Seasonal variation in body fat and weight of migratory *Sylvia* Warblers in central Jordan

By Fares Khoury

Abstract: KHOURY, F. (2004): Seasonal variation in body fat and weight of migratory *Sylvia* Warblers in central Jordan. Vogelwarte 42: 191–202.

The physical state of *Sylvia* Warblers stopping over in a large plantation on the edge of the eastern desert of Jordan was studied during spring and autumn migration. *Sylvia* species caught in autumn had generally higher fat loads than in spring, which can be attributed to common aspects of migration habits. However, variations in strategies of different species were indicated by different distributions of fat scores and physical changes during stopping over. In spring, Blackcaps stopping over replenished their fat reserves, possibly as preparation for crossing further desert areas in the Middle East. Several Lesser Whitethroats stopped over in spring without replenishing fat reserves. Thus their choice of a suitable site with low predation risk was probably to recover water balance and/or muscle tissue after crossing the Sahara. It is moreover assumed that Lesser Whitethroats are able to gradually cross open deserts of the Middle East where they may feed en route in spring. Many Garden Warblers stopped over without replenishing fat reserves but with a significant increase in body mass, which indicated recovery of water balance and/or muscle tissue. Garden Warblers were not recorded in open desert areas, thus they are believed to avoid further deserts and migrate gradually northwards along more fertile areas of the Middle East, where they feed en route. In autumn, most birds had high fat loads, but leaner Blackcaps and Lesser Whitethroats were frequent, some of which were found to stop over and replenish fat reserves, apparently in preparation for crossing the Sahara. Variations in migration patterns among closely related long distance migrants are especially evident after crossing the Sahara in spring, and might reflect different migration strategies.

Key words: *Sylvia*, physical state, bird migration, Middle East, Jordan.

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1. Introduction

Migratory birds which travel to and from winter quarters in Africa have to cross vast areas of sea and/or deserts of the Middle East and the Sahara of North Africa. These ecological barriers require special physiological adaptations, including deposition of sufficient fat reserves (BAIRLEIN 1992, YOM-TOV & BEN-SHAHAR 1995) and mechanisms related to water balance (BIEBACH 1990, IZHAKI & MAITAV 1998, KLAASSEN et al. 1999). Migrant passerines with high fat reserves are assumed to cross the Sahara without refuelling, if they can rely on adequate tail winds (BIEBACH 1992, IZHAKI & MAITAV 1998). Most birds landing in the desert just wait for the next evening to continue their migration. However, weak/lean birds may stop over for longer periods to replenish their fat reserves if they land in or near suitable habitats, e.g. oasis (BAIRLEIN 1985, BIEBACH et al. 1986, LAVEE & SAFRIEL 1989). BIEBACH (1990) suggested four possible strategies of desert crossing, ranging from gradual, nocturnal migratory movements to non-stop flight over the entire Sahara. The different possibilities are not mutually exclusive and combinations are possible, even within one species (BIEBACH et al. 2000).

Several Eurasian populations of various migrant species cross the Middle East, including Jordan, every autumn and spring on their way to and from Africa. Yet bird migration has not been studied in detail in Jordan and most other parts of the Middle East. A large proportion of the Middle East, including Jordan, is arid desert with few areas containing habitats with lush vegetation and abundant water and food resources all year round. Around 85% of Jordan's area receives annually an average rainfall of less than 200 mm (Meteorological Department, Marka-Amman). In autumn, food resources become scarce after the long summer characterised by drought and high temperatures. From the perspective of an autumn migrant, the greater part of the Middle East is thus considered as a further ecological barrier, where feeding is nearly impossible. In spring, conditions are usually more suitable after the winter rains. Many spring migrants may thus benefit from stopping over at suitable sites in the Middle East, including Jordan after crossing the Sahara (ALERSTAM 1997).

This paper presents the first results of passerine migration research in Jordan. The site where birds were trapped is a large farm situated on the edge of the desert with olive and fruit trees. It is considered as one of the last suitable sites to make final preparations before heading into the Sahara in autumn. It lies on the western edge of the vast Syrian-Jordanian Desert, which extends from central Jordan and Syria to Iraq and northern Saudi Arabia. In spring, exhausted birds are expected to stop over at the farm to recover physically after crossing the Sahara, and replenish their fat reserves. Such fuel reserves would be necessary particularly for birds that are to cross the next ecological barrier in the north-east. It is therefore predicted that birds landing in Jordan in spring will have low fat reserves, while in autumn migrants are expected to be physically prepared by deposition of fat reserves sufficient to cover the long flight distance over parts of the Middle East and the Sahara (YOM-TOV & BEN-SHAHAR 1995). The ultimate aim of this study is to gain further knowledge about the possible strategies of the most common migrant *Sylvia* species, which cross Jordan and the Middle East, by analysing the physical states of birds stopping over in both seasons. This study also aimed at shedding light on the importance of plantations and other man-made habitats in arid and semi-arid areas as stopover sites for migrants, in view of the degradation and loss of natural habitats by overgrazing, depletion of water resources and urban and industrial developments.

2. Methods

2.1. Site location and description

Passerine migrants were captured in a farm in central north-west Jordan at Dhleil (32°04' N 36° 15' E), c. 45 km east of Amman. The farm, which covers 150 ha, contains mainly olive trees which are being irrigated due to insufficient precipitation in this area (yearly mean c. 90–120 mm; Hashemite University meteorological station). Up to 10 ha are planted with various fruit trees, mainly cherry, apple, pear, peach, pomegranate and a few fig trees. The borders of the plantation are covered with natural scrub vegetation and *Tamarix*, as well as lines of pines, cypress, introduced acacia, eucalyptus and casuarina trees. The plantation, which has been established 30 years prior to the study, is surrounded by rocky limestone hills, with scanty low scrub vegetation (for further description: s. KHOURY 2003). It is located on the western edge of the eastern desert of Jordan. The eastern desert plateau itself offers a very limited number of sites with suitable habitat for migrants. Such sites, mainly along wadis, are usually rather small with limited resources for birds and in most cases probably unsuitable as stopover habitats for many Palearctic migrants.

2.2. Trapping and measuring of the birds

Mist netting commenced on 28th February 2002 and continued daily until the 24th May and from 25th August daily until 10th November 2002. 44, four-shelved nets, ranging in length from 7 to 14 m were set up in the different habitat types identified within the farm. The habitat types included olive trees, orchards and the borders of the plantation. The nets were usually opened 24 hours a day, and were closed for a few hours around noon when the daily maximum temperatures were above 30°C. The first round was always carried out during the first hour after dawn and the last round after sunset. During the day, the nets were controlled at least once every hour. Birds were ringed with numbered aluminum rings of the Jordanian ringing scheme, which is run jointly by the Royal Society for the Conservation of Nature and the Hashemite University. Age and sex were determined where possible and a set of measurements including wing and tail length, fat and muscle scores and body mass, were taken. Body mass was recorded to the nearest 0.1 g using a digital balance. The fat scores, or size of visible, subcutaneous fat depots were determined and classified according to the 9-grade score (0–8) (Bairlein 1995).

The stopover period of birds at the site was monitored by recaptures. The minimum stopover period of the nocturnal migrants was calculated in days by subtracting the date of the first trapping from the date of the last trapping plus one:$\Delta D + 1$ (BIEBACH et al. 1986). A bird recaptured one day after being caught for the first time accordingly had a minimum stopover period of two days. This would mean that this bird spent at least part of the first day, the following evening and the next day at the site. Real stopover periods along the migration routes are probably longer than the ones calculated in the way described above, as the birds may have arrived earlier than the day of first capture (e.g. BIEBACH et al. 1986, JENNI-EIERMANN & JENNI 1999). More realistic stopover durations can be estimated using advanced capture-recapture statistics (SCHAUB et al. 2001). However, minimum stopover periods are helpful when a parameter (e.g. body mass change) of individual birds is related to the time they stayed at the stopover place (SCHAUB and JENNI 2000).

The changes in body mass and fat scores were analysed only in birds with a minimum stopover period of more than two days. This was to exclude the factors related to physiological and food-access limitations, which usually lead to an initial decrease of body mass and refuelling rate at stopover sites (LINDSTRÖM 1995, SCHWILCH & JENNI 2001, GANNES 2002). The rate of body mass increase per day was calculated in all individuals by dividing the difference in body mass of first and last traps by the difference in respective dates. The result was divided by the initial body mass and multiplied by 100 to obtain the percentage of body mass increase for every bird, which had a minimum stopover period ($\Delta D + 1$) of more than two days. Means and standard deviations of the rate of increase were calculated for every period in every species and season if sample size was large enough. The daily pattern of trapping was similar throughout the two seasons, and the majority of birds, including retraps, was usually caught in the first 2–3 morning hours. Possible mass changes occurring during the day were thus not corrected for. An intraspecific comparison of rate of increase was carried out only with Blackcaps, as aging and sexing was in most cases possible and sample size large enough. Differences in body mass at first and last trap were tested for significance with the paired two-tailed t-test. Medians of fat scores and stopover periods and intraspecific differences in rates of mass increase were tested for significance with the Mann-Whitney-U-test.

3. Results

Nine species of *Sylvia* were captured during one or both migration seasons in 2002, two of which, the Ménétries (*Sylvia mystacea*) and Rüppel's Warblers (*S. ruepelli*), were rare and a third, the Sardinain Warbler (*S. melanocephala*), rather scarce and caught only in spring. These three species

Table 1: Number of birds belonging to the genus *Sylvia* captured in spring and autumn 2002 in at Dhleil, Jordan. The species are arranged according to the total number of birds in both seasons. Totals are the sum of birds caught, including recaptures. Recaptures are the sum of recapturing events.

Tab. 1: Anzahl der im Frühjahr und Herbst 2002 gefangenen Vögel der Gattung *Sylvia* bei Dhleil, Jordanien. Die Summen (totals) geben die Anzahl aller Fänge, inklusive Wiederfängen an.

Species	Spring		Autumn	
	total	recaptures	total	recaptures
Blackcap *Sylvia atricapilla*	1900	282	1248	70
Lesser Whitethroat *Sylvia curruca*	313	18	144	13
Garden Warbler *Sylvia borin*	336	42	102	3
Barred Warbler *Sylvia nisoria*	106	1	7	1
Orphean Warbler *Sylvia hortensis*	45	1	18	0
Whitethroat *Sylvia communis*	32	3	13	0
Sardinian Warbler *Sylvia melanocephala*	7	2	0	0
Rüppell's Warbler *Sylvia rueppelli*	3	0	0	0
Ménétrie's Warbler *Sylvia mystacea*	1	0	0	0

were thus excluded from further analysis. The other six species (Table 1) were caught in sufficient numbers to allow analysis of fat scores in the two seasons. Only three of these, the Blackcap (*S. atricapilla*), Garden Warbler (*S. borin*) and Lesser Whitethroat (*S. curruca*), were retrapped in numbers sufficient to analyse changes in physical state during stopping over in one or both seasons. The number of individuals belonging to the different *Sylvia* species at the site was more numerous in spring than autumn (Table 1). The Blackcap was in general the most common *Sylvia* (and passerine) species, followed by Lesser Whitethroat and Garden Warbler (Khoury 2003).

3.1. Seasonal variation in fat scores

The median fat score of Blackcaps in spring was significantly lower than in autumn (Median in spring = 2, and in autumn = 4; Fig. 1, statistics in legend). During autumn migration 40 % of the

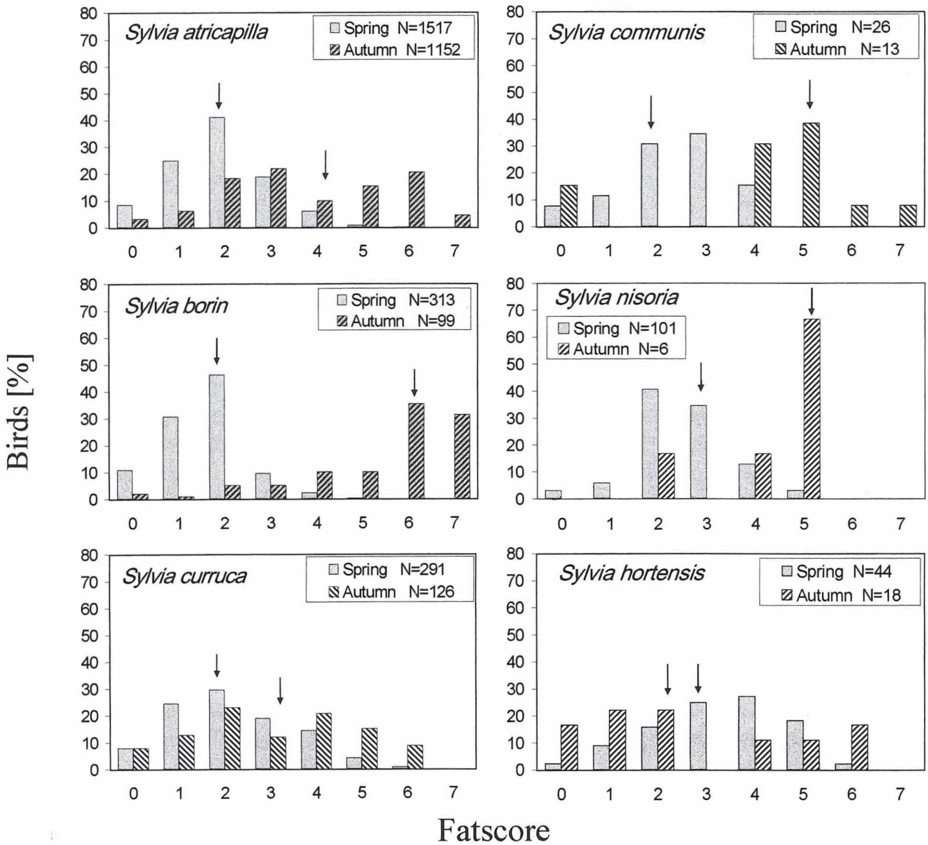

Fig. 1: Frequency distribution of fat scores in all captured birds (single traps and first retraps) of six *Sylvia* species in both seasons expressed as percentage of all birds (sexes and ages pooled). The median fat scores of autumn migrants, indicated in the figures as arrows above the respective column, are significantly higher than those of spring migrants ($p<0.001$, U-Test) in all species, except for the Orphean Warbler ($p>0.05$).

Abb. 1: Verteilung der Fettklassen bei sechs *Sylvia* – Arten. Alle Erst- und Einzelfänge wurden berücksichtigt. Die Mediane sind durch Pfeile angedeutet. Die sichtbaren Fettdepots sind bei allen untersuchten Arten, außer bei Orpheusgrasmücke, im Herbst signifikant höher als im Frühjahr.

Blackcaps had fat scores of 4 and more, while in spring, 75% of birds had fat scores of 2 and less. The distribution of fat scores in Blackcaps varied considerably in both seasons (Fig. 1). Intraspecific comparisons in Blackcaps did not reveal any differences between sexes and ages within a season, and the same result was obtained as for the pooled data when comparing the seasonal variation of the same age and sex groups.

In the Garden Warbler, the median fat score differed seasonally by 4 classes ($p < 0.001$; Fig. 1). The distribution of fat scores of Garden Warblers captured within a season was narrower than in Blackcaps, indicating a high degree of homogeneity. Most autumn migrants arrived with high fat loads: nearly 80 % of birds caught had fat scores of 5–7, while in spring, a high proportion of Garden Warblers had depleted fat reserves: 90 % of the birds caught had fat scores of 2 and less (Fig. 1). Similar results were obtained for Barred Warbler (*S. nisoria*), Whitethroat (*S. communis*) and Lesser Whitethroat, with significantly higher fat score medians in autumn than in spring (Fig. 1; statistics in legend), although fat scores of Barred Warblers in spring were relatively high. In the Orphean Warbler (*S. hortensis*), there was no significant seasonal difference in fat load (Fig. 1).

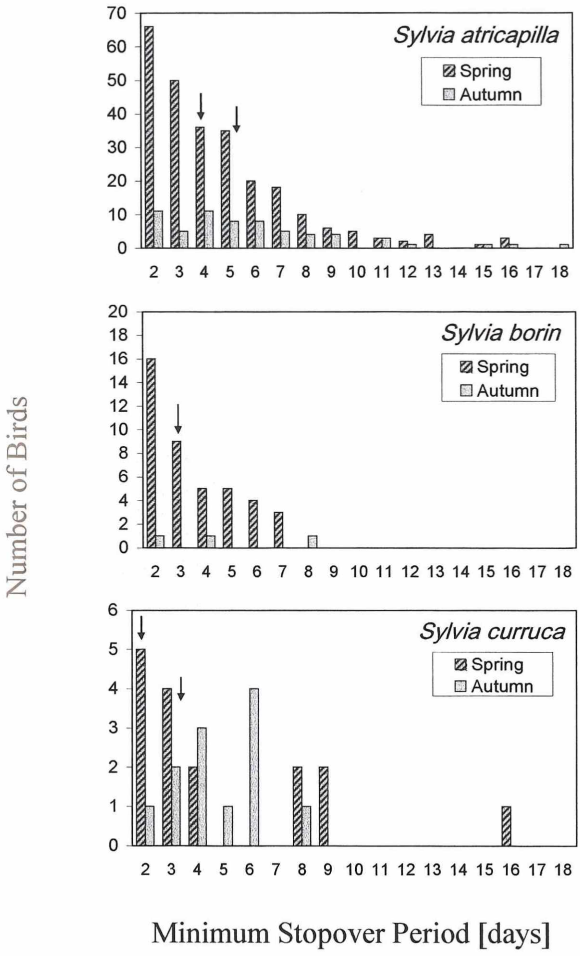

Fig. 2: Frequency distribution of the minimum stopover period ($\Delta D + 1$) of recaptured Blackcaps, Garden Warblers and Whitethroats (sexes and ages pooled) in spring and autumn. Medians are given as arrows above the respective column. The median stopover duration for Garden Warblers in autumn is not illustrated, due to small sample size ($n = 3$).

Abb. 2: Verteilung der minimalen Verweildauer der wiedergefangenen Mönchsgrasmücken, Gartengrasmücken und Klappergrasmücken im Frühjahr und Herbst. Mediane sind durch Pfeile angedeutet, außer bei Gartengrasmücke im Herbst (nur 3 Vögel wurden wiedergefangen).

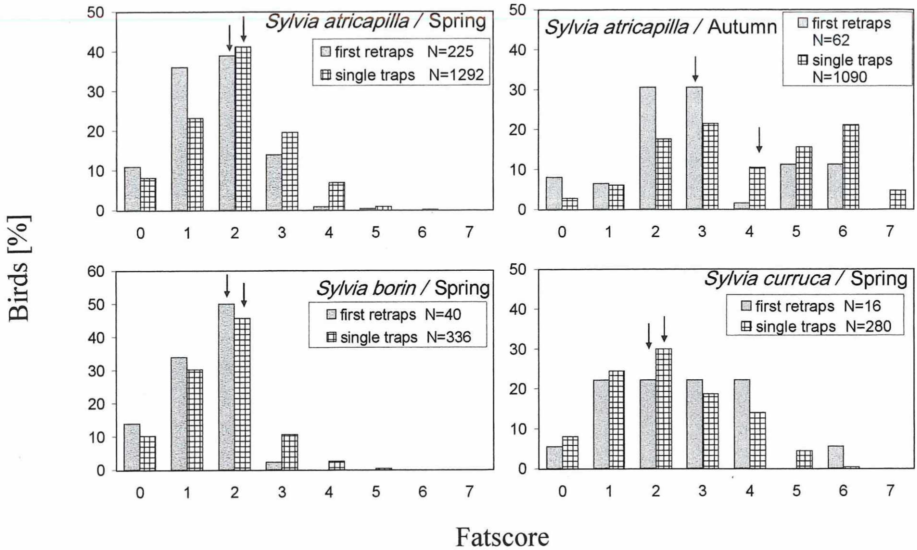

Fig. 3: Frequency distribution of fat scores of first captured retraps and single traps (sexes and ages pooled). The arrows above the respective columns indicate medians. In the Blackcap, the initial fat scores of retraps were significantly lower than those of single traps ($p < 0.01$ and $p < 0.001$ in spring and autumn respectively, U-Test). As for the Lesser Whitethroat and Garden Warbler, there were no significant differences between the initial fat scores of retraps and single traps ($p > 0.05$). Autumn data for Lesser Whitethroat not illustrated.

Abb. 3: Fettklassenverteilung von erstgefangenen Wiederfängen und Einzelfängen. Die sichtbaren Fettdepots waren nur bei erstgefangenen Mönchsgrasmücken in beiden Saisons signifikant niedriger als bei Einzelfängen. Bei Klapper- und Gartengrasmücken gab es jedoch keine signifikanten Unterschiede.

3.2. Changes in fat and body mass during stopping over

The proportion of retraps to first traps and single traps ranged in the three most common *Sylvia* species between 6 and 15% in spring and between 2 and 9% in autumn (Table 1). These numbers do not necessarily reflect the true percentage of birds with a stopover period of more than one day, due to low probability of recapturing (Biebach et al. 1986, Jenni-Eiermann & Jenni 1999). Several Blackcaps, Garden Warblers and Lesser Whitethroats remained longer than one day at the site in spring (Fig. 2). In autumn, a number of Blackcaps and Lesser Whitethroats remained longer than one day, but Garden Warblers were rarely recaptured in this season.

A comparison of fat scores of birds trapped only once with those of birds recaptured later (first retraps) was undertaken to relate the relative amounts of fat reserves with stopover behaviour. This analysis revealed a slight, but significant difference in the Blackcap during spring (medians in both cases = 2, but $p < 0.01$, U-Test) and a more pronounced difference in autumn (Fig. 3; $p < 0.001$). Lesser Whitethroats (autumn and spring) and Garden Warblers (spring), which stopped over several days did not have significantly different fat levels than birds assumed to be stopping over for only one day. The changes in fat scores and body mass of recaptured birds were analysed only in birds with minimum stopover periods of more than two days to exclude the factors related to physiological and food access limitations (Lindström 1995, Gannes 2002) causing an initial decrease in body mass (Fig. 5).

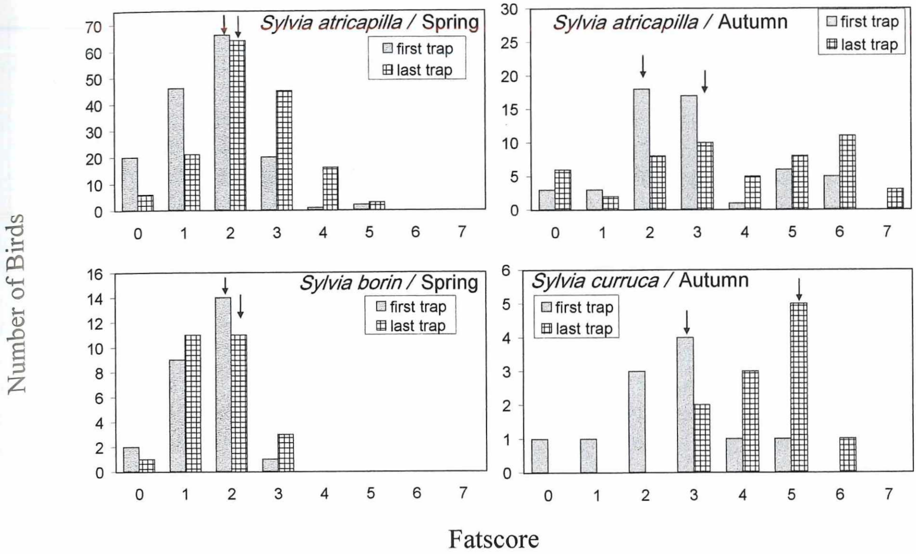

Fig. 4: Comparison of the frequency distribution of the fat scores at the first and last trapping of recaptured birds (sexes and ages pooled). Arrows above the respective columns indicate medians. In birds with a minimum stopover period of more than two days, the increase in fat scores was significant only in blackcap ($p<0.05$ and $p<0.001$ in spring and autumn respectively, U-Test) and Lesser Whitethroat (only autumn, $p<0.001$; spring data for Lesser Whitethroat not illustrated).

Abb. 4: Vergleich der Fettklassenverteilung bei den ersten und letzten Fängen. Mediane sind durch Pfeile angedeutet. Vögel mit einer Mindestverweildauer von mehr als zwei Tagen wurden analysiert. Die Zunahme der sichtbaren Fettdepots war bei Mönchsgrasmücken im Frühjahr und Herbst, bei Klappergrasmücken nur im Herbst signifikant.

Table 2: Mean change of body mass in recaptured birds in spring and autumn.

Tab. 2: Mittlere Körpermassenentwicklung bei wiedergefangenen Vögeln im Frühjahr und Herbst.

Species	Blackcap		Garden Warbler		Lesser Whitethroat	
season	spring	autumn	spring	autumn	spring	autumn
Median of minimum stopover period [d]	4	5	3		2	3
Mean change in body mass/day (%)[1]	2.28*	2.25*	2.42*		1.24	4.45**
Birds with mass increase (%)[2]	84	69	72		58	90
Birds with mass decrease (%)[2]	13	23	12		25	10
Birds without mass change (%)[2]	3	8	16		17	0

[1] = In % of body mass of the first trap; only birds with a minimum stopover period of more than 2 days were considered. Differences between body mass at last and first capture of birds with a minimum stopover duration of more than 2 days are significant, * $p < 0.01$, ** $p < 0.001$, values without asterisks not significant (paired two-tailed t-tests).

[2] = In % of the total number of re-traps with a minimum stopover period of more than 2 days.

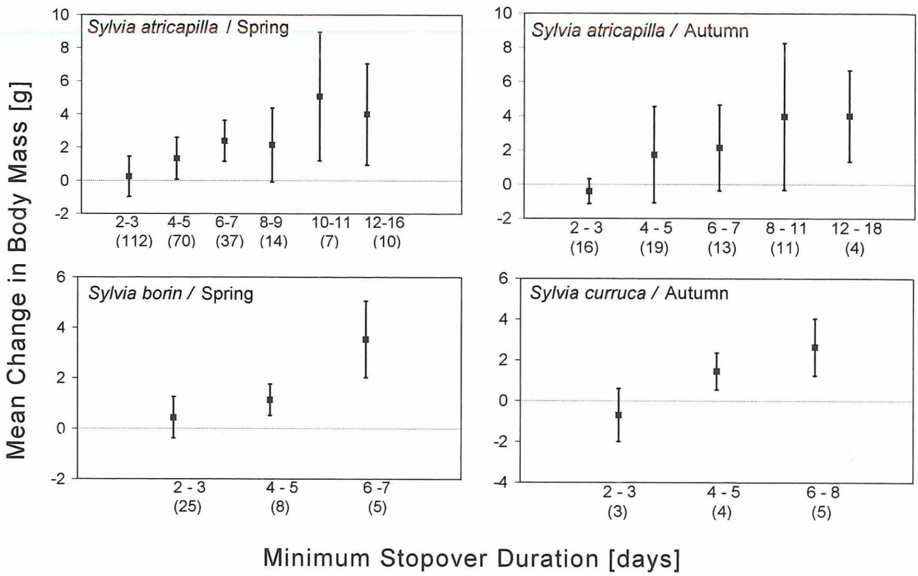

Fig. 5: Relationship between mean change in body mass (+ standard deviation) and minimum stopover duration ($\Delta D + 1$) in Blackcap (spring and autumn), Garden Warbler (spring) and Lesser Whitethroat (autumn, spring data not illustrated). Sample sizes for every period (pooled minimum stopover duration) in brackets. See Table 2 for rate of body mass increase.

Abb. 5: Zusammenhang zwischen mittlerer Körpermassenentwicklung und Mindestverweildauer bei Mönchsgrasmücken (Frühjahr und Herbst), Gartengrasmücken (Frühjahr) und Klappergrasmücken (Herbst, Frühjahrsdaten nicht dargestellt). Stichprobenumfänge in Klammern.

The increase in fat score and body mass was significant in Blackcaps stopping over during spring and autumn, and in the Lesser Whitethroat only in autumn (Fig. 4 and Table 2, statistics in the legends). In the Garden Warbler there was no increase in fat score in most of the individuals remaining at the site for more than two days during spring (Fig. 4). The same birds, however, showed a gradual increase in body mass and a significant difference between body mass at first and last traps (Fig. 5, Table 2). In Garden Warblers stopping over for several days, body mass increase did not correlate with an increase of visible fat deposits ($r = 0.24$, $p > 0.05$), while in Blackcaps and Lesser Whitethroats a significant correlation was found between the two parameters (Table 2, Fig. 4, correlation in both species, in both seasons: $r > 0.7$, $p < 0.01$).

Intraspecific comparisons within a season, carried out only with Blackcaps, did not reveal any significant differences in mean rates of body mass increase and minimum stopover duration between ages and sexes ($p > 0.05$), in both seasons.

4. Discussion

The significant seasonal differences in fat scores among migrant *Sylvia* Warblers are attributed to their migration habits. Similar results have been reported for various passerine migrants stopping over in Israel and Sinai (Lavee & Safriel 1989, Yom-Tov & Ben-Shahar 1995, Izhaki & Maitav 1998).

4.1. Spring migration

Following the crossing of the Sahara in spring, many migrant warblers captured at the site were fat-depleted (most birds had fat scores of 2 and less). The Barred and Orphean Warblers, unlike other *Sylvia* Warblers, had generally intermediate fat scores, in addition to low recapture rates. It is unlikely that birds will have relatively high (intermediate) fat scores following the crossing of an ecological barrier of nearly 2000 km (assuming a route across the Sahara, Sinai and the southern parts of Jordan) without refuelling somewhere on the way. Thus, one or several prolonged stopovers may be assumed before reaching this part of the Middle East, perhaps along the Nile Valley. Birds with intermediate fat scores are probably able to continue migration for several days without refuelling and are even able to cross small ecological barriers (DIERSCHKE & BINDRICH 2001). Barred Warblers may feed en route once they cross the Middle East and if fat reserves become depleted further north. Orphean Warblers landing at the site were approaching the end of their migratory journey (CRAMP 1992), the nearest breeding grounds are known to be c. 60 km away from the site, in western Jordan (ANDREWS 1995). Thus, prolonged stopovers in the Middle East are energetically unnecessary and would only postpone their arrival at breeding grounds (LAVEE & SAFRIEL 1989, ALERSTAM & LINDSTRÖM 1990).

After the rainy season, spring in the Middle East is characterised by an abundance of food resources, which is required by exhausted migrants following the long journey across the Sahara. Except for the Barred and Orphean Warblers, all other *Sylvia* Warblers analysed were making use of the abundant resources available at the site. There are no detailed observations about the ability of different species to utilise food resources at the research site, but it is assumed that resources were so abundant and diverse, that all analysed *Sylvia* species may have benefited. Annual ruderal vegetation *(Sysimbrium, Cardaria, Malva)* covered the ground beneath and between the trees. Insects of different sizes appeared to be abundant everywhere. Fruit and eucalyptus trees were in full blossom. Cherries were ripening already by late April. A few overripe olives from the previous season were still hanging on the trees. Many Blackcaps had traces of eucalyptus pollen on their foreheads and chins, strong evidence that they were feeding on nectar (c.f. SCHWILCH et al 2001), while in late April and May, Garden Warblers and Blackcaps were frequently observed feeding on cherries. It can be concluded from the results that Blackcaps recover physically and deposit fat as soon as they reach a suitable site in the Middle East in spring (GANNES 2002), so as to continue their journey north without further prolonged stopover periods. Blackcaps of eastern populations (east Causasus, N-Iran, and possibly W-Siberia; CRAMP 1992), that probably head in a north-easterly direction in spring would have to cross another 450 km of desert until they reach fertile areas along the Euphrates Valley. The crossing of such barriers may be difficult for lean and exhausted birds, which have just finished the crossing of the Sahara, hence they need to stopover for recovery and eventual fat deposition. It is assumed that Blackcaps generally do not depend on patches of suitable habitat in deserts for feeding/refuelling, as they tend to replenish fat reserces at or before reaching the desert edge (BIEBACH et al. 1986, LAVEE & SAFRIEL 1989, IZHAKI & MAITAV 1998). Lesser Whitethroats stopping over in spring apparently rested and possibly recovered physically (e.g. water balance, muscle tissues) without replenishing fat reserves. Lesser Whitethroats are common in the deserts of Jordan and other parts of the Middle East in spring (ANDREWS 1995, SHIRIHAI 1996), where they can be observed in bushes and dwarf shrubs. According to these observations, Lesser Whitethroats may be able to feed en route, even while crossing the deserts of the Middle East, when conditions are more suitable in spring. They may, however, prefer stopping over a few days in well-vegetated areas, which offer more protection from predators, to rest and physically recover.

The increase in body mass without visible fat deposition in Garden Warblers stopping over was likely to be the result of physical recovery upon reaching the first suitable site following the crossing of the Sahara. Body mass increase was observed in birds with a minimum stopover period of more than two days, i.e. after any possible initial decrease in body mass due to physiological and food access limitations. Rhythmic body mass changes of two weeks were observed in Garden Warblers kept under standard conditions (Bairlein 1986). The results obtained in this study suggest however, that the increase in body mass is related to recovery of water balance and the rebuilding of muscle tissue needed for improved flight performance. In fact, most Garden Warblers captured at the site in spring had highly reduced muscle tissue due to catabolism of muscle protein (Bauchinger & Biebach 2001). Kasarow and Pinchow (1998) showed in Blackcaps stopping over in Israel, that fat varies in concert with nonfat body components, including muscle protein and internal organs. More research is however needed to assess the importance of stopping over for raising flight performance (by regenerating flight muscle) and maintaining water balance, rather than fat deposition at stopover sites in the Middle East, i.e. after crossing the major ecological barrier. Provided Garden Warblers avoid the eastern deserts, safety fat reserves would not be necessary, as they can rely on resourses and suitable habitats along the fertile areas which stretch continuously in a S-N axis. In fact, there are no records of Garden Warblers in open desert areas in eastern and central Jordan (Khoury 2003). Garden Warblers thus minimise the time spent in spring migration after recovery by a gradual northward migration, i.e. flying at night (and possibly at day) and feeding en route during the day without the need for further prolonged stopovers (Alerstam & Lindström 1990; Biebach 1990).

4.2. Autumn migration

In autumn, fat birds were predominantly found. It is clear from the analysis of certain *Sylvia* species, e.g. Garden and Barred Warblers and Whitethroat, that the majority of the birds had crossed fertile areas further north and had built up fuel stores before reaching this part of the Middle East (Yom-Tov & Ben Shahar 1995, Izhaki & Maitav 1998). Although no flight range estimates were done, it can be assumed that birds with fat scores of 5 and more are able to cross the Sahara without the need to refuel along the route, especially if they profit from prevailing tail winds (Biebach 1992, Izhaki & Maitav 1998).

Fat scores varied considerably in both the Blackcap and Lesser Whitethroat captured in autumn. Birds with relatively low fat scores were probably more dependent on various sites in the Middle East (Lavee & Safriel 1989, this study) and North Africa (Bairlein 1985, Biebach 1986). Prolonged stopovers at such sites are of great importance for refuelling before heading into the Sahara. Birds with intermediate fat stores, although unable to cross the Sahara without refuelling, were assumed to be well prepared to confront the dry conditions in the Middle East during the autumn season. Their small „safety fat reserves“ probably enabled them to search for suitable sites to stopover or reach such sites further south. Such individuals may be rather flexible and decide *en route*, whether to continue the journey or stop over for some time. Spotted Flycatchers (*Muscicapa striata*) were recorded feeding en route in the Algerian Sahara (Bairlein 1992) and may therefore not need to fatten very much prior to migration (Alerstam & Lindström 1990). Blackcaps and Lesser Whitethroats stopping over for several days showed a marked increase in fat score and body mass. In contrast to the surroundings, which were poor in resources after the long and dry summer season, the site where birds were being captured contained many insects and ripe fruits (Figs, apples and pomegranates), as well as water sources (irrigation). Blackcaps and Lesser Whitethroats were observed feeding on fruits and were mainly caught in orchards. Nevertheless, at least one third of the Blackcaps and Lesser Whitethroats captured had high fat scores. Such birds had probably a similar strategy like Whitethroats, Garden and Barred Warblers, which are assumed to cross the Middle East and the Sahara in autumn without the need for prolonged stopovers to refuel. Some of the Blackcaps with low fat probably over winter in the Middle East, and may have been close to their winter quarters. The Blackcap is a scarce winter visitor in parts of Jordan (pers. obs.) and Israel (Shirihai 1996).

Newly established farms and sewage works in arid and semi-arid areas in Jordan are attracting large numbers of migrants (KHOURY 2003). As concluded from the present study, large farms with irrigation systems and diversity in crops, including olive, fruit and fig trees offer suitable habitats with an abundance of resources for long-distance migratory Sylvia warblers. The importance of such sites to migrant bird species is probably increasing, especially as suitable natural habitats are vanishing in Jordan (KHOURY 1996). Moreover, migrants depending on agricultural habitats as stopovers may be more affected, either directly or indirectly, by pesticide use (TANABE et al. 1998, BERTHOLD 2000). Thus, pesticide use may have an increasing impact on Eurasian populations of passerine migrants along their migration routes.

5. Zusammenfassung

Die Körperkondition rastender Grasmücken der Gattung *Sylvia* wurde in einer Plantage an der Wüstengrenze in Jordanien im Frühjahr und im Herbst untersucht. Dabei erreichten bei allen untersuchten Arten die Fettdepots im Herbst signifikant höhere Werte als im Frühjahr. Dies spricht für eine grundsätzliche Übereinstimmung der Zugstrategien der *Sylvia*-Grasmücken, die die Sahara überqueren. Artliche Unterschiede in den Strategien zeigten sich jedoch in Unterschieden in der Fettklassen-Verteilung und in der Entwicklung der Körperkondition rastender Vögel der verschiedenen Arten. Im Frühjahr wurden bei rastenden Mönchsgrasmücken die sichtbaren Fettdepots, möglicherweise als Vorbereitung für die Überquerung von Wüstengebieten nordöstlich des Gebietes, vergrößert. Rastende Klappergrasmücken füllten ihre Fettdepots nicht auf, was darauf hindeutet, dass Klappergrasmücken geeignete Habitate mit Schutzmöglichkeiten vor Feinden aufsuchten, um zu ruhen und gegebenfalls Nahrung aufzunehmen. Klappergrasmücken haben wahrscheinlich die Fähigkeit, die begrenzten Wüstengebiete des Nahen Ostens im Frühjahr ohne Fettdepots zu überqueren, da sie vermutlich in der Lage sind, auch dort Nahrung aufzunehmen. Bei Gartengrasmücken, die im Frühjahr mehrmals gefangen wurden, stiegen ebenfalls die Fettdepots nicht an, obwohl es zu einer deutlichen Zunahme der Körpermasse kam. Diese Zunahme hing möglicherweise mit einer Regeneration des Wasserhaushaltes und/oder des Muskelgewebes zusammen. Da Gartengrasmücken nicht in offenen Wüstengebieten nachgewiesen wurden, deuten die Ergebnisse darauf hin, dass die Vögel, nach einer Erholungsphase in Etappen durch die fruchtbaren Gebiete des Nahen Ostens weiterziehen. Im Herbst wiesen die meisten Vögel hohe Fettdepots auf, doch wurden auch viele Mönchsgrasmücken und Klappergrasmücken mit niedrigen Fettdepots gefangen. Die meisten wiedergefangenen Vögel dieser Arten wiesen eine Fett- und Massenzunahme auf, was darauf hindeutet, dass sich die Vögel für die Überquerung der Sahara vorbereitet hatten. Variationen in den Zugstrategien werden vor allem beim Heimzug nach der Überquerung der Sahara deutlich. Solche Unterschiede hängen zusammen mit dem weiteren Zugweg und den Fähigkeiten der verschiedenen Arten, u.a. in Wüsten des Nahen Ostens zu rasten und eventuell auch Nahrung zu finden.

6. References

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