

Status, Habitat Use, and Behaviour of Wintering Greater Flamingos *Phoenicopterus roseus* in Semi-Arid and Saharan Wetlands of Algeria

E. Bensaci, M. Saheb, Y. Nouidjem, A. Zoubiri, A. Bouzegag, M. Houhamdi

Abstract—The Greater flamingo is considered the flagship species of wetlands across semi-arid and Saharan regions of Africa, especially Chotts and Sebkhass, which also concentrate significant numbers of bird species. Flamingos have different status (wintering and breeder) which vary between sites in different parts of Algeria. We conducted surveys and recorded banded flamingos across distinct regions within two climatic belts: semi-arid (Hauts Plateaux) and arid (Sahara), showing the importance of these sites in the migratory flyways particularly the relation between West Mediterranean and West Africa populations. The distribution of Greater flamingos varied between sites and seasons, where the concentrations mainly were in the wide, lees deep and salt lakes. Many of the sites (17) in the surveyed area were regularly supporting at least 1% of the regional population during winter. The analysis of Greater flamingos behaviour in different climatic regions in relation showed that the feeding is the dominant diurnal activity with rates exceeding 60% of the time. While feeding varies between seasons, and showed a negative relationship with the degree of disturbance.

Keywords—Algeria, greater flamingo, *Phoenicopterus roseus*, Sahara, semi-arid.

I. INTRODUCTION

THE population of Greater Flamingo *Phoenicopterus roseus*, in the Western Mediterranean occupies mainly brackish and salt areas (lagoons, salt pans, etc.) and breed in colonies of up to several thousands of couples distributed around the Mediterranean Sea [1]. Previously, North Africa has traditionally been known as a wintering ground or a kind of "crèche" for immature flamingos [2].

In Algeria, the species has been considered as wintering with a total not exceeding 5000 birds [2]. Many reasons were prevented to study and update our knowledge on the status and distribution of this species in Algeria such as the lack of local ornithologists, the vastness of continental wetlands and the difficulty of access to them.

From 2005, where the first successful breeding was

recorded at Garaet Ezzemoul (Eastern Hauts Plateaux) [3], the breeding was confirmed in other sites mainly in the Sahara [4]-[6]. On the other hand, the Greater Flamingo made many breeding attempts always in the Hauts Plateaux [7], [8] and in the Sahara [6].

Although, there are still substantial gaps in knowledge regarding the distribution, habitat use and behaviour of Greater flamingos through the wetlands dispersed in the arid and Saharan regions of Algeria during wintering season.

In this paper, we review the status, distribution and behaviour ecology of greater flamingos regarding environmental factors across semi-arid and Saharan regions of Algeria in the aim to provide a general idea of the key sites of flamingos wintering for eventual conservation measures.

II. STUDY AREA

Algeria is the largest country in Africa with a total area of 2,381,741 km², also the situation in the southern shore of Mediterranean basin in the African continent is characterized by a distinct latitudinal climatic gradient (subtropical, semi-arid and arid) from the north to the south of the country (Fig. 1).

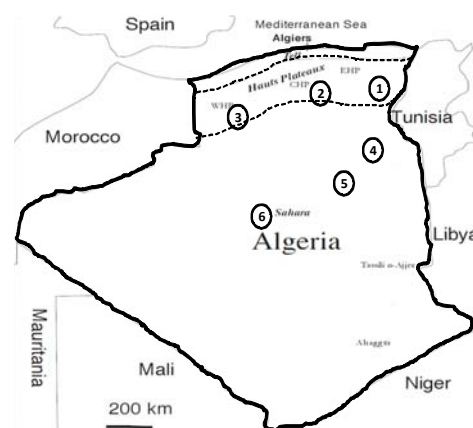


Fig. 1 Location of the surveyed regions across the Hauts Plateaux and the Sahara of Algeria. The three regions of the Hauts Plateaux are (1) Eastern Hauts Plateaux, (2) Central Hauts Plateaux, (3) Western Hauts Plateaux; the three regions of the Sahara are: (4) Oued Righ Valley, (5) Ouargla, and (6) El Goléa

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The Hauts Plateaux and the Saharan regions of Algeria occupy more 87% (80% and 7% respectively) of the total surface of the country. These regions characterized by

differentiation of combinations of rainfall, latitude and altitude that generate semi-arid climat in the Hauts Plateaux and an arid climate across the Sahara.

III. METHODS

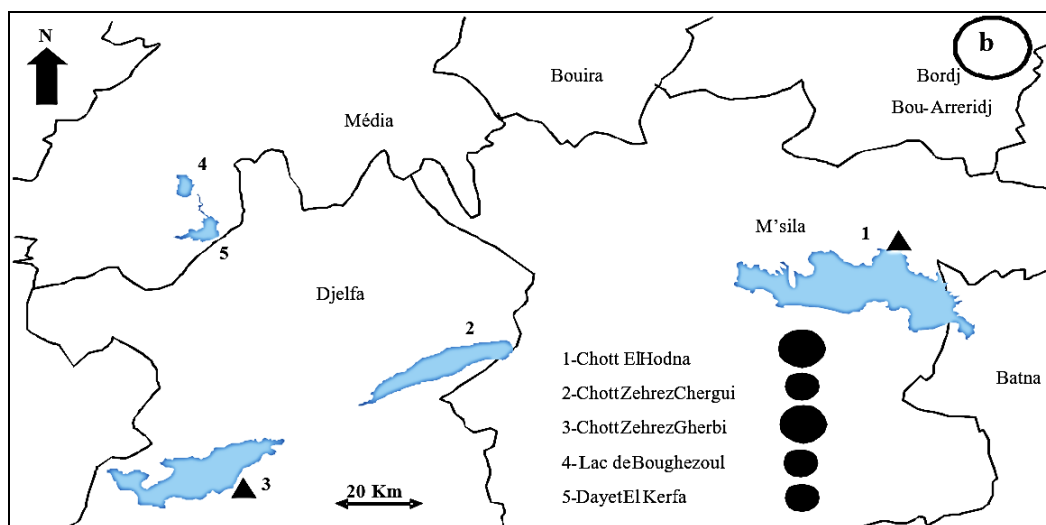
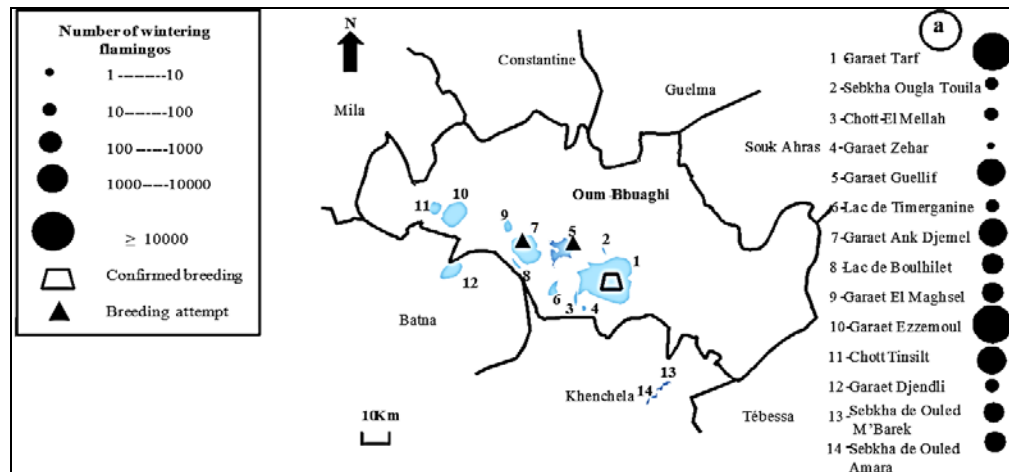
This contribution reports the results of the surveys of wintering Greater Flamingos in the Hauts Plateaux and the Saharan regions of Algeria between 2006 and 2011. A part of this survey was the Ph.D. thesis of members of the Laboratoire de recherche "Biologie- Eau & Environnement" (Algeria) in different regions of Algeria. A monthly survey was done in the Oued Righ valley, Western Hauts Plateaux, and Central Hauts Plateaux. Whereas the other wetland complex (El Goléa, Ouargla, and Eastern Hauts Plateaux) were visited each season.

In our search on the habitat use and behaviour of wintering Greater Flamingos, we focused on the Central High Plateaux (semi-arid) and the Oued Righ valley (Sahara).

The census of the Greater flamingos was done by direct observation using an Optolyth 20x80 telescope by a team of 5

to 2 observer from near the wetland in different observation points, where most of the surface area and the edge was visible, in the aim to identify and count all birds present [9]. Some sites were large salt lakes, at which it is difficult to obtain a complete count of the birds present (Chott Melghir and Chott Merouane).

With the aim to study the habitat use of wintering greater flamingos, environmental determinants were taken into account for each wetland used by flamingos mainly in the Central High Plateaux and Oued Righ Valley in 2007 and 2008. Six morphological parameters were measured: wetland area (WA), altitude (ALT), open water area ratio (OWA%), vegetation cover rate (VC%), water level fluctuation (WLF) and Water salinity (SAL). Wetland size, open water area, vegetation cover and open water area ratio were measured from aerial photos (1:5,000). These photographs were entered into a GIS program.



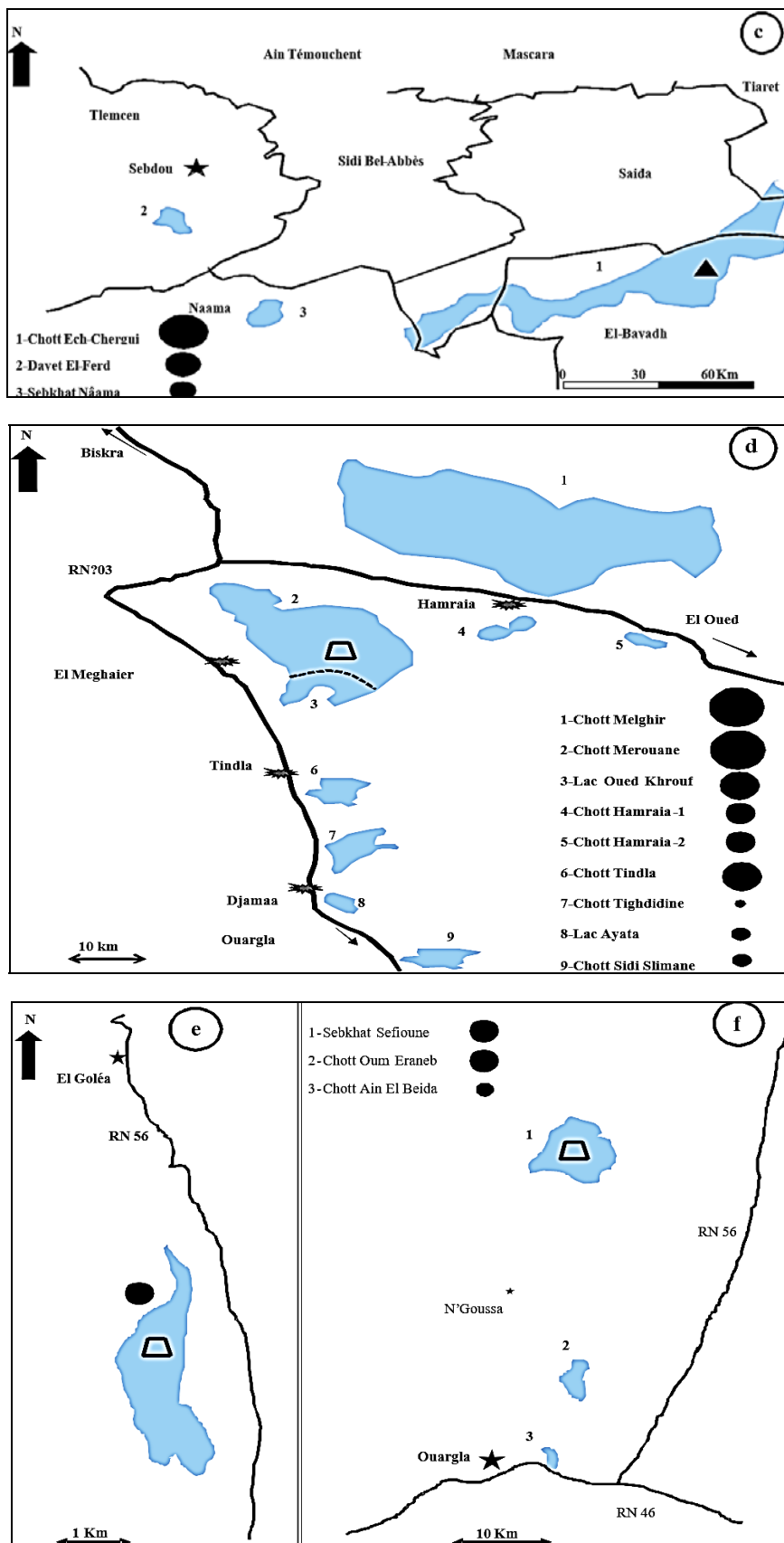


Fig. 2 Abundance distribution pattern of wintering Greater flamingos in the wetlands of the Hauts Plateaux and the Sahara of Algeria. Eastern (a) Hauts Plateaux, (b) Central Hauts Plateaux, (c) Western Hauts Plateaux, (d) Oued Righ Valley, (e) El Goléa, and (f) Ouargla

Behaviour of wintering Greater flamingos had also been followed in Oued Righ Valley and Central Hauts Plateaux. Its behaviour is divided arbitrarily into seven activities: feeding, walking, preening, sleeping, agonistic behavior, courtship, and flying.

Scan sampling method is the most appropriate for large wetlands, which requires that the behaviour of individuals in the sample be recorded instantaneously [10]. The activity budget studies utilising scan sampling involve surveying the entire local population at the time of sampling, that, e.g., all birds on a pond [11].

IV. RESULTS

A. Status and Wintering Distribution Pattern

Throughout the study area, the greater flamingos present the breeding and the wintering status which different from site to other. Our survey has shown the presence of flamingos during the winter period in the main Brakish and salt wetlands of the Hauts Plateaux and the Sahara, with high numbers particularly in the large area and restricted abundances in the small once.

Within all wetlands surveyed, thirty-five sites were used as wintering ground within four sites were considered till now as breeding area [3]-[6].

Gareat Ezzemoul and Gareat Guellif (EHP), Chott El Hodna (CHP), Chott Echergui (EHP), Chott Merouane and Chott Melghir (Sahara) are considered the important wintering areas which held the highest concentration of greater flamingos during the winter more than 10000 flamingos were recorded in each site (Fig. 2).

The analysis of geographical situations of confirmed breeding sites and nesting attempt sites in Algeria showed that in each wetland complex where many sites are adjacent, there is at least one site (the most difficult access and least disturbance) selected by flamingos as a nesting site.

Seventeen sites were regularly supporting at least 1% of the West Mediterranean population of Greater flamingo [12]. (Table I). Through our visits, the highest abundances of Greater flamingos were recorded during the months of November, December, and February.

TABLE I

STATUS OF GREATER FLAMINGOS ACROSS DIFFERENT REGIONS OF THE HAUTS PLATEAUX AND THE SAHARA

Region	Number of wetlands used for wintering flamingos	Number of wetlands held over 1% of biogeographic population	Number of breeding sites
Eastern Hauts Plateaux	14	5	1
Central Hauts Plateaux	5	2	0
Western Hauts Plateaux	3	2	0
Oued Righ Valley	9	4	1
Ouargla	3	3	1
El Goléa	1	1	1
Total	35	17	4

B. Ring Re-Sighting of Wintering Greater Flamingos

During our survey, particularly during wintering period, a total of 341 re-sightings of ringed flamingos were recorded only in the Sahara and the Central Hauts Plateaux (166 and 83

respectively), 249 bands were confirmed by their detailed life history received from different ringing centers through the Mediterranean basin: France, Italy, and Spain (Fig. 3).

The analyses of rings origin shown that the dominated observed rings in the Sahara were from France (56%) followed by those from (Spain 23%, Italy 15% and Algeria 6%), whereas in the Central Hauts Plateaux the resightings of banded flamingos were reported the dominance of Spanish rings (62.65%) followed by rings of other countries (France 21.69% and Italy 15.66%), when any Algerian ring was observed in this part of country. Elsewhere, the analysis of observed rings showed that 32% of them were observed previously in Algeria especially in the eastern Hauts Plateaux (76%). In fact, 1.6% of resighting rings have been seen in Turkey and Guinea-Bissau.

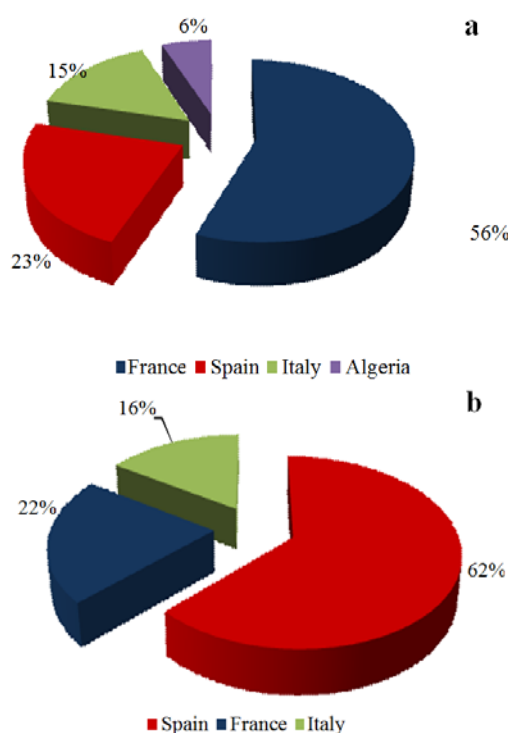


Fig. 3 Origin of sighted rings during wintering period: (a) Sahara, (b) Central Hauts Plateaux

C. Habitat Use by Wintering Greater Flamingos

The principal components analysis (PCA) of morphological characteristics of studied wetlands showed significant differences between sites. First and second axes of the PCA plotted in Fig. 4, explained 79.22% (57.22 x 21.97 respectively) of the total variance.

Chott Merouane, Chott Meghir, Chott Tindla, Chott Hamraia 2, Chott El Hodna, and Dayet El Kerfa (as shown in Fig. 4 (a)) are separated along the second axis from all other wetlands. These are characterized by the highest values of open water area ratio, wetland area and water salinity (Fig. 4 (b)). Whereas Lac Ayata, Chott Hamraia 1, Lac Oued Khrouf and Lac de Boughezoul are dispersed along the positive direction of the first axis which are characterized by the high values of vegetation cover rate, altitude and water level.

Results of the simple linear regression analysis shown that only three environmental variables were significantly correlated with flamingos' abundance. The wetland area and water salinity was positively correlated with the abundance ($r=0.69$ and $r=0.51$ respectively), while the abundance was negatively correlated negatively with the water level ($r=-0.51$). The other morphological characteristics (open water area, vegetation cover rate and the altitude) were weakly correlated with flamingos' abundance ($r=0.41$, $r=-0.43$, and $r=-0.31$ respectively).

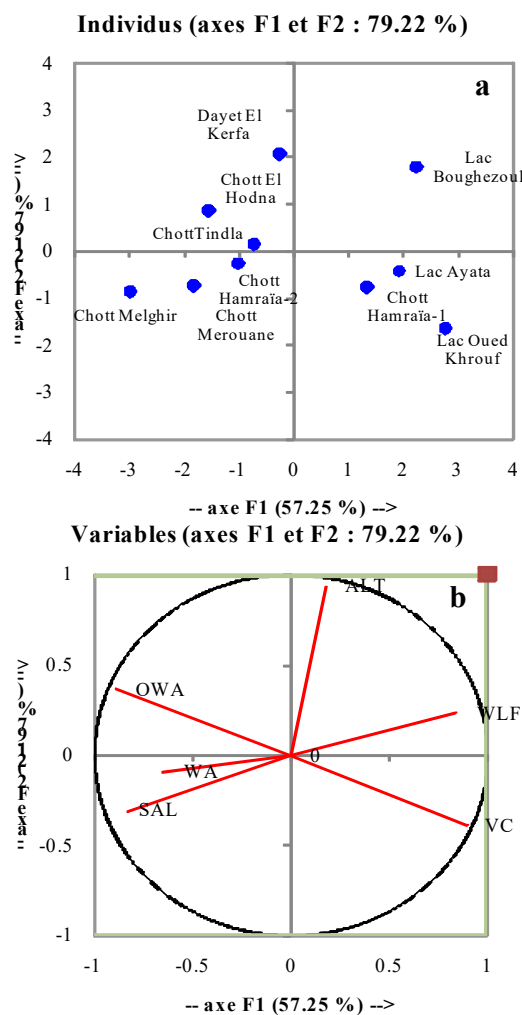


Fig. 4 (a) Principal components analysis of studied wetlands, (b) principal components analysis of morphological characteristics. WA: wetland area, ALT: altitude, OWA: open water area, VC: vegetation cover, VLF: water level fluctuation, SAL: water salinity

D. Behavior Ecology

The diurnal time budgets recorded for Greater flamingos in the two study regions; Oued Righ Valley and Central Hauts Plateaux (2007/08 and 2008/09), indicate that the birds devoted over half their time to feeding ($66.29 \pm 10.48\%$ and $69.09 \pm 0.95\%$ respectively). This last activity was followed by sleeping, preening, walking, agonistic behavior, courtship and flying in the Oued Righ Valley. However, the feeding was followed by walking, sleeping, preening, agonistic behavior,

flying and courtship in the Central Hauts Plateaux (Table II).

At both of the regions, feeding was significantly the dominant diurnal activity ($F_{6,96}=192.04$, $P<0.0001$ at Oued Righ Valley and $F_{6,96}=28.10$, $P<0.0001$ at Central Hauts Plateaux).

Not significant differences were found in the time allocated to different activities between the two regions ($\chi^2=4.3$, $P>0.05$). Temporal changes in the time spent in feeding displayed a similar pattern, with a high value of 74% (Central Hauts Plateaux) and 69.5% (Oued Righ Valley) during the early wintering period, followed by a decrease in feeding activity to 57% (Central Hauts Plateaux) and 62.2% (Oued Righ Valley) of diurnal time in late winter and spring.

TABLE II
 MEAN PERCENTAGE OF DIURNAL TIME SPENT BY GREATER FLAMINGOS ON DIFFERENT ACTIVITIES AT OUED RIGH VALLEY AND CENTRAL HAUTS PLATEAUX DURING WINTER.

Activity %	Oued Righ Valley		Central Hauts Plateaux	
	Mean	SD	Mean	SD
Feeding	66.29	10.48	69.09	0.95
Sleeping	10.79	1.49	8.22	1.61
Flying	2.31	0.01	2.06	0.32
Walking	6.19	3.12	12.28	0.02
Courtship	2.52	2.13	1.73	0.67
Agonistic behaviour	2.81	1.85	2.48	0.76
Preening	9.11	4.89	4.12	0.85

V. DISCUSSION

The variety of status and distribution of the Greater flamingos confirm the results reported in the former studies on the key roles played for the conservation of the Mediterranean flamingo metapopulation by Algerian wetlands, particularly those of semi-arid and Saharan regions as potential wintering grounds [13], [14] and as breeding area [6], [15].

Our results of rings resightings led us to start understanding the distribution of wintering flamingos originated from north-western Mediterranean colonies in Algeria. Where, the banded birds originate mainly from the Camargue (France) came in the first place, followed by those from Fuente de Piedra (Spain), Italy and Algeria in the Sahara (eastern of Algeria), which is similar to that found in Eastern Hauts Plateaux [16].

While in the Central Hauts Plateaux, the banded birds mainly originated from Spain in the first position followed by those from the Camargue (France). This distribution pattern of these birds suggests that the central and the western wetlands of Algeria are structured into Spain-to-Mauritania flyway [17] which need depth monitoring for confirmation. The observation of flamingos has been seen before in Turkey and Guinea-Bissau during wintering period shows the importance of Saharan wetlands in the linking between East Mediterranean and West Africa populations.

Wetland area, open water area ratio and water salinity of the habitat were the most important features that affected wetland flamingos' abundance. Many studies conducted in wetland ecosystems have demonstrated the importance of habitat area [17]. The high proportion of feeding activity may be explained

by the requirement of these birds to accumulate large amounts of body storage to meet their energy needs of long journeys and prepare the breeding period.

VI. CONCLUSION

Protective measures are needed for the Hauts Plateaux and Saharan wetlands, as these habitats are vulnerable to hydrological changes and human management. In the future, we aim to stretch the tasks started in the East of Algeria to the Sahara, Central and Western Hauts Plateaux by different actions such as monitoring and environmental education programs using this flagship species. However, some aspects deserve greater emphasis, like the factors affecting the distribution of the Greater Flamingo in Algeria, and the effect of climate changes and anthropogenic activities on the conservation of this species.

Our results also confirmed that the wintering Greater flamingos in Algeria seem to prefer the salt, less depth, and large wetlands than brackish, deep and small ones which is similar to their main distribution area in Mediterranean basin [13], [18], [19]. Additionally, we found that bird abundance was best predicted by water level fluctuation and wetland area, according to [20]. However, it's appeared that the open water area ratio, the vegetation cover rate, and the altitude did not have significant effects on the flamingos' abundance.

The dominance of feeding activity in the diurnal behavior of Greater flamingos in the two study regions, similarly to that previously reported by [21], [22].

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REFERENCES

- [1] A. Johnson, "Eco-ethology of Greater Flamingos in Camargue and in the West Palearctic" *Etho-écologie du Flamant, rose (Phoenicopterus ruber roseus Pallas) en Camargue et dans le l'Ouest paléarctique*. Ph.D. Thesis. Université Paul Sabatier, Toulouse (France), 1983. 343p.
- [2] P. Isenmann, and A. Moali, "Birds of Algeria" *Les Oiseaux d'Algérie*. Société d'Etudes ornithologiques de France, Paris, 2000. 336p
- [3] B. Samraoui, A. Ouldjaoui, M. Boulkhssaim, M. Houhamdi, M. Saheb, and A. Béchet, The first recorded reproduction of the Greater Flamingo *Phoenicopterus roseus* in Algeria: behavioral and ecological aspects. *Ostrich*, 77, vol 4, 153-59. 2006
- [4] A. Bouzid, A. Yousfi, M. Boulkhssaim, and B. Samraoui, "First success breeding of Greater Flamingos in the Algerian Sahara" Première nidification réussie du Flamant rose *Phoenicopterus roseus* dans le Sahara algérien. *Alauda*, 77: 139-143. 2009.
- [5] N. Bouchibi Baaziz, A. Bouzid, M. Boulkhssaim, A. Ouldjaoui, N. Baaziz, A. Bouchecker, and B. Samraoui, A new nesting site for the Greater Flamingo *Phoenicopterus roseus* in the Algerian Sahara and an account of the in the Algerian Sahara and an account of the 2010 breeding season. *Flamingo, Bulletin of the Flamingo Specialist Group*, 18, 71-75. 2010
- [6] E. Bensaci, A. Bouzegag, E. Guergueb, C. Bounab, H. Brahmia, Y. Nouidjem, A. Zeraoula, L. Bouaguel, M. Saheb, S. Metlaoui, B. Mayache, Z. Bouslama, and M. Houhamdi, "Chott Merouane: A new breeding site of Greater Flamingo" Chott Merouane (Algérie): un nouveau site de reproduction du Flamant rose *Phoenicopterus roseus*. *Flamingo, Bulletin of the Flamingo Specialist Group*, 18, 33-37. 2010.
- [7] B. Samraoui, M. Boulekhsaim, A. Bouzid, E. Bensaci, C. Germain, A. Béchet, and F. Samraoui, Current research and conservation of the Greater Flamingo *Phoenicopterus roseus* in Algeria. *Flamingo Special Publication, Proceedings of the IV International Workshop on Greater Flamingo in Mediterranean region and Northwest Africa* 20-25. 2009.
- [8] F. Baghdadi, M. Saheb, B. Mayache, Y. Nouidjem, E. Bensaci, A. Bouzegag, E. Guergueb, K. Oudihat, and M. Houhamdi, "The Greater Flamingos in the West of Algeria: a failure breeding attempts Chott Ech-Chergui (El-Bayadh) -Submitted for publication" *Le Flamant rose Phoenicopterus roseus dans l'Ouest Algérien: tentative de nidification échouée dans le Chott Ech-Chergui (El-Bayadh)*. *Flamingo, Bulletin of the Flamingo Specialist Group*, 19.
- [9] C. Bibby, N. Burgess, and D. Hill, *Bird Census Techniques*. Academic Press Limited, London. 1993.
- [10] J. Althmann, "Observational study of behavior: sampling methods". *Behaviour*, 4: 227-267. 1974
- [11] S.E. Adair, J. L. Moore, W.H. Kiel, "Wintering diving duck use of coastal ponds: an analysis of alternative hypotheses". *Journal of Wildlife Management*, 60, 83-93. 1996.
- [12] A. Béchet, Greater Flamingo Population in the Western Palearctic and their Estimated Sizes in 2005. *Flamingo Specialist Newsletters*, 13- 22. 2005.
- [13] M. Houhamdi, E. Bensaci, Y. Nouidjem, A. Bouzegag, M. Saheb, and B. Samraoui, "Eco-ethology of wintering Greater Flamingos in the Oued Righ Valley" *Eco-éthologie des Flamants roses Phoenicopterus roseus hivernants dans la Vallée de Oued Righ, Sahara oriental algérien*. *Aves*, 45, vol 1, 15-27. 2008.
- [14] E. Bensaci, "Eco-ethology of wintering Greater Flamingos in the Oued Righ Valley" *Eco-éthologie du Flamant rose Phoenicopterus roseus dans la Vallée d'Oued Righ (Sahara oriental algérien)*. Ph.D. Thesis in Biological Sciences. Université de Guelma (Algérie). 126p. 2011.
- [15] F. Samraoui, M. Boulkhssaim, A. Bouzid, N. Baaziz, A. Ouldjaoui, and B. Samraoui, « The Breeding of Greater Flamingos in Algeria » La reproduction du Flamant rose *Phoenicopterus roseus* en Algérie (2003-2009), *Alauda*, 78:15-25. 2010.
- [16] A. Bouchecker, B. Samraoui, R. Prodon, J. Amat, M. Rendón-Martos, N. Baccetti, F.V. Esquerre, S. Nissardi, Ö. Balkiz, C. Germain, M. Boulkhssaim, and A. Béchet, Connectivity between the Algerian population of Greater Flamingo *Phoenicopterus roseus* and those of the Mediterranean basin, *Ostrich: Journal of African Ornithology*, 82:3, 167-174. 2011.
- [17] Y. Diawara, A. Arnaud, C. Mohamed, and A. Béchet, "Monitoring of the Greater flamingo *Phoenicopterus roseus* in Mauritania". *Flamingo Special Publication, Proceedings of the IV International Workshop on Greater Flamingo in Mediterranean region and Northwest Africa* 34-36. 2009.
- [18] S. Cramp, (Ed.) "Handbook of the birds of Europe the Middle East and North Africa: The birds of the Western Palearctic. Vol. 1": *Ostrich Ducks*. The Royal Society for the Protection of Birds, Oxford University Press, Oxford. 722 pp. 1977.
- [19] A. R. Johnson, and F. Cézilly, *The Greater Flamingo*. Poyser, Londres. 2007.
- [20] A. Froneman, M. Mangnall, R. Little, and T. Crowe, "Waterbird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa." *Biodiversity and Conservation*, 10: 251-270. 2001.
- [21] J. Boukhriss, S. Selmi, A. Béchet, and S. Nouira, "Vigilance in Greater Flamingos Wintering in Southern Tunisia: Age-Dependent Flock Size Effect" *Ethology*, 113: 377-385. 2007
- [22] L. Bouaguel, M. Saheb, E. Bensaci, S. Bougoudjil, Z. Bouslama, and M. Houhamdi, "Status and Diurnal Behavior of the Greater Flamingo *Phoenicopterus roseus* in Algerian Eastern High Plains". *Annals of Biological Research*, 4, 8:232-237. 2013.