

# DIVERSITY AND SEASONAL VARIATION OF WADER COMMUNITY (AVES, CHARADRIIFORMES) IN THE MEKHADA MARSH (NORTHEASTERN ALGERIA)

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## Abstract

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Our study was conducted between October 2021 and April 2022 at the Mekhada marsh, a wetland of international importance, located in northeastern Algeria. This site hosts large concentrations of waterbirds in winter, including waders. Through this investigation in the region, we proposed to characterise and analyse the population structure of this group of birds, which remains very poorly documented in Algeria. The results obtained indicate the presence of 16 species belonging to three families and nine genera. The maximum number of birds was counted in January 2022 (2417 individuals).

The inventoried species showed two phenological statuses (wintering and sedentary breeding). Among these, three are listed on the IUCN Red List as lapwing *Vanellus vanellus*; the others are listed on international bird protection agreements (AEWA, Convention of Migratory Species of Wild Animals [CMS] or are protected by Algerian legislation.

The present study gives interesting and unpublished data on a group of birds that has been little investigated in Algeria and on a wetland that, due to its large area and various habitats, remains little or undocumented, particularly in terms of its ornithological richness, which is of great interest.

**Key words:** Mekhada marshes, waders, Aves, Charadriiformes, inventory, counting, phenological status, ecological indices.

## Introduction

For many waterbird species, wintering is a period of the year that requires important ecological and biological adaptations. To spend this period, they often migrate in search of favourable habitats, where they find food and adequate climate and good breeding conditions for some of them. During several phases of their life cycle, waterbirds prefer wetlands (Lazli et al., 2018).

North Africa has a wide variety of wetlands that serve as wintering and resting sites for migratory Palearctic birds (Steven-son et al., 1988; Fishpool, Evans, 2001; Boulkhssaim et al., 2006; Bensaci et al., 2013). Among this vast complex, Algeria, whose territory belongs to the Western Palearctic range, is known for its rich biodiversity, hosting almost all the habitats of the range, including wetlands and the species they support (Bensaci et al., 2013).

Located on a major migration way of the Atlantic-East corridor, the main Algerian wetlands play an important relay role between the two barriers for migratory fauna that constitute the Mediterranean Sea on the one hand and the Sahara on the other

(Lazli et al., 2018). Among these environments, the best known at present are those of the Numidia located in northeastern Algeria, which are reputed for their wetlands that are divided into two large complexes separated by Oued Seybouse: (i) Eastern Numidia composed of the Annaba and El-Kala complexes and (ii) Western Numidia represented by the Guerbes-Sanhadja wetland complex (Samraoui, De Bélair, 1997; Metallaoui, Houhamdi, 2010; Lazli, 2011; Bediaf et al., 2020).

In Eastern Numidia, there is a mosaic of wetlands (Lake noir bog, El Mellah lagoon, Lake des oiseaux, Lake Oubeira, Lake Tonga, etc.) characterised by a great ecosystem diversity with an inestimable biological richness (Zaafour, 2012; Bediaf et al., 2020). This eco-complex hosts a large number of migratory birds each year, of which more than 10 species are waders. Among the wetlands known in the region to host the largest number of these species, the Mekhada marsh remains one of the least explored and documented wetlands due to its large size and the variability of its habitats. The two most important studies conducted in this site were those of Bourafa (2019) and Bediaf (2020) on the wintering of waterbirds.

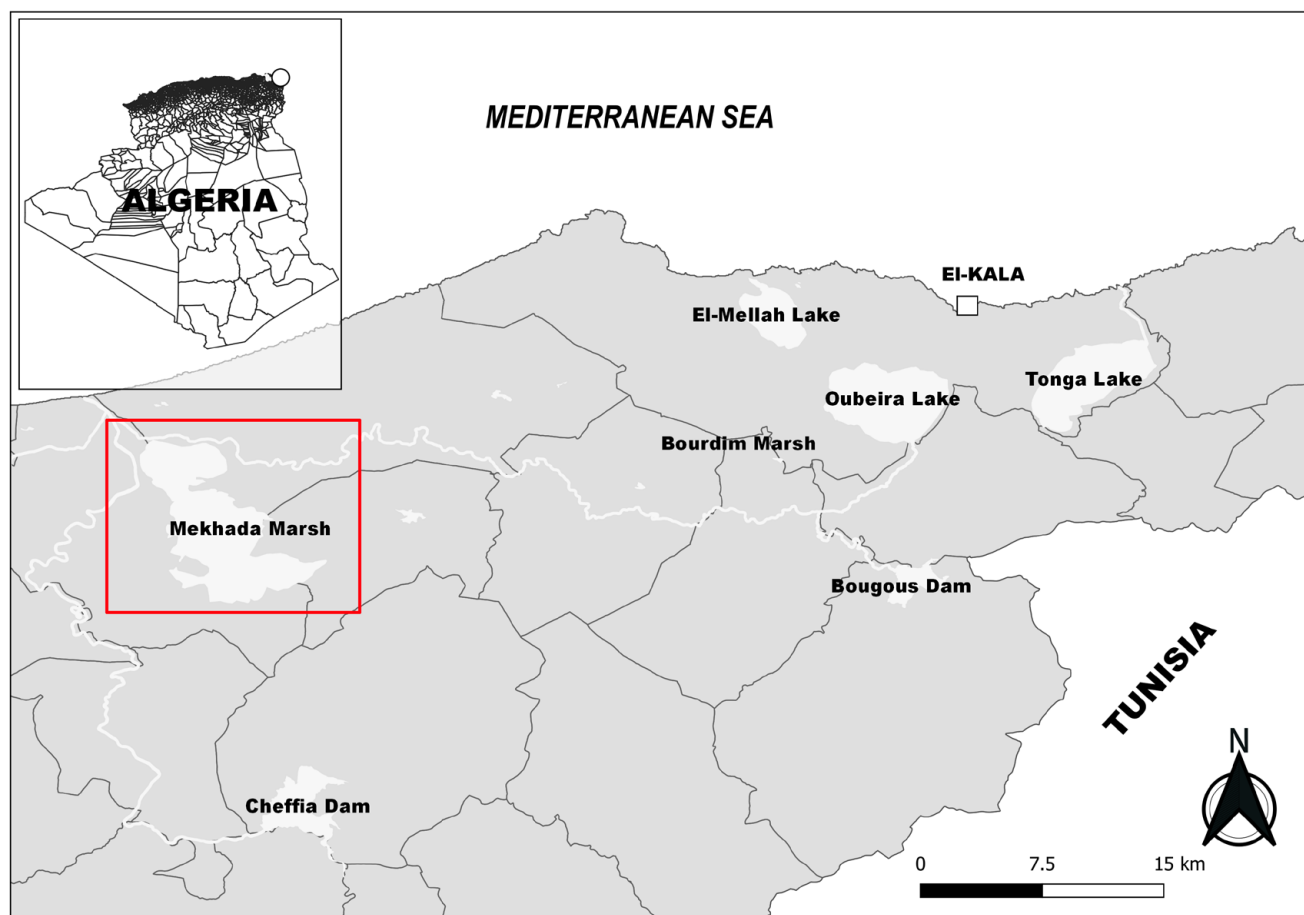


Fig. 1. Location of the study site in northeastern Algeria (map drawn up by Bouchecker A., 2021).

In Algeria, few studies have been devoted to waders, especially during the wintering period. However, some surveys have been carried out on some species mainly during the nesting period in the high plains of eastern Algeria (Maazi, 2009; Saheb et al., 2009; Seddik et al., 2010).

In recent years, evidence of impact climate change on waterbirds has continued to appear in their breeding, staging and/or wintering areas, and among the most obvious consequences has been the displacement of the ranges of several populations. The current study presents original and unpublished data on a group of birds and a wetland area that remain little documented or undocumented in Algeria and particularly in this region. It complements the data reported by the only two studies carried out in this marsh, which represents one of the main Algerian wetlands located on the major migration route of the eastern Atlantic corridor, playing an important relay role between the two obstacles for migratory avifauna, the Mediterranean Sea and the Sahara, and also provides more recent estimates for the avifauna of the site. To this purpose, we conducted an inventory of wader species present, counted their numbers and analysed their structure by calculating various ecological indices that enabled us to understand their wintering strategy, to distinguish their status in addition to the few available data (Bourafa, 2019; Bediaf et al., 2020) and to explain their abundance and diversity throughout their annual cycle.

It is important that regular monitoring is conducted on the different flyways to detect any problems or species decline, which will provide managers with periodic data to take appropriate action, including the implementation of national and international plans to safeguard these populations and their habitats.

## Material and methods

### Study site

Located in the extreme northeast of Algeria, the Mekhada marsh represents a temporary wetland, except for its northern part (Saoudi et al., 2018). It is a palustrine area, occupying the lower parts of the alluvial and colluvial filling basin of the Mafragh plain, whose waters are fresh, with the exception of its downstream part, where water is brackish due to the contact at the estuary with the Mediterranean Sea (Fig. 1) (DGF, 2003). With an area of about 10,000 ha, it is a large marshy area with a depth of 0.5–1 m and an average salinity of 4.6 g/l (Morgan, 1982). Its vegetation covers more than 90% of its surface (Houhamdi, 2002), composed mainly of *Scirpus lacustris* and *S. maritimus*, *Phragmites australis*, *Typha angustifolia*, *Myriophyllum spicatum* and various other herbaceous aquatic plants and algae (De Belair, Bencheich, 1987).



Fig. 2. View of Mekhada marsh (Lazli, 2022).



Fig. 3. Waders observed at Mekhada marsh (a: *Himantopus himantopus*; b: *Gallinago gallinago* and *Tringa erythropus*) (Soltani, Lazli, 2022).

This wetland has the highest concentration of waterfowl in the El Kala wetland complex, including waders (Bourafa et al., 2018; Bediaf et al., 2020), and is a feeding and staging site for various duck species and coots (Figs 2, 3).

Unfortunately, this marsh is subject to many degradation factors such as discharge of wastewater from the surrounding agglomerations, overgrazing from March, when the vegetation increases significantly, and disturbance mainly due to the proximity of the National Road RN-44 to the south and the Departmental Road CW-109 to the north (Bediaf et al., 2020).

### Bird inventory and count

The inventory and counting of birds were carried out between October 2021 and March 2022 from eight stations depending

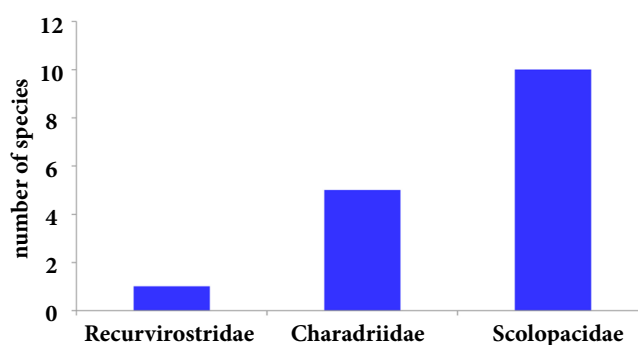


Fig. 4. Composition of the wintering wader's settlement in Mekhada marsh.

**Table 1.** Checklist of wintering waders recorded at Mekhada marsh.

| Families         | Species                                              | Months |      |      |      |      |      |     |     |      |
|------------------|------------------------------------------------------|--------|------|------|------|------|------|-----|-----|------|
|                  |                                                      | Oct.   | Nov. | Dec. | Jan. | Feb. | Mar. | Apr | Min | Max  |
| Recurvirostridae | Black-winged stilt<br><i>Himantopus himantopus</i>   | X      | X    | X    | X    | X    | X    | X   | 5   | 445  |
| Charadriidae     | Northern lapwing<br><i>Vanellus vanellus</i>         | X      | X    | X    | X    | X    |      |     | 60  | 1800 |
|                  | Little ringed plover<br><i>Charadrius dubius</i>     | X      | X    | X    | X    |      |      |     | 1   | 15   |
|                  | Common ringed plover<br><i>Charadrius hiaticula</i>  |        | X    | X    | X    | X    |      |     | 1   | 10   |
|                  | Kentish plover<br><i>Charadrius alexandrinus</i>     | X      | X    | X    | X    | X    |      |     | 3   | 55   |
|                  | Eurasian golden plover<br><i>Pluvialis apricaria</i> |        |      | X    | X    | X    |      |     | 220 | 350  |
| Scolopacidae     | Black-tailed godwit<br><i>Limosa limosa</i>          |        |      | X    | X    |      |      |     | 3   | 5    |
|                  | Curlew sandpiper<br><i>Calidris ferruginea</i>       | X      |      |      | X    |      |      |     | 2   | 14   |
|                  | Dunlin<br><i>Calidris alpina</i>                     | X      |      |      |      |      |      |     | 4   | 4    |
|                  | Common snipe<br><i>Gallinago gallinago</i>           |        |      |      | X    | X    |      |     | 3   | 39   |
|                  | Common greenshank<br><i>Tringa nebularia</i>         | X      | X    | X    | X    |      |      |     | 2   | 14   |
|                  | Common sandpiper<br><i>Actitis hypoleucos</i>        | X      | X    | X    | X    | X    | X    |     | 2   | 15   |
|                  | Common redshank<br><i>Tringa totanus</i>             | X      |      |      | X    | X    | X    |     | 22  | 150  |
|                  | Spotted redshank<br><i>Tringa erythropus</i>         |        |      | X    | X    |      |      |     | 6   | 20   |
|                  | Green sandpiper<br><i>Tringa ochropus</i>            |        |      | X    | X    |      |      |     | 5   | 6    |
|                  | Wood sandpiper<br><i>Tringa glareola</i>             |        |      |      | X    |      |      |     | 4   | 4    |

**Notes:** X: Species present; Min.: Minimum number counted; Max.: Maximum number counted.

on accessibility, bird groups' location and good visibility, using a KONUS-SPOT telescope (20 × 60) and a pair of binoculars (10 × 50).

Birds were counted using two methods: (i) individual counts when the group was less than 200 m away and (ii) quantitative estimates when groups were located further away (Lamotte, Bourlière, 1969; Blondel, 1975; Legendre, Legendre, 1979; Bediaf et al., 2020).

### Analysis of settlement structure

To characterise the shorebird population structure, we considered some ecological parameters: (i) total abundance (total number of individuals counted on a given date), (ii) relative abundance (ratio of individual numbers of each species to the total number of individuals, all species included), (iii) frequency of occurrence (ratio of the number of surveys during which the species was recorded to the total number of conducted surveys; and (iv) species richness (total number of different species recorded

in the same sample): Shannon–Weaver index (calculated according to the formula:  $H' = [\sum P_i \ln P_i]$ , where  $P_i$  is the proportion of each species in the sample (Daget, 1979)), Simpson's index (according to the formula  $D = 1 - \{\sum n_i (n_i - 1) / (N(N - 1))\}$ , where  $n_i$  is the total number of birds of each individual species and  $N$  is the total number of birds of all species), as well as Pielou's equitability index (corresponds to the ratio of Shannon–Weaver's diversity index ( $H'$ ) or true diversity to the value of the maximum theoretical diversity ( $H_{max}$ )).

### Statistical analysis

Data analysis was carried out using Minitab 19 Ink software. We used the Student's  $t$ -test to determine whether there were significant differences between the numbers of shorebird families surveyed.  $P < 0.05$  was used as the significance level.

Principal component analysis (PCA) was performed using the 'FactoMineR' and 'factoextra' packages, with 'R' software version R4.2.2.

**Table 2.** Relative abundance and local phenological and conservation status of observed species.

| Species                                              | Phenological status | Local status | Conservation status            | Relative abundance |
|------------------------------------------------------|---------------------|--------------|--------------------------------|--------------------|
| Black-winged stilt<br><i>Himantopus himantopus</i>   | SB/W                | C            | AEWA/CMS (A. II)/L.A           | 15.08              |
| Northern lapwing<br><i>Vanellus vanellus</i>         | W                   | MC           | UICN (Q.m.) / AEWA/CMS (A. II) | 62.49              |
| Little ringed plover<br><i>Charadrius dubius</i>     | W                   | MC           | AEWA/CMS (A. II)               | 0.37               |
| Common ringed plover<br><i>Charadrius hiaticula</i>  | W                   | UC           | AEWA/CMS (A. II)<br>L.A        | 0.30               |
| Kentish plover<br><i>Charadrius alexandrinus</i>     | SB/W                | UC           | AEWA/CMS (A. II)               | 2.34               |
| Eurasian golden plover<br><i>Pluvialis apricaria</i> | W                   | R            | AEWA/CMS (A. II)               | 12.83              |
| Black-tailed godwit<br><i>Limosa limosa</i>          | W                   | R            | UICN (Q.m.) / AEWA/CMS (A. II) | 0.12               |
| Curlew sandpiper<br><i>Calidris ferruginea</i>       | W                   | R            | UICN (Q.m.)/ AEWA/CMS (A. II)  | 0.27               |
| Dunlin<br><i>Calidris alpina</i>                     | W                   | E            | AEWA/CMS (A. II)               | 0.06               |
| Common snipe<br><i>Gallinago gallinago</i>           | W                   | UC           | AEWA/CMS (A. II)               | 0.73               |
| Common greenshank<br><i>Tringa nebularia</i>         | W                   | UC           | AEWA/CMS (A. II)               | 0.51               |
| Common sandpiper<br><i>Actitis hypoleucos</i>        | W                   | MC           | AEWA/CMS (A. II)               | 0.81               |
| Common redshank<br><i>Tringa totanus</i>             | W                   | R            | AEWA/CMS (A. II)               | 3.35               |
| Spotted redshank<br><i>Tringa erythropus</i>         | W                   | R            | AEWA/CMS (A. II)               | 0.46               |
| Green sandpiper<br><i>Tringa ochropus</i>            | W                   | R            | AEWA/CMS (A. II)<br>L.A        | 0.16               |
| Wood sandpiper<br><i>Tringa glareola</i>             | W                   | E            | AEWA/CMS (A. II)               | 0.06               |

Notes: Sedentary Breeder (SB); Wintering (W); Omnipresent species (O) ( $f_i = 100\%$ ); constant or common (C) ( $75\% < f_i < 100\%$ ); moderately frequent (MC) ( $50\% < f_i < 75\%$ ); uncommon (CU) ( $25\% < f_i < 50\%$ ); rare (R) ( $5\% < f_i < 25\%$ ) and exceptional (E) (5%).

## Results

### Settlement composition

Sixteen species belonging to three families and nine genera were recorded during the studied season. Scolopacidae family was the most abundant with 10 species, followed by Charadriidae with five species and Recurvirostridae with only one species (Fig. 4, Table 1).

### Ecological status of species

During the winter season, the Mekhada marsh was frequented by 16 species exhibiting the same phenological status: wintering. Among these birds, two were simultaneously wintering and sedentary breeders (Table 2).

The dominant wintering status of these birds shows the role of the Mekhada marsh as an ideal wintering site for many species.

On the basis of frequency of occurrence, one species was defined as constant, three as moderately frequent, four as uncommon, six as rare and two as exceptional (Table 2).

Of the 16 species recorded, three are listed on the IUCN Red List as near threatened, that is, nearly 19% (Table 2).

According to Algerian legislation, only 19% of species are protected. All species inventoried are protected under the African-Eurasian Migratory Waterbird Agreement (AEWA) agreement and 15 are listed in CMS (Appendix II) (Table 2).

### Wintering chronology of waders

The monitoring of waders' numbers has allowed us to divide the wintering season studied into three periods. The first one extends from October to November and shows a dominance of Charadriidae population. During the second period, which occurs from November to the end of February, we counted the largest numbers of overwintering birds in January. The third period

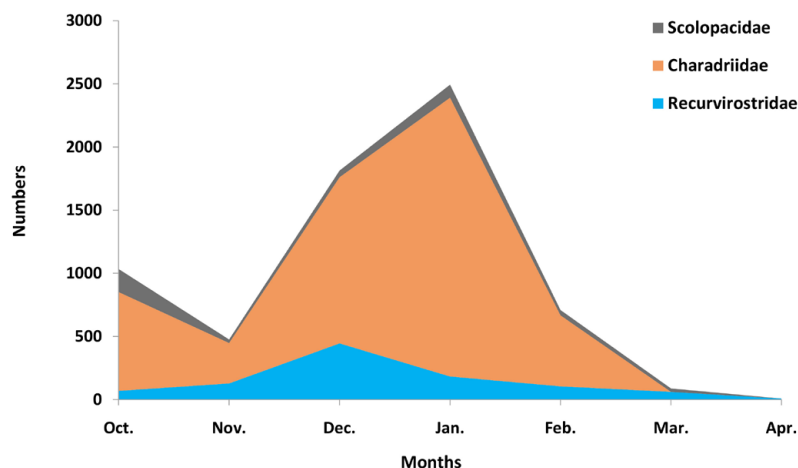


Fig. 5. Evolution of waders' total number per family in the Mekhada marsh during the studied wintering season.

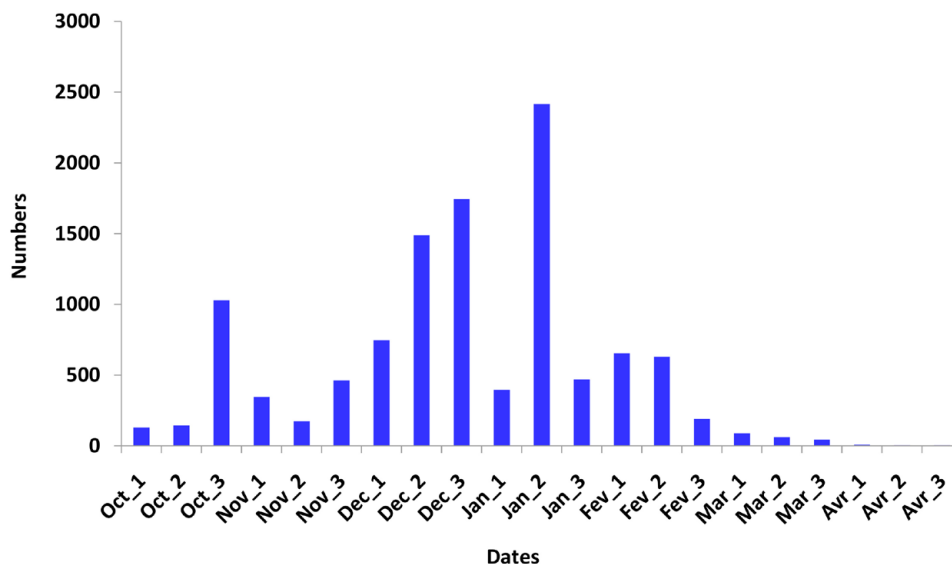


Fig. 6. Evolution of numbers in the Mekhada marsh during the study period.

starts in March and lasts till the end of April. It was characterised by a significant decline in waders' numbers (Fig. 5).

### Ecological parameters' trends

#### Abundance

The maximum number of waders that frequented the site during the study period was 2417 individuals, counted in January 2022 (Fig. 6). From the first weeks of the wintering season, a progressive increase in numbers was recorded due to the arrival of species. Indeed, Charadriidae had the highest individual numbers, especially northern lapwing with 1800 individuals. Scolopacidae peaked at 180 individuals in October, while Recurvirostridae were represented by a single species, the black-winged stilt, whose maximum number of 445 individuals was observed at the end of December (Fig. 6).

A decline in numbers was then noted between the end of January and the end of February. There was a significant difference between the numbers of Scolopacidae and Charadriidae during the study period:  $t = 2.87$ ,  $P = 0.046$ .

#### Species richness

During the study period, the Mekhada marsh was frequented by 16 wader species. An important number was observed from the second half of October (nine species). The maximum was observed in January (10 species). During March and April, a decrease in species number was recorded with very low numbers (Fig. 7).

#### Diversity and equitability indices

The two ecological indices reflecting population balance showed more or less similar curves. In general, the maximum values were

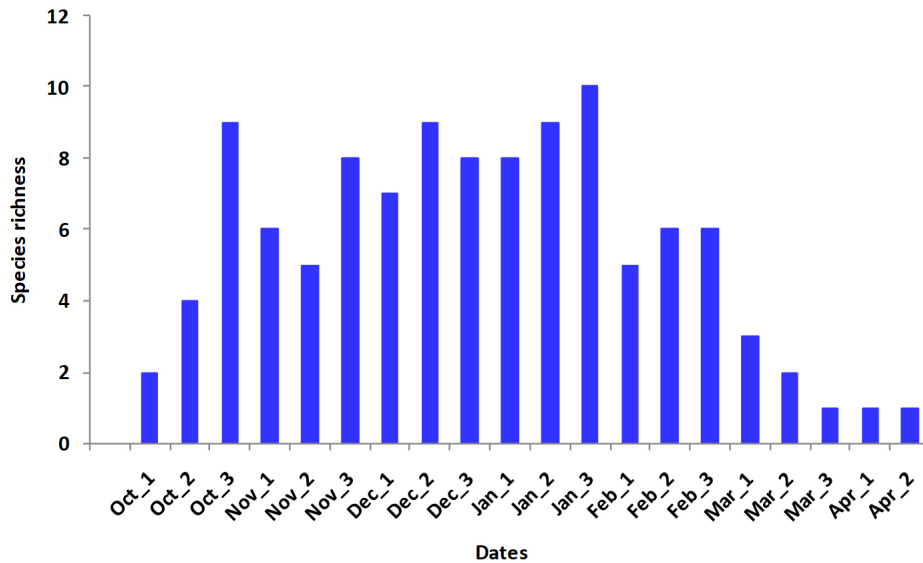


Fig. 7. Winter evolution of wader population species richness at the Mekhada marsh.

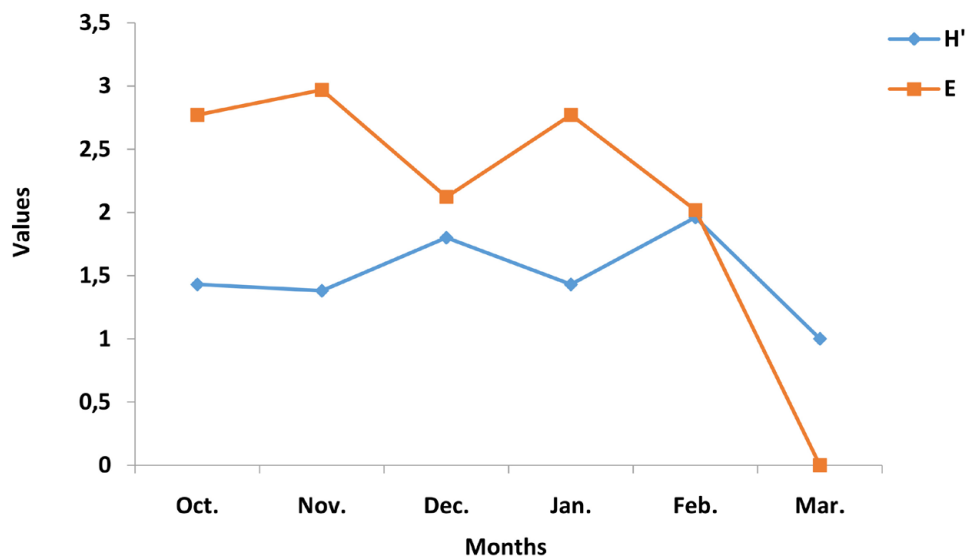


Fig. 8. Ecological indices evolution of the wader population in the Mekhada marsh during the study period.

recorded in October, November and January 2022 (Fig. 8), respectively: Oct:  $H' = 1.43$  -  $E = 2.77$ ; Nov:  $H' = 1.38$  -  $E = 2.96$ ; Jan:  $H' = 1.43$  -  $E = 2.77$ ).

Throughout our study, Shannon's diversity index showed values greater than 1 and Simpson's index presented a value of 0.5.

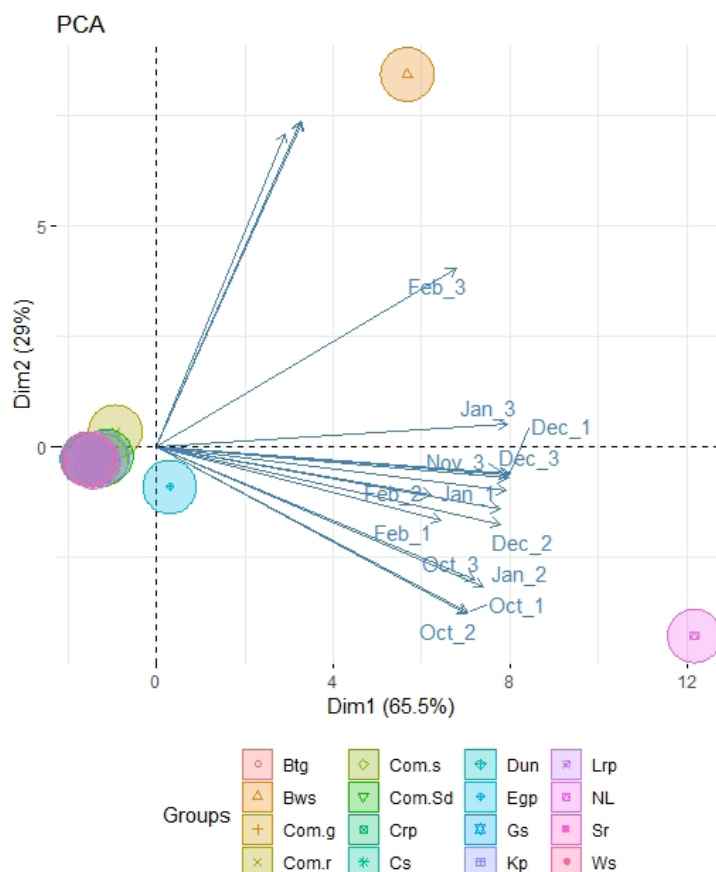
### Temporal evolution of wader community

The PCA method showed a temporal succession of the occupation of the Mekhada marsh by waders. The dimensional plane ( $D1 \times D2$ ) of PCA explains more than 94% of the variability. The first ordination axis (PC1, 65.5%) highlights the dates when rich-

ness and abundances were higher, particularly for three species which were most predominant (northern lapwing, black-winged stilt and Eurasian golden plover, respectively). PC2 accounted for 29% and showed a certain richness with low abundance for some species, notably sandpipers, snipes and redshanks, which were generally present in varying numbers throughout the winter season (Fig. 9).

### Discussion

The Mekhada marsh is a very important resting and wintering site for a wide diversity of Palearctic migratory birds (Stevenson



**Fig. 9.** Temporal evolution of wader assemblages at the Mekhada marsh (PCA – plan D1 × D2).

et al., 1988; Coulthard, 2001; Boulkhssaim et al., 2006; Bediaf et al., 2020). On the Mediterranean basin scale, it is a feeding and staging site for numerous ducks and coots (Bediaf et al., 2020). In fact, Bourafa et al. (2018) showed that the marsh southern region seemed to offer favourable conditions for wintering of a large number of waterbirds.

Data collected at the Mekhada marsh during the study period indicated the presence of 16 wader species belonging to three families. On the same site, Bourafa et al. (2018) and Bediaf et al. (2020) recorded 16 and 14 species, respectively. In the same wetland complex, various surveys have reported, depending on the sites considered, the presence of 12–13 species, also divided into three families (Lazli et al., 2018; Gherib et al., 2021). Among other wetlands in Algeria, those of the high plateau eco-complex host a significant diversity of waders each year. At Lake Timerganine, Seddik et al. (2010) reported the presence of 20 species and confirmed for the first time the wintering of Eurasian dotterel *Eudromias morinellus*. In Guerbes-Sanhadja complex, Metallaoui, Houhamdi (2010) recorded 12 species divided into three families, and in Souk Ahras, Guellati et al. (2014) inventoried 13 species. Between 2015 and 2017, 10 wader species were observed at Chott Tinsilt and Sebkhet Ezzemoul (Bezzalla et al., 2019). Waders were also present in an artificial wetland (Kef Doukhane, Ghardaia) in the Algerian Sahara, with 21 species belonging to four families (Cheddad et al., 2020).

Species observed at the Mekhada marsh during the wintering studied season showed globally the status of winterers with the exception of those that were also breeding. Similar studies reported the same status at various wetlands in the country, such as those of Setif, the Souk Ahras wetland complex, those of Oum El Bouaghi and other sites of the so-called 'El Kala' eco-complex (Seddik et al., 2010; Metallaoui, Houhamdi, 2010; Guellati et al., 2014; Lazli et al., 2018; Bezzalla et al., 2019; Bediaf et al., 2020; Cheddad et al., 2020; Loucif et al., 2020; Gherib et al., 2021).

Over the study period, Shannon diversity, Simpson's indices and equitability varied according to the richness and abundance of wader population at the Mekhada marsh, but generally showed a diversified population dominated by Scolopacidae and Charadriidae. Previous studies on other sites in the region have shown similar results (Lazli et al., 2018; Bourafa et al., 2018; Bediaf et al., 2020; Gherib et al., 2021). Among the most representative species in terms of numbers, northern lapwing was the most abundant and earliest species at the study site (Lazli et al., 2018; Bediaf et al., 2020; Loucif et al., 2020; Gherib et al., 2021).

Monitoring of the wintering chronology of these birds has permitted to distinguish three periods: (i) The first one corresponds to the beginning of the wintering period, characterised by low numbers. This period represents a particular population because the breeding period is not yet over (Bediaf et al., 2020), and waders present have not yet adopted the gregariousness typical

of the wintering season (Metallaoui, Houhamdi, 2010; Bourafa et al., 2018). During the third week of October, a large number of individuals were counted corresponding to the arrival of the early species (black-winged stilt, northern lapwing and common redshank). Between the end of November and the beginning of December, a gradual change in bird numbers was observed. (ii) The second winter period (from December to the beginning of February) was characterised by a brutal increase in the settlement, particularly in January, attesting to the arrival of numerous wintering birds dominated by Charadriidae and Scolopacidae such as northern lapwing, common greenshank, common sandpiper, spotted redshank and others. During this period, the population was more balanced as the water body was frequented by a maximum of species represented by generally equal numbers. These gatherings in January reflect the preparation of the pre-breeding migration and have also been reported by various studies conducted in Algerian wetlands (Metallaoui, Houhamdi, 2010; Seddik et al., 2012; Bensaci et al., 2013; Boudraa et al., 2014; Elafri et al., 2016; Halassi et al., 2016; Lazli et al., 2018; Bediaf et al., 2020; Loucif et al., 2020; Gherib et al. 2021). (iii) Finally, in the third period (between the end of February and the beginning of March), a gradual decrease in numbers was noted, reflecting the end of the wintering season and the departure of wintering and migratory species to the breeding grounds. Only sedentary breeders such as the white stilt remained on the site.

The low specific representativeness recorded at the Mekhada marsh during March and/or October was due to unfavourable climatic conditions causing the departure of birds for other more favourable areas. It should be noted that the dryness of the marsh accompanied by a significant vegetation development would also have obstructed our observations and limited our visibility, which would have affected our observations as already mentioned by Bediaf et al. (2020) at the same site.

It is important to point out that the use of this ecosystem by waterbirds depends mainly on its water level as well as on the abundance of trophic resources. Austin (2002) showed a direct relationship between the bird number observed and the water level (Bourafa et al., 2018). However, he also suggests taking into account the spatiotemporal factors of the studied areas.

## Conclusion

During our study, the Mekhada marsh was frequented by 16 wader species belonging to three families, of which Scolopacidae were the most represented. All the species found are listed in various international conventions and treaties, which gives this ecosystem a high heritage value, in addition to the three species listed in the International Union for Conservation of Nature's *red list* (IUCN). Over this survey, the site supported several species, which can be divided into two categories: wintering and sedentary breeders.

However, despite its protected status, this marsh faces many threats affecting its ecological specificities, which were mentioned in one of the only two avifauna surveys conducted on the same site.

This work complements two other research investigations (Bourafa et al., 2018; Bediaf et al., 2020) on the avifauna of a site that remains little or unstudied and provides information on the ecology of waders, a group of birds that has been little stud-

ied in Algeria, as well as on the key role played by the Mekhada marsh in the survival of a diversified population. According to the results obtained, it appears that the protection of this site is essential for the preservation and conservation of this avifauna, which is sensitive to climate change, especially when we consider the lack of rainfall in recent years, which has led to a significant drought that extends even into the wintering period of waterbirds, thus constituting an imminent threat to their survival and their biological and nutritional requirements.

This study will serve as a database for future works, as well as for the establishment of a management plan to safeguard and preserve the biodiversity and habitats of this particular ecosystem.

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