Journal of Research in Biology

An International Scientific Research Journal

ISSN No: Print: 2231 –6280; Online: 2231- 6299

Original Research

Characterization of the *Tadorna ferruginea* (Pallas, 1764) [Ruddy Shelduck] nests at its nesting areas in the Middle Atlas, Morocco

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ABSTRACT:

Reproduction of *Tadorna ferruginea* (Pallas, 1764)[Ruddy Shelduck] was studied in the two lakes of Middle Atlas, Morocco namely Afennourir lake and Sidi Ali lake. This water Duck is unusual to build nests at the cedar forests around these lakes. Most nests are placed in the holes in cedar trees (*Cedrus atlantica*) located at heights varying between 5 and 25m and an average distance of 3km lake. To characterize the nests of Ruddy Shelduck and analyze intrinsic determinants of the choice of type of nest, we conducted a factor analysis of Mixed Data (FAMD) of 13 mesological descriptors studied in 22 nests around the two lakes viz., Afennourir and Sidi Ali. This treatment was performed on the basis of morphometric characters and geomorphological data of the nests.

The classification obtained allowed us to highlight the main nest groups that have similarities and correlations between them. On the whole, the density and composition of the forest around the nesting tree, the age of the nest tree, nesting orientation, the nature of the vegetation cover and the persistence of nesting tree on the soil flux are the most explanatory variables that differ in the grouping of nests. The Ruddy Shelduck mainly uses the following techniques to build the nest: Presence of a dense and diverse forest stands with old cedar forests, soil cover flush with the shaft supporting the nest and Southwest orientation or Southeast opening of nests. This analysis confirms that the cedar forests around the Middle Atlas lakes offer good conditions for the construction of nests for this species.

Keywords:
Middle Atlas, Morocco, Ruddy Shelduck, reproduction, nest, morphometric characteristics, distribution.

Web Address:
http://jresearchbiology.com/documents/RA0513.pdf

Article Citation:
Dalai M, Chillasse L and HalimR.
Characterization of the Ruddy Shelduck *Tadorna ferruginea* (Pallas, 1764) nests at its nesting areas in the Middle Atlas, Morocco
Journal of Research in Biology (2015) 5(3): 1667-1675

Dates:
Received: 29 Mar 2015 **Accepted: 0**3 Apr 2105 **Published:** 14 May 2015

Journal of Research in Biology

INTRODUCTION

Reproduction of Ruddy Shelduck (Family: Anatidae), was studied in the two lakes of Moroccan Middle Atlas namely Afennourir lake and Sidi Ali lake.

This species is recorded as, rare and threatened as per Morocco's scale and presents a sedentary phenological status in its breeding in the Middle Atlas (El agbani 1997; Thevenot *et al.,* 2003; Chillasse 2004; Radi, 2008).

Regular monitoring of the population for three reproductive cycles 2010, 2011 and 2012, allowed us to frame the phenology of reproduction from pair formation to the hatching of eggs.Its reproductive cycle is triggered in mid-January by pair formation and extend until late July for post-nuptial moult.

The peculiarity of this species is that its lies in the aquatic nest at the cedar forests of the surrounding lakes. Most nests are placed in the holes of cedar trees (*Cedrus atlantica*) located in the heights between 5 and 25m and an average distance of 3km from the Lakes (Dalai, Chillasse 2010).

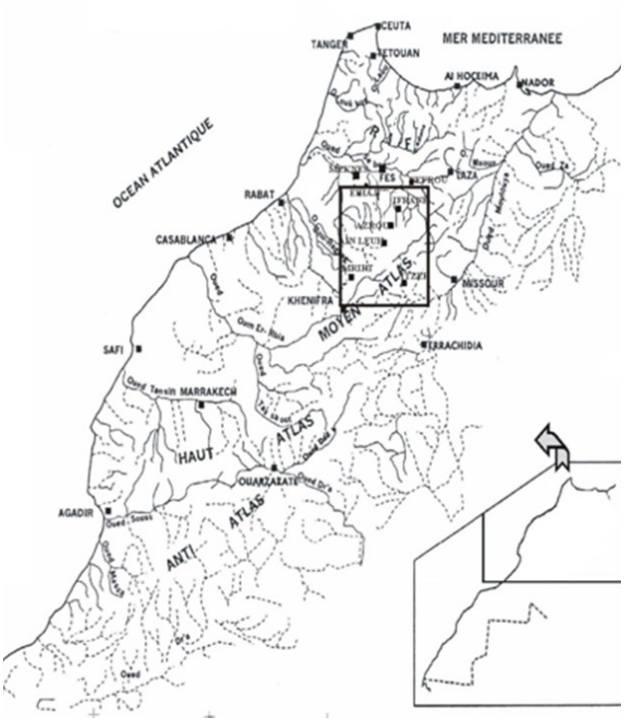

Figure 1: Study Area; Central Middle Atlas, Morocco

It is recognized that these birds lay their eggs and raise their young ones in a place where they are protected from the dangers that threaten them.

A well-hidden nest, protected from disturbance is the best possible shelter for the birds. For large species, it is difficult to make it invisible. The ideal protection will make it as an inaccessible nest (Cramp and Simmons, 1983).

To characterize the nests of Ruddy Shelduck and to understand the intrinsic determinants in the choice of nests, we developed a cluster analysis of 22 nests; all located at Cedar trees around the lakes. This analysis is used as a basis for determining the characteristics, auto ecology, synecological and grouping of nests where the reproduction of Ruddy Shelduck is effective.

MATERIALS AND METHODS

Study area

The study area was limited to the lakes of the Central Middle Atlas, as defined by Martin (1981). This geological and geographical entity is an average mountain, elongated from south west (SW) to North east (NE). It is the central section of the chain of the Middle Atlas (El Gharbaoui, 1987) (Figure 1)

The forests around the two lakes, mainly Afennourir lake and Sidi Ali lake, were selected as the study area; including the fact that they are a regular breeding site for the Ruddy Shelduck (Green *et al*., 2002; Chillasse *et al*., 2001; Franchimont *et al*., 1994). This choice is also justified that the authors have a good knowledge about the location of most of the nests and holes and also due to the prevalence of potential nests present in this area (Chillasse, 2010). Indeed, 22 nests were selected and taken into consideration for the study. (16 nests from Afennourir lake and 6 nest from the Aguelmame of Sidi Ali) lake. Most of these holes were listed in the 2010-2012 study period.

Table I: Codes, definitions, limits and terms of the parameters used

Settings	codes	Limitations	Terms	No of sites
Elevation in meters	Alt	1865 <	A1	13
		1848 <- <1865	A2	1
		<1848	A3	8
Nest exposure	Ori	NW-NE	N	2
		SW-SE	S	5
		NE-SE	E	7
		SW-NW	W	8
Height from floor to nest in meters	Hn	10 <	Hn 1	12
		8 <- <10	Hn2	6
		<8	HN3	4
Horizontal opening of the nest in cm	Oh	30 <	Oh1	14
		20 <- <30	OH2	6
		<20	OH3	2
Vertical opening of the nest in cm	Ov	30 <	OV1	14
		20 <- <30	Ov2	6
		<20	OV3	2
Depth of the nest in cm	P	65 <	P1	12
		30 <- <65	P2	7
		<30	P3	3
Range of the nest in cm	E	70 <	E1	6
		10 <- <70	E2	15
		<10	E3	1
Circumference of the shaft in meter	C1.30	4.6 <	C1	10
		4 <- <4.6	C2	8
		<4	C3	4
Total tree height in meter	Ht	20 <	Ht1	10
		14 <- <20	Ht2	6
		14 <	HT3	6
Tree density (number of trees per hectare)	D	dense	From	1
		dense medium	Dm	15
		low	Df	6
Stand composition (monospecific dispécifique, trispecific)	Comp	cedar	C	1
		Green cedar and oak	CQ	14
		Cedar, Holm oak and oxycèdre	CQO	7
Settlement stage	Ag	young grove	Jf	10
		old grove	Vf	12
Nature of the soil around the nest / 5m	Ns	Herbaceous> 50%	H	14
		Pebbles> 50%	C	6
		Herbaceous 50%, 50% stones	HC	2

Analytical method

To characterize the nests of Ruddy, we conducted a data processing using a Factorial Analysis of Mixed Data (FAMD) developed by Pagès (2004). In this treatment we analyzed 13 morphometric parameters that characterize the nests. The advantage of this method is that it can process the information of qualitative and quantitative parameters previously transformed into modalities. It is a synthetic tool for analyzing similarities and descriptors of environmental parameters by identifying the level of importance of each parameter to the explanation of the structures obtained; while taking it into account, the multiple correlation between appearance of mesological parameters are considered in this analysis.

The projection of the data on the factorial plan (F_1xF_2 plan), that best explains stational typology allows to provide relevant information on the nesting variables

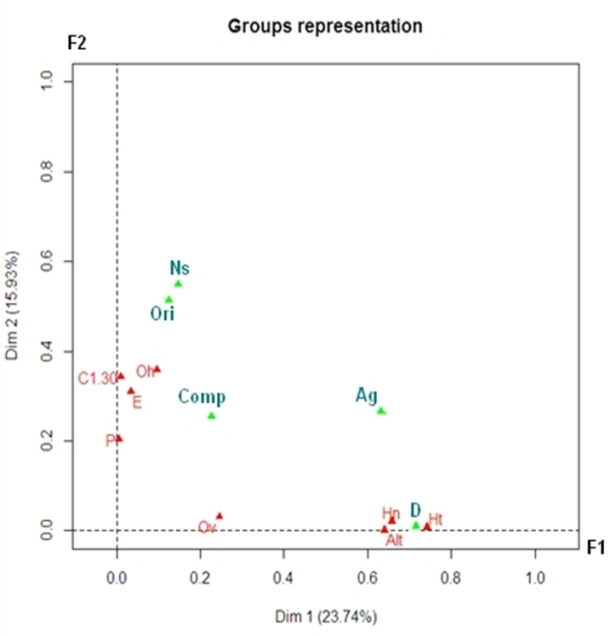

Figure 2: Distribution parameters of mesological nests in terms of F1intoF2

which are considered in this analysis.

Morphometric parameters

Table I shows 13 parameters used that tigger with a direct or indirect influence in the formation of the Ruddy Shelduck nests. Most environmental parameters described were collected in the field itself. These data were transformed into modality (2-4 modality for each parameter) (Appendix 1). This change was made to process the data as variables using a Factorial Analysis of Mixed Data (FAMD) by setting boundaries

Different modalities are done according to the method of reconciliation between the closest states for categorical variables and calculation for quantitative variables. Table that has been subjected to analysis is finally consisting of 22 nests,13 parameters and 39 terms (see Appendix 1).

RESULTS AND DISCUSSION

Mesological structure

Treatment of FAMD variable has resulted in an mesological organization of 22 nests studied in the factorial design F_1xF_2, with 39.67% of inertia, according to the characteristics of the nests.

To clarify the characteristics of these mesological nest groups, we conducted analysis on each of the 13 parameters of the medium to a projection of its terms in, the factorials F_1 and F_2. The most explanatory variables of this distribution (Figure 3) are represented by the nest exposure (Ori), the soil around nests / 5m (Ns), strand composition surrounding the nest tree (Comp), the age of the nest tree (Ag) and the tree density (D).

The altitude settings (Alt), the total height of the nest tree (Ht), the height from floor to nest (Hn), the horizontal opening of the nest (Oh), the vertical opening of the nest (Ov), the extent of the nest (E) and the circumference of the nest tree (1.30m) (C1,30) participate with low inertia to the explanation of this distribution. The distribution of their terms on the factorial F_1xF_2 is relatively random (Figure 3).

The depth of the nest parameter (P), is a contact information and is almost zero. Its contribution to the characterization of the nests Ruddy is very significant. Therefore it will be considered as an additional parameter, a small contribution to the inertia of the two axes.

After this change, considering the depth of the nest as an additional variable, the distribution of the variables were organized according to the following structure (Figure 4).

The percentage of inertia of the factorial axes is considered as an indicator of structured variables. It provides information on the presence of a correlation between variables and also the number of principal components to interpret (Husson, Pagès, 2009).

In this analysis, the first two axes F_1 and F_2 express 41.23% of the total inertia. In other words, a percentage 41.23% of the total variability of the individual cloud (or variable) is shown in the foreground that represents the well variability contained in the whole set of active data.

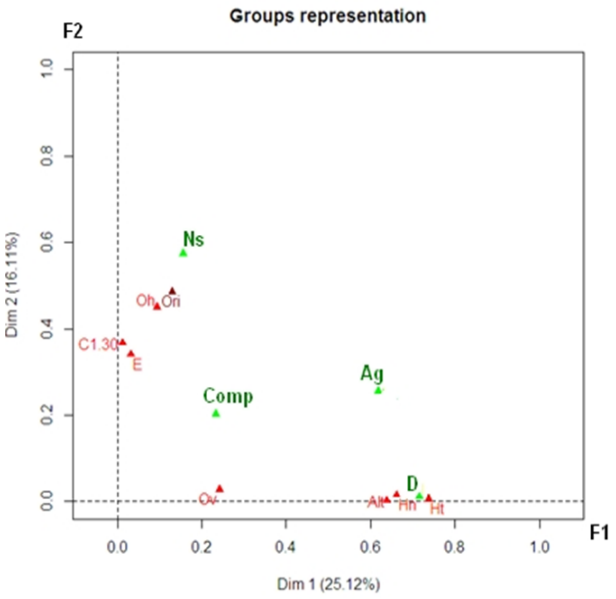

Figure 3: Distribution of nests variables with parameter P as illustrative

The analysis of figure 4 and table (Annexure 2) has enabled us to determine the following:

The description of the two main axes showed that the variable "total tree height (Ht), the height from floor to nest (Hn), the density of the forest (D) and the age of the nest tree (ag)"are most correlated to the first dimension. The variables *"horizontal opening of the nest (Oh), the circumference of the nesting tree 1.30m (C1.30), the soil around the nest/5m (Ns) and exposure of the nest (ori)"* are most correlated to the second dimension.

The correlation study between the different variables (Figure 4) shows that:

- The horizontal opening of the nest (Oh) is negatively correlated with the extent of the nest (E)
- The Altitude (ALT) is also negatively correlated with height from floor to nest (Hn) and total tree height (Ht).

From these observations, we can conclude that the axis F_1 represents the nests whose distribution is influenced by the total tree height (Ht) and the height from floor to nest (Hn). The axis F_2 corresponds more to the nests whose distribution is influenced by the horizontal opening of the nest (Oh) and the circumference of the nesting tree (C1.30).

Study Group nests (similarity and variability)

In order to study the similarity, variability, and the contrast between the different types of nests (occupied and empty) in a same group as between nest groups,we made an analysis of the structure of the various nests found on the factorial F_1xF_2 (Figure 5). This structure reveals the existence of four nest groups:

Group I: Represented by the nests NS_{11} nests, NS_{12}, NS_{13}, NS_{20}, NS_{21} and NS_{22}:

All of which are identified in the forest surrounding the lake Sidi Ali. They represent nests located on old forests of cedar, oriented in NW-NE direction.

The composition of the forest strand around the nest tree is tri-specific (Cedar, Holm oak and cèdreoxy). The ground below the nest tree is stony in nature and covered with grass .

Group II: It consists of the nests (holes) Na_{14}, Na_{15}, NA_{16}, NA_{17}, Na_{18} and Na_{19} found at the forests surrounding Afennourir lake. These nests were

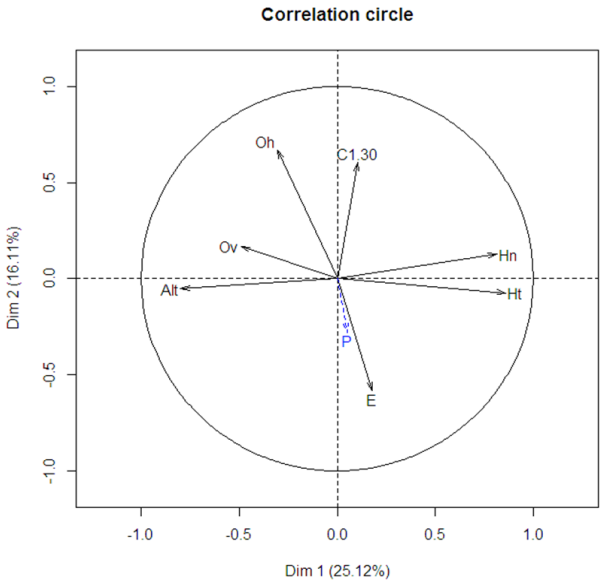

Figure 4: Correlation between parameters characterizing the nests of Ruddy Shelduck

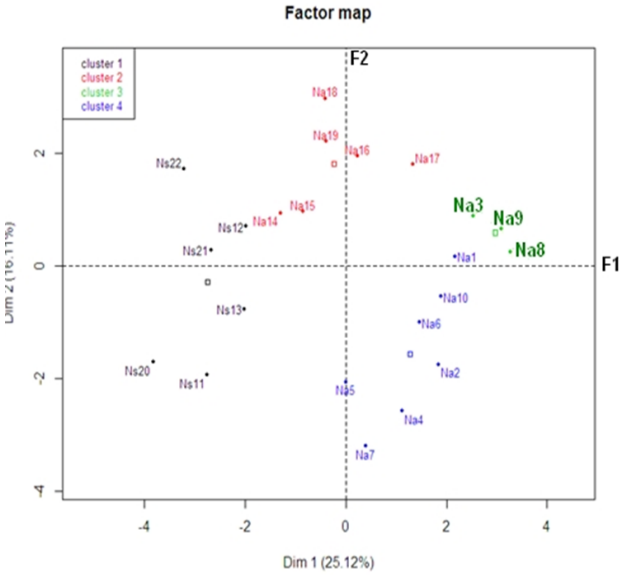

Figure 5: Distribution of four classes on the factorial F1intoF2

unoccupied by Ruddy but remain as potential nests. The openings of the nests are oriented in southwest to North - West. The composition of the forest strand level of this group is di-specific (Cedar and Green Oak). The vegetation on the ground is grass type

Group III: It is composed of nests Na_3, Na_8 and NA_9 located in the right of the forest strand. It is a young forest of dense cedar around the lake Afennourir.

Group IV: It consists of nests Na_1, Na_2, Na_4, Na_5, Na_6, NA_7 and NA_{10} ;all are detected at the forests of Afennourir lake. Most of these nests have a South-West to Southeast orientation. The forest strand is, sparse consisting especially of young cedar forest.

An analysis of the correlation between the distribution of nests and the specific terms for each class (Figure 6) showed at both the lakes, apart from the empty nests of the young forest of cedar at Afennourir that the nests are occupied and positively correlated with empty nests. These two types of nest have similarities in terms of their morphometric characteristics. They all have the same orientation NW-NE, a great similarity in the composition of the forest stand, the nature of the substrate flush of nests, and age of trees. Homogeneous morphometric characters suggest that these empty holes are potentially the colonized nests of Ruddy

DISCUSSION

This study allowed us to explain the mechanisms and factors that come into play in the nests formation of Ruddy Shelduck in the forests around the two lakes viz., Afennourir and Sidi Ali. Using Factor Analysis of Mixed Data (FAMD) of the 22 nests, mesological descriptors has been of great help. This treatment was done on the basis of morphometric characters and geomorphological data nests at the breeding areas of this species.

Thus, this automatic classification allowed us to highlight the main nest groups that have similarities to each other and to analyze the different correlations between the different types of nests; depending on whether they are occupied or empty.

The resulting structure mesologically highlights four groups of nests. We grouped within each class of nests with descriptors of characteristics that are closer together. Of all, the density and composition of the forest that stand around the nest tree, the age of the nest tree, nest orientation, the nature of the vegetation cover and soil flush remaining is the nest tree are the most explanatory variables present in the different nest groups.

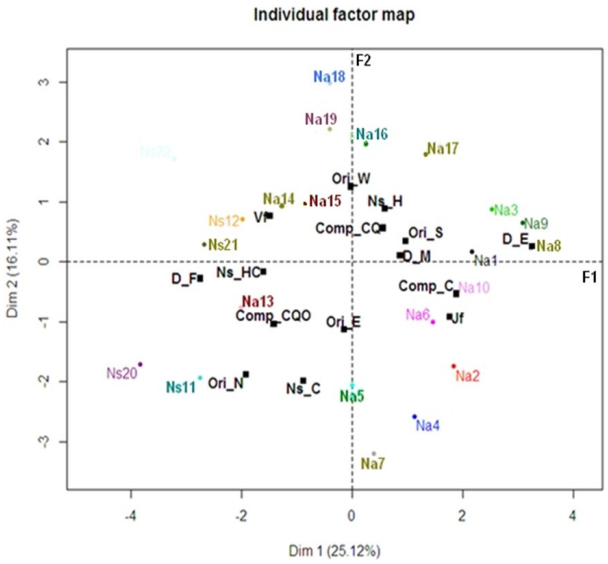

Figure 6: Correlation between nests and specific terms of each class

Ruddy shelduck in Lake Afennourir

Ruddy shelduck couple in Sidi Ali lake

Orientation of nest

Biométrie of nest

Eggs in a nest

Chicks in nest, the first day

Sidi Ali Lake

Afennourir Lake

Figure:7 Photograph showing Ruddy's nest and the study lake view

Ruddy uses the following techniques to build the nest:

- A dense forest stand that is diverse,
- On a old cedar forest
- Covered ground flush below the nest
- A nest with Southwest orientation to Southeast opening.

The holes that are not occupied in the forests around Sidi Ali Lake, have similarities with the occupied nests? This positive correlation between the two types of nests are to conclude that these holes remain as potential nests for the possible cases of Ruddy nesting.

The forests around the Lake Afennourir offer good conditions for building nests of Ruddy nests. A common feature for all the occupied nests is that they expose in SW or NW orientation.

Occupied nests forming two groups are characterized by a dense forest stands with high trees. The second group of nests have a south faced opening to their nests. The forest stand is dominated by a young medium of dense cedar forest.

CONCLUSION

It appears from this study that the Ruddy Shelduck do a careful selection of cedar trees to construct its nest.

The mesological parameters, mainly topographic, geomorphic and morphometric are decisive in the choice of the location of the nests.

Of all the density and diversity of the forest strand around the nesting tree, tree age (standby forests), the South West and South East orientation nests and the type of vegetation and ground flush trees remain the most predictors of nest locations.

The holes on the trees, unoccupied in forests around the lakes, have many similarities with occupied nests. Thus, they remain as potential nests for possible future nesting of Ruddy individuals.

To ensure the sustainable management of ecological habitats of Ruddy, it is recommended to include ruddy in the plans of management and development of these forests; their breeding areas are often forests around the lakes of the Middle Atlas and hence it should be protected.

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ANNEXURE

Table (Appendix 1): Terms of mesological assigned to the parameters of the 22 nests

Nests	Everything	Or	Hn	Oh	Ov	P	And	C1.30	Ht	D	Comp	At	Ns
NA1	1840	The	19.0	30	25	70	65	4.10	21.0	M	CQ	Cf	H
Na2	1827	And	18.0	25	34	60	55	4.00	24.0	M	CQ	Cf	C
Na3	1820	S	13.5	36	26	80	70	6.60	26.0	M	CQ	Cf	H
Na4	1869	And	15.8	20	30	180	60	4.00	22.5	M	CQO	Cf	C
NA5	1875	N	08.5	32	20	200	60	4.00	22.0	M	CQO	Cf	HC
On6	1896	And	14.5	29	33	29	70	5.10	25.0	M	CQO	Cf	H
NA7	1897	And	07.3	25	22	40	130	3.36	12.5	M	CQ	Cf	C
NA8	1839	S	20.0	32	30	65	60	4.60	25.0	And	CQ	Cf	H
Na9	2018	S	25.0	28	30	75	66	6.10	29.0	M	CQ	Cf	H
NA10	1818	The	15.0	34	32	81	68	3.60	26.0	M	C	Cf	H
Ns11	2222	And	08.0	24	35	110	53	4.11	14.0	F	CQO	Vf	C
NS12	2240	S	07.0	45	33	140	80	4.90	12.0	F	CQ	Vf	H
Ns13	2140	S	05.0	28	32	45	56	4.20	14.0	F	CQ	Vf	C
NA14	2112	The	08.0	40	80	80	80	3.90	18.0	M	CQ	Vf	H
NA15	2112	The	10.0	40	60	50	70	3.90	18.0	M	CQ	Vf	H
NA16	1863	The	13.0	50	30	30	30	4.60	17.0	M	CQ	Vf	H
NA17	1831	The	15.0	20	10	10	15	5.80	20.0	M	CQ	Vf	H
An18	1848	The	10.0	80	30	100	30	5.30	14.0	M	CQ	Vf	H
Na19	1817	And	11.0	80	40	80	25	5.20	15.0	M	CQ	Vf	H
Ns20	2151	N	03.5	44	50	40	70	4.50	12.0	F	CQO	Vf	C
Ns21	2178	And	08.0	30	40	15	10	5.00	12.0	F	CQO	Vf	H
Ns22	2166	The	08.0	60	50	50	30	6.00	15.0	F	CQO	Vf	HC

Table (Annex 2): Location and status of the nests

Nests	Lakes	Busy / empty
NA1	Afennourir	Busy
Na2	Afennourir	Busy
Na3	Afennourir	Busy
Na4	Afennourir	Busy
NA5	Afennourir	Busy
On6	Afennourir	Busy
NA7	Afennourir	Busy
NA8	Afennourir	Busy
Na9	Afennourir	Busy
NA10	Afennourir	Busy
Ns11	Sidi Ali	Busy
NS12	Sidi Ali	Busy
Ns13	Sidi Ali	Busy
NA14	Afennourir	Empty
NA15	Afennourir	Empty
NA16	Afennourir	Empty
NA17	Afennourir	Empty
An18	Afennourir	Empty
Na19	Afennourir	Empty
Ns20	Sidi Ali	Empty
Ns21	Sidi Ali	Empty
Ns22	Sidi Ali	Empty

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