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Ornithologie

ASPECTS OF THE BREEDING ECOLOGY OF THREE RALLIDAE SPECIES IN NORTHEASTERN ALGERIA

par

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The breeding ecology of the Purple swamphen (*Porphyrio porphyrio*), Common coot (*Fulica atra*) and Common moorhen (*Gallinula chloropus*) was investigated from 2013 to 2015 in the northern and north-western parts of the arboretum of Lake Tonga (north-eastern Algeria), which are subject to anthropogenic influence. Nests were located under different types of trees and constructed from their bark, branches and leaves. Moorhen and Coot egg-laying occurred between March and May. Purple swamphen egg-laying took place between the end of March and the beginning of April. The overall mean of clutch size is generally similar to that recorded for these species in other Algerian wetlands, and as reported in the literature. A higher hatching success was recorded in recent years in comparison to previous data collected at the same site, especially for Moorhen and Coot.

This study provides new data on the breeding phenology of these three species of Rallidae, in particularly Moorhen and Purple swamphen, which remain very poorly studied in North Africa, especially in Algeria. The results should help improve planning for the management and conservation of these birds.

Keywords: Nest-site selection, clutch size, breeding biology, Lake Tonga, *Porphyrio porphyrio, Fulica atra, Gallinula chloropus*.

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Aspects de l'écologie de reproduction de trois espèces de Rallidae dans le nord-est algérien

L'écologie de la reproduction de la Talève sultane *Porphyrio porphyrio*, de la Foulque macroule *Fulica atra* et de la Gallinule poule d'eau *Gallinula chloropus* a été étudiée, entre 2013 et 2015, au niveau des parties nord et nord-ouest du Lac Tonga (Nord-est algérien), les plus exposées aux activités humaines. Les nids étaient localisés au pied de différents types d'arbres et construits avec les écorces, branches et feuilles de ces derniers. La ponte a eu lieu globalement entre mars et mai pour la Poule d'eau et la Foulque et, plus brièvement, entre la fin mars et début avril pour la Talève sultane. La taille de ponte moyenne de la Gallinule poule d'eau est de 6,2 ± 1,3 œufs, N = 47, celle de la Foulque : 7,0 ± 2,3, N = 42 et celle de la Poule sultane : 4,5 ± 1,1, N=22. Les nids avec au moins un poussin éclos représentent 90 % des nids suivis. Les pontes qui ont survécu jusqu'au moment de l'éclosion ont eu un succès d'éclosion très élevé chez les trois espèces.

Cette étude tente d'apporter des données récentes et utiles sur la phénologie de la reproduction de trois espèces de Rallidés qui restent très peu étudiées en Afrique du Nord et notamment en Algérie, en particulier la Poule d'eau et la Talève sultane. De telles informations peuvent fournir des directives pour la gestion et la planification de la conservation et offrent des outils pour l'établissement de priorités pour d'éventuels plans d'action.

Mots-clés : sélection du site de nidification, taille des couvées, biologie de la reproduction, Lac Tonga, *Porphyrio porphyrio, Fulica atra, Gallinula chloropus*.

Introduction

The Common moorhen, *Gallinula chloropus,* and the Coot, *Fulica atra,* are among the most common Algerian wetland birds and have a wide distribution. The Purple swamphen, *Porphyrio porphyrio,* has a more restricted distribution.

The Common moorhen has a worldwide distribution, being present in North and South America, tropical Africa and the cold/temperate zones of Asia and Europe (SAUER, 1984). This bird is able to spread rapidly and colonize a wide range of habitats. In Algeria, it has a wide distribution, including the southern oases, the Oran and Algiers region, the complex of Guerbès/Sanhadja, and the wetlands around El Kala (ISENMANN & MOALI, 2000). Several studies on the species were conducted in Europe (RELTON, 1972; HUXLEY & WOOD, 1976) and in North America (FREIDRICKSON, 1971; BRACKNEY & BOOKHOUT, 1982; GREIJ, 1994; BANNOR, 1997), but not in North Africa for which there are only a few fragmentary reports of its breeding biology.

The Coot has an extremely large range and population sizes (BIRDLIFE INTERNATIONAL, 2012). Highly gregarious in winter and strongly territorial during the breeding season, it breeds on several North African wetlands of the Mediterranean area (ETCHECOPAR & HUE, 1964; CRAMP & SIMMONS, 1980; SNOW & PERRINS, 1998). In Algeria, it commonly breeds in many waterbodies, including the El Kala region, Macta, Boughzoul and Reghaia (ISENMANN & MOALI, 2000). Various studies have been conducted on this species (RIZI *et al.*,

1999; SAMRAOUI & SAMRAOUI, 2007; MERABET-NOURI, 2014; METNA *et al.,* 2016).

During the 20th century, the Purple swamphen population size has experienced a marked decrease in southern Europe and North Africa (CRAMP & SIMMONS, 1980). It became extinct on the Italian mainland, Sicily and the Balearic islands before the middle of the century, while there are only a few fragmented populations left now in Spain, Portugal and the North African countries (KASPAREK *et al.,* 1989). In Algeria, it is a resident breeding and protected species. It is found in low numbers in many wetlands of the northern, central and western parts of the country. Throughout the world, various authors conducted several studies on breeding ecology and nest-site selection of its subspecies, for example in India (DOSS *et al.,* 2009; FAZILI, 2014), in China (JUNHUA *et al.,* 2010), in New Zealand (BUNIN & JAMIESON, 1996), in Spain (SÁNCHEZ-LAFUENTE, 1993; SÁNCHEZ-LAFUENTE *et al.,* 1998), in Italy (GRUSSU, 1985, 1999), but few investigations had been carried out in North Africa, especially in Algeria, which still supports a relatively large concentration of this species in the Northeast (SAMRAOUI *et al.,* 2015).

During the breeding season, the monitoring of nests, laying, hatching, clutch and brood sizes, success of hatching and fledging, are important knowledge to evaluate breeding habitats and this may be essential to formulate management strategies to protect populations and especially those that are vulnerable and endangered (ROBINSON *et al.,* 2005).

The present paper aims to: (1) document variation in some basic characteristics about reproduction of the three considered species; (2) examine within – and between – clutch sources of variation in egg length, breadth, volume and shape; and (3) determine if hatching success is related to nesting and life-history traits.

Materials and methods

Study area

The study was conducted in the northwestern part of the Arboretum of Lake Tonga in northeastern Algeria. Lake Tonga, a freshwater marsh of 2600 ha, forming part of the El Kala National Park. It is also designated as both a Ramsar Site and an Important Bird Area (COULTHARD 2001; SAMRAOUI & SAMRAOUI 2008), mainly because of its role as a breeding ground for the White-headed Duck and the Ferruginous Duck (LAZLI *et al.,* 2011a,b; LAZLI *et al.,* 2012).

Situated at the northern edge of the lake (Fig. 1), the Arboretum is a plantation of Bald cypress (*Taxodium distichum*), Alder (*Alnus glutinosa*), Ash (*Fraxinus angustifolia*) and Poplars (*Populus* spp.). It is a centrepiece site because of its importance for birds, although the western side is relatively impacted by human settlement.

Its position at the interface between terrestrial and aquatic environment confers on the Arboretum a role of refuge for many species of animals, including mammals, amphibians, reptiles and birds. It plays a major role by sheltering the northern part of

Lake Tonga from view and traffic noise from the national road (No. 44). This function is ecologically vital to ensure optimal breeding conditions in northern parts of the lake.

An ongoing inventory of the fauna and flora has shown the presence of 44 plant species, including 3 with protected status in Algeria: *Populus nigra, Marsilia diffusa, Osmunda regalis*. The 27 species of birds observed are distributed in 13 families and include 12 protected species, in particular *Aythya nyroca, Hieraaetus pennatus, Milvus migrans, Serinus serinus* and *Aigretta garzetta*. During the eighties and nineties, few nests of White-headed Duck were reported in this northwest part of Lake Tonga.

Nest and egg characteristics

Between 2013 and 2015, we checked all nests twice a week from mid-February to mid- September. Each nest was labelled with a permanent marker and its internal and external diameters and height, as well as water depth at its location, were recorded. The majority of nest positions were recorded using a Global Positioning System (GPS). Eggs were also individually marked and weighed to within 0.1 g using a Pesola spring balance. Lengths and breadths were measured to the nearest 0.1 mm using Vernier callipers. Egg volume (V, in cm^3) was calculated using Hoyt's formula ($V = 0.000509\ L*B^2$) (HOYT, 1979).

A rowing boat was used to reach the nests, particularly during the rainy period (February-March).

Breeding parameters

The breeding parameters used are the dates of laying and hatching, clutch size and breeding success. A brood was considered to be complete when chick number hatched was equal to that of laid eggs.

Data on egg laying were recorded and analyzed according to the date of the first egg (LACK, 1950). Hatching success was defined as the percentage of eggs in nests that produced chicks. Successful nests were deemed to be those where at least one chick fledged.

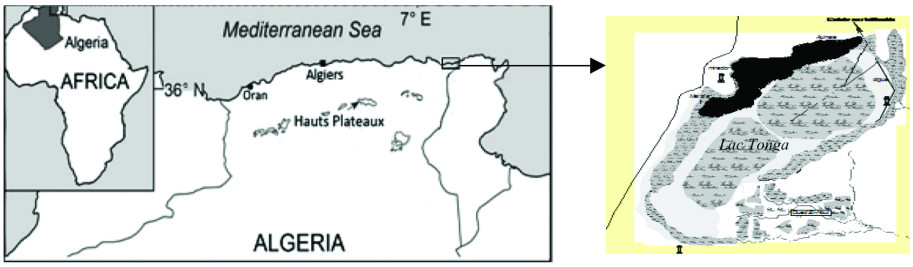

Figure 1

Location of the study area in Lake Tonga (northeastern Algeria).
Localisation du site d'étude dans le Lac Tonga (Nord-est algérien).

Data analyses

Statistical analyses were carried out using Minitab 17. Ink with values reported as mean ± S.D. and $p < 0.05$ used as significance level. Because the data complied to a normal distribution, relations between nest measurements were tested using coefficient of correlation. Student's test was used to determine whether there was a difference between nest measurements and difference between nest clutch sizes, and to check whether egg dimensions were different in the different years of research.

Results

Nest characteristics and location

Between 2013 and 2015, 111 nests were identified, 47 of Common Moorhen, 42 of Coot and 22 of Purple Swamphen. The maximum number of nests for the three species together (47) was observed in 2015. Location and composition of nests differed between species (Tab. 1). 73% of Moorhen nests were found in trunks of Alder (*Alnus glutinosa*), 48% of Coot nests were observed in Willow (*Salix pedicellata*) and 82% of Purple Swamphen nests were found in Willow.

Between 2013 and 2015, bark, branches and leaves of Cypress were the main components of common Moorhen nests (53%). During the same period, 92% of coot nests were built with Bur-reed leaves and Club rushes.

Purple Swamphen nests were mostly constructed with Club rushes, Cypress and Alder leaves.

Tables 2, 3 and 4 summarize all available information on nest characteristics of the three species observed during the study period. Table 4 show that the largest nests are those of Purple swamphen.

Nest dimensions were correlated with water depth at nestling sites for the three species. A correlation was recorded between external diameter of coot nests and depth ($r_{42} = 0.350$, p=0.023).

Table 1

Nest characteristics and location.
Caractéristiques et localisation des nids.

Species	Nest location or support	Nest composition
Common moorhen	Alder Cypress	Cypress bark, branches and leaves; Bur-reed leaves; Club rushes; Alder leaves
Coot	Willow Alder Club rushes	Bur-reed leaves; Club rushes; Alder leaves.
Purple swamphen	Willow Club rushes	Club rushes; Cypress and Alder leaves

Table 2

Nest and egg measurements
of Common moorhen breeding at the study area (2013-2015).
Mesures des nids et des œufs de la Gallinule poule d'eau (2013-2015).

Characteristics	Mean ± SEM	(Min-Max)	N	Mean ± SEM	(Min-Max)	N	Mean ± SEM	(Min-Max)	N
		2013			2014			2015	
External diameter (cm)	17.4 ± 3.5	(12-21)	10	18.2 ± 3.2	(13-22)	17	18.6 ± 2.6	(14-22)	20
Internal diameter (cm)	11.2 ± 3.5	(7-16)	10	13.2 ± 3.5	(8-18)	17	12.8 ± 2.6	(8-16)	20
Nest height (cm)	29.2 ± 6.8	(17-35)	10	22.2 ± 8.4	(8-35)	17	27.8 ± 7.1	(17-38)	20
Water depth (cm)	59.2 ± 18.8	(25-80)	10	55.2 ± 31.6	(25-150)	17	55.8 ± 16.6	(30-80)	20
Egg weight (g)	21.96 ± 1.4	(17-24)	63	22.45 ± 1.9	(20-32)	103	22.7 ± 0.9	(20-24)	129
Egg length (mm)	41.90 ± 1.7	(36-45)	63	42.23 ± 1.8	(38-45)	103	41.9 ± 1.6	(37-45)	129
Egg breadth (mm)	27.74 ± 1.5	(23-29)	63	27.9 ± 1.0	(23-29)	103	28.2 ± 0.7	(25-29)	129

Table 3

Nest and egg measurements for Coot breeding at the study area (2013-2015).
Mesures des nids et des œufs de la Foulque macroule (2013-2015).

Characteristics	Mean ± SEM	(Min-Max)	N	Mean ± SEM	(Min-Max)	N	Mean ± SEM	(Min-Max)	N
		2013			2014			2015	
External diameter (cm)	29.2 ± 4.1	(26-35)	11	24.8 ± 3.8	(20-30)	14	25.7 ± 7.8	(15-35)	17
Internal diameter (cm)	17.36 ± 2.5	(14-20)	11	14.5 ± 3.1	(11-18)	14	14.2 ± 3.7	(10-20)	17
Nest height (cm)	16.45 ± 2.3	(15-20)	11	19.1 ± 2.2	(15-21)	14	16.8 ± 6.8	(8-25)	17
Water depth (cm)	95.4± 20.5	(50-120)	11	91.4 ± 20.8	(50-115)	14	87.6 ± 26.4	(50-115)	17
Egg weight (g)	38.3 ± 4.1	(31-45)	75	37.1 ± 4.0	(31-44)	98	35.6 ± 3.1	(31-43)	124
Egg length (mm)	51.37 ± 3.1	(45-57)	75	49.9 ± 3.6	(43-55)	98	50.4 ± 2.6	(40-59)	124
Egg breadth (mm)	33.9 ± 0.9	(32-35)	75	34.1 ± 0.8	(32-36)	98	33.9 ± 1.2	(32-38)	124

Table 4

Nest and egg measurements for Purple swamphen breeding at the study area (2013-2015).

Mesures des nids et des œufs de la Talève sultane (2013-2015).

Characteristics	Mean ± SEM	(Min-Max)	N	Mean ± SEM	(Min-Max)	N	Mean ± SEM	(Min-Max)	N
		2013			2014			2015	
External diameter (cm)	29.2 ± 0.8	(28-30)	5	29.5 ± 0.5	(29-30)	7	29.8 ± 0.9	(29-31)	10
Internal diameter (cm)	21.6 ± 0.8	(20-22)	5	21.0 ± 0.8	(20-22)	7	21.0 ± 0.9	(20-22)	10
Nest height (cm)	28.6 ± 1.3	(27-30)	5	28.4 ± 1.5	(27-30)	7	34.1 ± 13.12	(20-55)	10
Water depth (cm)	90.0 ± 36.7	(50-120)	5	86.4 ± 34.4	(50-125)	7	75.6 ± 21.6	(55-110)	10
Egg weight (g)	37.15 ± 3.0	(32-40)	19	38.1 ± 2.7	(32-40)	29	39.0 ± 1.7	(32-40)	55
Egg length (mm)	49.8 ± 2.4	(46-52)	19	50.6 ± 2.9	(45-53)	29	51.7 ± 1.6	(46-53)	55
Egg breadth (mm)	34.1 ± 1.3	(32-40)	19	34.2 ± 1.3	(32-35)	29	34.2 ± 1.2	(32-35)	55

Significant differences were found in Common moorhen nest heights between those found in 2013 and 2014 ($t=2.35$, $df=22$ $p=0.028$) and between nest heights for 2013 and 2015 ($t= -2.15$, $df=31$, $p=0.040$).

Significant differences were recorded for nest dimensions of the Coot between 2013 and 2014 (internal diameters: $t=2.53$, $df=22$, $p=0.019$; external diameters: $t=2.73$, $df=20$, $p=0.013$) and between 2013 and 2015 (external diameters: $t=2.69$, $dl=25$, $p=0.012$). A significant difference in nest height was found between 2013 and 2014 ($t= -2.90$, $df=20$, $p=0.009$). The difference in the measurements of nests from one year to another, especially between 2013 and 2015, can be explained by changes in environmental conditions and the effort invested to maximise reproductive success, since nests of large size may contain more or larger eggs.

For Purple swamphen nest dimensions, a difference was found only for nest heights between 2013 and 2015 ($t= -2.69$, $df=9$, $p=0.025$) and between 2014 and 2015 ($t= -2.70$, $df=9$, $p=0.024$).

Egg characteristics

295, 297 and 103 eggs of Common moorhen, Coot and Purple swamphen were measured respectively between 2013 and 2015.

Eggs dimensions varied between species (Tables 2-4).

Significant differences were found in egg weight for the three species between 2013 and 2015 (Common Moorhen: t= -4.03, df=87, *p*=0.000; Coot: t= 2.95, df=108, *p*=0.004; Purple swamphen: t= -2.57, df=22, *p*=0.017).

Significant differences were recorded for Purple swamphen egg length between 2013 and 2015 (t= -3.17, df=23, *p*=0.004), and for Coot between 2013 and 2014 (t= 2.74, df=167, *p*=0.007) and between 2013 and 2015 (t= 2.12, df=113, *p*=0.036).

Moorhen eggs showed noticeable differences between 2013 and 2015 for breadth (t= -2.36, df=74, *p*=0.021) and volume (t= -2.12, df=89, *p*=0.036).

The number of deserted nests, which remained low compared to the total number of nests found, was noted before egg measurements were taken.

Breeding parameters

Laying period

The first clutches are generally observed in March for the three species, while the last clutches were seen in either April or May, depending on the year and the species.

The laying season lasted 7 to 9 weeks for Moorhen, 5 to 8 weeks for Coot and 3 weeks for Purple Swamphen.

Egg-laying started between mid-March and early April in all monitored years. The maximum percentage of nests with eggs was reached in May for Moorhen, with 60% in 2013 and about 41% in 2014 and 2015. The largest percentage of clutches was observed in March for Coot, with 73% in 2013, 57% in 2014 and 41% in 2015. For Purple swamphen, 80% of clutches were recorded in May 2013, 57% in May 2014 and 80% in April 2015.

No nest was ever reused during the study period, and no information on second broods was obtained. In Algeria, assuming that it takes 50-60 days to raise a brood (HUXLEY & WOOD, 1976), there may not be enough time to raise a second brood and probably only a small fraction of the local population will attempt to do so (SAMRAOUI *et al.*, 2013).

Hatching

First hatchings were recorded in April for the three species and the last in May and June. Maximum number of hatching was observed in June for Common moorhen, in April for Coot and in May for Purple swamphen (Fig. 2).

Monitoring of the nests of the three species showed a hatching success of 89% for Common moorhen, 90% for Coot and 100% for Purple swamphen (2013-2015).

During our fieldwork, 12% of Moorhens eggs failed to hatch in 2014 and 15% in 2015. For Coots, 9% of eggs failed in 2013 and 12% in 2015.

Clutch size

Mean clutch size for Common moorhen was 6.2 ± 1.3 (N = 47 nests), with clutches ranging from 4 to 8 eggs. For the Coot, it was 7.0 ± 2.3 (N = 42 nests), with clutches ranging from 4 to 11 eggs. In the Purple swamphen it was 4.5 ± 1.1 (N = 22 nests), with clutches ranging from 3 to 7 eggs (Table 5).

Table 5

Clutch size of Common Moorhen, Coot and Purple swamphen (2013-2015) (mean ± SD). N = Number of broods.

Taille des nichées de la Gallinule poule d'eau, de la Foulque macroule et de la Talève sultane (2013-2015) (moyenne ± écart-type).

	2013		**2014**		**2015**		**Pooled**	
	N	Clutch size (*mean ± SD*) *(Min-Max)*	**N**	Clutch size (*mean ± SD*) *(Min-Max)*	**N**	Clutch size (*mean ± SD*) *(Min-Max)*	**N**	Clutch size (*mean ± SD*) *(Min-Max)*
Common moorhen	**10**	6.3 ± 1.2 (5-8)	**17**	6.1 ± 1.4 (4-8)	**20**	6.4 ± 1.3 (5-8)	**47**	6.2 ± 1.3 (4-8)
Coot	**11**	6.8 ± 2.7 (4-11)	**14**	7.0 ± 2.2 (4-10)	**17**	7.3 ± 2.0 (4-10)	**42**	7.0 ± 2.3 (4-11)
Purple swamphen	**5**	3.8 ± 1.1 (3-5)	**7**	4.1 ± 0.9 (3-5)	**10**	5.5 ± 1.3 (4-7)	**22**	4.5 ± 1.1 (3-7)

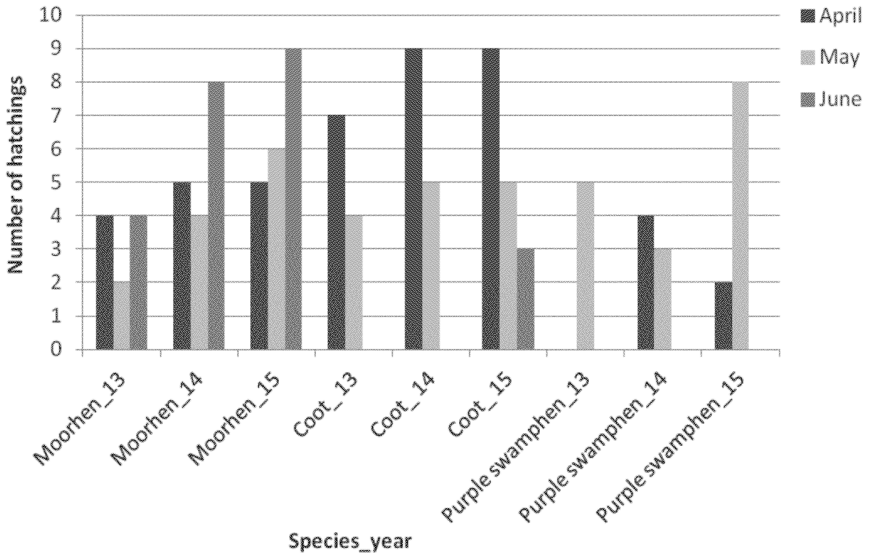

Figure 2

Monthly pattern of hatching of Common Moorhen, Coot and Purple swamphen in the study area (2013-2015).

Chronologie mensuelle des éclosions de la Gallinule poule d'eau, de la Foulque macroule et de la Talève sultane au niveau du site d'étude (2013-2015).

No significant difference between years was found for Common moorhen clutch sizes or for Coot clutch sizes.

Significant differences were found in Purple swamphen clutch sizes between 2013 and 2015 (t= -2.61, df= 9, *p*= 0.028), and between 2014 and 2015 (t= -2.48, df= 14, *p*= 0.026).

A significant correlation was found between clutch size and average volume of eggs for all three species (Moorhen: $r_{47} = 0.355$, P= 0.014; Purple swamphen: $r_{22} = 0.727$, p = 0.000; Coot: $r_{42} = -0.480$, p=0,001).

Breeding success

Nests that had at least one hatched chick accounted for 90% of monitored nests. Clutches that survived till hatching had a very high hatching success between 2013 and 2015 (89% for Common moorhen, 93% for Coot and almost 100% for Purple swamphen).

Eight nests were deserted during the study period: two coot nests in 2013 and one in 2015; four of Common moorhen in 2013 and one in 2014. The cause would probably have been our visit or predation.

Because of the nature of the habitat (high vegetation density), monitoring the survival of broods was difficult. Ten cases of predation on nests were recorded between March and April. The Viperine snake (*Natrix maura*) was observed near and within nests. Also, due to proximity of human habitations to the study site, the poaching of eggs continues unabated at lake Tonga, despite legal protection.

Discussion

For waterbirds, breeding success depends largely on the choice of nesting site. This choice must respond to certain conditions such as density and height of the aquatic vegetation, water depth and quietness.

The results obtained in this study show that nesting sites varied greatly for Moorhen, Coot and Purple swamphen but were mostly characterized by high and dense vegetation such as *Alnus glutinosa, Taxodium distichum, Salix pedicellata, Scirpus lacustris* and *Scirpus maritimus* which protect eggs and chicks from all types of predators.

All Moorhen nests were found in emergent vegetation, especially of Alder trunks. Various types of nesting sites of the species have been reported in numerous wetlands of Numidia and Algerian Hauts plateaux, like Bulrushes, Typhas, Alder and Tamarisk (SAMRAOUI *et al.,* 2013; MENIAIA *et al.,* 2014). But the species can also choose to build its nests on small islands of land surrounded by water or suspend above it (WOOD, 1974). It appears as the Moorhen can accommodate with plant resources found on a site given either trees or other alternative emergent vegetation.

Data collected during this study indicate that Coot nests were discovered mainly in Willow (*Salix pedicellata*) and, to a lesser extent, in *Alnus glutinosa* and Bulrushes (*Scirpus lacustris* and *S. maritimus*). At Timerguanine, a shallow freshwater pond, located in the semi-arid Hauts-Plateaux of northeast Algeria, most nests were found in *Phragmites australis* (SAMRAOUI & SAMRAOUI, 2007).

Purple swamphen nests observed during this study were most frequently located in Willow. At Boussedra, *Typha angustifolia* stands and *Scirpus maritimus* were the preferred nesting sites for the species (SAMRAOUI *et al.,* 2015). Favorite habitat at Hokersar wetland (India), was characterised by thick growth as Phragmites communis, *Butomus umbellatus* and *Sparganum ramosum* (FAZILI, 2014).

The spatial occupation strategy seems to differ between the three species studied here. Despite the fact that Moorhen and Coot occupied the same part of Lake Tonga during the three years of study, nest location choice remains distinct: Coot predominantly built nests nearest water at vegetation fringe and Moorhen installed its nests in height and dense herbage (SAMRAOUI *et al.,* 2013).

The first nests found were those of the Moorhen, which were under construction. However, Coots were the first to start egg-laying. Their eggs were discovered between 7 to 10 days earlier than those of Moorhen. It seems that Common moorhen nesting depended on growth emergent macrophytes, food availability and favourite climatic conditions as low rains and optimal temperature (SAMRAOUI *et al.,* 2013).

During our fieldwork, we found that a significant number of Moorhen nests was located close to regular human activities. It seems that these sites would offer the species protection against predators. CEMPULIK (1993) also reported this fact. We estimated an average distance of 40 m between Moorhen nests and habitations.

Two cases of interspecific brood parasitism were recorded in 2014. After our first visits, we found one Moorhen nest holding respectively six eggs of Moorhen and two of Coot, and the other contained four eggs of Moorhen and one of Coot.

Purple swamphen nests were located far from those of the other two species. An average distance of 12 m was recorded between Moorhen nests and those of Purple swamphen, and a distance of about 8 m between those of Coots and Purple swamphens.

Purple swamphen nests were also located close to those of the Little grebe, *Tachybaptus ruficollis* (average 3 m between nests), and Ferruginous Duck, *Aythya nyroca* (average 6 m between nests).

Moorhen and Coot nest sizes decreased as water depth increased. CRAMP & SIMMONS (1980) support this assertion. At Arboretum of Lake Tonga, the species use generally reeds and branches of trees found there, including those from Alder, allowing them to build large nests. RIZI *et al*. (1999) suggested that building nests with rigid materials allows them to have a larger external diameter. SAMRAOUI & SAMRAOUI (2007) support our latter interpretation.

During our study, egg-laying generally occurred between March and May for Moorhen and Coot, and between late March and early April for Purple swamphen.

The Moorhen breeding season was relatively short and varied little between years. The results confirm that the breeding period in North Africa is limited to spring. MENIAIA *et al*. (2014) reported a relatively short egg-laying period for *Gallinula chloropus,* between mid-April and the end of June, peaking in the first half of May at Lake Tonga, while SAMRAOUI *et al*. (2013) recorded it as occurring between early April and the end of June at the same site.

At Arboretum of Lake Tonga, Coot egg-laying occurred in early March (9 & 10 march). It was earlier than observed in Timerganine, Hauts Plateaux of Algeria and Lake Reghaia (April in each wetlands) (MERABET-NOURI, 2014; METNA *et al*., 2016) and in Europe (HAVLIN, 1970; GADSBY, 1978). RIZI *et al*. (1999) reported an egg-laying starting in late April and May in 1996 and 1997 in Lake Oubeira, and in early May in Lake Tonga in 1997.

Purple swamphen egg-laying started in late March and hatching took place in late April. BARA *et al*. (2014) reported first laying in early March, with hatching in late March, at the wetland complex of Guerbes-Sanhadja, North-east Algeria. The onset of egg-laying was found to occur earlier (mid-February) than was recorded previously (late-March) at Lake Tonga (2009) and Boussedra (2008) (SAMRAOUI *et al*., 2015).

During the present investigation, the mean clutch size differed between species, that of Moorhen was 6.2 (range 4-8) with no significant difference from the findings of other workers in the region (SAMRAOUI *et al*., 2013; MENIAIA *et al*., 2014). FAZILI & IMTIAZ (2013) recorded an average clutch size of 8 eggs (range 4-11) at Hokersar wetland (India), 7.6 was found at Newburgh, a coastal region in Aberdeenshire, Scotland (ANDERSON, 1965), 7.5 by ANFINNSEN (1961), and 6.8 by STEINBACHER (1939).

At the study site, Coot mean clutch size (7.0) is significantly higher than that of 4.3 measured by RIZI *et al*. (1999), but close to the value of 6.1 obtained by SAMRAOUI & SAMRAOUI (2007), that of MERABET-NOURI (2014) at Boussedra and Timerganine. GADSBY (1978) recorded a clutch size of 6.0 for Europe.

At Arboretum of Lake Tonga, Purple swamphen mean clutch size was 4.5, with clutches ranging from 3 to 7 eggs. ISENMANN & MOALI (2000) indicate clutches of 2-4 eggs. In 2008, SAMRAOUI *et al*. (2015) reported a mean of 3.4 at Boussedra and 3.9 at Lake Tonga in 2009. BARA *et al*. (2014) observed a low mean clutch size of 2.75 for this species at the wetland complex of Guerbes-Sanhadja. In Europe, CRAMP & SIMMONS (1998) have indicated that clutch size varies from 3 to 5, while the studies of *Porphyrio porphyrio seistanicus* in southern India have indicated a variation in clutch size from 3 to 7 (DOSS *et al*., 2009). FAZILI (2014) has noted a mean of 4 eggs at Hokersar wetland (Kashmir), which is lower than that of *Porphyrio porphyrio melanotus,* reported in New Zealand by CRAIG (1980). According to SÁNCHEZ-LAFUENTE (2004), clutch size depends mainly on the availability of food at nest site. According to the hypothesis of LACK (1968), FAZILI (2014) proposes that clutch size varies geographically and decreases with latitude.

High hatching and breeding successes were recorded in this study for the three studied species. Our data are supported by those of RIZI *et al*. (1999), MERABET-NOURI (2014), SAMRAOUI *et al*. (2013), SAMRAOUI *et al*. (2015), METNA *et al*. (2016), BOUKROUMA *et al*. (2016) for the Algerian populations of Moorhens, Coots and Swamphens. The high breeding success in the Arboretum and in the north-western part of Lake Tonga may be attributed to the nature of habitats and choice of nesting sites. It was mostly characterized by thick and high vegetation that provides adequate cover and protection to eggs and nestlings from predators. This fact was reported in other studies in Algeria.

In conclusion, data obtained in this study suggest that Common Moorhen, Coot and Purple swamphen may be considered as birds almost constant in terms of life-history traits in Algeria.

Further studies are necessary to improve knowledge of the ecology and breeding biology of these three species still poorly studied to date in Algeria. Several long-term investigations covering a range of habitats and environmental variables are required to identify the factors that influence their breeding success and behaviour.

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