Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2020, 10 (2), 33-39, doi: 10.15421/2020_60

RESEARCH ARTICLE

Assessments of physico-chemical parameters of Garaet Hadj Tahar wetland and their effect on waterbirds settlement

Y. Bara[1,2], M. Bara[3*], M. Bensouilah[4], M. Saheb[2], S. Atoussi[3], M. Houhamdi[3]

[1]Laboratoire Ressources Naturelles et Aménagement des Milieux Sensibles, University of Oum El-Bouaghi, Algeria

[2]Departement of Natural and Life Sciences, University of Oum El-Bouaghi, Algeria

[3]Laboratoire Biologie, Eau et Environnement (LBEE). Faculté SNV-STU, Université 8 Mai 1945 Guelma. BP. 401 24000 Guelma (Algeria)

[4]Laboratoire Ecobiology for Marine Environments and Coastal Areas, University of Annaba, Algeria

Corresponding author E-mail: mouslim.bara@gmail.com

Received: 13.03.2020. Accepted: 13.04.2020

This topic presented the relationship between physicochemical parameters and waterbirds assembling at Garaet Hadj Tahar (occidental Numidia, northeast of Algeria). Our data were collected from January 2018 to December 2018. Five physical parameters and four nutrient parameters, were measured at this wetland. We have noted 35 waterbirds species belonging to eleven family. All waterbirds of this wetland listed as least concern according to IUCN red list, except the three Anatidae key species with a conservation statuts: *Aythya nyroca* (near threatned), *Oxyura leucocephala* (endangered species) and *Marmaronetta angustirostris* (vulnerable). The maximum values of abundance, species richness, Shannon diversity index and Simpson diversity index were noted in wintering period but not for the Pielou's evenness index. Only five physicochemical parameters influenced the waterbirds population assembling at this wetland. Garaet Hadj Tahar wetland must getting more conservation interest and surveys in order to maintain the biodiversity of this hotspot wetland.

Keywords: Wetland; Physicochemical; Numidia; Waterbirds; Garaet Hadj Tahar

Introduction

The coexistence of many waterbirds species is favored by availability of resources and productivity (Gatto et al., 2008). This productivity and availability is determined by the variability in physicochemical factors of site-selected, such as: electric conductivity of the wetlands, water depth and presence of muddy shoreline (Brandolin & Blendinger, 2015). So, the criteria of site-selection were determined by biological and environmental parameters and variables (Wiens, 1989; Ewers & Didham, 2006; Lindenmayer & Fisher, 2006; Haddad et al., 2015; Fahrig, 2017). In this context, it is extremely important to understand ecosystem plasticity according to variability in environmental parameters. For example: Alonso et al., (1991) reported that physical features and food availability were related to habitat selection of white storks (*Ciconia ciconia*). Waterbirds which are described by Hoyer (2013), used wetlands for many functions: wintering/breeding, roosting/feeding (Keke & Elizabeth, 2018). In heterogeneous environments waterbirds develop alternative fitness and adaptation (Relyea, 2002). These alternative functions allow temporal change in waterbirds assembling (Cody, 1985).

The wetland: Garaet Hadj Tahar is situated in a main bird's flyway which switched between two important migratory bird areas: the central and south of Europe and the Sahara desert and Sahel region (Bezzala et al., 2019). It produces a significant habitats heterogeneity and resources which providing this pond available for stopover, resting, feeding, nesting and roosting for many waterbird species. In North African wetlands (especially in occidental Numidia), the main waterbirds settlement studies were focused only on structure, composition and distribution (Metallaoui & Houhamdi, 2010; Elafri et al., 2016; Bara & Segura, 2019), but data focused on the effect and/or consequences of physicochemical conditions of wetlands have not been thoroughly studied. In this topic, we addressed the following questions: (i) Does physicochemical parameters of the Garaet affect the waterbirds abundance? (ii) How these parameters change this settlement?

Materials and Methods

Study area

Garaet Hadj Tahar (Figure 1; 36°51′ N, 7°15′ E) is a freshwater wetland of Guerbes-Sanhadja complex (western Numidia, Skikda province/northeast of Algeria), inside agricultural landscape receiving farming and organic pollution (Bara & Segura, 2019). This wetland is classified as Ramsar site and important area birds (IBA). Garaet Hadj Tahar is filled by colluvial landslides which give a surface area about 100 ha (become 75 ha under warming conditions and local water pumping). Samraoui & De Belair (1997) noted 89 plant species in this natural site, stratified in four belts around the open water. These plant species are: hydrophytes (mainly Potamogetonaceae and Nympheaceae) which cover 50% of the area, amphiphytes (mainly *Phragmites australis* and *Scirpus lacustris*) which cover 25% of this area and hygrophytes (mainly Betulaceae *Alnus glutinosa*) which cover 25% of this area (Samraoui & De Belair, 1997). The climate in this area is situated in a sub humid stratum. According to Köppen's classification, Skikda is situated in Mediterranean climate (Csa) with a mild climate and hot summers, a maximum air temperature was recorded in

August (34°C) and the minimum in February (6°C). The annual rainfall was 754.51 mm and the mean windy speed was 16.08 Km/h. The quotient of Emberger is 95.14 (Stewart, 1968), the De Martonne's index is 26.32 and the humidity index is 85%.

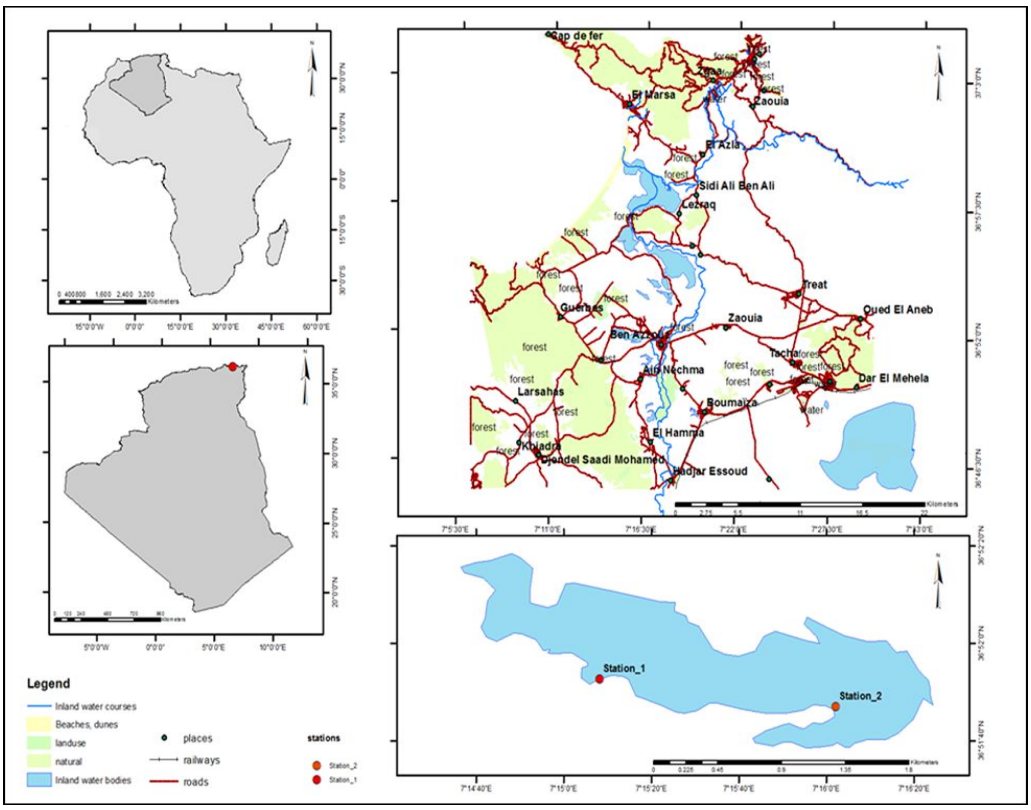

Figure 1. Geographical situation of Garaet Hadj Tahar (Guerbes-Sanhadja, northeast of Algeria).

Data sampling

Our waterbirds counts were carried out twice-monthly from January 2018 to December 2018 in Garaet Hadj Tahar. Due to its shape, two sampling points situated in north and south shore were selected. We used a new approaches of IPA (punctual abundance indices), a methods called PFS (progressive frequency sampling). This technic is derived from IPA making use frequency of occurrence of each species per unit-time of 20 minute (Blondel, 1975). Two observers noted simultaneously a partial IPA (PFS) during 20 minute in each point, remember that IPA unite=PFS (in sampling point 1) + PFS (in sampling point 2). Also, We have calculated abundance (A), Species richness (S), Shannon-Weaver indices: H'= (Σ Pi x log Pi), Simpson diversity indices: D=1/∑pi2, where pi is the proportional abundance of the i, given by Pi=ni/N, i varied between 1 and S, n=number of individuals of i species and N=total number of individuals (Shannon & Weaver, 1949; Dustan & Fox, 1996), and Pielou's Evenness indices E= H' / (log S) (Magurran, 1988). We have also noted Frochot constancy status, phenology status and conservation status of waterbirds settlements observed at Garaet Hadj Tahar (Table 1).

The physicochemical parameters

water temperature (WT), pH, Turbidity (Tur), electric conductivity (EC) and salinity (Sal) were measured *in situ* using a multi parameters (WTW Multi 350i, WTW GmbH - Germany) and suspended solid (SS) was measured using differential weighing methods (Rodier et al., 2009). The five nutrients parameters: nitrate (NO_3-N), nitrite (NO_2-N), ammonium (NH_4-N) and orthophosphate (PO_4-P) were dosed according to chemical method ISO (see ISO, 1994).

Data analysis

The Shapiro-Wilk test was applied on all variables in order to test the normality of distribution. Kruskal-Wallis test was used to compare between numbers of individuals of waterbirds during study period. Pearson correlation coefficients between abundance of waterbirds and physicochemical and between each physicochemical were calculated. Waterbirds settlements were distributed at Garaet Hadj Tahar by Gaussian distribution shown by humped curve, so multivariate regression by MANOVA test was fitted in order to identify the combined effect of physicochemical parameters on waterbirds abundance. All data are presented as Min/Max, Mean, standard deviation, median and coefficient of deviation. The results of all statistical testes are considered: non-significant (if $p > 0.05$), significant (if $p<0.05$) and highly significant (if $p<0.01$). The ecological analysis (Shannon, Simpson and Pielou's Evenness indices) was done using software Past 3.12 (2016) (Hammer et al., 2001). The statistical tests were done using software XLSTAT (2009.1.02).

Results

Abundance and richness of waterbirds settlements

The number of waterbirds in Garaet Hadj Tahar reached a maximum in late January (with a number of 14893 individuals), then the number decreased gradually until the last week of July (511 individuals) (figure 2). Our data revealed that the waterbirds settlements in this Garaet were formed by 35 species of 11 family. The richest family was *Anatidae* (11 species), following by *Ardeidae* and *Scolopacidae* (5 species), *Rallidae* (3 species), *Podicipididae*, *Recurvirostridae*, *Theskiornithidae* and *Laridae* (2 species) and finaly *Phalacrococidae*, *Sternidae* and *Phenecopteridae* with only 1 species (Table 1).

Table 1. Frochot, phenology and conservation statutes of waterbirds recorded in Garaet Hadj Tahar from January 2018 to January 2019.

Scientific nomenclature	Frochot constancy status*	Phenology status**	Conservation satus***
Podiceps cristatus		R	LC
Tachybaptusruficollis		R	LC
Bubulcus ibis		R	LC
Ardea alba		R	LC
Plegadisfalcinellus		VP	LC
Anas platyrhynchos		R	LC
Anas clypeata		R	LC
Aythyanyroca		R	NT
Fulicaatra		R	LC
Egrettagarzetta		R	LC
Oxyuraleucocephala	Constant statut	R	EN
Gallinulachloropus		R	LC
Larusmichahellis		R	LC
Ardea cinerea		R	LC
Anas crecca		WV	LC
Tringastagnatilis		R	LC
Anas strepera		WV	LC
Anas penelope		WV	LC
Aythyaferina		WV	LC
Phalacrocoraxcarbo		WV	LC
Aythyafuligula		WV	LC
Porphyrioporphyrio		R	LC
Ardeolaralloides		BV	LC
Himantopushimantopus		BV	LC
Recurvirostraavosetta	Accessorystatus	BV	LC
Chlidonias hybrida		BV	LC
Anas querquedula		BV	LC
Marmaronettaangustirostris		R	VU
Platalealeucorodia		PV	LC
Tringatotanus		R	LC
Larusridibundus		BV	LC
Phoenicopterusroseus	Rare statue	PV	LC
Calidris minuta		PV	LC
Tringaerythropus		R	LC
Gallinagogallinago		R	LC

***Frochot constancy status:** Constant status (recorded in more than 50% of observations), accessory status (between 50 and 25% of observations) and rare status (uncommon species, less than 25% of observations).
****Phenology status:** According to literary quotes. R: Resident, WV: Wintering Visitor, BV: Breeding Visitor, PV: Passage visitor.
*****Conservation status:** According to birdlife international data base. LC: Least Concern, NT: Near Threatened, EN: Endangered, VU: Vulnerable.

The richest month of our study was late January where 25 species were recorded (Figure 2). We have noted a significant difference between number of individuals of these 11 family (K=94.63, p-value <0.0001).

Shannon, Simpson and Pielou's Evenness indices

The temporal evolution of the two diversity indexes (Shannon H' and Simpsom D) and Pielou's Evenness is shown in Figure 3. We observed two distinctive periods, the first, was a crossing over between post-wintering and pre-nuptial period. This one which started in early march is marked by high values of Shannon and Simpson indexes (2.12 and 0.834). The second which characterized by arrival of wintering birds is marked by a second peak of these two indexes (2.08 and 0.846). The Pielou's evenness index reached maximum in early July, with a value of 0.448. hence, Shannon and Simpson indexes evolved in same trend of abundance curve, contrariwise, the Pielou's enenness and species richness curve involved inversely proportional. Note that, Pielou's evenness curve is marked by a light peak in March which coincide with the crossing over (post-wintering / pre-nuptial periods).

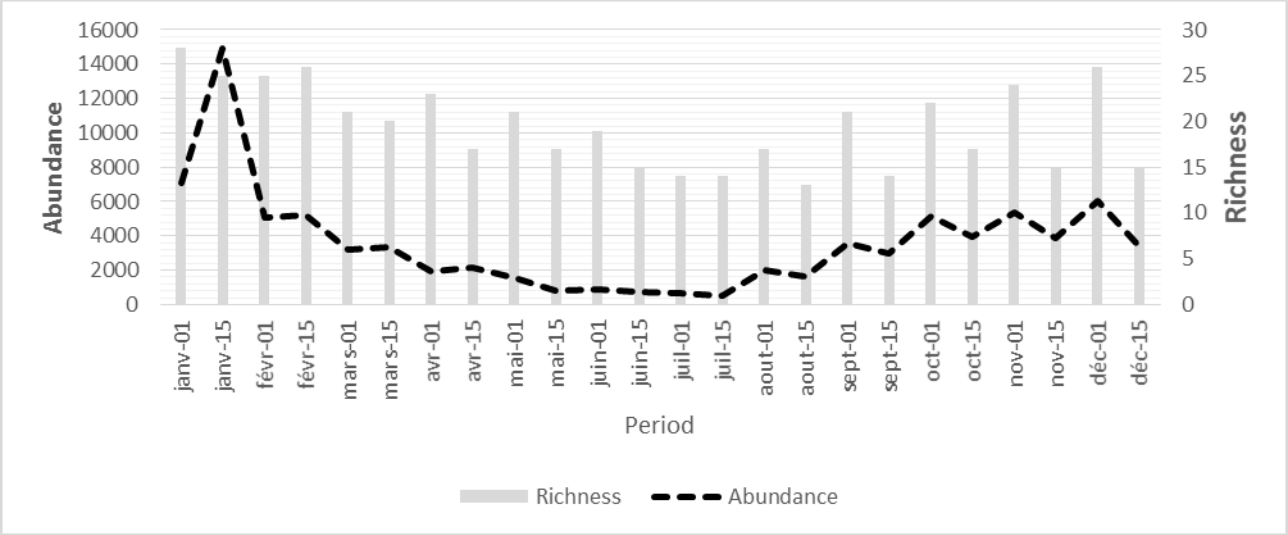

Figure 2. Abundance and species richness of waterbirds settlements at Garaet Hadj Tahar from January 2018 to December 2018.

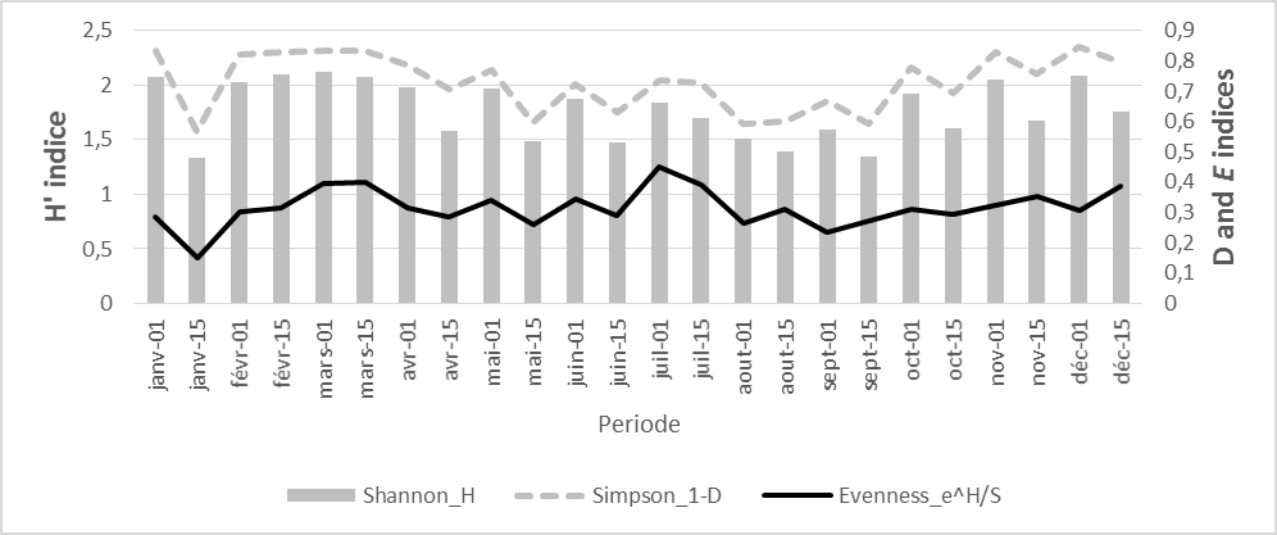

Figure 3. Monthly variation of Shannon (H'), Simpson (D) and Pielou's Evenness (E) indices at Garaet Hadj Tahar from January to December 2018.

Waterbirds settlements status

The most waterbirds recorded in Garaet Hadj Tahar had a constant status (dominant/frequent species) (21 species) which noted in more than 50% of all observation. Only seven species had either accessory status (auxiliary species) which noted in 25-50% of all observations, or rare status (uncommon species) which noted in less than 25% of all observations. Resident species represented 19 species in Garaet Hadj Tahar, wintering visitors represented 6 species, breeding visitors represented 6 species and passage visitors represented 4 species. According to birdlife international data, all waterbirds observed has least concern status (conservation status), except three species: *Aythya nyroca* (which is near threatned species), *Oxyura leucocephala* (which is endangered species) and *Marmaronetta angustirostris* (which is vulnerable species) (Tab.1; See Appendix).

Effect of physicochemical parameters on waterbirds assembling

The mean, min/max, standard deviation, median and coefficient of variation of the six physical parameters (water temperature, pH, electric conductivity, suspended solid, salinity and turbidity) and the four nutrients parameters (NO_3-N, NO_2-N, NH_4-N and PO_4-P) concentration measured at Garaet Hadj Tahar are summarized in Table 2. The waterbirds abundance at Garaet Hadj Tahar was significantly correlated to water temperature, pH, salinity, nitrate and nitrite (p-value<0.05) and correlation coefficient is summarized in Table 3. All environmental parameters are correlated at Garaet Hadj Tahar, and the significant correlation is summarized in Table 3. According to modeling regression (multiple regression: MANOVA), assembled environmental parameters did not effected the waterbirds abundance at Garaet Hadj Tahar (R^2=0.99, F=92.82, p=0.08062).

Discussion

Our data presented a new approach of waterbirds structure in wetlands of northeast Algeria. The relationship in this topic illustrated the effect of physicochemical parameters on waterbirds settlement. Many studies around the world associated limnological heterogeneity to the ecology and dynamic of birds (Dmitrenko et al., 2005; Polak & Kasprzykowski, 2010; Keke & Elizabeth, 2018). Our resulted considering physicochemical plasticity of Garaet Hadj Tahar as key components in structuring bird settlement.

Table 2. Mean, min/max, standard deviation, median and coefficient of variation of environmental parameters at Garaet Hadj Tahar from January 2018 to December 2018.

	WT	pH	CE	SS	Sal	Tur	NO_3	NO_2	NH_4	PO_4
Min	11, 2	7, 02	1084, 20	11, 22	0, 5	7, 89	1, 75	0, 16	1, 225	0, 94
Max	27, 6	7, 6	1848, 33	12, 82	0, 8	11, 42	2, 08	0, 36	2, 76	2, 1
Mean	19, 78	7, 28	1572, 19	12, 24	0, 60	9, 50	1, 91	0, 25	1, 78	1, 32
Stand. dev	5, 88	0, 17	266, 74	0, 45	0, 086	1, 21	0, 10	0, 055	0, 40	0, 37
Median	18, 3	7, 27	1688, 83	12, 43	0, 6	9, 38	1, 89	0, 25	1, 67	1, 27
Coeff. var	29, 7	2, 4	16, 96	3, 71	14, 1	12, 8	5, 27	22, 1	22, 8	28, 6

Table 3. Correlation matrix of physicochemical parameters and waterbirds abundance at Garaet Hadj Tahar from January 2018 to December 2018.

Variables	**WT**	**pH**	**EC**	**SS**	**Sal**	**Tur**	**NO_3**	**NO2**	**NH_4**	**PO_4**
Abundance	-0.71	-0.61	-0.54	-0.61	0.49	0.57	0.70	0.59	-0.29	-0.12
WT		0.68	0.79	0.72	-0.40	-0.17	-0.66	-0.56	0.10	-0.36
pH			0.54	0.65	-0.17	-0.03	-0.50	-0.35	-0.06	-0.13
EC				0.68	-0.49	-0.40	-0.82	-0.26	0.31	0.04
SS					-0.75	-0.03	-0.63	-0.62	0.17	-0.18
Sal						0.33	0.50	0.50	-0.53	-0.23
Tur							0.58	0.21	-0.76	-0.74
NO_3								0.47	-0.53	-0.17
NO_2									-0.47	0.21
NH_4										0.59

*: Bold values are significantly correlated with p-value < 0.05.

Our results show that 35% of all species recorded in Algerian wetlands were observed at Garaet Hadj Tahar. Amidst these species richness, six (06) species cited previously in Garaet Hadj Tahar were not observed at current study: Northern Lapwing *Vanellus vanellus*, Common Snipe *Gallinago gallinago*, Green Sandpiper *Tringa ochropus*, Common Sandpiper *Actitis hypoleucos*, Little Bittern *Ixobrychus minutus* red crested pochard *Netta rufina* (Metallaoui & Merzoug, 2009; Metallaoui & Houhamdi, 2010). Moreover, despite the low surface of this wetland (which covering only 100 ha), the Garaet is more diversify compared to neighboring fresh water marches. For example, Elafri et al. (2015) at lake Tonga (which covering 2.600 ha) listed only 52 species belonging to 13 family. Decreasing in number reported at the middle of July was explained by departure of breeding and wintering who delayed incoming at this 'Garaet'. This dynamic in arrival/departure of waterbirds was reported in many studies at the neighboring wetlands (in northeast part of Algeria). Second, geographical situation of Garaet Hadj Tahar offered heterogeneous stopover sites for waterbirds. In fact, this "Garaet" is crossing by Palearctic-trans-Saharan migrant's flyways and contribute as migratory stopover between Palearctic and Hauts plateau and Sahara wetlands of Algeria (Samraoui et al., 2011). We supposed that, three species observed frequently in this "Garaet" are originated from south-western Europe and Turkey. Therefore, flamingos, ibises and gulls of Garaet Hadj Tahar crossing this area during migratory period, hence, these birds were noted as passage visitors at Garaet Hadj Tahar. Habitat composition and various hydrophytes covering the "Garaet" also offered breeding availability and site-selection during nestling for many waterbirds (Bara et al., 2014), e.g. Squacco Heron *Ardeola ralloides*, Black-winged Stilt *Himantopus himantopus*, Pied Avocet Recurvirostra avosetta, Whiskered Tern *Chlidonias hybrida* and Black-headed Gull *Larus ridibundus* were noted as breeding visitors 'pers. comm.'.

We supposed that inter-months variability in number of individuals is explained by functional schema of waterbirds. The movement of waterbirds between Garaet Hadj Tahar and rest wetlands of Guerbes-Sanhadja complex is due to their ecological requirement especially diurnal activities (feeding, resting and sleeping). Tamisier (1978), reported that ducks and coots have a strong social organization leads to multi groups called: functional units "FU" which exploit separate geographical sectors to roost/feeding activities. This movement of FU is observed within months and also between consecutive months (Tamisier & Tamisier, 1981). So, the distribution of birds in functional schema is the result from a mixture of many factors such as site productivity, food resources and/or habitat structure and changes in water level (Carrascal et al., 2012; Ferger et al., 2014). According to all these factors waterbirds changed their diversity dynamic depending on these functional units (explained previously by diurnal activities; roost and/or feeding).

Palacio & Montalti (2013) reported that seasonal changes in species richness and abundance is attributed to the arrival of migratory species (our study case is: Anatidae, wintering frequently at this Garaet). The waterbird populations of Garaet Hadj Tahar is divided in two groups: the coots, moorhen, grebes and some ducks were observed during the whole study period. But, other species visited the "Garaet" occasionally, perhaps, owing to breeding or wintering (such as: gulls and flamingo).

In winter, this wetland became too deep/shallow owning to rising of coots, ducks and certain species abundance. It is known that ducks and coots have a diving behavior during feeding (Tamisier, 1974; McKnight, 1998). We noted that in early December Shannon and Simpson indexes reached maximum, it coincide with arrivals of wintering visitors and rare species (passage visitor incoming in this wetlands mainly in early December and in March). Demaya et al. (2019) reported that, this differences in diversity indexes between months could likely be referred to migration patterns of birds. We also noted that maximum values of Pielou's evenness is due to equitability in richness/abundance relation (Bara & Segura, 2019). At the middle of summer (all days of July),

Garaet Hadj Tahar is characterized by a regular uniformity (evenness) between number of individuals (abundance) and number of species (richness) of coots, moorhen and grebes which allow a high values of this index (Pielou's evenness).
Waterbirds assembling is also explicated by physicochemical parameters variation, such as water temperature, pH, suspended solids, nitrite and nitrate. These parameters depend on agricultural and human activities in this wetland, mainly photosynthetic activities of phytoplankton and N-cycling pathway. So, suspended solid, N-nutrients and orthophosphates can be explained by the recycling of sediment and dead matter at this wetland. For exemple, salinity reduce strongly waterbird settlement. We suggest that this factor can affected physiology and diet of birds. Hannam et al. (2003) reported that salt causes loss of bird's weight by dehydration. Ma et al. (2010) reported that salt also reduces the waterproofing of feathers, by increasing the energy cost of thermoregulation. Also, Brandolin & Blendinger (2015) reported that this salinity concentration affected plant and invertebrate species at the pond (which constitute the main diet of waterbirds) and can affected indirectly the use of this pond as foraging wetland. Moreover, the combination of factors such as: salinity, water temperature, suspended solid and nitrate/nitrite allow structuring of vegetation growth which determining waterbirds composition (mainly coots and ducks) (Brandolin & Blendinger, 2015). In our study area, waterbirds settlements was determined significantly by these water quality parameters, so ducks was influenced by salinity and nitrate/nitrite concentration and coots was influenced by water temperature and suspended solid.

Conclusion

In summary, waterbirds settlement reported in this study, in addition to its trend according to physicochemical parameters, allow us to highlight the importance of preserving the Garaet Hadj Tahar as a waterbird refuge during wintering and breeding period. So, this Garat is classified as an IBA and Ramsar site according to criteria A-1 (Garaet Hadj Tahar regularly holds three waterbirds with conservation concern and threatened status: white-headed duck, ferruginous duck and marbled duck) and attribute a functional schema for roost/feeding ground to many waterbirds (mainly ducks and coots). We strongly recommend to the government to finance more conservation projects and surveys in this wetland, in order to maintain this highly level of diversity and equitability. These conservation projects must combined two factors: protecting selected wetlands representative of the diversity of regional habitats and the urgent implementation of management actions at the local scale.

Acknowledgments

We are very grateful for all volunteers which helps us during the realization of this study, especially the riverine of Garaet Hadj Tahar locality.

References

Alonso, J.C., Alonso, J.A., & Carrascal, L.M. (1991). Habitat selection by foraging White Storks, Ciconia ciconia, during the breeding season. Can. J. Zool., 69, 1957-1962.
Bara, M., & Segura, N.L. (2019). Effect of Air Temperature and Water Depth on Bird Abundance: A Case Study of Rallidae and Anatidae in the Northeastern Algerian Garaet Hadj Tahar. Pakistan J. Zool., 51 (1), 211-217.
Bara, M., Merzoug, S.E., Khelifa, R., Bouslama, Z., & Houhamdi, M. (2014). Aspects of breeding ecology of the purple swamphen Porphyrio porphyrio in the wetland complex of Guerbes-Sanhadja, northeast of Algeria. Ostrich, 85, 185-191.
Bezzalla, A., Houhamdi M., Maazi M.C., & Chenchouni, H. (2019). Modelling climate influences on population dynamics and diurnal time budget of the Shelduck (Tadorna tadorna) wintering in Ramsar wetlands of Algeria. Avian Biology Research, 12 (3), 77-95.
Blondel, J. (1975). Analyse des peuplements d'oiseaux d'eau. Élément d'un diagnostic écologique. I : La méthode des échantillonnages fréquentiels progressifs (E.F.P). Terre et Vie, 29, 533-589.
Brandolin, P.G, & Blendinger, P.G. (2015). Effect of habitat and landscape structure on waterbird abundance in wetlands of central Argentina. Wetlands Ecol Manage, 24 (1), 93-105.
Cody, L.M. (1985). Habitat selection in birds. Academic press, INC. Harcourt Brace Jovanovich, publisher.
Carrascal, L.M., Seoane, J. & Villén-Pérez, S. (2012). Temperature and Food constraints in wintering birds an experimental approach in montane Mediterranean oakwoods. Commun. Ecol., 13, 221-229.
Demaya, S.G., Luiselli, L., Di Vittorio, M., Dendi, D., & Lado, F.T. (2019). Bird community structure across habitats in a protected area of South Sudan. African journal of ecology, 1, 1-5.
Dmitrenko, I., Kirillov, S., Eicken, H., & Markova, N. (2005). Wind-driven summer surface hydrography of the eastern Siberian shelf. Geophysical research letters, 32 (14), 1-5.
Dustan, C.E., & Fox, B.J. (1996). The effects of fragmentation and disturbance of rainforests on ground dwelling small mammals on the Robertson Plateau New south Wales Australia. J. Biogeogr, 23, 187–201.
Elafri, A., Halassi, I., & Houhamdi, M. (2016). Diversity patterns and seasonal variation of the waterbird community in Mediterranean wetlands of Northeastern Algeria. Zoology and Ecology, 26 (2), 85-92.
Ewers, M.R., & Didham, K.R. (2006). Confounding factors in the detection of species responses to habitat fragmentation. Biological reviews, 81 (1), 117-142.
Fahrig, L. (2017). Ecological Responses to Habitat Fragmentation Per Se. Annual reviews, 48, 1-23.
Ferger, S.W., Schleuning, M., Hemp, A., Howell, K.M., & Böhning-Gaese, K. (2014). Food resources and vegetation structure mediate climatic effects on species richness of birds. Glob. Ecol. Biogeogr., 23, 541-549.
Fishpool, L.D.C., & Evans, M.I. (2001). Important Bird Areas in Africa and associated islands: priority sites for conservation. BirdLife Conservation Series No. 11, Pisces Publications and BirdLife International, Newsbury and Cambridge, UK.
Haddad, M.N., Brudvig, A.L., Clobert, J., Davies, F.K., Gonzalez, A. et col. (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. Science advanced, e1500052.
Hammer, ø, Harper, D.A.T, & Ryan, P.D. (2001). PAST: paleontological statistics software package for education and data analysis. Palaeontologia Electronica, 4 (1), 9.
Hoyer, M.V. (2013). Lake Management and Aquatic Birds. Fish & wildlife management, 17, 17-20.
International Organization for Standardization. (1994). Environment: water quality. Chemical methods ISO Standards Compendium, Technical comity/147, Volume 2. 1st edition.
International Union for Conservation Nature. (2019). The IUCN red list of threatened species. Available at: http: //www.iucnredlist.org/technicaldocuments/spatial (accessed September 2019).

Keke, M.M, & Elizabeth, A.O. (2018). Aquatic bird assemblages of a tropical African man-made lake. Ukrainian Journal of Ecology, 8 (4), 41-45.
Lindenmayer, D.B., & Fischer, J. (2006). Habitat Fragmentation and Landscape Change: an Ecological and Conservation Synthesis. Island Press, Washington, D.C.
Magurran, A.E. (1988). Ecological diversity and its measurement. Princeton, NJ: Princeton University Press.
McKnight, K.S. (1998). Effects of food abundance and environmental parameters on foraging behavior of gadwall sand American coots in winter. Canadian Journal of Zoology, 76 (11), 1993-1998.
Metallaoui, S., & Merzoug, A.E. (2009). Wintering observation of red crested pochard Netta rufina beside Skikda (Algeria). Alauda, 77, 57.
Metallaoui, S., & Houhamdi, M. (2010). Biodiversity and ecology of aquatic avifauna wintering in Garaet Hadj Tahar (Skikda, northeast of Algeria). Hydroecol. Appl., 17, 1-16.
Palacio, X.F., & Montalti, D. (2013). Seasonal variation and effect of non-native invasive vegetation on two bird communities in northeast of Buenos Aires province, Argentina. Ornitologia Neotropical, 24, 157–168.
Polak, M., & Kasprzykowski, Z. (2010). Reproduction parameters of the Great Bittern Botaurus stellaris in the fish ponds of eastern Poland. Acta ornithological, 45 (1), 75-81.
Relyea, R.A. (2002). Costs of phenotypic plasticity. The American naturalist, 159 (3), 272-282.
Rodier, J., Leguebe, B., Merlet, N. et col. (2009). L'analyse de l'eau. Eaux naturelles. Résiduaires. Eau de mer. 9éme edition. Dunod. Paris, 1511p.
Samraoui, B., & De Belair, G. (1997). The Guerbes- Senhadja wetlands. Part I: An overview. Ecologie, 28, 233–250.
Samraoui, F., Alfarhan, A.H., Al-Rasheid, K.A.S., & Samraoui, B. (2011). An appraisal of the status and distribution of waterbirds of Algeria: indicators of global changes? Ardeola, 58 (1), 137-163.
Shannon, C.E., & Weaver, W. (1949). The mathematical theory of communication. Urbana, IL: University of Illinois Press.
Stewart, P.H. (1968). Quotient pluviothermique et dégradation biosphérique quelques réflexions. Bull. Soc, Hist Nat, Afr. N., 59, 23-36.
Tamisier, A. (1974). Etho-ecological studies of teal wintering in the camargue (Rhone Delta, France). Wildfowl, 25, 123-133.
Tamisier, A. (1978). Réalités et signification de l'organisation sociale chez les canards en période hivernale. Bull. Soc. Fr. Etude Comp. Animal, 2, 11-24.
Tamisier, A., & Tamisier, M.C. (1981). L'existence d'unités fonctionnelles démontrée chez les sarcelles d'hiver en camargue par la bio télémétrie. Rev. Eco., 35, 563-579.
Wiens, J.A. (1989). Spatial scaling in ecology. Functional Ecology, 3, 385-397.

Citation:
Bara, Y., Bara, M., Bensouilah, M., Saheb, M., Atoussi, S., Houhamdi, M. (2020). Assessments of physicochemical parameters of Garaet Hadj Tahar wetland and their effect on waterbirds settlement. *Ukrainian Journal of Ecology, 10* (2), 33-39.