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Laying dates, clutch size and breeding success in the Pallid Swift *Apus pallidus* in Sofia, Bulgaria

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Abstract - Breeding biology of Pallid Swift *Apus pallidus* was studied between 1997 and 2000 in Sofia city, a place lying at the northern boundary of the species' range on the Balkan Peninsula. It was found that first clutches were laid mainly during the second half of May and second clutches - the end of July and the first half of August. Breeding period in Sofia tended to be more compressed and synchronized compared to that in Piedmont (NW Italy). The proportion of pairs laying second clutches was 55 %, 90 % and 66 % in 1998, 1999 and 2000 respectively. Pallid Swifts laid on average 2.93 ± 0.54 eggs (2 - 4) in the first clutches and 2.12 ± 0.48 eggs (1 - 3) in the second clutches. Comparisons with other colonies of this species in Piedmont (Italy), Gibraltar, Tunisia and Corse showed that clutch size of both first and second clutches was highest in Sofia. First breeding had an average overall success of 2.6 fledged young/pair and second breeding - 1.4 fledged young/pair. Values of the fledging rate proved greatest in Sofia though significantly different only in relation to Gibraltar.

Introduction

Pallid Swift *Apus pallidus* is at present a well-studied species concerning its breeding biology, ecology and behaviour (Bretagnolle *et al.* 1994). The most comprehensive long-term studies covering various aspects of its life history have been carried out in Piedmont, North-Western Italy (Boano and Cucco 1989; Malacarne and Cucco 1991; Cucco *et al.* 1992; Boano *et al.* 1993; Cucco and Malacarne 1996) but studies on the breeding biology are also available from some other parts of Pallid Swift's range (Finlayson 1979 in Cramp 1985; Rodrigues de Los Santos and Rubio Garcia 1986; Thibault *et al.* 1987). However, researches other than distribution ones are not known for the Balkan Peninsula.

According to some authors this Mediterranean species is spreading northwards but the difficulties in identification may have concealed the real trend, delaying the discovery of long-established nesting colonies (Boano & Cucco 1989). This doubt holds for Bulgaria too, where the species was first detected in 1986 in the southernmost part of the country with subsequent discoveries of more northerly situated colonies (Furman 1987; Little *et al.* 1988; Iankov 1990; Iankov 1991).

Sofia may be regarded as lying at the northern boundary of the range of Pallid Swift in Bulgaria. Information on its breeding biology could give some indication of the possibility this Mediterranean species spreading further north across the Balkan Peninsula. In this study we report data on the breeding performance of Pallid Swift in Sofia, and compares it with other localities of its range in Western Palearctic with particular attention to Piedmont as another northern inland locality.

Methods

The study was carried out between 1997 and 2000 in the city of Sofia (Western Bulgaria). The city is situated at 550 m a.s.l. under the conditions of continental climate. The mean annual temperature is 10 0C. The minimum mean monthly temperature (January) is -1,5 0C. The maximum mean monthly temperature is 21 0C being similar for July and August. Mean October temperature is 11.5 0C. Rainfall reaches a maximum in June. The mean rainfall for August and September is similar, averaging 47.6 mm. October mean rainfall is 54.9 mm (report from the National Institute of Meteorology and Hydrology, Sofia).

Three colonies consisting of 5, 3 and 7 pairs respectively were investigated. One of the colonies was lost due to restoration of the building and the data for it refers only to 1997. There was not any change in the numbers of breeding pairs for the period of study. All the nests were placed inside the eaves of 4-storey

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buildings and easily reached from the garrets. Colonies were visited daily or every other day.
We regarded as second clutches those laid in the same nests where the young of the first broods had successfully fledged. For 2 pairs the existence of genuine second clutches was proved by ringing of the parents.Broods of at least one 40 day-old young were considered as successful.

Results

Laying dates

The laying season in Sofia extends from mid-May to the end of August (Fig 1). Laying of second clutches occurred at most nests. The percentage of pairs that laid second clutches in the studied colonies was 55%, 90% and 66% in 1998, 1999 and 2000 respectively.
The bulk of the eggs of first clutches was laid during the third week of May, although some were laid late in June. The mean laying date was 27 May ± 12.1 days (14 May - 22 June, n = 25). The sample is too small to allow comparisons between the three years, but at least between 1999 (n = 8) and 2000 (n = 9) there was no significant difference (Mann-Whitney test, U = 39, P = 0.81).
The mean time elapsed from fledging of the last young from first broods to laying the first egg of second clutches was 8.8 ± 3.2 days (range 3 - 14, the mode was 7 days, n = 14 exactly known instances).
The mean laying date of the second clutches was 6 August ± 9.31 days (26 July - 29 August, n = 18). More than half of them were laid within the first 2 weeks of August (55.5%), but several were laid in the last week of July (33.3%), and only 2 clutches (11.1%) were laid during the last week of August.

Clutch size

In Sofia Pallid Swifts laid 2 - 4 eggs in their first clutches. The mean clutch size was 2.93 ± 0.54 eggs, (n = 29). Three-egg clutches were most common (n = 21, 72.4%), and clutches of 2 (n = 5, 17.2%) or 4 eggs (n = 3, 10.3%) were rare. All the 4-egg clutches were recorded in 2000. There was not statistically significant difference in the average clutch size between 1999 and 2000 seasons (Mann-Whitney test, U = 53, P = 0.55).
Second clutches consisted of 1 - 3 eggs. The mean clutch size was 2.12 ± 0.48 eggs (n = 17). Most frequent were clutches of 2 (n = 13, 76.5%) while those of 3 were rare (n = 3, 17.6%) and there was only one 1-egg clutch.

Breeding success

Parameters of the breeding success are shown in Table 1. All the data refer to original (not replacement) clutches. Pairs were treated as successful when produced at least 1 successfully fledged young. No unsuccessful pairs were recorded except 3 which lost their nests due to restoration of the building. The latter were excluded from the results.
The data indicate slightly higher hatching rate and survival of young in the first broods in comparison to

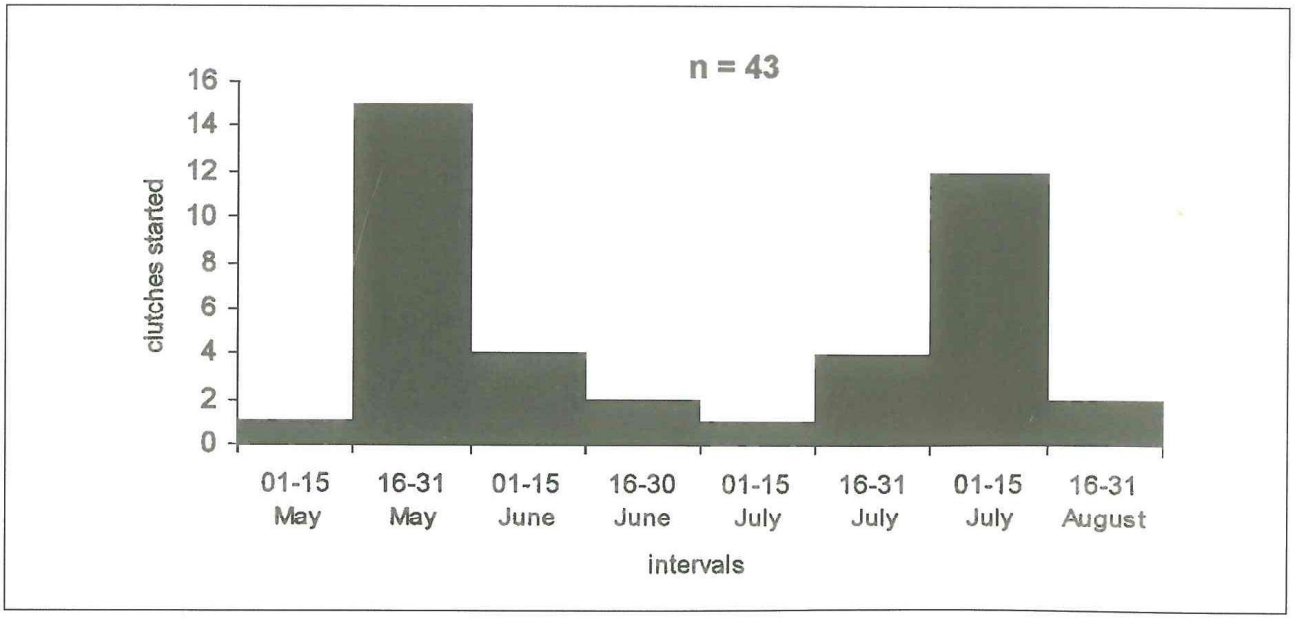

Figure 1. Laying season of Pallid Swift in Sofia. The figure shows number of clutches started during 15 day intervals.

Table 1. Breeding success of Pallid Swift in Sofia.

	p	e	h	f	h/e %	f/h %	f/e %	f/p
I broods	25	80	79	65	98.7	82.3	81.2	2.6
II broods	17	33	30	24	91.0	80.0	72.7	1.4
Total	42	113	109	89	96.5	81.6	78.8	2.1

Notes: p-nesting pairs; e-eggs laid; h-hatched eggs; f-young fledged; h/e-hatching rate; f/h-survival of young in nests; f/e-fledging rate; f/p-fledged young per pair (all pairs were successful).

second ones, though results were not significant (χ^2 = 0.19, df = 1, P = n.s. for hatching rate and χ^2 = 0.04, df = 1, P = n.s. for fledging rate). Thus, although second clutches were less productive (due to the reduced clutch size) they did not differ from first ones as for hatching and fledging rate.

Discussion

Our results are compared with the main studies on the breeding biology of Pallid Swift carried out in other parts of its range (Castan 1955 in Cramp 1985 for Tunisia; Finlayson 1979 in Cramp 1985 for Gibraltar; Thibault *et al.* 1987 for Corsican Islets; Boano & Cucco 1989; Cucco *et al.* 1992 for Piedmont, North-Western Italy).

The proportion of pairs rearing second broods in Sofia appears to be higher than in Piedmont where on average 27% (0 - 77%) of females laid second clutches. The reasons for this are not clear. It is surprising how large the proportion of second breeders could be at such a northern locality as Sofia.

Laying dates are thought to be dependent on the latitude, that in turn determines the onset of spring (Boano & Cucco 1989). Indeed laying dates of Pallid Swifts are earliest in North Africa (Tunisia) with first eggs laid at the end of March and main laying season April-May. Those of Gibraltar are earlier than both Sofia and Piedmont, with first eggs appearing in the second half of April. The peak laying of first clutches in Gibraltar, however, is similar to that in Sofia (third week of May).

Breeding season of Pallid Swift in Sofia (considering the extreme laying dates) starts at about the same time as in Piedmont, but is about 2 months shorter. This shortening is achieved by a greater synchrony in the laying dates and by reducing the gap between the two broods.

Laying dates of first clutches (defined for the purpose of this paper between 1 May and 30 June) in Carmagnola, Piedmont are similar to those of Sofia. However, the distribution of laying dates at the two cities is significantly different (χ^2 = 21.25, df = 3, P <0.001). In Sofia 68.2% of the first clutches started 16-31 May whilst in Piedmont laying dates were more dispersed and the peak is shared between 16-31 May and 1-15 June (Cucco *et al.* 1992).

It appears that laying period of second clutches in Piedmont is more protracted and the eggs are laid on average later. September laying in Sofia is not recorded at all, while it is common in Piedmont where eggs are laid even in the first half of October (Cucco *et al.* 1992). Probably the weather in late autumn is milder in Piedmont which allow a longer stay of second breeders.

Comparing Tunisia, Gibraltar, Piedmont and Sofia,the average first clutch size is lowest in Tunisia and highest in Sofia (Table 2). Differences in clutch size are accounted for by different proportions of the four clutch classes at each place. Clutches of 2 and 3 are almost equally frequent in Tunisia, while in Sofia and Piedmont a clutch size of 3 is commoner. Comparisons of Piedmont and Sofia data show a slightly higher proportion of 3-egg clutches in Sofia than in Piedmont, but difference is not statistically significant (χ^2 = 1.25, df = 2, P = 0.53). Clutches of 4 were detected in Sofia and Piedmont, but they are very rare in both places.

Second clutches in Piedmont averaged 1.92 ± 0.57 eggs in 1977-1986 (Boano and Cucco 1989) and 2.03 ± 0.53 eggs in 1987-1990 (Malacarne and Cucco 1991). These figures were slightly lower than values we reported for Sofia. The same was true for Gibraltar where average second clutch size was 1.95. These small differences are linked with slightly different proportions of clutch classes. The proportion of 1-egg clutches in Piedmont (20%) was higher than the same in Sofia (5.9%) and 3-egg second clutches are a bit more frequent in Sofia (17.6%) than in Piedmont (12.0%).

A comparison of breeding success in Sofia to that reported in Gibraltar, Corsican Islets and Piedmont is shown in Table 3. The fledging rate of first broods is highest in Sofia. However, the difference is significant only in relation to Gibraltar where the breeding

Table 2. Average clutch size of Pallid Swift in the first clutches at four places of its range.

	source	mean	s	n	z - test	P
Gibraltar	Finlayson (1979)	2.89	0.46	19	0.27	n.s.
Piedmont (Italy)	Boano & Cucco (1989)	2.67	0.50	70	2.23	< 0.05
Tunisia	Castan (1955)	2.56	0.50	32	2.77	< 0.01
Sofia	current paper	2.93	0.54	25	–	–

Values of z - test are computed for the first three places against Sofia data

Table 3. Comparisons of fledging rate in the Pallid Swift of three European places with Sofia data.

	eggs laid	eggs hatched	young fledged	χ^2	P
Gibraltar (Finlayson 1979 in Cramp 1985)					
I brood	55	48	28	4.45	< 0.05
II brood	43	28	13	6.84	< 0.001
Corse (Thibault *et al.* 1987)					
I brood	99	92	83	0.05	n.s.
II brood	-	-	-	-	-
Piedmont (Italy) 1975-1986 (Boano & Cucco 1989)					
I brood	189	137	115	3.38	n.s.
II brood	46	20	19	3.41	n.s.
Piedmont (Italy) 1987-1990 (Malacarne & Cucco 1991)					
II brood	163	114	82	2.29	n.s.

success is lowest. The same trend holds for second broods.

Hatching rate in the first broods is highest in Sofia and lowest in Piedmont but differences are not significant ($\chi^2 = 3.7$, df = 2, P = 0.20). Hatching rate of second broods again is highest in Sofia but results are significant only in relation to the data in Boano & Cucco (1989) ($\chi^2 = 6.7$, df = 1, P < 0.001). Comparisons of hatching rate between first and second clutches for each place show no significant differences in all studies. The only exception is Piedmont where in 1975-1986 second clutches had significantly lower hatching rate ($\chi^2 = 4.9$, df = 1, P < 0.05). However, in 1987-1990 there was not significant difference between first and second clutches.

Survival of young in the first broods is lowest in Gibraltar and greatest in Corsican Islets, the differences being significant only between these two places ($\chi^2 = 4.2$, df = 1, P < 0.05). Survival of young in the second broods is lowest in Gibraltar (46.4%) and highest in Sofia (80%) but the difference is not significant ($\chi^2 = 4.8$, df = 2, P = 0.09). Survival of young in the first broods does not differ significantly from that in second in all studies in review.

In conclusion, breeding of Pallid Swift in Sofia, a point at the northern boundary of its range far inland, has retained the main life-history trait of 'southern' origin, namely double-broodedness for the majority of pairs. Breeding can be characterized by a shorter and more synchronized laying season than in Piedmont, larger clutch-size together with a high reproductive success of both spring and autumnal broods. This could be the result of the local climatic conditions which influence seasonal phenology and abundance of aerial insects (Lack 1954).

Pallid Swift is obviously well adapted to colder climates since it is known as breeding at elevations exceeding 2000 m a.s.l. (Iankov 1991) in Bulgaria. Moreover, most pairs breeding at about 1000 m a.s.l. at Rila Monastery reared second clutches in late October in 1998 and survived after a snowfall (own unpubl. data). So we could expect this species to spread further north in the Balkan Peninsula with retaining its double-broodedness.

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