to convince the authorities involved of the importance of the preservation of the priority habitats and areas, such that the migrations can continue through the Middle East with minimal human impact.

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