THE BLOCKAGE OF THE OUED CHEBEIKA ESTUARY AND ITS EFFECTS ON THE AVIFAUNA*

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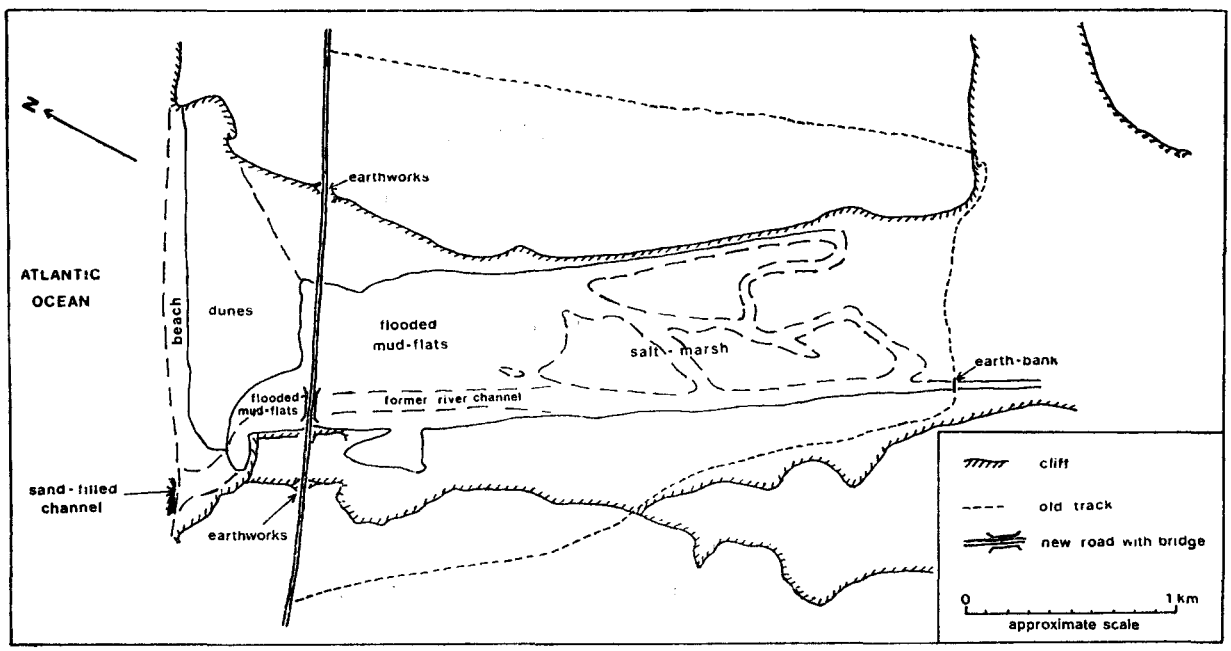
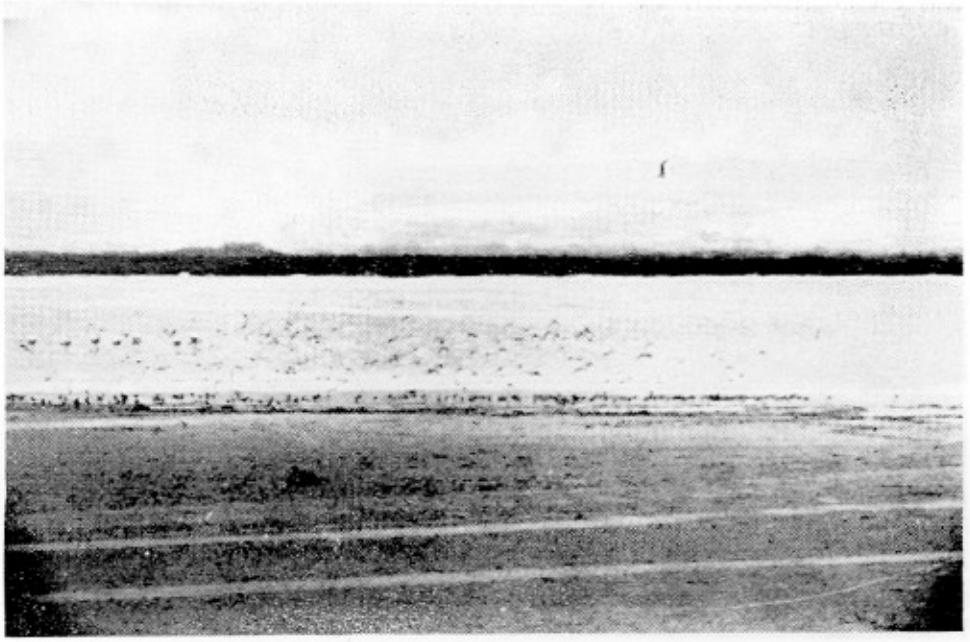


Figure 1. — Sketch map of the estuary of Oued Chebeika in September 1972.



1. A flock of small waders landing with other waders and Flamingoes at a roosting site ahead of the rising tide, Oued Chebeika Estuary, September 1971. Salt-marsh is in middle distance, beyond the water.

2. Flooded mud-flats and salt-marsh, Oued Chebeika Estuary, September 1972. New road-bank in distance with coastal dunes and sea beyond.

3. View of new road-bank, the two new lakes and the coastal dunes from the east side of the Oued Chebeika Estuary, September 1972.

4. View seawards at the mouth of Oued Chebeika, September 1972. Wide drifted sand-bar (centre) blocks river channel (foreground). The former channel is marked by dashed lines.

SUMMARY

Physical and biological changes at the Oued Chebeika Estuary due to its temporary blocking by an embankment carrying a new road are described, with particular reference to birds. The implications of the unpredicted nature of some of the physical changes, and the abilities of animals to adjust to them are briefly discussed.

RESUME

En 1972, l'estuaire de l'oued Chebeika fut obstrué par une digue sur laquelle passait provisoirement la nouvelle route de Tantan à Tarfaya. En 1974, la construction d'un pont a de nouveau permis l'écoulement de l'oued et le retour à des conditions marégraphiques normales.

Cet article décrit les changements physiques et biologiques intervenus lors du blocage temporaire de l'estuaire. L'accent est mis par les auteurs sur la capacité de la faune, tout particulièrement l'avifaune, à s'adapter aux modifications de certaines caractéristiques physiques du milieu.

INTRODUCTION

The census of wetland avifauna made by J. and C. Blondel in January 1964 showed that there were two major wetlands in S. W. Morocco, the lagoon of Puerto Cansado and the Oued Chebeika estuary, holding respectively about 100,000 and 3,000 waders (Charadrii). Studies by University of East Anglia (UEA) expeditions in 1971 and 1972 further established the significance of these sites during the autumn migration period when the relative importance of O. Chebeika may be greater than in winter, being much used by birds on passage (see Pienkowski 1972, 1975 and Pienkowski et al. 1976).

In 1972, construction of a bank to carry a new road from Tan-Tan to Tarfaya blocked water flow in the estuary of Oued Chebeika a short distance above the mouth, resulting in marked changes in the physical nature, flora and fauna of the estuary. Later construction of a bridge and subsequent erosion of a sandbank which had formed across the mouth, led to a return to tidal conditions in 1974. The sequence of changes can be documented because of visits by ourselves and others over this period.

The UEA Expedition to Morocco 1971 studied the birds of the Oued Chebeika Estuary from 29 August to 11 September, and also made outline surveys of the intertidal invertebrates and salt-marsh vegetation. Further observations were made on several visits in August and September 1972 by the UEA Expedition to Tarfaya Province. Brief visits and bird counts were made by Blondels in January 1964, Dr. J. Brock in May 1972, the Oxford and Cambridge Mauritanian Expedition in December 1973, A.R. Johnson and O. Biber in January 1974, M. Thévenot in January 1975, and P. Vandenbulcke in November 1975.

PHYSICAL CONDITIONS AND VEGETATION

1. Before the building of the road

In 1971, extensive sand dunes stretched across the mouth of the estuary, with, on the south-west side, a fairly narrow channel through which flowed a fast current, connecting the shallow lagoon to the open sea (Figure 1). Behind the sand dunes, at low tide mud-flats stretched back about 1 ½ km, giving way fairly sharply to salt marsh. Much of the marsh remained above the high water level of most tides, and

consisted almost entirely of bushy *Halocnemum strobilaceum* (Pall.) M.B. up to 1 m high, with *Arthrocnecum indicum* (Willd.) Moq. and *Salicornia arabica* (L.) If the rings in the stems of these plants are indicative of annual growth increments, the larger bushes were at least 20 to 30 years old. Even on the highest spring tides observed, the water level near the mouth of the estuary did not reach the base of the cliff on the eastern side, but did so further inland, where the salt marsh occurred. The old, rough, unmetalled track from Tan-Tan to Tarfaya crossed the river channel by a small earth-bank above the estuary, about 4 km inland (figure 1). A pipe through this allowed water flow.

2. After construction of the road-bank

In early 1972 a large embankment was bulldozed across the estuary, about 500 m south of the sea, using material from the cliff-sides, through which the road was constructed. The road-bank caused several major changes in the area. The first, and most obvious, was the marked rise in water level and the cessation of tidal movement to landward side of the road-bank, forming a stagnant, brackish lagoon. The small flow of the Chebeika was sufficient to raise the water level higher than on the highest spring tide observed in 1971, and to flood the bay on the western side and the mud-flats and salt-marsh on the eastern side. The main salt-marsh in the middle of the estuary was drowned, and the water level was obviously still rising in September 1972.

Tests conducted above and below the earth-bank carrying the old track across the estuary (4 km inland from the mouth) in autumn 1971 showed that salinity above the bank was about one-third of that below, which was similar to that of the sea (Miss B.E. Jeremiah, unpublished). Although no tests were conducted in autumn 1972, the salinity of the lake was probably lower than that of the sea due to the low-salinity flow down the Chebeika which filled the lake. An unexpected consequence of the road-bank was the deposition across the mouth of the old channel of a sand bar, several hundred metres wide and, in August 1972, solid enough to drive a vehicle on. That such a large amount of sand could be deposited in less than a year seems remarkable, and gives some indication of the enormous carrying capacity of the current and wave action. Clearly when the volume of tidal water within the estuary was drastically reduced by the building of the road bank, the scouring effect of the tide was much diminished and the channel became blocked. As a result, the sand-and mud-flats between the road-bank and the sand bar also became devoid of any tidal flow, although a small pool remained. A major change in both lake areas formed would have been the de-oxygenation of the mud and water : when tidal flow ceased the plants and animals were no longer exposed to the air at low tide, mixing and oxygenation of the water were reduced, and the decay of organisms in the stagnant water presumably depleted the oxygen supplies previously dissolved.

The construction of the road also affected wildlife in another way, by giving relatively easy access to the area for visitors. In 1971 the area was almost devoid of people, apart from local tribesmen and occasional visitors from the north, but in 1972 a tarmacked road led down to the estuary, and there was much evidence of campers, picnickers and hunters. By December 1973 the surfaced road had been extended to cross O. Amma Fatma and reach O. el Ouaâr, and, by November 1975, to Tarfaya, leading to much increased traffic.

3. After construction of the bridge

In late 1972 the section of the road-bank across the former river channel was replaced by a bridge approximately 150 m long (figure 1). Consequently, the lakes on either side of the roadbank were joined. However, tidal conditions did not return, because of the sand-bar which had formed across the mouth of the estuary. This situation still prevailed in December 1973.

4. Return to tidal conditions

At some time in 1974 the channel at the mouth of the estuary re-opened, but we do not know whether this was due to erosion by water flowing down the Chebeika, to storm tides, or to any other agency. A visit in November 1975 showed the estuary to be tidal to a similar extent to that observed in 1971.

EFFECTS ON BIRDS AND OTHER ANIMALS

1. Before the building of the road

In September 1971 many waders (Charadrii), gulls (Larinae) and terns (Sterninae) of several species, Flamingoes *Phoenicopterus ruber* (L.) and Spoonbills

Platalea leucorodia L., and some passerines (possibly breeding in the salt marsh) were present in the estuary of O. Chebeika, and on the sea beach (Table 1). A brief survey of the invertebrate fauna of the mud-flats showed high densities (up to 240 animals per m^2) of nereid worms (Nereidae); and the prosobranch gastropod *Hydrobia* and the bivalves *Abra tenuis* (Montagu) and *Scrobicularia plana* (da Costa) were also common.

2. After construction of the road-bank

The changes which the building of the road-bank caused on these inveretebrates and birds were far reaching. In August 1972 numerous dead barnacles (Cirripedia) seen on the rocks beneath the water and many dead molluscs (Mollusca) in the mud provided evidence that most of the intertidal invertebrates had died, presumably due to a combination of the reduced salinity, the continual immersion and the reduced oxygen concentration in the water. In the drowned salt-marsh some of the plants were dying. Thus the communities associated with both the salt-marsh and the mud-flats were considerably affected.

By autumn 1972 the water's edge was the only remaining suitable feeding area for wading birds to the landward side of the road-bank. Between the road and the sand-bar a few small waders were observed feeding on the sand and mud flats at the edge of the small pool. With the loss of feeding grounds the numbers of nearly every wader species were reduced to about 10 % of their autumn 1971 level (Table 1). They were also at similarly low levels in spring 1972 (Dr. J. Brock *in litt.*), but unfortunately there are no earlier spring counts for comparison. There was also a marked reduction in the numbers of Flamingoes, but the relative importance of the changed condition of the estuary and the increased human disturbance is uncertain. Jenkin (1975) reported that Flamingoes can, in some circumstances, feed on organic mud instead of the more usual diet of invertebrates. Disturbance was obviously important; it was observed that the passing lorry drivers (in convoy to Tarfaya), clearly being impressed by the sight of the birds in flight, had taken to sounding their vehicle horns while crossing the causeway. With about 40 vehicles passing through each day on four days per week, the effect could be quite marked. In 1971 our activities apparently caused a marked reduction in the numbers of Flamingoes at first, but the birds returned later, presumably as they became accustomed to the disturbance.

In contrast, there was a marked increase in the numbers of Lesser Black-backed Gulls *Larus fuscus* L. from about 1200 in autumn 1971 to about 10,000 in autumn 1972. This could have been caused by a short-term increase of food in the form of dead intertidal animals (see above), or possibly the gulls were attracted by the reduced salinity, prefering to drink brackish-, rather than sea-water.

The presumed loss of fish in the lagoon probably caused the reduction in numbers of Cormorants *Phalocrocorax carbo* (L.) and herons (Ardeidae). However, the numbers of terns were not affected. Possibly they were able to obtain enough food by fishing in the adjacent sea which was probably their main feeding area in any case.

The flooding of the salt-marsh reduced the area suitable for passerines. In view of the migrations across the desert proper (Moreau 1961), it is doubtful if this was of great significance to most migrant species, but certain passerines, e.g. Scrub and Fan-tailed Warblers, *Scotocerca inquieta* (Cretech.) and *Cisticola juncidis* (Rafinesque), were resident in 1971, and the loss of breeding habitat may be more important.

The salt-marsh, being a productive area in contrast to the surrounding desert (see Leah, in Pienkowski 1975), was used as grazing for camels; and the loss of this may have had some effect on the local semi-nomadic people.

3. After construction of the bridge

As indicated above, despite the building of the bridge, tidal conditions were still not re-established in January 1974, Wader numbers were still very low, compared with the Blondels' counts in January 1964 (Table 1), even allowing that there seems to have been a general decline in numbers of many species of waders wintering in Morocco since 1964 (see Pienkowski and Knight 1976). However, the new conditions were obviously suitable for wintering ducks (Anatinae), 500 being present in December 1973. Although it is usual for ducks to winter in large numbers in north Morocco, they are less common in the south (e. g. Blondel and Blondel 1964, Johnson and Biber 1974).

4. Return to tidal conditions

When tidal conditions returned, bird populations in January and November 1975 became similar to those of 1971 and earlier (Table 1). In January wa-

ders again numbered 2-3,000 and, in November, about 1800. Numbers of ducks and gulls, inflated during the presence of the lake, dropped to near their former levels on the estuary, while those of the fish-eating species — herons and cormorants — increased again. However, numbers of Flamingoes remained low, possibly due to increased disturbance.

DISCUSSION

The changes at the estuary of the Oued Chebeika are of particular interest in two respects, firstly because of the prolonged and unexpectedly drastic changes to the nature of the estuary following a relatively short period of blockage by the road-bank. Secondly, it is remarkable how rapidly the invertebrate prey of the wading birds must have re-established themselves once tidal conditions returned, such that high numbers of waders were able to return within a year.

Estuaries are highly productive areas, and in the semi-desert conditions of Tarfaya Province, the contrast between estuary and its unproductive surroundings is extreme. Permanent blocking of the estuary would have caused a great and unnecessary loss. It is fortunate that the tidal channel was eventually recut and that tidal flow is adequate to maintain it.

Besides the natural community supported by it, the salt-marsh vegetation was utilised for the grazing of animals by the local people. We have not been able to re-examine the salt-marsh to assess its state after prolonged immersion. However, in view of the probable ages of individual plants, any change in the vegetation could be long-lasting.

Although migrant birds may tend to return to the same sites each year (see Pienkowski in press), they are probably not rigidly dependent on individual sites if nearby alternatives are available. The Oued Chebeika estuary is only about 70 km from the much larger intertidal area at Puerto Cansado, and it is unlikely that migrants were markedly affected by its unavailability as a feeding station. However, the loss, even temporarily, of a larger or more isolated site could be more serious. Additionally, the recent sighting of a large flock of Slender-billed Curlews *Numenius tenuirostris* V. at O. Chebeika (M. Thévenot, *in litt.*) should be noted, as it is important to conserve sites used by this rare species. The effect of increased public access is difficult to assess.

No data are available on intertidal invertebrate densities after the return of tidal conditions. It is clear, however, from the large numbers of waders (which feed almost entirely on such animals) present in January and November 1975 that large invertebrate populations must have been re-established between the re-opening of the mouth, at some time after December 1973, and January 1975. Comparable re-establishments of high densities of inter-tidal invertebrates have been recorded in Florida after depopulations due to naturally occurring toxins (Dauer and Simon 1976); and in the River Tees Estuary, England, where over-winter predation by shorebirds reduced numbers of their prey by 80-90 % or more, before recovery in the following summer (Evans 1974, Evans *et al.* in prep.). In the case of Oued Chebeika, it is not known whether re-establishment arose from resistant forms within the estuary, recolonisation from adjacent sea-beaches, or long range dispersal from other estuaries or tidal inlets. In all three situations mentioned above, it may have been important that the nature of the substrate remained unchanged.

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REFERENCES

BLONDEL, J. et BLONDEL, C., 1964. — Remarques sur l'hivernage des limicoles et autres oiseaux aquatiques au Maroc (janvier 1964). *Alauda,* 32 : 250-279.

DAUER, D.M. and SIMON, J.L., 1976. — Repopulation of the polychaete fauna an intertidal habitat following natural defaunation : species equilibrium. *Oecologia,* 22 : 99-117.

EVANS, P.R., 1974. — The effects of partial reclamation of Seal Sands, Teesmouth on the bird populations, January - September 1974. Report to the Royal Society for the Protection of Birds, Sandy, England.

EVANS, R.P., HERDSON, D.M. KNIGHTS, P.J. and PIENKOWSKI, M.W. — In prep. Short term effects of reclamation of part of Seal Sands, Teesmouth on wintering waders and Shelduck, 1. Shorebird diets and invertebrate densities.

JENKIN, P., 1957. — The filter-feeding and food of Flamingoes (Phoenicopteri). *Phil. Trans. Royal Soc. Lond. B.,* 240 : 401-493.

JOHNSON, A.R. et BIBER, O. 1974. — Dénombrement de la sauvagine hivernant le long de la côte atlantique du Maroc en janvier 1974. Report to International Waterfowl Research Bureau, Slimbridge, England. (Summary in *Bull. Inst. Waterfowl. Res. Bur.,* 37 : 76-81.)

MOREAU, R.E., 1961. — Problems of Mediterranean - Saharan migration. *Ibis,* 103 a : 373-427, 580-623.

PIENKOWSKI, M.W. (Ed.), 1972. — University of East Anglia Expedition to Morocco 1971. Report. UEA Expeditions to Morocco, Norwich, England.

PIENKOWSKI, M.W. (Ed.), 1975. — Studies on coastal birds and wetlands in Morocco 1972. The joint report of the University of East Anglia Expedition to Tarfaya Province, Morocco and the Cambridge Sidi-Moussa Expedition 1972. Norwich, England.

PIENKOWSKI, M.W., in press. — Recurrence of waders on autumn migration at sites in Morocco. *Vogelwarte.*

PIENKOWSKI, M.W. et KNIGHT, P.J., 1976. — La migration postnuptiale des limicoles sur la côte atlantique du Maroc. *Alauda,* 45 ; 165-190.

PIENKOWSKI, M.W., KNIGHT, P.J., STANYARD, D.J. and ARGYLE, F.B., 1976. — The primary moult of waders on the Atlantic coast of Morocco. *Ibis,* 118 : 347-365.

VANDENBULCKE, P., 1976. — Waterfowl counts along the Atlantic coast of Morocco and the ex-Spanish Sahara and on some inland barrages of Morocco during the months of November and December 1975. Report to International Waterfowl Research Bureau, Slimbridge, England.

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Table 1. **Counts of wetland birds at the estuary of Oued Chebeika before and after building of the road bank.**

	Spring	Autumn		Winter				
	2-3 / 5 1972 (a)	30/8-10/9 1971 (b)	(c) 8/8-16/9 1972	11 / 1 1964 (d)	9 / 12 1973 (e)	16-18 / 1 1974 (f)	1 / 1 1975 (g)	27-29/11 1975 (h)
Phalacrocorax carbo (L.)	—	10-15	1	n.d.	10	30	38	50
Ardea cinerea L.	—	10-20	5	n.d	—	19	27	9
Egretta garzetta (L.)	—	5-15	1-3	n.d.	—	27	22	25
Ciconia ciconia (L.)	—	—	—	n.d.	—	2	—	—
Platalea leucorodia L.	—	1	37	5	—	—	—	—
Phoenicopterus ruber (L.)	—	22-180	10-33	39	15	29	—	8
Tadorna tadorna (L.)	—	—	—	—	24	—	—	—
Tadorna ferruginea (Pallas)	—	—	—	—	—	—	2	—
Anas platyrhynchos L.	—	3-14	—	—	—	—	—	—
Anas crecca L.	—	—	—	—	—	5	—	—
Anas acuta L.	—	12	12	—	—	—	—	6
Anas clypeata L.	—	—	—	—	10	47	25	—
Anas sp.	—	—	—	—	500	—	—	—
Aythya ferina (L.)	—	—	—	—	—	150	—	45
Aythya fuligula (L.)	—	—	—	—	—	6	8	—
Haematopus ostralegus L.	—	50-300	4-30	30-50	—	—	450	123
Charadrius hiaticula L.	7	100-400	10-100	200-300	—	—	*	173
Charadrius alexandrinus L.	14	20-250	3-12	40-60	—	15	*	50
Pluvialis squatarola (L.)	6	40-75	1-12	—	—	4	—	176
Arenaria interpres (L.)	1	1-20	2	—	—	—	—	—
Numenius arquata (L.)	—	15-60	5	50-60	—	11	1	130
Numenius phaeopus (L.)	—	5-70	15	—	—	—	—	—
Numenius tenuirostris V.	—	10-50	10	—	—	—	123	—

Limosa limosa (L.)	—	1-15	1-3	—	—	—	—	10
Limosa lapponica (L.).	5	10-50	10	500	5	3	2	371
Tringa ochropus L.	—	1-7	—	—	—	—	—	—
Tringa glareola L.	—	1-10	—	—	—	—	—	—
Tringa hypoleucos L.	—	5-20	5	—	—	1	*	3
Tringa totanus (L.)	—	50-250	1-35	800-1000	—	5	*	82
Tringa erythropus (Pallas)	—	1	1-4	—	—	—	—	—
Tringa nebularia (Gunn)	4	2-20	1	—	—	—	—	6
Calidris canutus (L.)	—	10-100	4-20	50	—	—	7	82
Calidris minuta (Leisl.)	3	3-50	2-5	—	10	—	—	23
Calidris temminckii (Leisl.)	—	—	1	—	—	—	—	—
Calidris alpina (L.)	10	400-1000	5-50	1000-1200	—	—	*	468
Calidris ferruginea (Pontopp.)	—	10-30	3-20	—	—	—	*	—
Calidris alba (Pallas)	5	20-400	5-30	50-60	—	—	10	142
Philomachus pugnax (L.)	—	1-7	3	—	—	—	—	—
Recurvirostra avosetta L.	9	1-245	10-32	—	11	—	—	—
Larus fuscus L.	n.d.	80-1200	10000	n.d.	n.d.	—	250	800
Larus argentatus Pontopp.	n.d.	10-20	10-20	n.d.	n.d.	—	present	200
Larus audouinii Payr	n.d.	2-4	2	n.d.	n.d.	—	—	—
Larus genei Breme	n.d.	1-6	—	n.d.	n.d.	—	—	—
Larus ridibundus L.	n.d.	1-10	3	n.d.	n.d.	—	present	—
Chlidonias niger (L.)	n.d.	10-250	50	n.d.	n.d.	—	—	—
Gelochelidon nilotica (Gm.)	n.d.	2	—	n.d.	n.d.	—	—	—
Hydroprogne tschegrava (Lepechin)	n.d.	1-2	—	n.d.	n.d.	1	1	2
Sterna hirundo L. / *S. paradisea* Pontopp.	n.d.	10-100	100-200	n.d.	n.d.	—	75+	—
Sterna albifrons Pallas	n.d.	2-25	25	n.d.	n.d.	—	—	—
Sterna sandvicensis Lath.	n.d.	100-500	10-250	n.d.	n.d.	—	—	—

Sources. — (a) Dr. J. Brock ; (b) & (c) UEA Expeditions ; (d) Blondel & Blondel (1964) ; (e) P.J. Knight, on Oxford & Cambridge Mauritanian Expedition 1973 ; (f) Johnson & Biber (1974) ; (g) M. Thévenot (*in litt.*) ; (h) P. Vandenbulcke (1976, and *in litt.*). n.d. = no data. * Total of these wader species: 2-3000.