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An ecological survey of Laro–limicolae in Northeastern Algeria

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Abstract

An ecological survey of Laro–limicolae in Northeastern Algeria. We conducted an inventory and characterization of Laro–limicolae settlement at three Ramsar sites located in Eastern Numidia (Lake Tonga, Lake Oubeira and El Mellah Lagoon) between 2014 and 2016. We identified 27 species belonging to six families, dominated by Scolopacidae (10 sp.) and Laridae (9 sp.) followed by Charadriidae (4 sp.), Recurvirostridae (2 sp.) and for Glareolidae and Haematopodidae families (1 sp.) Inventoried species exhibited different phenological status: resident (26 %), wintering (44 %), migratory breeders (19 %) and wintering/breeding (11 %). Population analysis showed the presence of protected species such as black–tailed godwit and Northern lapwing. Bird counts showed monthly variations in total abundance and richness, peaking during winter. Highest numbers were recorded in January and lowest numbers in August. Analysis of diversity and equitability indices indicated that maximum values (*H*' = 3.01 and E = 0.94) were noted at El Mellah Lagoon in November and at Lake Oubeira in June. Our study provides recent and unpublished data on a group of birds that are little–documented for North Africa, particularly for Algeria. Our findings open the way for further, more detailed work on the subject, and may serve to develop action plans for the management and conservation of these bird populations and their habitats.

Data published through GBIF (DOI: 10.15470/tehczv)

Key words: Laro–limicolae, Eastern Numidia, Inventory, Count, Ecological indices

Resumen

Estudio ecológico de aves larolimícolas en el noreste de Argelia. Entre 2014 y 2016 realizamos el inventario y caracterización del asentamiento de aves larolimícolas en tres sitios Ramsar ubicados en Numidia oriental (lago Tonga, lago Oubeira y laguna El Mellah). Identificamos 27 especies pertenecientes a seis familias dominadas por Scolopacidae (10 especies) y Laridae (9 especies), seguidas de Charadriidae (4 especies), Recurvirostridae (2 especies), Glareolidae (1 especie) y Haematopodidae (1 especie). Las especies inventariadas mostraron diferentes estados fenológicos: residentes (26 %), invernantes (44 %), criadores migratorios (19 %) e invernantes/reproductores (11 %). El análisis poblacional reveló la presencia de especies protegidas como la aguja colinegra y la avefría europea. Los recuentos de aves presentaron variaciones mensuales en la abundancia y riqueza totales, alcanzando su punto máximo durante el invierno. Las cifras más altas se registraron en enero y las más bajas en agosto. El análisis de los índices de diversidad y equidad indicó que los valores máximos (*H*' = 3,01 y E = 0,94) se registraron en la laguna El Mellah, en noviembre, y en el lago Oubeira, en junio, respectivamente. Nuestro estudio aporta datos recientes e inéditos sobre un grupo de aves que sigue estando muy poco o nada documentado en el norte de África y particularmente en Argelia. Abre el camino para un trabajo posterior y más detallado sobre el tema que servirá para desarrollar planes de acción para la gestión y conservación de estas poblaciones de aves y sus hábitats.

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Palabras clave: Larolimícolas, Numidia oriental, Inventario, Recuento, Índices ecológicos

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Resum

Estudi ecològic d'ocells larolimícoles al nord–est d'Algèria. Entre 2014 i 2016 vam portar a terme l'inventari i caracterització de l'assentament d'ocells larolimícoles en tres llocs Ramsar situats a la Numídia oriental (llac Tonga, llac Oubeira i llacuna El Mellah). Hi vam identificar 27 espècies pertanyents a sis famílies dominades per Scolopacidae (10 espècies) i Laridae (9 espècies), seguides de Charadriidae (4 espècies), Recurvirostridae (2 espècies), Glareolidae (1 espècie) i Haematopodidae (1 espècie). Les espècies inventariades van mostrar diferents estats fenològics: residents (26 %), hivernants (44 %), reproductors migratoris (19 %) i hivernants/reproductors (11 %). L'anàlisi poblacional va revelar la presència d'espècies protegides com ara el tètol cuanegre i la fredeluga europea. Els recomptes d'ocells van presentar variacions mensuals en l'abundància i la riquesa totals, amb un màxim durant l'hivern. Les xifres més altes es van registrar al gener i les més baixes a l'agost. L'anàlisi dels índexs de diversitat i equitat va indicar que els valors màxims (*H*' = 3,01 i E = 0,94) es van registrar a la llacuna El Mellah, al novembre i al llac Oubeira, al juny, respectivament. El nostre estudi aporta dades recents i inèdites sobre un grup d'ocells que continua estant molt poc o gens documentat al nord d'Àfrica i particularment a Algèria. Obre el camí per a un treball posterior i més detallat sobre la matèria que servirà per desenvolupar plans d'acció per a la gestió i conservació d'aquestes poblacions d'ocells i els seus hàbitats.

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Paraules clau: Larolimícoles, Númidia oriental, Inventari, Recompte, Índexs ecològics

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Introduction

Mediterranean coast wetlands constitute outstanding hotspots for numerous taxa in this region and are one of the richest places in the world in terms of waterbirds (Cuttelod et al., 2008). Each spring and autumn, billions of birds migrate between wintering and breeding grounds along well–established routes known as flyways (Barnagaud et al., 2019). Situated on the western Paleartic–African flyway, Eastern Numidia wetlands (North–East Algeria) play a very important role for many species of birds. During migration, the Eastern Numidia are the most important stopover sites for birds in Algeria (Samraoui and Samraoui, 2008). Migratory birds (particularly Charadriidae, Scolopacidae, Laridaes and several other families (hereafter, Laro–limicolae) are strict invertebrates or piscivores, and thus occupy a top–position in trophic networks, making them an important component of the dynamics of the wetland, and they are considered an efficient indicator of their ecological integrity (Burger, 1984; Boere et al., 2006; Amat and Green, 2010). Laro–limicolae occur on nearly every shoreline of the world and many other biotopes, with the exception of Antarctica (Cramp and Simmons, 1977). They are attractive birds, of economic and ecological importance, and accordingly, they are well–studied in some parts of the world (Stroud et al., 2006). Despite the protective measures that have been instituted around the world, most populations of Laro–limicolae show a declining trend (Boere et al., 2006). The reasons for such decline are diverse but are generally caused by loss of habitat or degradation (Zöckler et al., 2003). In Algeria, Laro–limicolae have benefited from the following two protective measures: (i) Decree 83–509, 20 August 1983, which covers protected non–domestic animal species; and (ii) Decree No. 12–235, 24 May 2012, that establishes a list of protected, non–domestic animal species. Nevertheless, the role of wetlands as Laro–limicolae diversity reservoirs remains relatively poorly known in this areas despite the studies carried out in the region to date (Heim de Balsac and Mayaud, 1962; Le Fur, 1975; Ledant et al., 1981; Boucheker et al., 2009), and information about Laro–limicolae phenology and richness in Eastern Numidia is scant, with the exception of a few studies describing waterbirds wintering and breeding patterns (e.g., Saheb et al., 2009; Maazi et al., 2010; Bourafa et al., 2018; Lazli et al., 2018; Bediaf et al., 2020; Loucif et al., 2020; Gherib et al., 2021).

Our study is the first to show the structure and migration phenology of Laro–limicolae in the North–Eastern Algerian wetlands, particularly in three Ramsar sites in the El Kala National Park. This study thus provides a new Laro–limicolae assessment of these sites. We aimed to increase our knowledge of Laro–limicolae migration in these poorly known North–African areas and to monitor abundances and species distribution in these sites. This is the first study to monitor and evaluate Laro–limicolae diversity in the El Kala National Park sites over two consecutive years, and may serve as a scientific baseline for the sustainable management and conservation of these wetlands.

Material and methods

Study area

The study was carried out at three Ramsar wetlands in the El Kala National Park, located in the extreme north eastern Algeria (fig. 1):

(1) Lake Tonga (36º 51' N 8º 29' E), a large shallow exorheic lake with an area of 2,700 ha and an average depth of 1 m. It is fed by three tributaries: the El Hout wadi from the southeast, the El Eurg wadi from the east, and the Messida Channel from the north (fig. 1). Due to the richness and diversity of its habitats, it is a renowned wintering and breeding site for a multitude of waterbird species, some of which are rare and declining in range, such as the white–headed duck *Oxyura leucocephala* and the marbled teal *Marmaronetta angustirostris* (Boumezbeur, 1993; Lazli et al., 2011a, 2011b, 2012; Menasria and Lazli, 2017; Mecif et al., 2020; Gherib et al., 2021).

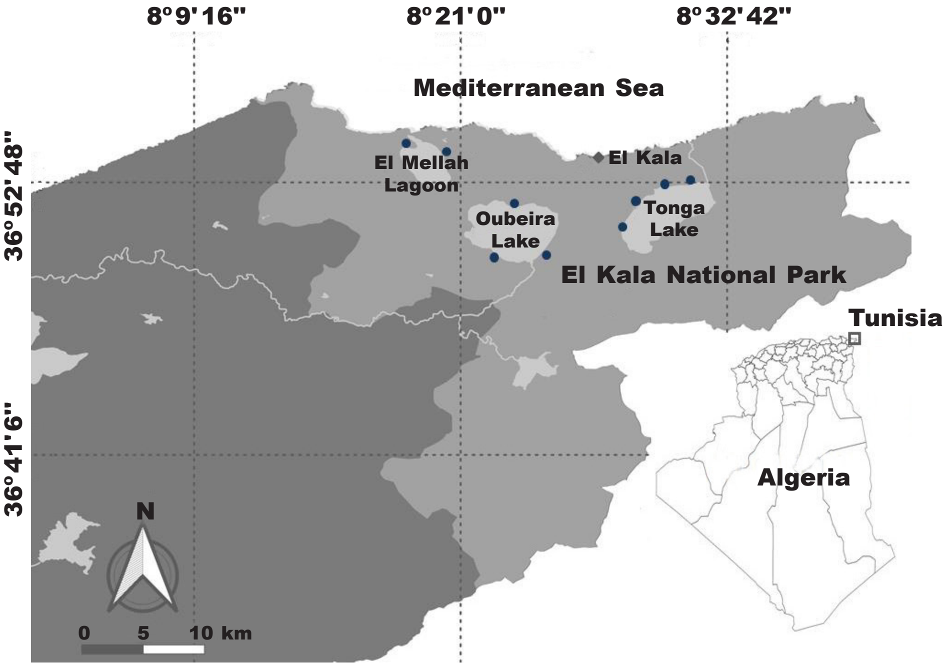

Fig. 1. Location of the study sites in Eastern Numidia (Northeast Algeria). Dots indicate the observation points.

Fig. 1. Localización de los lugares de estudio en Numidia oriental (noreste de Argelia) con los diferentes puntos de observación.

(2) Lake Oubeira (36º 50' N 8º 23' E), an endorheic freshwater lake with an area of 2,200 ha and an average depth of 2.15 m (fig. 1). With a typical spatial organisation of belt vegetation, it is considered a wintering and nesting site, hosting numerous species, such as the greylag goose *Anser anser*, the great cormorant *Phalacrocorax carbo* and several shorebird species, such as the pied avocet *Recurvirostra avosetta*, the black–winged stilt *Himantopus himantopus*, the little ringed plover *Charadrius dubius* and the Eurasian bittern *Botaurus stellaris* (DGF, 2002; Lazli et al., 2018).

(3) El Mellah Lagoon (36º 53' N 8º 19' E), the only lagoon on the Algeria coast, connected to the sea by a 900 meter channel. It has a surface area of 860 ha and is ranked fifth largest among the 14 North African lagoons (Baba Ahmed, 2008). This lagoon is not only fueled by marine waters, which are partly responsible for its brackish nature, but also by the gentle waters of two wadis: R'guibet and Boularoug (fig. 1).

Inventory and count of waterbirds

To assess richness and abundance of Laro–limicolae species in the three Ramsar sites we made bi–weekly visits from September to August 2014–2015 and from September to August 2015–2016. We conducted a total of 192 counts. At each visit, the sites were systematically covered, following a course chosen in advance (fig. 1). Censuses of avian populations were carried out from various points to allow the most exhaustive count of species and their numbers. Observations of Laro–limicolae were made from 8:00 h to 16:00 h using a telescope (Kowa™ 20 x 60). Because we were able to count the birds at short range it was easy to determine the exact number of birds and their species using the scanning sampling protocol.

Analysis of avian population structure

Laro–limicolae phenology and ecology were measured using the following ecological indices: (1) total abundance, that is, the total number of birds that visited site on a given day; (2) specific richness, that is, the number of species observed at a given visit; (3) the Shannon–Weaver diversity index, that is a way to measure the diversity of a species in a community, this index was calculated according to the formula:

$$H' = \Sigma \text{Pi ln Pi}$$

where Pi is the proportion of each specie in the sample,
and (4) equitability index, is a way to measure the evenness of species in a community, this index is calculated as:

$$E = H'/\ln(S)$$

where S is the total number of unique species and when E is close to 1 (the diversity observed reflects an abundance distribution close to equilibrium (Shannon and Weaver, 1949; Legendre and Legendre, 1979).

Phenological status observed: (1) resident, observed throughout the year; (2) wintering, observed only in the winter; (3) migratory breeders, observed only in breeding season; and (4) wintering/breeding, observed during winter and breeding season.

Statistical data analysis

To perform comparisons between years we used a χ^2 test and a multivariate factor analysis (CFA). Statistical analyses were applied using R–version software. 4.3.1 (R Core Team, 2023).

Results

Laro–limicolae population comparison in eastern Numidia

During the study period, six families and twenty–seven Laro–limicolae species were reported (table 1 and dataset published through GBIF with DOI: 10.15470/tehczv). The most species rich families were Scolopacidae (ten species) and Laridae (nine species), followed by Charadriidae (four species), Recurvirostridae (two species) and four Glariolidae and Haematopodidae families (one species) (table 1). The comparison of species family during the two years showed a highly significant difference (χ^2 = 65.84, df = 5, p < 0.0001).

Regarding ecological status of birds at the three study sites, the species monitored exhibited different phenological status: residents, wintering, migratory breeders and wintering/breeding (table 1; fig. 2). Wintering birds accounted for over 44 % of the species surveyed and residents accounted for 26 %. Approximately 19 % of the species were reported as migratory breeders and 11 % as wintering/breeding (fig. 2).

Four of the species recorded are listed on the IUCN Red List (Birdlife International, 2017a, 2017b, 2017c, 2019), representing almost 15 % of the settlement richness (table 1). Those protected by Algerian legislation, such as *Recurvirostra avosetta, Numemnius arquuata* and *Ichthyaetus andouinii,* account for over 22 % of the richness.

Table 1. Laro–limicolae frequenting studied sites in both years (2014–2015 and 2015–2016): x, mean, x±SD (min–max) (SD, standard deviation; min, minimum; max, maximum); FCS, Frochot constancy status (CS, constant status, > 50% of observations; AS, accessory status, between 25 to 50% of observations). PS, phenology status (R, resident; W, wintering; MB, migratory breeder; WB, wintering/breeding). IUCN, IUCN conservation status (LC, least concern; NT, near threatened (IUCN, 2022)).

Tabla 1. Larolimícolas que frecuentaron los sitios estudiados durante los dos años (2014–2015 y 2015–2016). x, media x±SD (min–max) (*SD, desviación estándar; mín, mínimo; máx, máximo); FCS, estado de constancia de Frochot (CS, estado constante, > 50% de las observaciones; AS, estado accesorio, entre 25 y 50% de las observaciones); PS, estado fenológico (R, residente; W, invernante; MB, reproductor migratorio; WB, invernante/reproductor); IUCN, estado de conservación de la UICN (LC, preocupación menor; NT, casi amenazado (IUCN, 2022)).*

	El Mellah Lagoon		**Tonga Lake**		**Oubeira Lake**				
	Year 2014–2015	**Year 2015–2016**	**Year 2014–2015**	**Year 2015–2016**	**Year 2014–2015**	**Year 2015–2016**	**FCS**	**PS**	**IUCN**
Glareolidae									
Glareola pratincola	4±7(1–28)	4±6 (1–20)	–	–	3±5 (1–19)	3±4 (1–15)	AS	W	NT
Haematopodidae									
Haematopus ostralegus	73±110 (8–344)	76±117 (7–393)	62±100 (4–302)	50±79 (1–263)	32±45 (4–154)	53±83 (1–303)	CS	W	LC
Recurvirostridae									
Recurvirostra avosetta	87±121 (1–344)	92±133 (1–396)	88±123 (1–370)	14±23 (1–77)	41±62 (1–204)	78±115 (1–343)	CS	R	LC
Himantopus himantopus	135±117 (15–379)	139±129 (17–445)	83±120 (1–358)	64±103 (1–347)	54±74 (1–220)	68±110 (1–365)	CS	R	LC
Scolopacidae									
Limosa limosa	–	–	56±79 (4–234)	42±64 (1–224)	23±35 (3–122)	51±79 (1–279)	CS	W	NT
Calidris alba	62±97 (3–294)	63±102 (3–342)	57±85 (4–262)	50±78 (275)	32±48 (4–178)	50±82 (2–268)	CS	W	LC
Calidris alpina	38±63 (1–224)	40±60 (1–205)	51±76 (5–232)	41±62 (1–223)	39±68 (1–240)	37±56 (1–197)	CS	W	LC
Calidris minuta	47±81 (2–268)	46±75 (1–236)	57±87 (4–261)	47±71 (1–226)	41±67 (1–234)	46±76 (1–249)	CS	R	LC
Tringa nebularia	54±89 (1–248)	56±87 (1–302)	74±106 (1–323)	61±90 (1–278)	54±85 (1–255)	62±93 (1–317)	CS	W	LC
Tringa erythropus	35±65 (2–238)	34±58 (2–201)	42±66 (3–200)	38±61 (1–205)	35±64 (2–245)	37±60 (1–202)	CS	R	LC
Actitis hypoleucos	44±71 (1–237)	51±81 (1–297)	55±86 (1–260)	52±81 (1–265)	42±67 (4–251)	52±83 (1–310)	CS	W	LC
Tringa totanus	45±73 (4–256)	55±87 (1–313)	50±75 (1–225)	50±79 (3–254)	38±66 (1–243)	51±81 (1–297)	CS	R	LC
Gallinago gallinago	83±112 (1–344)	81±112 (1–360)	41±50 (5–176)	71±102 (1–342)	67±92 (1–326)	73±104 (1–359)	CS	MB	LC
Numenius arquata	35±59 (2–202)	39±60 (5–193)	37±53 (6–156)	32±51 (1–179)	29±49 (3–165)	33±53 (1–174)	CS	W	NT
Charadriidae									
Charadrius dubius	23±35 (5–115)	24±35 (1–120)	23±35 (1–103)	18±28 (1–88)	17±33 (1–129)	17±28 (1–93)	CS	W/B	LC
Charadrius hiaticula	19±29 (4–95)	25±39 (1–127)	12±19 (3–59)	20±31 (1–97)	19±34 (2–128)	19±30 (1–94)	CS	W/B	LC
Charadrius alexandrinus	14±20 (2–68)	13±19 (1–72)	13±20 (1–60)	11±18 (1–62)	8±14 (2–51)	10±17 (1–63)	CS	W/B	LC
Vanellus vanellus	77±102 (1–333)	97±128 (1–406)	157±254 (2–776)	135±212 (1–728)	128±204 (5–745)	138±217 (2–764)	CS	W	NT
Laridae									
Larus michahellis	47±66 (1–232)	57±44 (8–158)	35±46 (1–137)	33±34 (3–121)	38±37 (3–155)	32±38 (3–123)	CS	R	LC
Larus fuscus	11±17 (1–58)	7±10 (1–34)	3±5 (1–15)	3±5 (1–20)	4±5 (1–23)	6±7 (1–31)	CS	W	LC
Chroicocephalus genei	22±31 (2–114)	23±24 (3–87)	–	–	7±6 (1–25)	6±5 (1–16)	CS	MB	LC
Ichthyaetus audouinii	8±10 (1–33)	7±9 (1–29)	–	–	–	–	AS	W	LC
Chroicocephalus ridibundus	181±210 (17–793)	186±199 (18–745)	97±121 (1–385)	101±158 (1–550)	45±195 (4–788)	134±212 (4–764)	CS	MB	LC
I*chthyaetus melanocephalus*	16±14 (2–46)	18 ±19 (2–64)	–	–	–	–	AS	W	LC
Thalasseus sandvicensis	30±34 (5–120)	29±29 (2–115)	–	–	20±20 (4–65)	20±25 (3–92)	CS	W	LC
Sterna hirundo	43±52 (2–197)	37±39 (6–149)	13±26 (1–80)	23±21 (3–73)	20±20 (3–63)	8±23 (2–84)	CS	MB	LC
Chlidonias hybrida	–	–	325±686 (31–3020)	302±598 (14–2395)	7±15 (1–61)	12±21 (1–69)	AS	R	LC

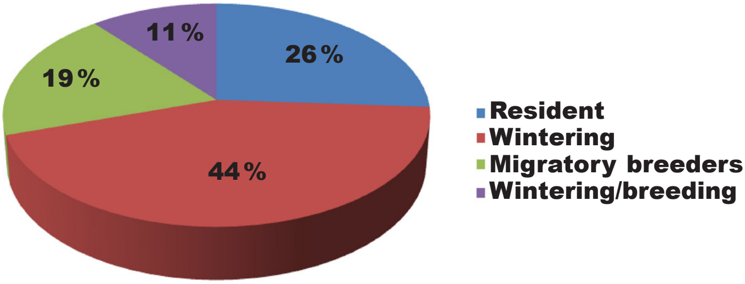

Fig. 2. Phenological status of Laro–limicolae species observed at the study sites.

Fig. 2. Estatus fenológico de las especies de aves larolimícolas observadas en los sitios de estudio.

Abundances

The lowest Laro–limicolae abundances over the two years were counted in August for all sites (74 and 94 individuals, respectively) and the highest counts were in January (3,550 and 3,789 individuals, respectively) (table 1, fig. 3). No significant differences in abundance of Laro–limicolae were observed in either year at any sites (χ^2 = 0.96; df = 1; p = 0.33). However, the abundance of Laro–limicolae between sites showed significant differences for both within–year ($\chi^2_{\text{year 2014–2015}}$ = 189.89; df = 2; p < 0.0001 and $\chi^2_{\text{year 2015–2016}}$ = 45.18; df = 2; p < 0.0001).

In both years, maximum abundances of Laro–limicolae families were recorded in overwintering and migratory periods (prenuptial and postnuptial migration) (fig. 3, 4). Furthermore, we found significant differences between the two years only in Lake Tonga ($\chi^2_{\text{years 2014–2015 and 2015–2016}}$ = 22.87; df = 1; p < 0.0001) and Lake Oubeira ($\chi^2_{\text{years 2014–2015 and 2015–2016}}$ = 8.23; df = 1; p < 0.004).

Species richness

During the study years, mean ± standard deviation species richness at the three RAMSAR sites was 16 ± 8 Laro–limicolae species. The minimum (three Laro–limicolae species) was observed at Lake Tonga in August (fig. 4). However, the maximum was recorded in wintering seasons (January) at El Mellah Lagoon (25 Laro–limicolae species) (fig. 4).

Shannon diversity index

The Shannon diversity index tended to fluctuate slightly. The average values were 2.16 ± 0.89 (not less than 0.07 noted at Lake Tonga in June and up to 3.01 in El Mellah Lagoon in November) (fig. 5).

Equitability index

The equitability index shows that the mean values were between 0.8 ± 0.23. The minimum was observed at Tonga Lake (0.08 in June) and the maximum was observed at Oubeira Lake (0.94 in June) (fig. 5).

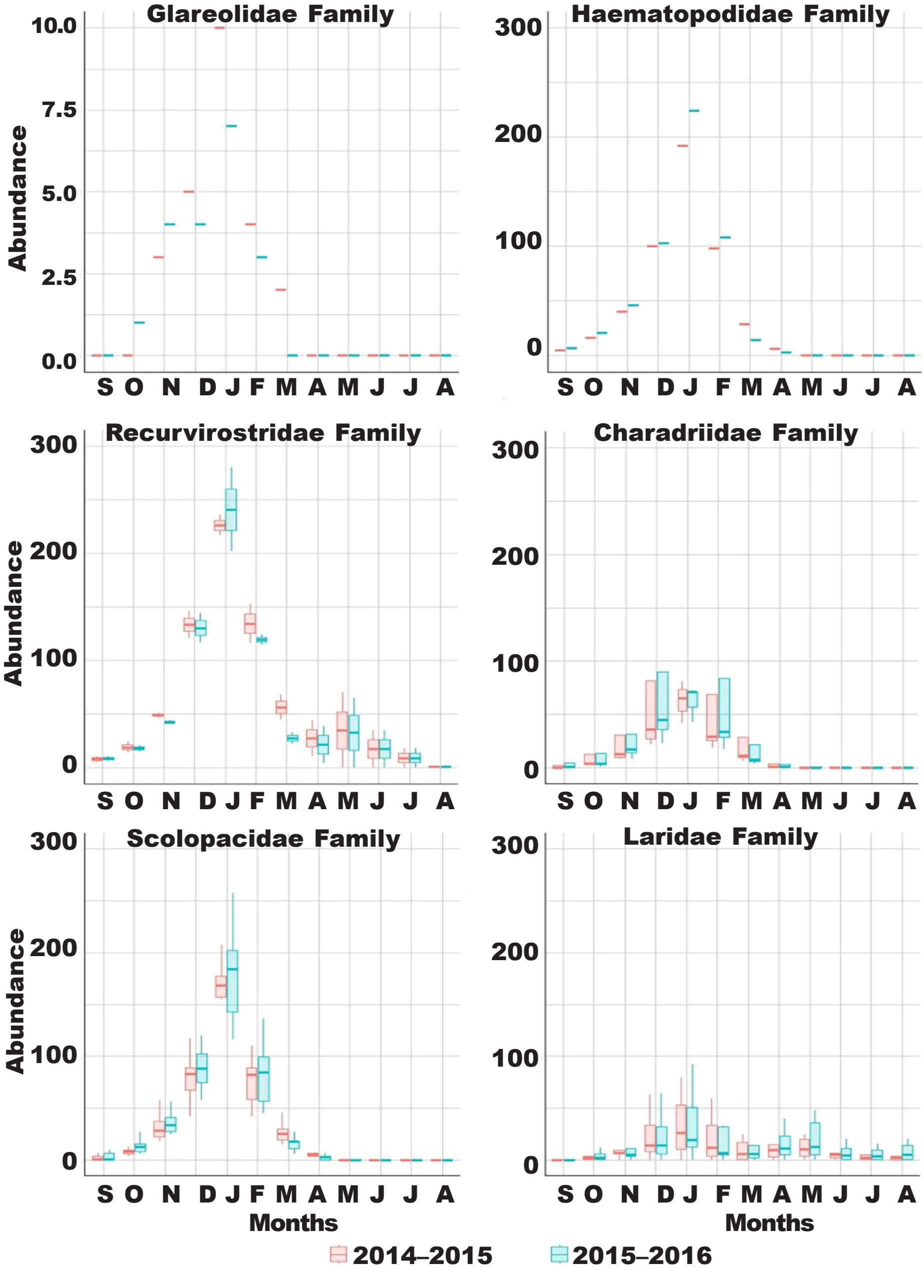

Fig. 3. Monthly variation in Laro–limicolae family abundance using all three Ramsar sites over the two years (2014–2015 and 2015–2016).

Fig. 3. Variación mensual de la abundancia de la familia larolimícolas en los tres sitios Ramsar durante los dos años (2014–2015 y 2015–2016).

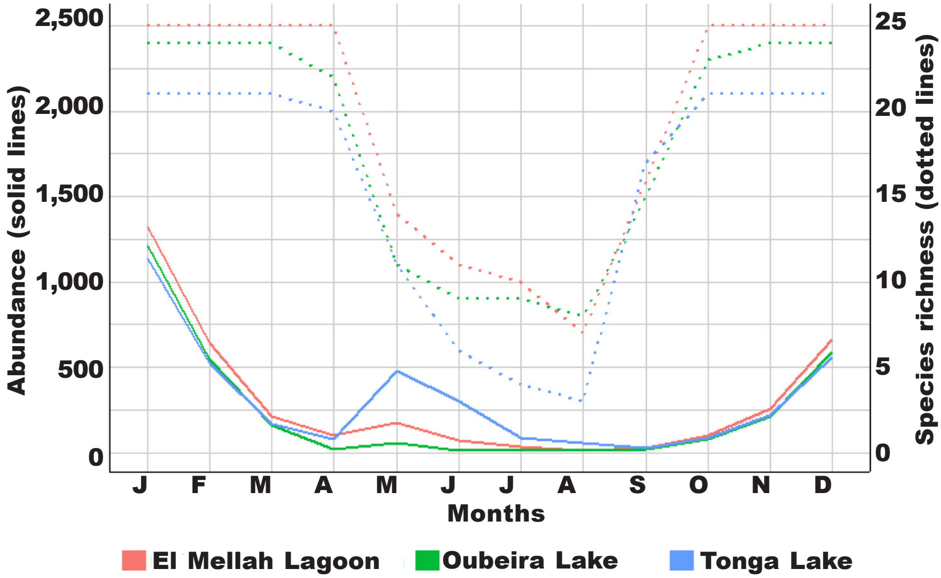

Fig. 4. Variation in monthly means of Laro–limicolae abundance and species richness at studied sites.

Fig. 4. Variación mensual de la abundancia de larolimícolas y riqueza de especies en los sitios estudiados.

Correspondence factor analysis

The factorial plan (Dim1 and Dim2) of the correspondence factor analysis of the counted Laro–limicolae families frequenting the three Ramsar sites during the two years had inertia of 97.4 % (fig. 6). These results showed that Scolopacidae, Chardriidae, Haematopodidae, and Glareolidae families were mainly observed in winter and autumn (wintering season) in the three Ramsar sites, whereas the Laridae and Recurvirostridae families were mainly observed in spring and summer (breeding season). The recurvirostridae family was particularly associated with the El Mellah Lagoon.

Discussion

Our data provide a detailed overview of Laro–limicolae phenology at inter–annual and intra–seasons and highlight the importance of the El Kala wetland complex. Although the data are incomplete, previous studies showed that the region is the major site in Algeria for migrating waterbirds (Ochando and Jacobs, 1978; Boumezbeur, 1993; Lazli et al., 2011a, 2011b; Lazli et al., 2012; Gherib and Lazli, 2017; Menasria and Lazli, 2017). Similar to the other Algerian coastline wetlands, this region has also proved to be a favourable location for Laro–limicolae, which remain little studied (Seddik, 2011). Our findings indicate that the El Kala wetland complex seems to offer favourable conditions for overwintering of Laro–limicolae (as only one–quarter of recorded Laro–limicolae phenological status belonged to resident species), and support results from several previous studies. In the study by

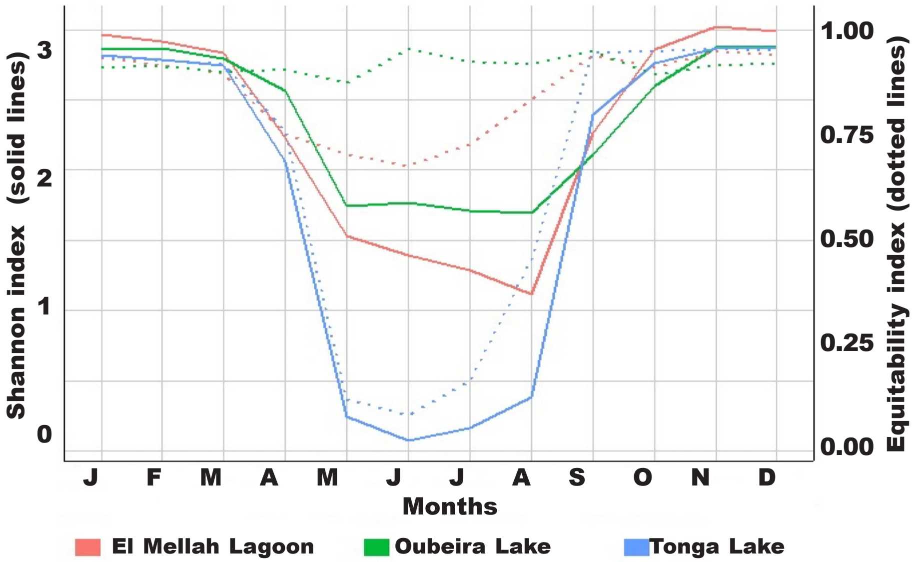

Fig. 5. Monthly means variation of Laro–limicolae Shannon diversity and equitability indices between studied sites.

Fig. 5. Variación mensual de los índices de diversidad y equidad de larolimícolas Shannon entre los sitios estudiados.

Telailia et al. (2017) at El Mellah Lagoon, 25 species of Laro–limicolae were counted. Among these, the black–headed gull *Chroicocephalus ridibundus* and the sandwich tern *Thalasseus sandvicensis* were the most abundant in winter and the yellow–legged gull *Larus michahellis* and the black–winged stilt were the most abundant in the breeding season *Himantopus himantopus*. At Oubeira lake, Lazli et al. (2018) counted 19 species of Laro–limicolae, while Northern lapwing *Vanellus vanellus* and black–headed gull *Chroicocephalus ridibundus* dominated in the wintering period. Elafri et al. (2016), Loucif et al. (2020) and Gherib et al. (2021) reported 16, 07 and 19 of Laro–limicolae species, respectively, at Tonga Lake: the most abundant were Northern lapwing *Vanellus vanellus* in winter and whiskered terns *Chlidonias hybrid*, yellow–legged gulls *Larus michahellis*, black–headed gulls *Chroicocephalus ridibundus* in the breeding season.

At the Constantinois high plateaus (north–eastern of Algeria), Djerboua (2022) counted 28 species of Laro–limicolae at Sebkhet Bazer, some of which have only been observed in this wetland, such as the black tern *Chlidonias niger*, the white–winged tern *Chlidonias hybrid,* the Eurasian golden plover *Pluvialis apricaria*, and the curlew sandpiper *Calidris ferruginea*. In the same region, Seddik et al. (2010) recorded 25 species of Laro–limicolae at Timerganine Lake, 52 % of which had wintering status.

Factorial correspondence analysis (FCA) showed a temporal succession of the occupation of the El Kala wetlands complex by Laro–limicolae. Two periods were distinguished: the first corresponds to the breeding season (April to September) characterized by Laridae and Recurvirostridae families. The second period (November to March) is characterized by an increase in the Laro–limicolae population and is dominated by Scolopacidae and Charadriidae families. This Laro–limicolae diversity succession is probably related to habi-

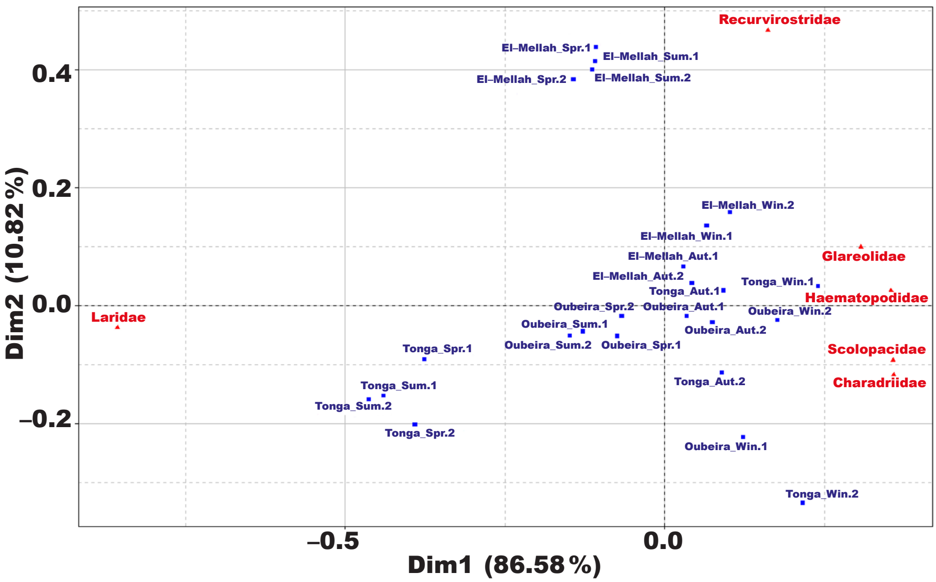

Fig. 6. Correspondence factor analysis of Laro–limicolae families observed at Tonga Lake, Oubeira Lake and El Mellah Lagoon during the study periods (2014–2015 and 2015–2016): Aut, autumn; Win, winter; Spr, spring; Sum, summer; 1, 2014–2015; 2, 2015–2016.

Fig. 6. Análisis del factor de correspondencia de las familias de larolimícolas observadas en el lago Tonga, el lago Oubeira y la laguna El Mellah durante los períodos de estudio (2014–2015 y 2015–2016): Aut, otoño; Win, invierno; Spr, primavera; Sum, verano; 1, 2014–2015; 2, 2015–2016.

tat heterogeneity and resource availability (Menasria and Lazli, 2017; Telailia et al., 2017; Bouali et al., 2021).

The values of Laro–limicolae species richness, abundances and ecological indices during the two years were linked to seasonal fluctuation. The highest values were observed during the wintering season, while they remained low during the breeding season due to the departure of wintering and visiting Laro–limicolae species to their breeding grounds (Elafri et al., 2016; Loucif et al., 2020; Gherib et al., 2021). Interestingly, despite the decrease in species richness before breeding seasons, we observed a nesting colony of the whiskered tern *Chlidonias hybrida* on Tonga Lake, which is considered the only breeding site in Algeria and North Africa (Bakaria et al., 2009).

The El Kala wetlands are clearly an important wintering and breeding area for Laro–limicolae. In light of our findings, the protection of these sites is critical for the preservation and conservation of Laro–limicolae.

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