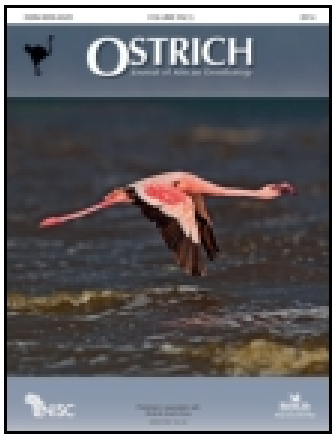

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Aspects of the breeding ecology of the Purple Swamphen *Porphyrio porphyrio* in the wetland complex of Guerbes-Sanhadja, north-east Algeria

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The Purple Swamphen *Porphyrio porphyrio* is a common rail that previously was little investigated in North Africa. From 2011 to 2013, its breeding ecology was studied at two natural wetlands in north-east Algeria, namely Garaet Hadj Tahar and Garaet Messaoussa. Numbers of Purple Swamphens at both localities peaked in late April and early May. Egg-laying started in early March, whereas hatching started in late March. Peak egg-laying took place in late March and early April, and peak hatching from mid-April to early May. There were significant differences in the size and weight of eggs between years and localities. The mean clutch size was 2.75 ± 0.70 eggs and it was not significantly different between localities and years. Mean hatching success was 51% and it was positively correlated to nest depth only at Garaet Hadj Tahar. Most nests were built in dense tufts of *Typha angustifolia* and *Phragmites australis.* The main nesting materials were *Phragmites australis* and *Scirpus maritimus*.

Keywords: Algeria, breeding ecology, breeding phenology, breeding success, nest characteristics, Purple Swamphen

Introduction

The family Rallidae, examples of which include Eurasian Coot (*Fulica atra*) and the Common Moorhen (*Gallinula chloropus*), is one of the dominant avian groups in freshwater ecosystems. One of the family, the Purple Swamphen (*Porphyrio porphyrio*) has a widespread distribution in Africa, south-west Europe, south and south-west Asia, Australia, New Zealand and some islands in the Pacific Ocean (del Hoyo et al. 1996). Marked morphological and ecological variations have been noted between geographically isolated populations of the species, leading to assumption of genetic variations between populations (Sangster et al. 1998). However, splitting of the species into different subspecies has not been followed by BirdLife International (2012), because a detailed analysis of character differences is required to determine levels of distinctiveness and variation. The Western Mediterranean populations are usually considered to form the nominal subspecies *P. porphyrio porphyrio* (Cramp and Simmons 1980; Glutz von Blotzheim et al. 1973; Grussu 1999; Sánchez-Lafuente et al. 1992).

The Purple Swamphen is currently listed as Least Concern in the IUCN Red List (BirdLife International 2012) but it has experienced a substantial loss of habitat in parts of its range due to anthropogenic pressure (Sánchez-Lafuente et al. 1992; del Hoyo et al. 1996; Taylor and van Perlo 1998). For example, the European population that is restricted to the Mediterranean and Atlantic basins (Cramp and Simmons 1980) suffered from severe habitat degradation between the end of the nineteenth and the mid-twentieth century, which led to it being regarded as Endangered on the continent (Cramp and Simmons 1980; Sánchez-Lafuente et al. 1992; del Hoyo et al. 1996).

Knowledge of the breeding ecology of a species is helpful in understanding ecological parameters that influence breeding success (Traylor et al. 2004). These parameters are usually related to nest site selection and they encompass territory suitability (Cody 1985; Good 2002), resource accessibility (Sánchez-Lafuente et al. 1992) and predation avoidance (Craig 1980). Although the Purple Swamphen has been well studied in Australia (Norman and Mumford 1985), New Zealand (Craig 1980; Paramanantha Swami et al. 2009; Hegg et al. 2011) and south-west Europe (Sánchez-Lafuente et al. 1992, 1998; Grussu 1999; Sanchez-Lafuente et al. 2001; Pacheco and McGregor 2004; Sánchez-Lafuente 2004), and the biology and ecology of some rails have been investigated in north-west Africa, little information on the breeding ecology of the Purple Swamphen is available for this region (Heim de Balsac and Mayaud 1962; Ledant et al. 1981; Isenmann and Moali 2000). The aim of the current study was to research aspects of the breeding biology and ecology of the Purple Swamphen in two natural wetlands located in Guerbes-Sanhadja (a Ramsar site) in north-east Algeria.

Materials and methods

Study site

The study was conducted at two natural wetlands that are situated 30 km east of the town of Skikd, north-east Algeria (Figure 1) in the subhumid region of Guerbes-Sanhadja: Garaet Hadj Tahar (36°51′ N, 7°15′ E) and Garaet Messaoussa (36°56′ N, 7°14′ E), which have areas of 100 ha and 280 ha, respectively. The mean water depth

of Garaet Hadj Tahar is 2 m and that of Garaet Messaoussa is 0.5 m. Vegetation cover at both localities is dominated by the common reed (*Phragmites australis*), the lesser bulrush (*Typha angustifolia*) and the seaside bulrush (*Sciprus maritimus*). However, *Rumex conglomeratus*, *Alisma plantago-aquatica*, *Callitriche stagnalis* and *Lemna gibba* were found at Garaet Hadj Tahar, whereas *Callitriche stagnalis, Lemna minor, Potamogeton trichoïdes* occurred at Garaet Messaoussa (Samraoui and De Belair 1997).

Data collection

Counts of individual Purple Swamphens at both localities were carried out at weekly intervals during two consecutive split years (2011/12 and 2012/13) from August to July using a 60 × 40 *Konus* telescope. During the breeding season (between March and May), active nests were surveyed biweekly until hatching within an area of 2 ha at each locality.

Four nest parameters, namely internal and external diameters, nest depth and height of nest above the water surface, were measured with a decameter to the nearest centimetre. A fifth parameter, the depth of water under each nest, was measured to the nearest centimetre with a graduated stick. Plants used to build nests were identified, as was vegetation where nests were placed.

Eggs were marked with permanent markers so that each could be recognised and its outcome established.

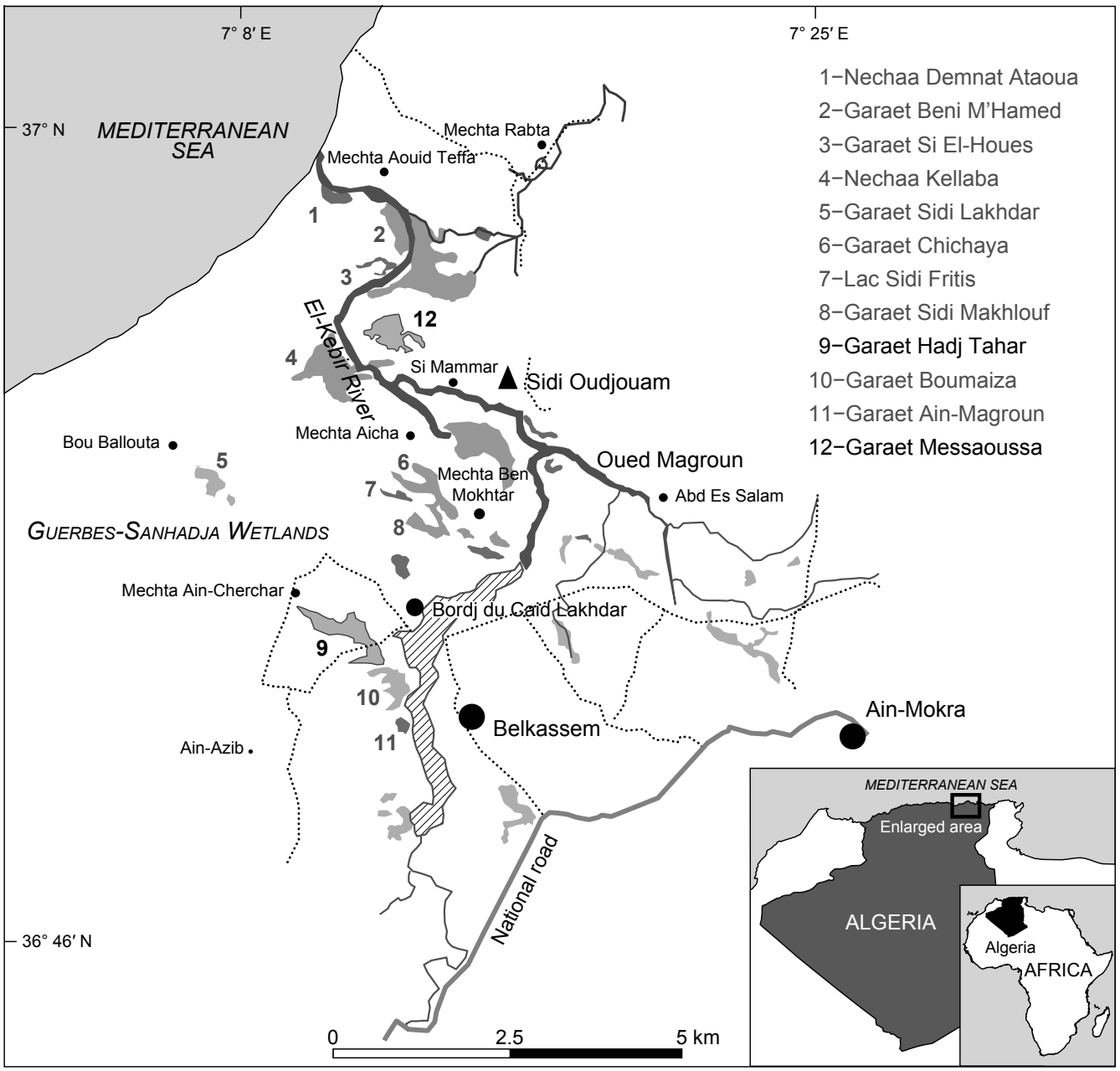

Figure 1: Map showing the locations of the wetland complex of Guerbes-Sanhadja and the two study wetlands, Garaet Hadj Tahar and Garaet Messaoussa

The length and breadth of eggs were measured with a digital caliper to the nearest 0.01 mm and their weight was measured with a pesola balance to the nearest 0.1 g. Egg volume was estimated using Hoyt's (1979) formula:

$$V\ (\text{cm}^3) = 0.509 \times L \times B^2/1\,000,$$

where L = egg length (mm) and B = egg breadth (mm).

Clutch size was taken to be the number of eggs at the nest, when this did not increase between two subsequent visits. Hatching success (%) was calculated as:

$$\text{Hatching success} = 100 \times n/N,$$

where n = number of eggs hatched and N = total number of eggs laid.

Fledging success was not estimated because chicks left their nests soon after hatching.

Statistical analyses

Statistical analyses were undertaken using SPSS 17.0 (SPSS, Inc., Chicago, USA). Data are presented as the mean ± SD and were first tested for normality. Non-parametric tests were used when data were not normally distributed. Mann–Withney *U* tests were used to establish the significance of differences in egg volume, egg weight and clutch size between the two split years and between the two study sites. Chi-square tests were used to examine whether nests were randomly distributed within different types of vegetation and to test for significant differences in the five nest parameter between years and sites. Spearman correlations were performed between clutch size, hatching success and the five nest parameters.

Results

Counts of individuals

Trends in numbers of individuals recorded between August and July were similar between study sites and split years. Peaks in numbers of individuals were recorded in late April and early May; minima were noted in late June and early July. Throughout the two years of observation Purple Swamphens were more abundant at Garaet Messaoussa than at Gareat Hadj Tahar, showing peaks of 54 and 37 at the former site and 28 and 23 at the latter site in 2011/12 and 2012/13, respectively (Figure 2).

Breeding phenology

In 2011/12, the first eggs were recorded on 11 and 6 March at Garaet Hadj Tahar and Garaet Messaoussa, respectively. The peak of egg laying was noted on 27 March and 8 April at Garaet Hadj Tahar and Garaet Messaoussa, respectively. First hatching was observed

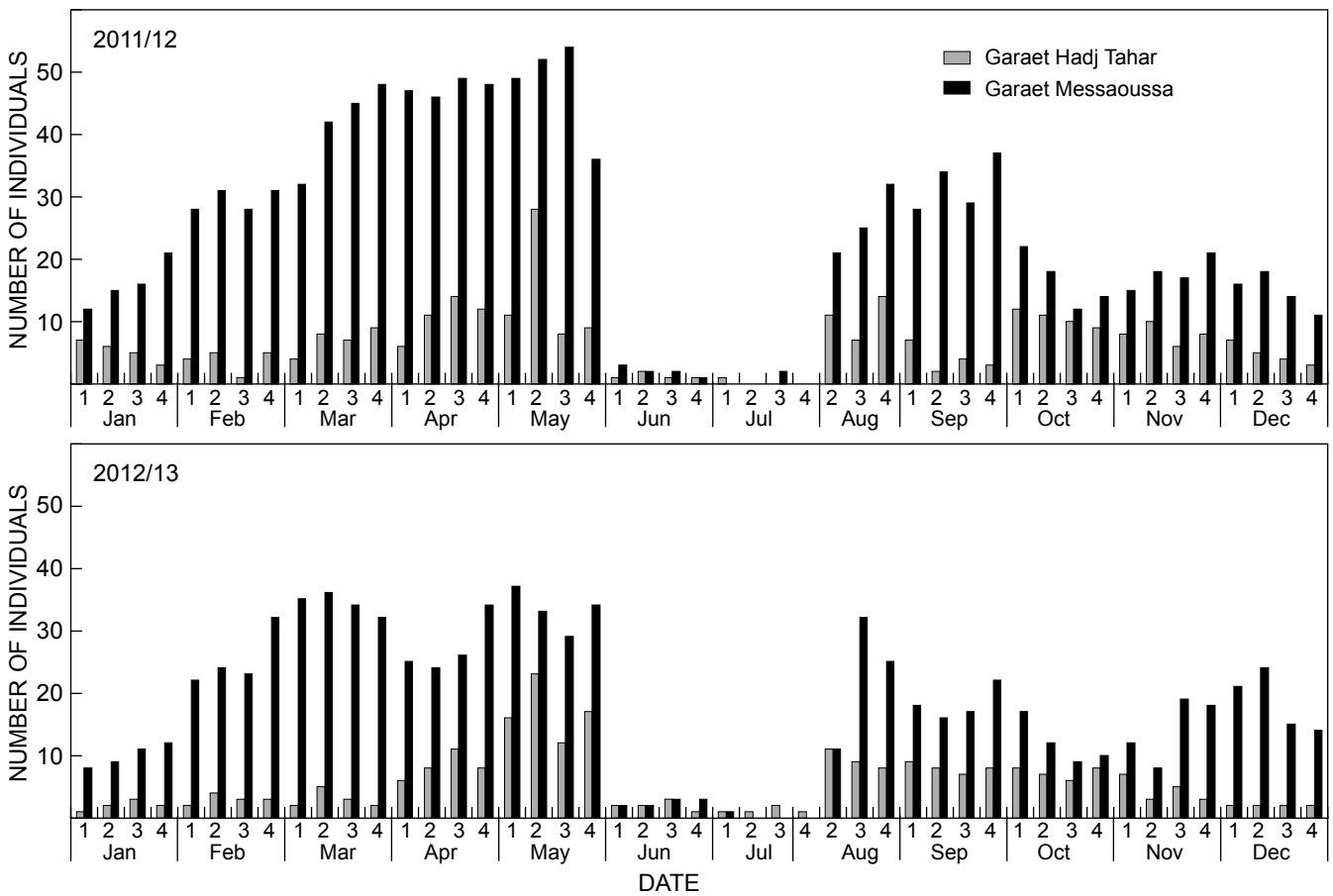

Figure 2: Weekly counts of number of Purple Swamphens during the split years 2011/12 and 2012/13 at Garaet Hadj Tahar and Garaet Messaoussa

on 30 March at both sites and peaked in late April and early May at Garaet Hadj Tahar and Garaet Messaoussa, respectively. In 2012, first eggs were noted on 6 and 7 March, whereas the peak of egg laying was recorded on 8 and 11 April at Garaet Hadj Tahar and Garaet Messaoussa, respectively. The first eggs hatched on 27 and 21 March, whereas peak hatching was observed on 17 April and late April–early May at Garaet Hadj Tahar and Garaet Messaoussa, respectively.

Egg size

A total of 165 Purple Swamphen eggs was measured during the two breeding season at the two wetlands. Mean egg length was 50.86 ± 3.60 mm, mean egg breadth was 35.12 ± 0.92 mm, mean egg volume was 31.96 ± 2.86 cm^3 and mean egg weight was 41.47 ± 4.37 g (Table 1).

Significant differences in egg volume and egg weight were recorded between sites and breeding seasons. Egg volume and egg weight were significantly higher at Garaet Messaoussa than at Garaet Hadj Tahar in 2011/12 (U = 331.5, P = 0.001; U = 443.5, P = 0.03, respectively) and 2012/13 (U = 539.5, P = 0.001; U = 420, P = 0.0001, respectively). At Garaet Messaoussa, egg volume and egg weight were significantly different between breeding seasons (U = 861.5, P = 0.001; U = 1009.5, P = 0.01, respectively). At Garaet Hadj Tahar, egg volume was significantly different between 2011/12 and 2012/13 (U = 188, P = 0.0001) but egg weight was not (U = 351.5, P = 0.21).

Nest building and site selection

During both study seasons, at both localities material used by the Purple Swamphen to build nests was dominated by *P. australis* and *S. maritimus;* these plants contributed at least about 89% of nest material. In 2011/12 and 2012/2013, *T. angustifolia* accounted for 5.59% vs 9.1% and 9.09% vs 11.11% of material in nests at Garaet Messaoussa and Garaet Hadj Tahar, respectively (Table 2).

There was random distribution of nests within different strata of vegetation at both sites in both split years (chi-square test: $P > 0.05$). Nest site selection was not significantly different from one site to another and between years (chi-square test: $P > 0.05$). Nests were mainly installed in *T. angustifolia* and *P. australis* strata (72–82%) with a small proportion of nests being noted in *S. maritimus* (18–28%) (Table 2).

Breeding success and ecology

Clutch size varied from 2 to 4 eggs per nest (Figure 3). The overall mean clutch size was 2.75 ± 0.70 eggs. Mean clutch size was 3.00 ± 0.71 eggs in 2011/12 and 2.91 ± 0.83 eggs

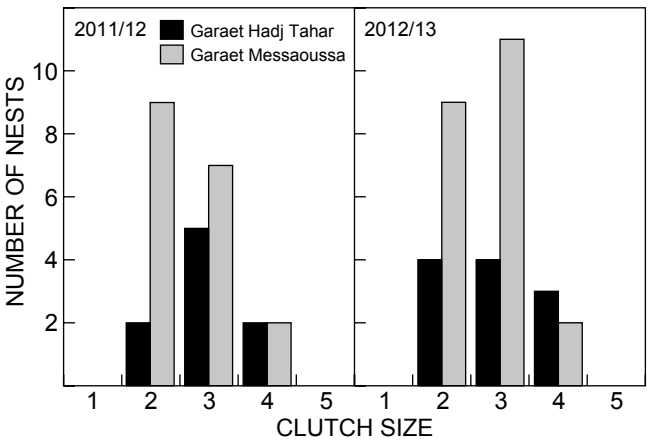

Figure 3: Frequency distribution of clutch sizes of Purple Swamphens during the 2011/12 and 2012/13 breeding seasons at the two study localities

Table 1: Mean egg measurements for the Purple Swamphen in the 2011/12 and 2012/13 breeding seasons at two wetlands of the Guerbes-Sanhadja complex, Algeria. At Garaet Hadj Tahar n = 9 in 2011/12 and 11 in 2012/13; at Garaet Messaoussa n = 18 in 2011/12 and 22 in 2012/13

Site	Year	Egg length (mm)	Egg breadth (mm)	Egg volume (cm^3)	Egg weight (g)
Garaet Hadj Tahar	2011/12	53.14 ± 4.56	35.07 ± 0.83	33.24 ± 2.83	40.03 ± 3.00
	2012/13	50.14 ± 2.24	34.34 ± 0.84	30.14 ± 2.33	40.31 ± 4.23
Garaet Messaoussa	2011/12	49.25 ± 3.19	35.36 ± 0.89	31.38 ± 2.79	41.70 ± 2.21
	2012/13	51.50 ± 3.38	35.38 ± 0.77	32.83 ± 2.60	43.80 ± 4.26
Mean		50.86 ± 3.60	35.12 ± 0.92	31.96 ± 2.86	41.47 ± 4.37

Table 2: Percentage composition of plants used to build and support nests of the Purple Swamphen during the breeding seasons of 2011/12 and 2012/13 in two wetlands of the Guerbes-Sanhadja complex. Numbers in parentheses indicate numbers of nests built in different plants. The sum of nests in each column provides the sample size

	Species	Garaet Hadj Tahar		Garaet Messaoussa	
		2011/12	2012/13	2011/12	2012/13
Building materials	*Typha angustifolia*	11.11	9.09	5.59	9.10
	Phragmites australis	44.44	36.30	50.00	54.54
	Scirpus maritimus	44.44	54.50	44.41	36.36
Nest support	*Typha angustifolia*	44.40 (4)	45.50 (5)	44.44 (8)	45.45 (10)
	Phragmites australis	33.30 (3)	36.30 (4)	27.77 (5)	31.81 (7)
	Scirpus maritimus	22.20 (2)	18.20 (2)	27.77 (5)	22.72 (5)

in 2012/13 at Garaet Hadj Tahar, whereas it was 2.61 ± 0.70 eggs in 2011/12 and 2.68 ± 0.65 eggs in 2012/13 at Garaet Messaoussa. Clutch size was not significantly different between breeding seasons at Garaet Messaoussa ($U = 184$, $P = 0.71$) or Garaet Hadj Tahar ($U = 46$, $P = 0.82$). Similarly, clutch size was not significantly different between localities in 2011/12 ($U = 56$, $P = 0.21$) and 2012/13 ($U = 103$, $P = 0.31$).

In 2012/13, at both localities the number of eggs recorded within the study area was higher than in the previous season (Table 3). At Garaet Messaoussa, 47 eggs were noted in 2011/12 and 59 were recorded in 2012/13. At Garaet Hadj Tahar, 27 eggs were observed in 2011/12 and 32 eggs were noted in 2012/13. Hatching success was higher in 2012/13 than in 2011/2012 at both localities (Table 3).

Information on five parameters measured at nests is given in Table 4. At both localities and in both seasons none of these parameters was significantly related to either clutch size or hatching success, except that in 2012/2013 at Garaet Hadj Tahar nest depth was positively correlated to hatching success (Table 5)

Discussion

During both split years, the wintering and breeding populations of the Purple Swamphen were higher at Garaet Messaoussa than at Garaet Hadj Tahar. This difference is attributable to a higher level of disturbance (to individuals and eggs) at Garaet Hadj Tahar, which unlike Garaet Messaoussa is frequented by hunters that disturb waterbirds. Furthermore, environmental characteristics

Table 3: Hatching success of the Purple Swamphen during the 2011/12 and 2012/13 breeding seasons at two wetlands of the Guerbes-Sanhadja complex, Algeria

	Garaet Hadj Tahar		Garaet Messaoussa		Mean
	2011/12	2012/13	2011/12	2012/13	
Eggs laid	27	32	47	59	
Eggs hatched	12	18	22	33	
Hatching success (%)	44.40	56.25	46.80	55.93	50.85

Table 4: Parameters of nests of the Purple Swamphen during the 2011/12 and 2012/13 breeding seasons at two wetlands of the Guerbes-Sanhadja complex, Algeria. At Garaet Hadj Tahar $n = 9$ in 2011/12 and 11 in 2012/13; at Garaet Messaoussa $n = 18$ in 2011/12 and 22 in 2012/13

Site	Year	Water depth (cm)	Nest height (cm)	Nest depth (cm)	External diameter (cm)	Internal diameter (cm)
Garaet Hadj Tahar	2011/12	93.89 ± 5.13	24.44 ± 3.28	12.22 ± 2.44	41.67 ± 3.39	31.11 ± 4.14
	2012/13	100.45 ± 13.98	24.55 ± 3.21	14.29 ± 4.58	44.36 ± 5.24	28.09 ± 4.64
Garaet Messaoussa	2011/12	114.00 ± 10.05	24.78 ± 1.86	12.56 ± 1.50	43.11 ± 4.89	30.17 ± 5.92
	2012/13	112.00 ± 9.98	25.27 ± 3.24	13.55 ± 2.76	44.05 ± 4.18	29.00 ± 3.77

Table 5: Correlation between clutch size and hatching success of the Purple Swamphen and five nest characteristics during the 2011/12 and 2012/13 breeding seasons at two wetlands of the Guerbes-Sanhadja complex, Algeria. Values *r* and *P* are shown; those in bold indicate a significant correlation. At Garaet Hadj Tahar $n = 9$ in 2011/12 and 11 in 2012/13; at Garaet Messaoussa $n = 18$ in 2011/12 and 22 in 2012/13

Site	Year	Parameter	Correlation	Water depth	Nest height	Nest depth	External diameter	Internal diameter
Hadj Tahar	2011/12	Clutch size	*r*	0.29	−0.58	0.06	−0.26	−0.42
			P	0.44	0.09	0.86	0.49	0.25
		Hatching	*r*	−0.42	0.45	0.08	0.10	−0.52
			P	0.25	0.21	0.83	0.78	0.14
	2012/13	Clutch size	*r*	0.30	−0.58	0.00	0.34	−0.58
			P	0.35	0.05	0.98	0.29	0.05
		Hatching	*r*	−0.18	−0.02	0.66	0.26	−0.27
			P	0.59	0.95	0.02	0.42	0.41
Messaoussa	2011/12	Clutch size	*r*	0.46	0.20	0.14	0.34	−0.27
			P	0.05	0.40	0.55	0.15	0.27
		Hatching	*r*	0.42	0.25	0.32	0.17	−0.08
			P	0.07	0.30	0.18	0.48	0.73
	2012/13	Clutch size	*r*	0.00	0.06	0.05	−0.09	−0.17
			P	0.96	0.75	0.81	0.68	0.44
		Hatching	*r*	0.29	−0.14	−0.34	0.24	0.01
			P	0.17	0.52	0.12	0.27	0.94

(types of vegetation and area) are more favourable for Purple Swamphens at Garaet Messaoussa than at Garaet Hadj Tahar. The timing of breeding was similar at both localities and split years, taking place between March and early May. Del Hoyo et al. (1996) stated that the breeding phenology of the Purple Swamphen depends on local rainfall and therefore varies from one region to another across the geographical range of the species. Onset of breeding in north-east Algeria was similar to that in Portugal, where egg laying started in March (Ramos 1994), but substantially later than in southern Spain (Grussu 1999) and south India (Paramanantha Swami et al. 2009) where egg laying started in January.

The mean egg volume varied according to localities and year and was slightly smaller than that of *P. p. poliocephalus* (32.3 ± 3.5 cm^3) in south India (Paramanantha Swami et al. 2009). During this study, clutch size varied between 2.61 ± 0.70 eggs and 3.00 ± 0.71 eggs according to years and localities. Larger clutch sizes were recorded in the Iberian Peninsula (3–6 eggs; Sánchez-Lafuente 2004), Spain (up to 8 eggs; Hidalgo 1973), and south India (3–7 eggs; Paramanantha Swami et al. 2009). However, smaller clutches were noted in the related Takahe *P. hochstetteri,* which is endemic to New Zealand (1–3 eggs; Hegg et al. 2011). Clutch size and egg mass may be determined by food availability around the nest and larger eggs are more likely to survive (Sánchez-Lafuente 2004). Factors such as population age structure and female condition may influence clutch size.

Materials used by the Purple Swamphen to construct nests consisted exclusively of the three dominant plant species, in which nests were also constructed. Nests were substantially larger than those reported by Hu et al. (2010) from China. Purple Swamphens showed no marked preference for any of the three dominant plant species but usually most nests were built in stands of *T. angustifolia* or *P. australis* with a low tendency to nest in *S. maritimus*. In contrast, Hu et al. (2010) found that the species preferred clusters of *S. tabernaemontani*. In north-east Algeria, it appears that stands of *T. angustifolia* and *P. australis* provided good shelter against predators because they were higher and denser than *S. maritimus* at both localities. The species avoided open and low vegetated areas during nest site selection. In addition to predation, egg mass could have an effect on hatching success of the species. Sánchez-Lafuente (2004) found that lighter eggs of the Purple Swamphen had small hatching probability.

The mean hatching success reported in this study (51%) was smaller than that of *P. p. poliocephalus* (61%) in south India (Paramanantha Swami et al. 2009). The low hatching success was mainly due to high rates of predation of eggs by mammals and reptiles. The depth of water beneath nests (c. 1 m) was sufficient to discourage most mammalian predators (Sánchez-Lafuente et al. 1998), so rats (*Rattus rattus*), which were observed swimming from one platform to another, were assumed to be the only mammal able to cross deep water and affect breeding success. In addition, viperine snakes (*Natrix maura*) were abundant at both study localities, usually resting on platforms and exposing themselves to sunlight. At one site, hatching success was positively correlated to nest depth. It is reasonable to think that eggs laid in deeper nests were less likely to be reached by predators and thus had higher hatching success.

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