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# Breeding ecology of the Purple Heron *Ardea purpurea* in Numidia, north-eastern Algeria

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During 2002–2007, we assessed the status of the Purple Heron *Ardea purpurea* in Numidia, Algeria by surveying all the major wetlands in the region. We located six distinct breeding sites; four of these were not previously known. We also investigated nest site selection and determined the species' reproductive success at Dakhla, a dunary pond during two successive years (2006 and 2007). The egg laying period was comparable to that reported for southern Europe (March–May) and a seasonal change of breeding success was recorded. A growth curve was derived for developing nestlings and the impact of an ectoparasite (mite) infestation upon nestling's growth was considered. We also examined 73 food boluses regurgitated by nestlings and identified 329 prey items. Fish, mainly *Gambusia holbrookii* and *Cyprinus carpio*, dominated by mass, whereas insects, mainly aquatic Coleopteran larvae and aeshnids (Odonata), were the most frequent prey (67.1%). Loss of habitat is identified as a major threat to the future of colonial herons in Algeria.

## Introduction

The Purple Heron is a reed swamp species (Kushlan and Hancock 2005) whose habitats, mainly dense, emergent, flooded reed or sedge beds, are in decline or intensively managed throughout its range (Bibby and Lunn 1982, Tamisier and Grillas 1994, van der Putten 1997). Reedbeds are important breeding habitats for Purple Heron and other species of colonial herons (Grey Heron *Ardea cinerea*, Cattle Egret *Ardea ibis*, Little Egret *Egretta garzetta*, Squacco Heron *Ardeola ralloides*, and Black-crowned Night Heron *Nycticorax nycticorax*) and Glossy Ibis *Plegadis falcinellus* (Boucheker et al. 2009); in Algeria, as elsewhere in the Mediterranean area, they are also sanctuaries for other vulnerable species like Swamphen *Porphyrio porphyrio* and Bittern *Botaurus stellaris* (Tucker and Heath 1994).

The Purple Heron has been known to breed in Algeria since the mid-nineteenth century when eggs were obtained for the now-drained lake Halloula (Heim de Balsac and Mayaud 1962). Early in the twentieth century, it was also recorded breeding at Lake Fetzara (Zedlitz 1914). However, the known breeding sites are few and disjunct with some sites in need of confirmation because of a heavy human impact, provoking mainly hydrological changes, over the last decades (Samraoui and Samraoui 2008).

Drought in the wintering grounds of West Africa has been argued to play a key role in the survival of migrating herons (Den Held 1981, Cavé 1983). Obviously, conditions at breeding sites also influence population fluctuations (Hafner and Fasola 1997, Deerenberg and Hafner 1999). Knowledge of how habitat characteristics affect breeding success is essential for conservation management. Several authors have examined nest site selection and breeding success (Thomas et al. 1999). We herewith try to increase knowledge of the ecology of the North African population. Diet of nestlings was investigated to identify key prey taxa and foraging habitats.

In 2007, Dakhla was markedly infested by an outburst of mites (Acarina) and, considering that ectoparasites inflict a heavy burden on nestlings (Brown and Brown 1996, Richner et al. 1993, Weddle 2000), we attempted to evaluate their impact.

This study aims at providing guidance to conservation efforts.

### *Study area*

Numidia in north-eastern Algeria houses a vast array of coastal wetlands made up of shallow freshwater lakes, marshes, lagoons and temporary ponds (Samraoui and de Bélair 1998). From 2002 to 2007, we monitored Purple Heron colonies at four sites: Lake Tonga (36°52′ N, 8°31′ E), Chatt (36°49′49″ N, 7°54′41″ E), Dakhla (36°50′40″ N, 7°59′12″ E) and Lake Fetzara (36°48′ N, 7°30′ E) (Figure 1). Lake Tonga, a Ramsar site, is a freshwater marsh of 2 400 ha with a maximum depth of 2.5 m. Vegetation includes willow *Salix atrocinerea*, bulrush *Scirpus lacustris*, white water-lily *Nymphaea alba*, lesser reedmace *Typha angustifolia* and yellow flag *Iris pseudoacorus*. Dakhla is an unprotected dunary pond of 8 ha with willow *S. atrocinerea*, prickly twig rush *Cladium mariscus*, tufted sedge *Carex elata*, bulrush *S. lacustris* and lesser reedmace *T. angustifolia*. Chatt is an unprotected 2 ha marsh with yellow flag *I. pseudoacorus*, lesser reedmace *T. angustifolia* and bur-reed *Sparganium* sp. Lake Fetzara, a Ramsar site, is a

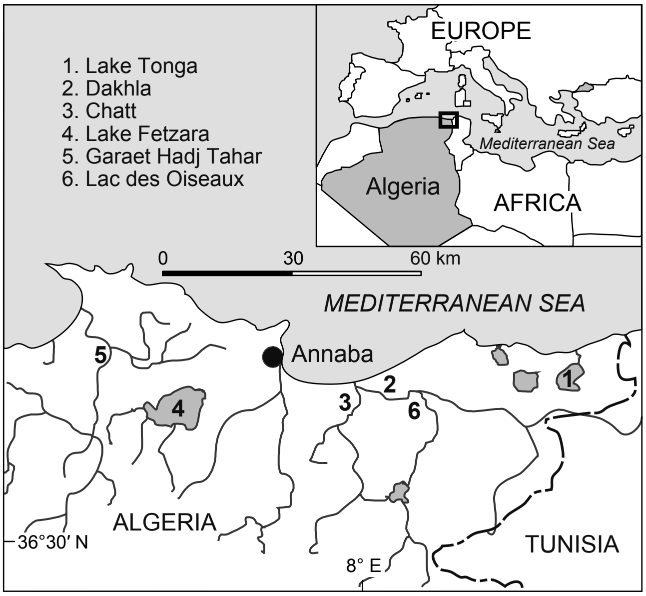


**Figure 1:** Map showing the location of the study sites in Numidia, Algeria

vast marsh of 24 000 ha mainly covered by sea club-rush *Scirpus maritimus*, reed *Phragmites australis* and lesser reedmace *T. angustifolia*. Heron colonies were located on floating islets with dense stands of willows and lesser reedmaces. All colonies, with the exception of Chatt, were established far from human settlements and were within easy reach of surrounding foraging areas (<10 km).

## Methods

All lakes and marshes were visited during the breeding season. Colonies were inspected well after the start of incubation to record nest content, which was checked thereafter twice a week. In 2007 at Dakhla, Purple Herons nested in discrete nuclei and, in order to prevent undue disturbance to Glossy Ibises nesting in the earliest nucleus, we refrained from monitoring this part of the habitat. Many nests at Lake Fetzara, Chatt and Lake Tonga that could not be checked systematically or which at times could not be relocated had fragmentary nest histories and were mainly used to characterise nest site selection. Each nest was labelled with a permanent marker and nest height above water and nest diameters were measured. Eggs were also individually marked and their lengths and breadths were measured to the nearest 0.1 mm using vernier callipers. Egg volume was calculated from the equation of Hoyt (1979): Volume = 0.509 * (length * breadth$^2$). A total of 71 chicks from 17 broods were also individually marked, their beak (+ head) and tarsometatarsus measured; their body mass weighted. Because most chicks were too mobile after 15 d of age, not all of them could be measured after that age.

Clutches were considered as complete when the number of eggs did not change between successive nest inspections and when hatching was noted. Assuming an incubation period of 26 d (Tomlinson 1975), hatching dates were used to estimate the sequence of egg-laying and hatching success was defined as the percentage of eggs in nests that produced chicks. Annual reproductive performance (estimated by clutch size, hatching success and number of chicks surviving to 15 d) was determined and tested against environmental variables.

A total of 73 food boluses were collected from chicks. The prey samples were kept in 70% alcohol and later sorted in the laboratory. Prey items found in regurgitates were identified and number and occurrences were recorded. Growth rates (g $d^{-1}$ or mm $d^{-1}$) were linear from the age of 4 d up to 24 d of age (Moser 1986) and are given by the equation $y = ax + b$ for each hatch rank (A-, B-, C- or D-chick assigned on the basis of their order of hatching). They were calculated from least squares linear regressions of body measurements and chick age.

All statistical analyses were carried out using Minitab 15 (Minitab, Coventry) with values reported as means ± 1 SD and $p < 0.05$ used as the significance level. Data were analysed using parametric and non-parametric tests (Siegel 1956). Normality checks (Kolgomorov-Smirnov tests) and standard data transformations were made where appropriate. When the null hypothesis in one-way analysis of variance was rejected, we conducted *a posteriori* Tukey tests to distinguish differences between means. Regressions were used to define environmental factors influencing Purple Heron's breeding success.

## Results

### *Population density*

Among the six colonies located, four (Dakhla, Chatt, Lac des Oiseaux and Mekhada Marsh) were unknown prior to this study (Table 1). Another site, Garaet Hadj Taher in the Guerbes-Senhadja wetland complex, hosted single nests in two separate years. In 2007, a total of 300 nests were recorded. Most nests were located in reedbeds; some were solitary, others were in monospecific or mixed colonies. Some sites were occupied for a number of years whereas others were deserted by birds after a few breeding attempts.

### *Nesting sites*

The type and structure of vegetation had a marked influence on nest characteristics. The mean nest height above water was 98.2 ± 36.55 cm ($N = 217$) with nests located on willow *S. atrocinerea* (Dakhla and Lake Tonga) situated significantly higher up than nests located in reed *P. australis* or lesser reedmace *T. angustifolia* (Lake Fetzara and Chatt, respectively) ($K = 132.13$, dl = 3, $p < 0.001$, Kruskal-Wallis test). These nests also had lower mean external and internal diameters. These differences were significant between Chatt and Fetzara on one hand and Dakhla and Lake Tonga on the other ($K = 17.71$, dl = 3, $p = 0.001$; $K = 15.74$, dl = 3, $p = 0.001$, Kruskal-Wallis tests for the external and internal diameters, respectively). The mean nest external and internal diameters were 50.15 ± 7.21 cm ($N = 190$) and 31.64 ± 5.06 cm ($N = 178$), respectively.

The mean egg length and breadth were 54.70 ± 1.75 mm and 40.36 ± 1.14 mm ($N = 120$ nests), respectively.

**Table 1:** Breeding pairs and nest site characteristics of Purple Heron in Numidia, northeast Algeria. M = monospecific colony, P = plurispecific colony, S = single nest

| Site | Vegetation type | Year | Recorded pairs (estimated pairs) | Nest type |
|---|---|---|---|---|
| Lac des Oiseaux | *Typha angustifolia* | 2002 | >16 (16–20) | M |
| Mekhada | *Phragmites australis* | | 5 (>20) | M and P |
| Tonga | *Salix atrocinerea* | | 1 (>10) | P |
| Lac des Oiseaux | *Scirpus maritimus* | 2003 | >1 (3 – 5) | S |
| Tonga | *Salix atrocinerea* | | >12 (50) | P |
| Garaet Hadj Tahar | *Phragmites australis* | | 1 (3 – 5) | S |
| Tonga | *Salix atrocinerea* | 2004 | >20 (>50) | P |
| Garaet Hadj Tahar | *Scirpus lacustris* | | 1 (3 – 5) | S |
| Tonga | *Salix atrocinerea* | 2005 | >20 (>50) | P |
| Fetzara | *Phragmites australis* | 2006 | >100 (>300) | M |
| Chatt | *Typha angustifolia* | | >50 (>50) | P |
| Dakhla | *Cladium mariscus, Salix atrocinerea* | | >150 (>200) | P |
| Tonga | *Polygonum senegalense*, *Salix atrocinerea* | | >20 (>50) | P |
| Tonga | *Polygonum senegalense*, *Salix atrocinerea* | 2007 | 0 (50) | P |
| Chatt | *Typha angustifolia* | | >50 (>50) | P |
| Dakhla | *Cladium mariscus, Salix atrocinerea* | | >150 (>200) | P |
| Fetzara | *Phragmites australis* | | >100 (>300) | M and P |

### *Timing of breeding*

Purple Herons started laying toward the end of March (Lake Tonga in 2005 and Dakhla in 2006) and early April (Lake Tonga in 2004) but distinct nucleii within the same site may differ in their timing, as at Dakhla in 2007 where clutches of a late nucleus were initiated at a later date (24 April). The mean laying date at Dakhla in 2006 was 13 April and that of the late nucleus at the same site in 2007 was 10 May. Whatever the timing of clutch initiation, egg laying is highly synchronised and the duration of egg-laying within a colony or a subcolony rarely extends over a month. Egg laying is generally over by the end of May or early June.

### *Egg measurements*

There was some difference in egg volume between sites ranging from 43.8 $cm^3$ (Chatt) to 46.6 $cm^3$ (Lake Tonga) but this variation was not significant ($F_{3,116} = 1.0$, $p = 0.40$). At Dakhla in 2006, egg volume was significantly and negatively correlated with laying date ($r = -0.39$, $p < 0.02$, $n = 38$) (Figure 2). The difference in mean egg volume between years at Dakhla was not significant ($F_{1,67} = 0.01$, $p = 0.93$).

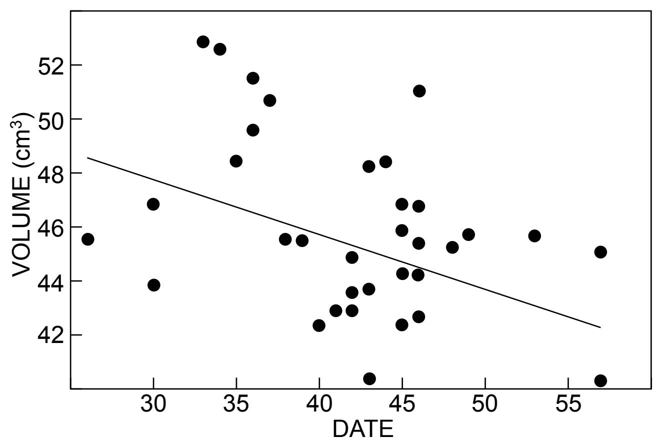


**Figure 2:** Seasonal changes in egg volume ($cm^3$) at Dakhla in 2006. Date = date of hatching with 1 April = 1

### *Clutch size*

The data revealed a mean clutch size of 4.1 ± 0.95 eggs per nest ($n = 65$; complete clutches only) with a mode of 4 and a maximum of 7 (Table 2), but we recently noted a nest containing 10 eggs at Chatt in 2009, likely due to two females. We could find no seasonal trend in clutch size at Dakhla in 2006. Clutch size did not differ significantly between colonies ($K = 3.53$, dl = 3, $p = 0.32$) and between years at Dakhla ($F_{1,45} = 0.58$, $p = 0.45$). It was also neither correlated with egg laying date ($r = -0.05$, $p = 0.77$) nor with egg volume ($r = 0.16$, $p = 0.38$).

**Table 2:** Clutch size of Purple Heron in Numidia, northeast Algeria

| Clutch size | 2 | 3 | 4 | 5 | 7 | *N* | Mean ± SD |
|---|---|---|---|---|---|---|---|
| Dakhla 2006 | 1 | 5 | 18 | 9 | 1 | 34 | 4.2 ± 0.89 |
| Dakhla 2007 | 1 | 0 | 7 | 4 | 1 | 13 | 4.4 ± 1.12 |
| Fetzara 2006 | 2 | 1 | 6 | 1 | 0 | 10 | 3.7 ± 1.01 |
| Tonga 2004 | 0 | 2 | 4 | 1 | 0 | 7 | 3.9 ± 0.69 |
| Total | 4 | 8 | 35 | 15 | 2 | 64 | 4.1 ± 0.95 |

### *Breeding success*

Hatching was asynchronous and the percent hatch at Dakhla in 2006 totalled 77% ($n = 34$). The mean net productivity per nest (up to 15 d of age) for 2006 was 2.5 ± 1.52 chicks ($n = 32$ clutches). The percent survivorship from eggs laid was 60.0%, whereas percent survivorship from hatching was 77.0%. We found a clear seasonal trend in productivity with the number of chicks/nest negatively correlated with date of egg-laying ($r = -0.38$, $p = 0.03$, $n = 29$) (Figure 3).

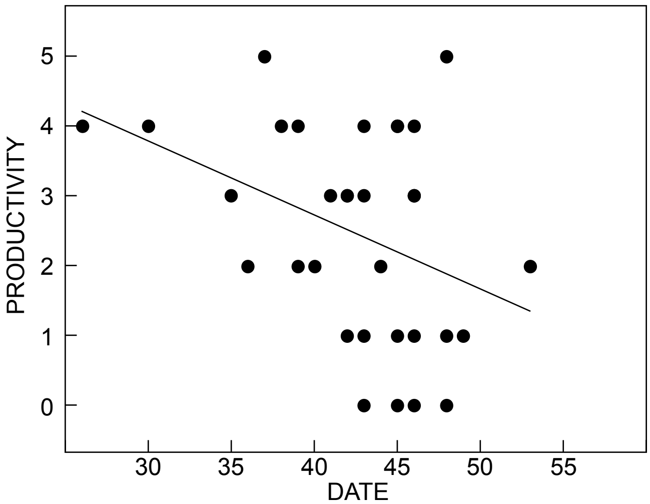


**Figure 3:** Seasonal changes in productivity (surviving chicks per nest) at Dakhla in 2006

Productivity did not differ significantly between years at Dakhla ($F_{1,36} = 0.20$, $p = 0.66$).

### *Growth rates*

Growth curves based on 36 nestlings in 2006 and 25 nestlings in 2007 and derived from the mean age-specific body mass, head and bill length and tarsus were obtained. Growth rates for all variables were essentially linear for the age interval (4–20 days) considered (Table 3). Differential growth was associated with hatch rank in 2006, whereas in 2007 the pattern was obscured by the influence of ectoparasites. Two lone chicks, heavily parasitised, exhibited the lowest growth rate.

### *Diet of chicks*

Purple Herons in Numidia preyed mainly on fish and aquatic insects (Table 4). The main components of the diet (by weight) were fish, principally the mosquitofish *Gambusia holbrookii* and the common carp *Cyprinus carpio*, but aquatic insects composed of Coleoptera (*Hydrous piceus*

**Table 3:** Growth rates of Purple Heron chicks from a) Dakhla (2006) and b) Dakhla (2007)

| Morphometric character | Hatching order | Mean | Intercept | $r^2$ | $p$ | $n$ |
|---|---|---|---|---|---|---|
| **Dakhla 2006** | | | | | | |
| Mass gain (g d⁻¹) | A | 34.42 | −74.29 | 0.95 | <0.0001 | 11 |
| | B | 32.07 | −42.3 | 0.93 | <0.0001 | 10 |
| | C | 35.25 | −66.84 | 0.92 | <0.0001 | 10 |
| | D | 31.69 | −76.61 | 0.96 | <0.0001 | 5 |
| | All chicks | 33.44 | −61.52 | 0.93 | <0.0001 | 36 |
| Tarsus growth (mm d⁻¹) | A | 3.93 | 9.27 | 0.99 | <0.0001 | 11 |
| | B | 3.80 | 11.7 | 0.97 | <0.0001 | 10 |
| | C | 1.67 | 17.44 | 0.74 | <0.0001 | 10 |
| | D | 3.80 | 7.98 | 0.94 | <0.0001 | 5 |
| | All chicks | 3.83 | 10.67 | 0.95 | <0.0001 | 36 |
| Head and beak (mm d⁻¹) | A | 4.82 | 30.87 | 0.97 | <0.0001 | 11 |
| | B | 4.57 | 34.62 | 0.98 | <0.0001 | 10 |
| | C | 4.72 | 33.36 | 0.95 | <0.0001 | 10 |
| | D | 4.51 | 30.34 | 0.97 | <0.0001 | 5 |
| | All chicks | 4.66 | 32.76 | 0.96 | <0.0001 | 36 |
| **Dakhla 2007** | | | | | | |
| Mass gain (g d⁻¹) | A | 37.61 | −108.1 | 0.94 | <0.0001 | 6 |
| | Parasitised A | 30.99 | −124.1 | 0.98 | <0.0001 | 2 |
| | B | 34.47 | −32.97 | 0.92 | <0.0001 | 7 |
| | C | 37.61 | −108.1 | 0.94 | <0.0001 | 4 |
| | D | 35.82 | 10.06 | 0.89 | <0.0001 | 5 |
| | E | 44.23 | −198.99 | 0.99 | <0.0001 | 1 |
| | All chicks | 35.05 | −52.51 | 0.85 | <0.0001 | 25 |
| Tarsus growth (mm d⁻¹) | A | 3.84 | 5.86 | 0.95 | <0.0001 | 6 |
| | Parasitised A | 3.05 | 7.63 | 0.95 | <0.0001 | 2 |
| | B | 3.20 | 16.46 | 0.92 | <0.0001 | 7 |
| | C | 4.40 | 1.78 | 0.95 | <0.0001 | 5 |
| | D | 3.65 | 17.69 | 0.93 | <0.0001 | 5 |
| | E | 4.25 | -0.31 | 0.99 | <0.0001 | 1 |
| | All chicks | 3.68 | 38.61 | 0.88 | <0.0001 | 26 |
| Head and beak (mm d⁻¹) | A | 4.66 | 29.69 | 0.95 | <0.0001 | 6 |
| | Parasitised A | 4.52 | 23.53 | 0.98 | <0.0001 | 2 |
| | B | 3.81 | 44.02 | 0.93 | <0.0001 | 7 |
| | C | 4.65 | 33.46 | 0.95 | <0.0001 | 5 |
| | D | 4.52 | 43.33 | 0.9 | <0.0001 | 5 |
| | E | 5.22 | 23.97 | 0.96 | <0.0001 | 1 |
| | All chicks | 4.20 | 38.61 | 0.88 | <0.0001 | 26 |

and *Cybister* sp. larvae) and Odonata (mainly *Anax* spp. and *Aeshna* spp. larvae) were more numerous.

## Discussion

### *Status and habitat characteristics*

A recent survey of Algerian wetlands has revealed that the status of waterbirds in the country was in need of reassessment (Samraoui and Samraoui 2008). Ideally, for inaccessible wetlands such as the Mekhada Marsh or Lake Fetzara, heron breeding pairs should be counted using aerial surveys. The present study, despite the severe limitations of ground surveys, suggests that the Purple Heron population in Numidia exceeded a total of 500 breeding pairs in the years studied. Because of the secretive nature of the species, this may be an underestimate. This number may reflect a marked increase over the last decades (or be due to insufficient study during historical times). Two important colonies (Lake Fetzara and Dakhla) each harboured well over 120 nests. Previous estimates of breeding pairs of the Purple Heron in Algeria never exceeded 60 (Isenmann and Moali 2000). Most probably, previous surveys did not adequately cover the area, and important sites like the Mekhada Marsh and Lake Fetzara were barely sampled. It is also likely that other factors underlie this population increase. Favourable climatic spells both in breeding and wintering areas may have favoured the Purple Heron. A recent long-term study of heron and egret populations in Italy suggested a number of ecological factors influencing their dynamics but, for the Purple Heron, the study did not identify an environmental factor associated with the observed pattern (Fasola et al. 2010). However, herons are less persecuted than in the past and this pattern holds true across the whole range of the species (Fasola et al. 2010), thus possibly benefiting the North African population also.

A vertical and a horizontal stratification among different species of herons is the rule (Jenni 1969, Beaver et al. 1980). In our mixed colonies with other species of herons and ibises, the Purple Heron did not seem to compete for nest sites, being the first to occupy the breeding site, nesting at lower heights compared to later species. Its nest generally attracted other herons, and its nucleus gradually transformed into a huge plurispecific colony. Competition with the Grey Heron has been suggested as a cause of displacement of the Purple Heron or to constrain it to breed at low heights (Fasola and Alieri 1992) but in Numidia the Grey Heron is a rare breeder.

Protection against ground predation was considered the most important factor in nest site selection (Tomlinson 1974). Nest diameters varied markedly between sites, a consequence of nesting material often collected close to nesting sites that affected nest width (Samraoui and Samraoui 2007). Nests were larger (and probably had higher mass) in reedbeds (Lake Fetzara and Chatt) but were located at lower heights above water. In the Netherlands Purple Herons readily occupy bushes, with

**Table 4:** Analysis of 399 prey items representing 73 food boluses from Purple Heron nestlings

| Class/order | Family | Species | Number | Occurence (%) |
|---|---|---|---|---|
| **Invertebrates** | | | | |
| Crustacea | | | | |
| Decapoda | Atyidae | *Atyaephyra desmaresti* | 1 | 1.37 |
| Insecta | | | | 67.12 |
| Odonata | | | | 43.83 |
| | Libellulidae | *Diplacodes lefebvrii* | 3 | 2.74 |
| | Libellulidae | Larval stage | 3 | 39.73 |
| | Aeshnidae | Larval stage | 57 | 4.11 |
| Orthoptera | Gryllotalpidae | *Gryllotalpa gryllotalpa* | 1 | 1.37 |
| Coleoptera | | | | 57.53 |
| | Dytiscidae | *Cybister* sp. larva | 2 | 2.74 |
| | | Coleoptera sp. imago | 3 | 4.11 |
| | | Coleoptera sp. larva | 101 | 53.42 |
| | Hydrophilidae | *Hydrophilus piceus* | 2 | 2.74 |
| | Carabidae | Imago | 1 | 1.37 |
| **Vertebrates** | | | | |
| Pisces | | | | 57.53 |
| | Poeciliidae | *Gambusia holbrookii* | 63 | 13.70 |
| | Cyprinidae | *Cyprinus carpio* | 44 | 21.92 |
| | Cyprinidae | *Barbus callensis* | 1 | 1.37 |
| | | Fish sp. | 32 | 23.29 |
| Amphibia | | | | |
| | Ranidae | *Rana saharica* | 8 | 10.96 |
| | | *Rana saharica* larva | 4 | 2.74 |
| Reptilia | | | | |
| | Colubridae | *Natrix maura* | 1 | 1.37 |
| | Emydidae | *Emys orbicularis* | 1 | 1.37 |
| Aves | | | | |
| | | Indetermined | 1 | 1.37 |

nests frequently exceeding 2 m above ground or water (van der Kooij 1991, 1997).

***Breeding parameters***

The onset of egg-laying in Numidia occurred 7–15 d earlier than was found in Delta del Ebro, Spain (Gonzalez-Martin 1994) and is one of the most precocious in the Western Palearctic. Early laying dates may prove beneficial if females need to renest because of clutch failure.

The Purple Heron normally lays a clutch of 4–5 eggs (Kushlan and Hancock 2005), which is in close agreement with our data. The average clutch-size (4.2) in Numidia compares well with that reported (3.5) from the Camargue (Moser 1984), the lowest value recorded in Europe. It is similar to values of 4.1 and 4.2 recorded in Spain (Gonzalez-Martin 1994) and Switzerland (Manuel 1957), respectively, but it is smaller than values of 4.5 in Central France (Ferry and Blondel 1960), 4.5 in Holland (Haverschmidt 1961) and 5.3 in the Czech Republic (Kral and Figala 1965). Our data show a seasonal trend between egg size and laying date and they also suggest a slight variation of clutch size between sites. Conspecific brood parasitism (Yom-Tov 2001, Yom-Tov and Geffen 2006) may surely account for the ten-egg clutches recorded during this study and in Hungary (Kral and Figala 1965). Cases of nine-egg clutches are also known (Kral and Figala 1965, Lebreton 1977, Recorbet and Cantera 1997) and the former authors reported an incredible case of 18 eggs laid successively in one nest in Hungary. Cases of polygyny (one male and two females attending a nest) have been reported (Voisin 1991) and Tomlinson (1974) suspected that in Zimbabwe nesting in trios was relatively common.

***Nestling development and survival***

The growth of body mass of an avian chick has a sigmoid shape (Ricklefs 1968) but the growth shape is essentially linear between 4 and 24 d (Moser 1984). Growth rates of 33.4 g $d^{-1}$ (2006) and 35.1 g $d^{-1}$ (2007) compare well with those reported in the Camargue between 1997 and 1999 (Barbraud et al. 2001). The Camargue population has experienced lower nestling growth and survival rates between 1981 and 1999 (Barbraud et al. 2001).

It is unusual for broods of five chicks to survive to fledging but in 2007 the growth rate of one nestling of rank E (last to hatch in a brood of five) was the highest, followed by nestlings of rank A and C.

In 2007, Dakhla was heavily infested by mites, which led to the desertion of the site, the following year, by all colonial herons and Glossy Ibises. Ectoparasites are known to induce colony desertion (Feare 1976). Chicks from nests with relatively high ectoparasite loads had a low overall body mass (Richner et al. 1993). It is possible that the brood reduction process could be either facilitated (Christe et al. 1998) or thwarted by parasites, depending on how the parasites are distributed among host nestmates (Weddle 2000).

Nestling losses were attributable to starvation or ectoparasite infestation but the principal causes of clutch failure recorded were hatching failure and inclement weather (strong winds that sank whole islets with heron colonies). We also recorded cases of egg and nestling predation by the Swamphen. Other potential predators include Marsh Harrier *Circus aeruginosus*, wild boar *Sus scrofa*, jackal *Canis aureus*, red fox *Vulpes vulpes*, stray cats and dogs.

***Reproductive strategies***

Survivorship as expressed by the number of nestlings of 15 d exhibited a seasonal downward trend at Dakhla in 2006. There is an apparent trade-off between early and late breeding with the former enjoying a higher survivorship but incurring a higher vulnerability due to density-independent factors such as adverse climatic conditions (cold spells, strong winds and rain). In birds in general, larger volumes in the early stages of egg laying may provide a higher hatching rate (Thomas 1983) and a higher hatching mass (Moser 1984, Jager et al. 2000), thus conferring better prospects of post-fledging survival and recruitment (Parson 1970, Coulson and Porter 1985, Nisbet et al. 1999). Smaller egg sizes may be due to declining food resources or to younger birds initiating breeding at a later stage than experienced ones (Curio 1983). To optimise brood size to available resources, the Purple Heron resorts to two mechanisms: clutch size adjustments and brood reduction are used (Moser 1986). Nestlings can even become cannibalistic, probably during periods of food shortages (Kral and Figala 1965, Walmsley 1974, Amat and Herrera 1978).

***Geographical variation of nestlings' diet***

Competition for food seems to be lessened by a high degree of food resource partitioning among local breeding herons. The diet of Purple Heron differs significantly from that of other herons in the distribution of the size class of fish, aquatic Coleoptera and Odonata, thus revealing specialisation on distinct size classes of certain taxa (Samraoui et al. unpublished data). The Odonata most preyed upon belong to the family Aeshnidae (*Anax* sp. and *Aeshna* sp.) and the aquatic beetles most preyed upon are *Cybister* sp. and *Hydrous* sp. All these taxa represent the largest prey size within their respective groups. These, combined with small fish (*Gambusia holbrookii* and small-sized *Cyprinus carpio*) provide the most adequate food for developing nestlings (Campos and Lekuona 2000). Noteworthy is the relatively small proportion of frogs (*Rana* spp.) in the diet recorded in our study. Purple Herons prey almost exclusively on fish in southern Africa (Tomlinson 1975) and, elsewhere, fish is a dominant component of its diet (Moser 1984, Rodriguez de los Santos and Canavate 1985, Laszlo 1986, Fasola et al. 1993, Campos and Lekuona 1997). In the Camargue, a shift towards a more insectivorous diet has been reported (Thomas et al. 1999, Barbraud et al. 2001).

***Population dynamics***

Previous decline of some Purple Heron populations has been linked to conditions in its sub-Saharan winter grounds (Fasola et al. 2000, Barbraud and Hafner 2001) and in their breeding grounds in southern Europe (Barbraud et al. 2002). Colony size seems to be related to the total area of reedbeds available (Broyer et al. 1998, Grüll and Ranner 1998), whereas water levels and reed harvesting intensity (Barbraud and Mathevet 2000) have been shown to be major proximal factors to reedbed occupancy for breeding (Barbraud et al. 2002). Reedbeds in Algeria are unmanaged but they are often the targets of deliberate fires that are set by cattle owners and hunters to facilitate access. Further investigations are needed to assess the influence of these fires. In Numidia, cattle may inflict significant damage to reedbeds and they may also disturb breeding birds and cause nest trampling.

Illegal shooting is relatively uncommon but it does occur. Egg or chick collecting, whenever heron colonies are within reach, is still an issue (Samraoui et al. 2007). However, herons suffer relatively less than other species like Coot *Fulica atra*, Ferruginous Duck *Aythya nyroca* or Greater Flamingo *Phoenicopterus roseus,* which are often induced to desert their nesting grounds (Samraoui et al. 2006).

Land reclamation for agriculture has been extensive in the last few years and despite its status as a Ramsar site, Lake Fetzara has been the target of partial draining and large parts of the lake have been converted to pasture lands and agriculture. Likewise, the Mekhada marsh, another Ramsar site, has been subjected to major anthropogenic pressure through highway and road construction that encroach and even cross the marsh, fragmenting significantly this outstanding natural habitat. Hydrological changes can have a profound effect on breeding Purple Herons, a species sensitive to water level changes (Moser 1984) and the construction of the Mexenna dam is bound to impact negatively on the Mekhada marsh, which used to be annually flooded by Wadi El Kebir. Dam construction is a major conservation issue as under current models of climate change, the aridity of North Africa is expected to increase with concomitant increase in pressure on freshwater. In the Hauts Plateaux, many brackish (e.g. Boulhilet) as well as many salt lakes (Guelif, Chott Hodna), classified as Ramsar sites, have been negatively impacted since the building of reservoirs on the wadi that feed them. In North Africa, Purple Herons face a challenging future in a water-stressed region and the apparent increase of the local population may not be sustained in the long term.

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