Journal of Biological Research **3**: 47–58, 2005
J. Biol. Res. is available online at http://www.jbr.gr

Patterns of occurrence of waders (Aves, Charadrii) in the Axios Delta, Macedonia, Greece

VASSILIS GOUTNER[1*], SAVAS KAZANTZIDIS[2] and IRIS CHARALAMBIDOU[3]

[1] *Department of Zoology, School of Biology, Aristotle University, 54124 Thessaloniki, Greece*
[2] *National Agricultural Research Foundation, Forest Research Institute, 57006 Vassilika, Thessaloniki, Greece*
[3] *Birdlife Cyprus, P.O. Box 280716, 2090 Lefkosia (Nicosia), Cyprus*

Received: 14 December 2004 Accepted after revision: 6 June 2005

In the Axios Delta, northern Greece, thirty one species of waders were recorded from January to December 1990. Most species presented population peaks that indicated characteristic temporal patterns of occurrence in the area. The highest total numbers were observed in the winter, early spring and in mid-summer. The number of species varied from 10 to 24 and was not correlated to total population size ($r_s = -0.311$, n.s.). Some populations of species dominated on two or three successive visits, but dominance changed over time. Total wader numbers were negatively correlated with average tide heights ($r_s = -0.685$, $p = 0.0002$), probably because the lack of safe roosting sites at high water forced part of the population out of the area. Cluster analysis revealed that wader species in the Axios Delta were grouped according to their seasonal pattern of occurrence. The same analysis of spring population trends, including data from other Greek coastal wetlands, showed a strong association of counts in monthly groups. Analyses suggest that the occurrence of wader populations in the Axios Delta follows wider regional patterns. The geographical position of Greek coastal wetlands along the eastern Mediterranean flyway makes them more useful to waders in the winter and during spring migration. Wader populations in the Axios Delta would benefit from artificial flooding and the regulation of grazing in the lower delta during the summer. The Axios Delta exceeds 14.1 times the criterion of 1% as a key site for wintering waders on a national level and also constitutes an internationally important staging area.

Key words: Waders, patterns, populations, Axios Delta, Greece.

INTRODUCTION

The waders or shorebirds (Charadrii) are a diverse group of birds occurring in all types of wetland habitats, such as coasts, deltas, shallow lakes and river plains (Cramp & Simmons, 1983). Being a major feature of coastal and estuarine ecosystems, waders are the subjects of extensive conservation effort throughout their range. Part of this effort aims at the protection under the Ramsar Convention of wetlands that have been designated as internationally important for waders and/or other waterbirds. Flyway conservation strategies, enforced by a variety of conservation bodies, focus particularly on the waders' needs (Stroud *et al*., 2004). The basis for implementing these and other national and international conservation measures is a good understanding of the size and distribution of each biogeographical wader population and of its trends (Davidson *et al.*, 1998).

Despite the international interest in the conservation of waders, limited relevant research has been carried out in Greece, and this mainly during short visits in some coastal wetlands. Contributors were the Dutch WIWO (Werkgroep Internationaal Wadden Watervogelonderzoek) spring projects in northeastern and western Greece (Meininger, 1990; De Nobel, 1995) and some independent studies in the Evros Delta (Goutner, 1983; Goutner & Kazantzidis, 1993) and Alyki Kitrous (Papakostas, 1989; Goutner & Papakostas, 1992).

This paper presents information on the occur-

* Corresponding author: tel.: +30 2310 998341, fax: +30 2310 998269, e-mail: vgoutner@bio.auth.gr

rence, population levels, and seasonal trends of waders during the course of a year cycle in the Axios Delta, northeastern Greece, an internationally important wetland from which such information is lacking. It also presents the results of a comparison with other Greek coastal wetlands with regard to seasonal patterns of wader occurrence.

MATERIALS AND METHODS

The Axios Delta (40º 30' N, 22º 53' E) is part of a large wetland complex covering about 70 km^2 along the northwest coast of Thermaikos Gulf (Athanasiou, 1990). The area is listed under the Ramsar Convention as an internationally important wetland and by Birdlife International as an IBA (Important Bird Area) of Europe (Grimmet & Jones, 1989). The study area was about 53 km^2 and included a variety of bird habitats such as salt- and freshwater marshes, mudflats, lagoons, open sea, vegetated coastal islets, sandy shores, ricefields, forested river bank and tamarisk bushland. The Axios Delta is threatened by habitat destruction resulting from building, pollution and the reduction of water and sediment fluxes to the coastal zone (Poulos *et al*., 1994).

The area was surveyed from January to December 1990. One to three visits were paid each month. Each visit covered the total area of the Axios Delta and lasted 10 hrs (from 08.00 to 18.00). The waders were counted with a 20-60 X telescope and their positions were recorded on a 1:10000 map.

Seasonal patterns of occurrence were investigated in 24 species by cluster analysis performed by Primer 5 software (Primer-E Ltd) on standardized data. The Bray-Curtis similarity was used as distance measure and complete linkage was used as linkage rule. To compare trends among different coastal wetlands, the same analysis was applied to data from 22 species recorded from March to May in the wetlands of Axios (this study), Evros (data collected in 1988-89; Goutner & Kazantzidis, 1993), Nestos and Porto Lagos (data from 1989; Meininger, 1990), Messolonghi (data from 1990; De Nobel, 1995) and Alyki Kitrous (data from 1989; Papakostas 1989). In this analysis, monthly averages were used whenever more than one visits were made per month.

Tide height data were used to check the effect of the tide cycle on the occurrence of waders in the Axios Delta. These data were based on measurements made by a Hellenic Hydrographic Service automatic tide recorder, which was located at the port of Thessaloniki (c. 20 km away from the study area). Instrument values were transformed, so that low values represented low water and high values high water. The lower the value was, the more extensive tidal flat areas were available to waders in the Axios Delta. Each visit's mean tide height was calculated by averaging hourly values recorded on that date between 08.00 hrs and 18.00 hrs (*i.e.* during the period of observation).

The importance of the Axios Delta as a wintering area for waders was evaluated comparing the maximum numbers counted in the Delta with these available from the mid-winter waterfowl census in 1990 (Hellenic Bird Ringing Center, 1990). For this comparison we considered the maximum numbers counted in the Axios Delta between 14 January to 2 February, that is the period the mid-winter waterfowl census was carried out in Greece.

RESULTS

Species population levels and time of occurrence

Figs 1-4 show changes in population levels over the course of 1990 for 23 wader species that were observed in the Axios Delta more regularly and/or in larger numbers (species are grouped taxonomically).

Oystercatcher (*Haematopus ostralegus*) (Fig. 1)

Oystercatchers were observed in small numbers throughout the study. The largest numbers (c. 40 birds) were recorded in March and October, and were probably due to migrating birds. A few pairs bred in the area.

Ringed and Little Ringed Plovers (*Charadrius hiaticula* and *Charadrius dubius*) (Fig. 1)

Both species were present in small numbers (< 30 birds) during the summer and in the autumn, but a few Ringed Plovers were also observed in the spring. Little Ringed Plovers nested on sandy islets in the upper part of the river Axios, but not in the Delta.

Kentish Plover (*Charadrius alexandrinus*) (Fig. 1)

This plover was a common bird in the area, occurring all year long, but often in small numbers. After a sudden peak of > 200 birds in mid-March, numbers increased to over 300 at the end of August, and then declined until the end of the year. A few pairs nested in the Delta.

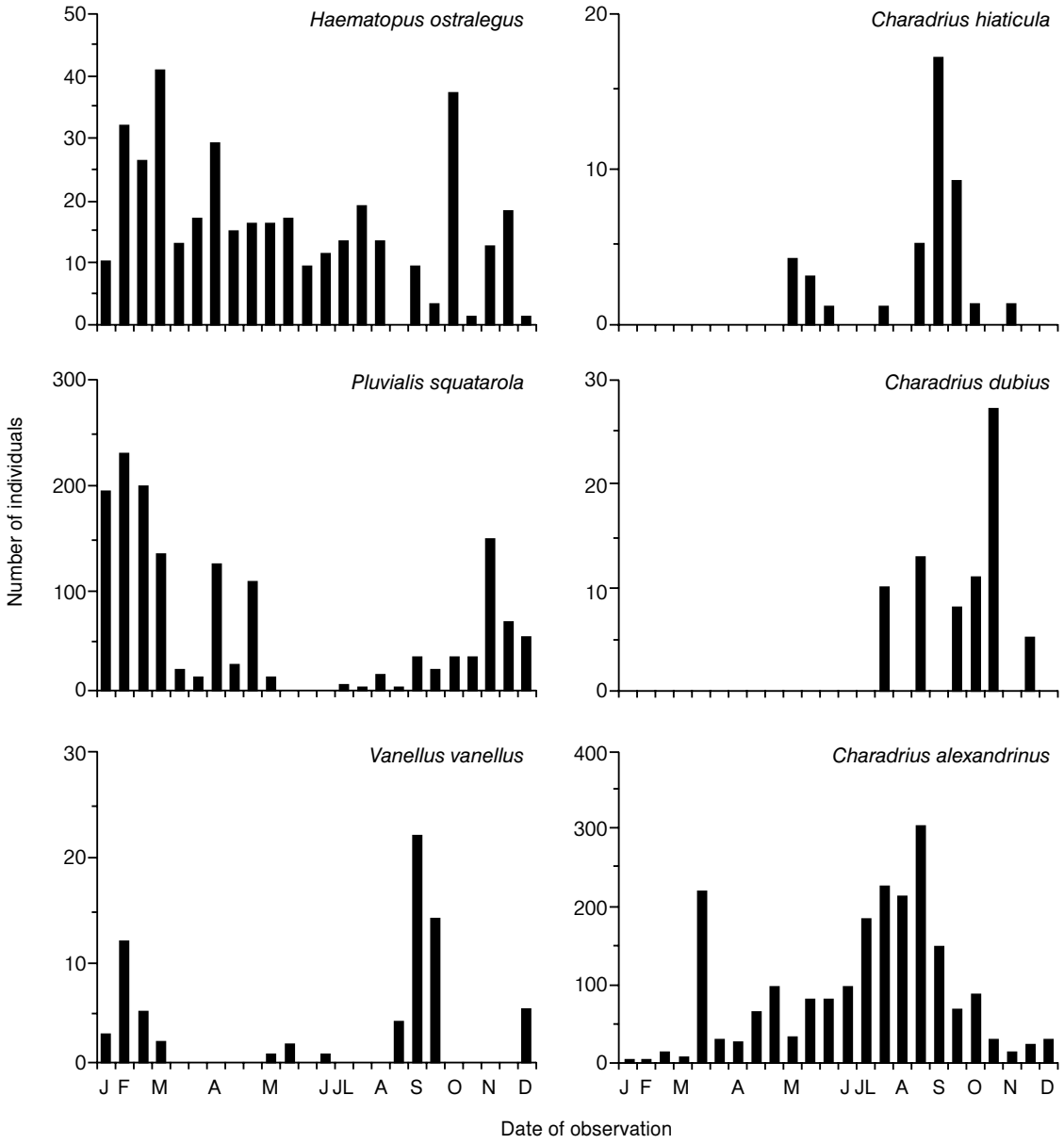

FIG. 1. Population changes of *Haematopus ostralegus* (Oystercatchers), *Charadrius hiaticula* (Ringed Plovers), *Charadrius dubius* (Little Ringed Plovers), *Pluvialis squatarola* (Grey Plovers), *Vanellus vanellus* (Lapwings) and *Charadrius alexandrinus* (Kentish Plovers) in the Axios Delta from January to December 1990. The actual survey dates corresponding to each column are indicated in Table 1.

Grey Plover (*Pluvialis squatarola*) (Fig. 1)

Though observed in all but one field visit, its numbers fluctuated greatly and were highest in the winter (> 200 birds) and in mid-November (> 150), whereas two peaks occurred in April.

Lapwing (*Vanellus vanellus*) (Fig. 1)

Lapwings were present in small numbers, mainly in the winter and in September. Some pairs nested in the wider area of the Axios Delta, most frequently on rice field dykes.

Turnstone (*Arenaria interpres*) (Fig. 2)

Small numbers visited the area during most of the year, being greatest in mid-February and in the spring.

Little Stint (*Calidris minuta*) (Fig. 2)

Several hundreds of birds were counted during late

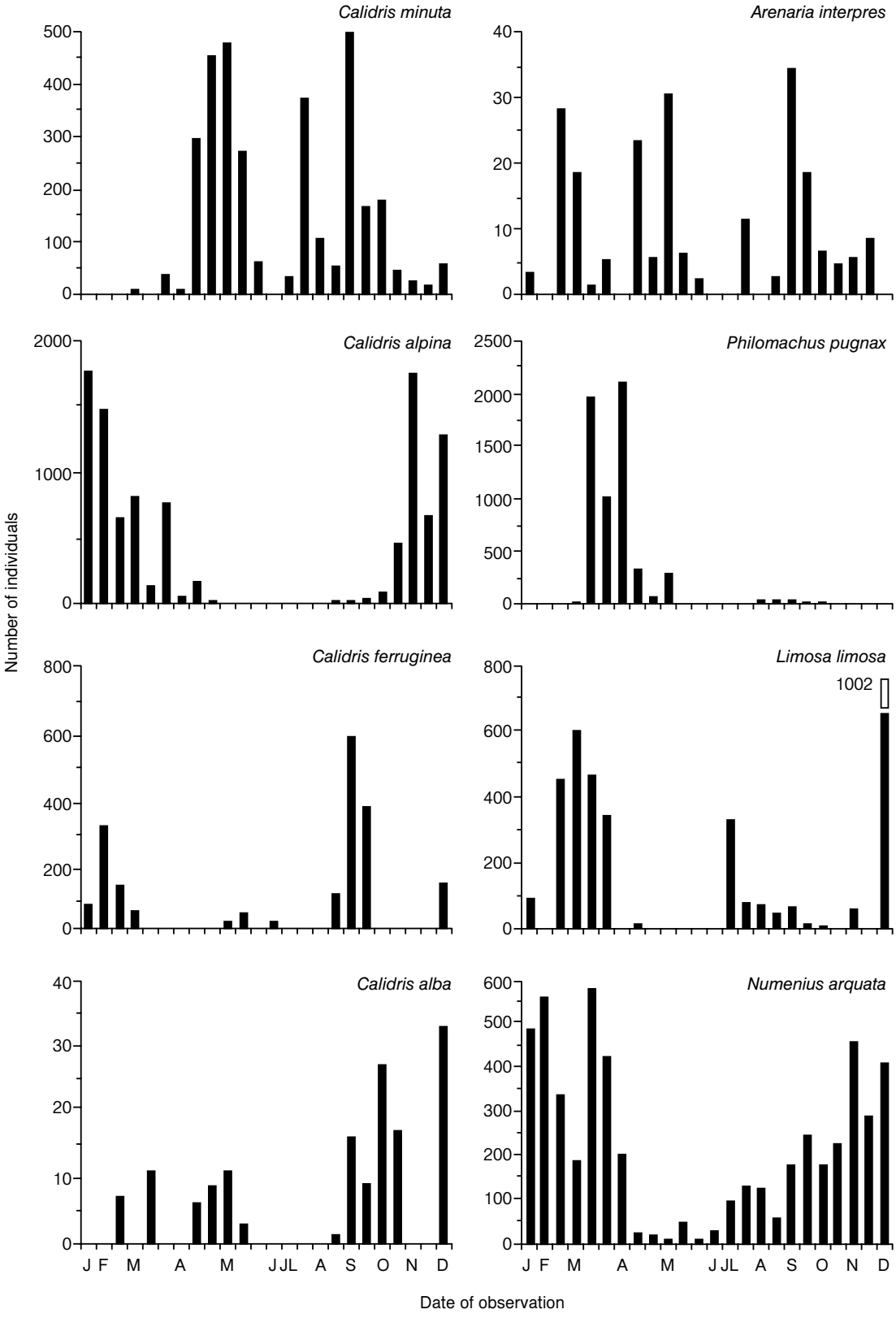

FIG. 2. Population changes of *Calidris minuta* (Little Stints), *Arenaria interpres* (Turnstones), *Calidris alpina* (Dunlins), *Philomachus pugnax* (Ruffs), *Calidris ferruginea* (Curlew Sandpipers), *Limosa limosa* (Black-tailed Godwits), *Calidris alba* (Sanderlings) and *Numenius arquata* (Curlews) in the Axios Delta from January to December 1990. The actual survey dates corresponding to each column are indicated in Table 1.

spring (mid-April to mid-May) and early autumn (September) migrations, but also in July. Little Stints were also present in the Delta during most of the rest of the study period, but in much smaller numbers.

Temminck's Stint (*Calidris temmincki*)

A few of these small waders were observed on two visits in September (Table 1).

Dunlin (*Calidris alpina*) (Fig. 2)

The highest populations (> 1700 birds) were recorded in late autumn and in the winter. Smaller numbers passed through the Delta during the early spring migration, while a few Dunlins were seen in the summer and in early autumn.

Curlew Sandpiper (*Calidris ferruginea*) (Fig. 2)

Curlew Sandpipers migrated through the area in late spring, peaking in early May (c. 800 birds) and then gradually dropping in numbers until the end of the month. Much fewer birds were present in the area in the summer.

Knot (*Calidris canutus*)

A scarce visitor was observed in Axios Delta on June 9th (Table 1).

Sanderling (*Calidris alba*) (Fig. 2)

Sanderlings were observed only in small numbers. Their presence in the Delta was more regular during the spring and autumn migrations, but the largest number (33 birds) was observed in December.

Ruff (*Philomachus pugnax*) (Fig. 2)

Ruffs were the commonest spring migrants, exceeding 2000 birds and outnumbering all other waders in mid-March and early April. A few birds were also seen in the autumn.

Black-tailed Godwit (*Limosa limosa*) (Fig. 2)

This wader uses the Axios Delta mostly in the winter (c. 1000 birds in late December) and during early spring migration (peak of c. 600 birds in early March). A lower peak (c. 350 individuals) occurred in mid-July, after which low numbers were recorded until mid-November.

Curlew (*Numenius arquata*) (Fig. 2)

The highest numbers (> 550 birds) were counted in late winter and in the early part of spring migration. The Curlew population in the Delta remained at low levels between mid-April and June, but increased thereafter, to exceed 400 individuals in November and December.

Spotted Redshank (*Tringa erythropus*) (Fig. 3)

This wader was observed in the Delta during short periods and in moderate numbers. Over 300 birds were observed in late April, while smaller populations were present in the second half of July and in early September.

Redshank (*Tringa totanus*) (Fig. 3)

The Redshank was present in the Axios Delta throughout the year. Over 800 birds were observed in the second half of July (summering individuals) and again in early October (autumn migrants). Lower peaks (< 400 birds) occurred irregularly during the rest of the study period.

Marsh Sandpiper (*Tringa stagnatilis*) (Fig. 3)

After a sudden peak of c. 200 spring migrants in April, this wader had a more permanent presence in the area during summer (when c. 300 birds were observed in late July) and in early autumn.

Greenshank (*Tringa nebularia*) (Fig. 3)

Small numbers were observed in the spring and between the end of July and early September. An exceptional peak of 117 birds, probably early autumn migrants, occurred at the end of August.

Green Sandpiper (*Tringa ochropus*)

This bird was observed occasionally and in small numbers in February and May, and from mid-July to the end of October, being mostly a summer visitor and early autumn migrant (Table 1).

Wood Sandpiper (*Tringa glareola*) (Fig. 3)

These sandpipers were observed in small numbers in the spring and from the end of July (when a peak of 42 birds occurred) to the end of October.

Common Sandpiper (*Tringa* (*Actitis*) *hypoleucos*) (Fig. 3)

A few birds were seen during spring migration, in July and in October.

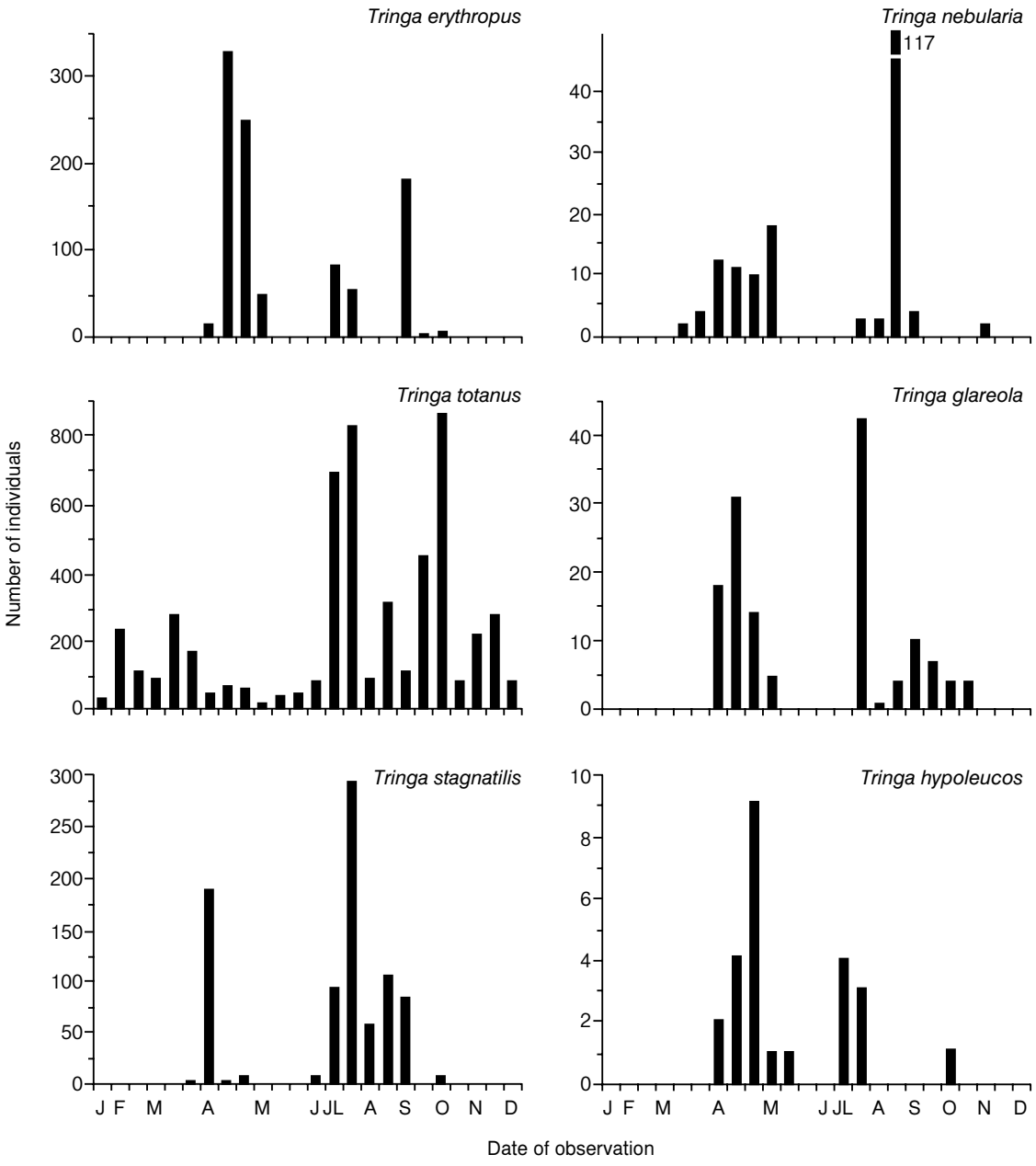

FIG. 3. Population changes of *Tringa erythropus* (Spotted Redshanks), *Tringa nebularia* (Greenshanks), *Tringa totanus* (Redshanks), *Tringa stagnatilis* (Marsh Sandpipers), *Tringa glareola* (Wood Sandpipers) and *Tringa hypoleucos* (Common Sandpipers) in the Axios Delta from January to December 1990. The actual survey dates corresponding to each column are indicated in Table 1.

Whimbrel (*Numenius phaeopus*)

A scarce migrant through the area. It was observed only twice in the spring and once in late September (Table 1).

Woodcock (*Scolopax rusticola*) and Snipe (*Gallinago gallinago*)

A single Woodcock was seen in the Delta on July 29th. Snipes were seen in very small numbers, in February and sporadically between August and October (Table 1).

Pied Avocet (*Recurvirostra avosetta*) (Fig. 4)

Avocets were observed during all field visits, but in highly fluctuating numbers. Peaks occurred in the winter (> 1500 birds in January, > 1250 in Decem-

TABLE 1. Relative percentages of wader populations in the Axios Delta from January to December 1990. The numbers underlined indicate the species dominating in each visit. Species' codes are given for only these used in cluster analysis (Fig. 7)

Species	Species code	20 Jan.	3 Feb.	17 Feb.	3 Mar.	17 Mar.	28 Mar.	7 Apr.	21 Apr.	29 Apr.	5 May	19 May	26 May	9 June	14 July	29 July	19 Aug.	31 Aug.	9 Sep.	22 Sep.	6 Oct.	21 Oct.	11 Nov.	24 Nov.	29 Dec.
C. alpina	CL	42.28	47.64	20.39	17.44	3.52	19.74	1.32	7.77	0.62	0.12	–	–	–	0.03	0.10	–	1.45	1.20	2.33	4.78	46.97	44.22	33.81	27.77
R. avosetta	RA	37.86	17.85	41.99	58.50	10.29	8.86	10.78	5.83	4.32	7.94	9.66	15.69	23.20	17.08	4.71	2.35	2.72	2.35	0.85	2.03	3.14	12.93	25.24	28.18
P. pugnax	PP	–	–	–	0.52	47.65	26.31	60.10	16.97	3.84	12.18	–	–	–	–	0.10	1.23	1.80	1.45	1.06	0.46	–	–	–	–
C. ferruginea	CF	–	–	–	–	–	0.03	–	1.58	6.54	32.38	28.44	24.98	0.12	0.63	3.60	0.53	5.33	2.20	–	–	–	–	–	–
C. minuta	CM	–	0.03	0.03	0.11	–	0.91	0.09	15.03	21.67	19.43	18.23	5.01	–	0.76	12.45	5.99	3.07	24.62	11.44	8.74	4.60	0.48	0.71	1.14
H. himantopus	HH	–	–	–	–	–	0.29	4.69	17.08	18.55	17.19	27.28	38.07	46.63	14.07	16.42	28.23	11.88	3.00	–	–	–	–	–	–
T. totanus	TT	0.91	7.53	3.66	2.15	6.82	4.45	1.60	3.53	3.36	0.69	2.86	4.74	10.58	18.12	27.99	5.52	18.31	6.01	31.99	43.90	9.00	5.76	14.18	1.97
N. arquata	NA	11.72	17.95	10.60	3.99	13.98	11.02	5.75	1.28	0.86	0.16	3.20	0.37	3.49	2.48	4.37	7.22	3.24	8.76	17.30	8.94	23.22	11.58	14.69	8.94
P. squatarola	PS	4.71	7.46	6.25	2.95	0.58	0.42	3.60	1.43	5.14	0.61	0.14	–	0.12	0.18	0.10	1.06	0.23	1.65	1.69	1.83	3.77	3.77	3.52	1.16
L. limosa	LL	2.09	0.03	14.04	12.94	11.14	8.80	0.03	0.66	–	0.08	–	–	–	8.56	2.56	3.93	2.32	3.05	0.85	0.30	–	1.28	0.05	21.96
H. ostralegus	HO	0.24	1.03	0.81	0.89	0.32	0.44	0.83	0.77	0.77	0.65	1.16	0.84	1.32	0.34	0.64	0.76	–	0.45	0.21	1.88	0.10	0.31	0.92	0.02
A. interpres	AI	0.07	–	0.88	0.39	0.02	0.13	–	1.18	0.24	1.22	0.41	0.19	–	–	0.37	–	0.12	0.05	1.06	0.30	0.42	0.13	0.41	–
V. vanellus	VV	0.07	0.39	0.16	0.04	–	–	–	–	–	0.04	0.14	–	0.12	–	–	–	0.23	1.10	0.99	–	–	–	–	0.11
C. alexandrinus	CA	0.05	0.10	0.44	0.09	5.34	0.76	0.77	3.27	4.52	1.26	5.44	7.43	11.18	4.78	7.54	12.38	17.38	7.36	4.73	4.27	2.82	0.33	1.12	0.57
T. erythropus	TE	–	–	–	–	0.02	–	0.46	16.56	11.87	2.00	–	–	0.12	2.14	1.88	–	–	9.01	0.14	0.25	–	–	–	–
T. nebularia	TN	–	–	–	–	0.05	0.10	0.34	0.56	0.48	0.73	–	–	–	–	0.10	0.18	6.78	0.20	–	–	–	0.05	–	–
T. stagnatilis	TS	–	–	–	–	–	0.03	5.35	0.05	0.34	–	–	–	0.84	2.40	9.76	3.17	6.03	4.10	–	0.15	–	–	–	–
T. glareola	TG	–	–	–	–	–	–	0.51	1.58	0.67	0.20	–	–	–	–	1.41	0.06	0.23	0.50	0.49	0.20	0.42	–	–	–
T. hypoleucos	TH	–	–	–	–	–	–	0.06	0.20	0.43	0.04	0.07	–	–	0.10	0.10	–	–	–	–	0.05	–	–	–	–
N. phaeopus	–	–	–	–	–	–	–	–	0.10	–	0.04	–	–	–	–	–	–	–	0.05	–	–	–	–	–	–
P. lobatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.23	0.06	0.05	0.14	–	–	–	–	–
B. oedicnemus	–	–	–	–	–	–	–	–	0.02	0.05	–	–	–	–	–	–	0.41	–	–	–	–	–	–	–	–
G. pratincola	GP	–	–	–	–	–	–	–	3.48	0.53	2.36	2.59	2.60	2.16	0.03	0.20	3.64	1.04	–	–	–	–	–	–	–
C. dubius	CD	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.34	–	0.75	–	0.56	0.56	2.82	–	0.25	–
C. hiaticula	CH	–	–	–	–	–	–	–	–	–	0.16	0.20	0.09	–	–	0.03	–	0.29	0.85	0.64	0.05	–	0.03	–	–
C. alba	CB	–	–	0.22	–	0.27	–	–	0.31	0.43	0.45	0.20	–	–	–	–	–	0.06	0.80	0.64	1.37	1.78	–	–	0.72
T. ochropus	TO	–	–	0.03	–	–	–	–	–	–	0.08	–	–	–	0.78	0.61	0.23	0.46	0.10	0.21	0.10	0.10	–	–	–
C. canutus	–	–	–	–	–	–	–	–	–	–	–	–	–	0.12	–	–	–	–	–	–	–	–	–	–	–
C. temmincki	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.10	0.64	–	–	–	–	–
S. rusticola	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.07	–	–	–	–	–	–	–	–	–
G. gallinago	–	–	–	0.03	–	–	–	–	–	–	–	–	–	–	–	–	0.06	0.06	–	0.21	0.25	0.84	–	–	–
Tringa & *Calidris**		–	–	0.47	–	–	17.71	3.72	0.87	14.80	–	–	–	–	27.52	4.54	23.47	16.22	21.17	22.60	19.56	–	19.13	5.10	7.45
Number of species		10	10	14	12	13	15	16	22	20	23	15	11	13	16	23	19	23	24	21	20	14	12	11	11
Totals		4165	3109	3198	4615	4120	3839	3496	1956	2081	2455	1470	1077	832	3830	2972	1704	1726	1998	1416	1968	956	3921	1961	4563

*Unidentified

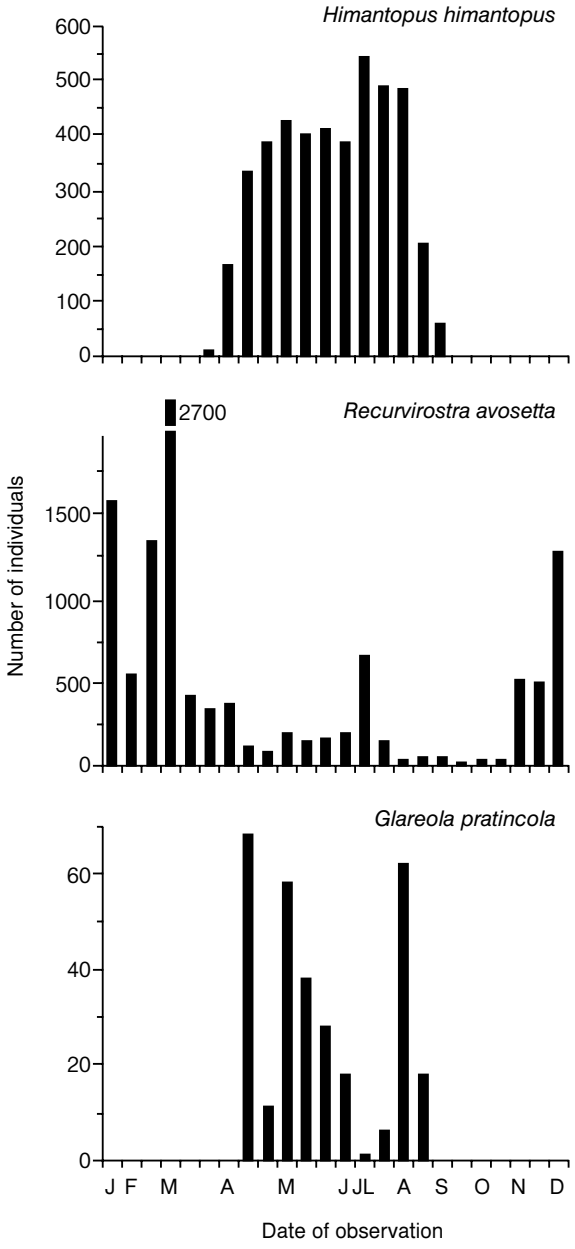

FIG. 4. Population changes of *Himantopus himantopus* (Black-winged Stilts), *Recurvirostra avosetta* (Pied Avocets) and *Glareola pratincola* (Collared Pratincoles) in the Axios Delta from January to December 1990. The actual survey dates corresponding to each column are indicated in Table 1.

ber) and early in the spring migration period (c. 2700 individuals in early March). With the exception of a summering peak (> 500 birds) in mid-July, the population remained at relatively low levels (< 200 birds) between mid-April and late October, to increase again in November (> 500 birds). A small population nested in loose colonies, together with Black-winged Stilts, or as solitary pairs in coastal saltmarshes.

Black-winged Stilt (*Himantopus himantopus*) (Fig. 4)

Black-winged Stilts were present in the Delta from the end of March to the beginning of September. After a gradual increase through April, numbers remained stable (c. 400 birds) until June, due to the establishment of a breeding population of at least 150 pairs. The population increased later in the summer, partly due to the arrival of summering birds, but dropped quickly at the end of August.

Red-necked Phalarope (*Phalaropus lobatus*)

A few of these waders were seen on only four visits, in August and September, probably on early autumn migration (Table 1).

Stone Curlew (*Burhinus oedicnemus*)

This species was occasionally seen in April and August. A few pairs probably nested in the Delta (Table 1).

Collared Pratincole (*Glareola pratincola*) (Fig. 4)

Pratincoles were present in low to moderate numbers from mid-April to late August. At the beginning and at the end of this period most birds were migrants. Numbers declined between April and July, as part of a small breeding population abandoned the nesting grounds due to disturbance by grazing cattle.

Patterns of occurrence

The total number of waders in the Axios Delta (including birds unidentified at species level, Table 1) was highest in the winter and early spring months, when it reached a maximum of c. 4600 birds. Another high peak (c. 3800 individuals) appeared in July, due to migrating birds. Much fewer waders were present in the intermediate periods (Fig. 5).

The number of species recorded on each visit varied from 10 to 24 (Fig. 5, Table 1) and it was not correlated with the total population size ($r_s = -0.311$, n = 24, n.s.). Some species were dominant (the most numerous) during two or three successive visits. Species dominance changed within and between seasons. Dunlins were dominant on a total of five visits (two in January and February, and three in October and November), accounting for 33.8% to 47.6% of the total population present. Avocets were dominant on

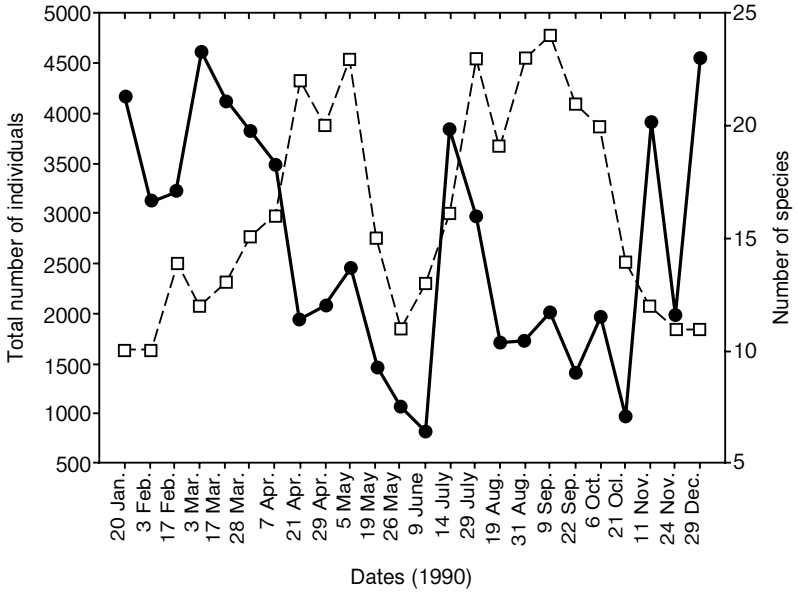

FIG. 5. Changes in total population sizes and number of species of the waders in the Axios Delta from January to December 1990. Closed dots-solid line: number of individuals; open squares-stippled line: number of species.

three visits (in February, March and December) (28.2% to 58.5%), Ruffs on three (in March and April) (26.3% to 60.1%), Curlew Sandpipers on two visits in May (28.4% and 32.4%), Little Stints on two (April and December) (21.7 to 24.6%), Black-winged Stilts on four (in April, May, June and August) (17.1% to 46.6%), and Redshanks on five (in July, August, September and October) (18.1% to 43.9%). Some of the above percentages may be underestimates, because many unidentified birds (which sometimes made up a substantial portion of the population, see Table 1) could belong to the dominant species. Sometimes, the dominant species represented a relatively small portion of the total population, because other waders were also numerous at the same time. This situation was evident especially during the spring and summer. For example, on April 21st, the percentages of Ruffs and Black-winged Stilts were very similar (17.0% and 17.1% of the total population, respectively). The Curlew, Black-tailed Godwit, Spotted Redshank and Kentish Plover were never dominant, but they occasionally made up more than 10% of the total population. The total number of waders on each field visit was negatively correlated with the average tide height in the area ($r_s = -0.685$, $n = 24$, $p = 0.0002$; Fig. 6).

Cluster analysis (Fig. 7) divided wader species in five distinctive groups. On the left side of the diagram is a group of winter residents (*Recurvirostra avosetta* (RA), *Numenius arquata* (NA), *Pluvialis squatarola* (PS), *Calidris alpina* (CL)) and early spring migrants (*Limosa limosa* (LL) and *Philomachus pugnax* (PP)). Neighbouring, it is a cluster of less regular visitors, whose numbers peaked in the winter, early spring and autumn (*Haematopus ostralegus* (HO), *Arenaria interpres* (AI) and *Calidris alba*

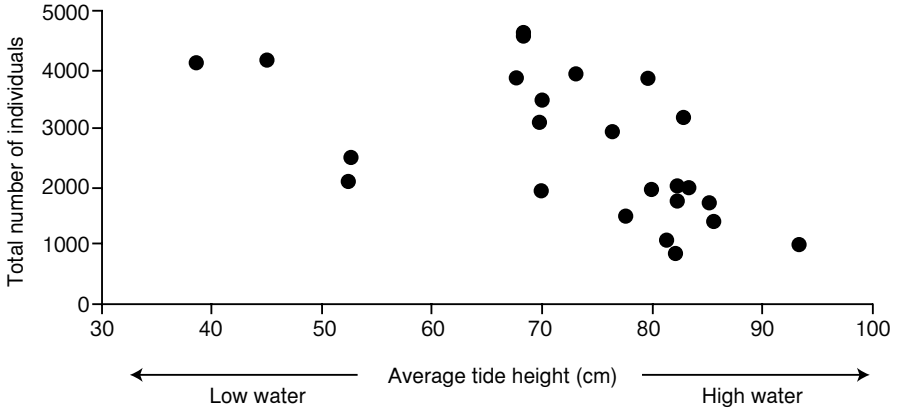

FIG. 6. Relationship of total number of waders and tide height in all 24 counts carried out (Table 1). The lowest the tide height, the most extensive feeding grounds are available to the waders.

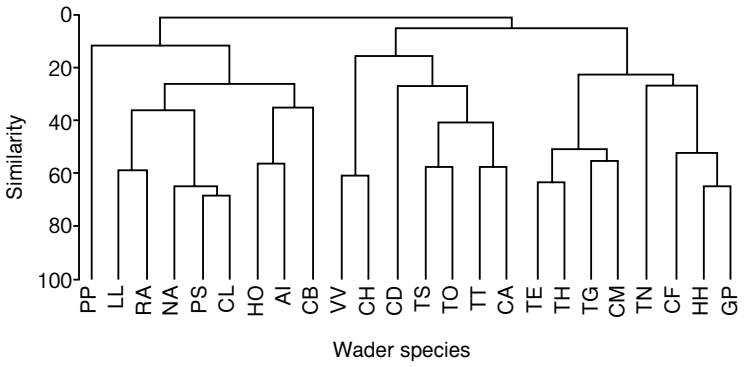

FIG. 7. Cluster analysis of the populations of 24 species of waders occurring in the Axios Delta from January to December 1990. The initials of the species are explained in Table 1.

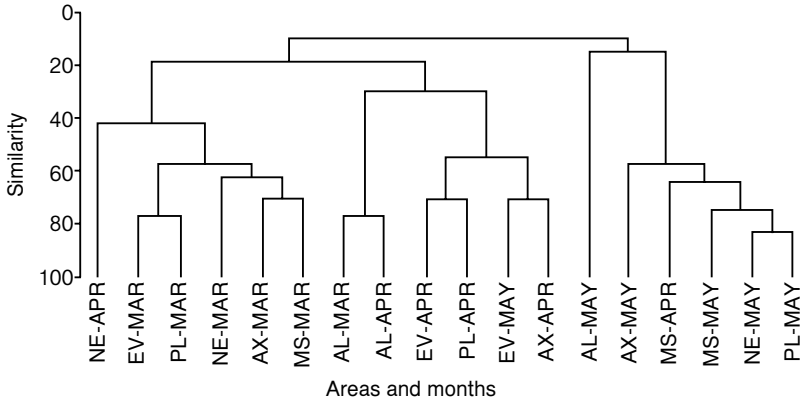

FIG. 8. Cluster analysis of the populations of 22 species of waders commonly occurring in some Greek coastal wetlands from March to May. NE: Nestos Delta; EV: Evros Delta; PL: Porto Lagos area; AX: Axios Delta (this study); MS: Messologhi Lagoon; AL: Alyki Kitrous.

(CB)). On the far right side of the diagram are clustered species present only in the spring and summer (*Calidris ferruginea* (CF), *Himantopus himantopus* (HH), *Glareola pratincola* (GP)). Associated with them are waders that are found in the area in mid-spring and in mid- to late summer (*Calidris minuta* (CM), *Tringa erythropus* (TE), *T. hypoleucos* (TH) and *T. glareola* (TG)). Species seen in the Delta, mainly in the summer and autumn, are grouped together in a centrally located cluster (*Vanellus vanellus* (VV), *Charadrius hiaticula* (CH), *Tringa stagnatilis* (TS), *Calidris ochropus* (TO), *Tringa totanus* (TT), *Charadrius alexandrinus* (CA) and *C. dubius* (CD); numbers of *T. stagnatilis* and *C. alexandrinus* also peaked in early spring).

A cluster analysis of data collected in the spring at Axios, Evros and Nestos Deltas, Porto Lagos, Messolonghi and Alyki Kitrous (see methods) revealed that most counts were associated in monthly groups (Fig. 8).

DISCUSSION

Some wader species previously reported in the Axios Delta (MEHPW, 1986a; Goutner & Handrinos, 1990; Handrinos & Akriots, 1997), namely the Slender-billed Curlew (*Numenius tenuirostris*), Spur-winged Plover (*Hoplopterus spinosus*), Broad-billed Sandpiper (*Limicola falcinellus*), Purple Sandpiper (*Calidris maritima*), Bar-tailed Godwit (*Limosa lapponica*), Great Snipe (*Gallinago media*) and Jack Snipe (*Lymnocryptes minimus*), have not been observed in this study, probably due to their scarcity. The Slender-billed Curlew is the most rare wader of the western Palearctic (Grimmet & Jones, 1989) and the Spur-winged Plover is normally seen only in the wetlands of eastern Greece (Makrigianni, 2003). The rest of the above species are scarce for other Greek wetlands, too (Handrinos & Akriots, 1997). On the other hand, species such as the Grey Phalarope (*Phalaropus lobatus*) and the Knot had not been previously reported in the Delta, though they are known to occur occasionally in the wider area (Bauer *et al*., 1969). The numbers of some of the smaller and less distinctive species (like the Kentish Plover, *Calidris* spp. and even some *Tringa* spp.) may sometimes have been underestimated, and even their presence may have occasionally been overlooked, when substantial numbers of waders were unidentified at the species level (Table 1). This happened when large mixed-species flocks were observed from a long distance

and under unfavourable weather conditions.

The importance of tidal flats as foraging grounds for many wader species is well known (Lambeck *et al*., 1989; Gill & Hander, 1990; Moreira, 1993). Tidal cycles in the eastern Mediterranean lack the amplitude of such phenomena along ocean coasts and are greatly affected by wind direction and intensity (Babalonas, 1979). However, the intertidal areas of Greek coastal wetlands can be extensive, due to low water depth. In the Axios Delta, coastal mudflats are the main foraging habitat for most wader species. Ricefields are also used by numerous waders (mainly spring migrants), but only during the short period when they are flooded. Coastal mudflats are also important as resting areas, because their long distance from roads buffers them from human activities that may cause disturbance (e.g. hunting). The availability of this valuable habitat to waders is reduced at high tide. The tendency of the wader population to drop at high tide is probably due to the fact that few safe high-water roosts (e.g. coastal islets) exist in the area. Thus, part of the population may move out of the study area, probably to other parts of the wetland complex of Thermaikos Gulf.

In the Axios Delta, waders showed distinctive patterns of occurrence. Wader population levels and trends in other Greek coastal wetlands are poorly known. Some published information comes from January wader counts up to 1986, conducted as part of the mid-winter waterfowl count project of the non-governmental organization "Wetlands International" (formerly International Waterfowl Research Bureau, IWRB). A comparison between these mid-winter data and the findings of the present study suggests that some of the commonest winter residents at Axios (such as the Avocet and Black-tailed Godwit) were also numerous in other Greek coastal wetlands in January (Porto Lagos and surrounding area, Axios-Loudias-Aliakmon Delta, Amvrakikos Gulf; Athanasiou, 1987). Besides, the Avocet, Curlew, Grey Plover, Redshank and Lapwing have often been reported as the commonest waders wintering in the coastal wetlands of Messolonghi, Amvrakikos and the Vistonis–Porto Lagos area (MEHPW 1986b, c, d). The cluster analysis of spring (March to May) data from Axios, Evros and Nestos Deltas, Porto Lagos, Messolonghi and Alyki Kitrous suggested a strong similarity in the temporal pattern of wader occurrence among these wetlands. These lines of evidence suggest that some wader species follow a common pattern of seasonal occurrence in coastal Greek wetlands, at least during part of the year (winter and spring). This is probably due to the location of these wetlands within the Mediterranean wintering grounds and along the eastern Mediterranean migration flyway.

This study also revealed that in the period between mid-June and mid-August, the Axios Delta hosts good numbers of several wader species. This fact had not been previously documented anywhere in Greece and its importance lies in that during this period waders moult and acquire their winter plumage before autumn migration. Thus, wader populations would benefit from the maintenance of good foraging conditions in the area. This can be promoted by the increase of suitable foraging habitat in the lower delta through artificial flooding, since the extensive rice fields of the upper delta are not available to foraging waders during this season, due to the height and density of rice plants (Kazantzidis, 1998). Breeding waders in the Axios Delta, such as the Avocet and Collared Pratincole, suffer from nest trampling by grazing cattle along the coastal saltmarshes. These species would greatly benefit from the regulation of grazing in the spring and early summer.

The comparison of mid-winter population levels of waders from Axios with the available collected during the mid-winter waterfowl census in Greece in 1990, indicated that among 13 wetlands (out of 33 surveyed) where waders were present and/or counted (HBRC, 1990) the Axios concentrates 14.1% of the total wader population wintering in them. It means that Axios far exceeds the 1% criterion as a wetland of national importance for this bird group. Species of waders exceeding the 1% criterion in Axios were *Limosa limosa* (40.5% of the total Greek wintering population), *Haematopus ostralegus* (36.4%), *Pluvialis squatarola* (30.9%), *Recurvirostra avosetta* (20.5%), *Calidris alpina* and *Numenius arquata* (both 18.4%) and *Tringa totanus* (6.6%).

Regarding the importance of the Axios Delta as a staging area for migration waders, it seems to be quite important. Migration takes place from the beginning of March to mid-May and from the beginning of July to mid Nonember. Waders have a high turnover rate during migration. If we assume that the waders counted in each survey in the above mentioned period stayed for short periods in the Delta, by summing their numbers a minimum of 43000 birds migrated through the Axios Delta during the study, that is twice as high the threshold of 20000 birds for the identification of a wetland of Africa-

Western Eurasia as internationally important for waders (Stroud *et al.*, 2004). By all means, the levels of wader populations migrating through Axios Delta need further investigation.

ACKNOWLEDGMENTS

We express out thanks to the Hellenic Hydrographic Service for tide height data from the port of Thessaloniki. Dr. Grigorios Papakostas and the Editor Dr. A. M. Bosabalidis made useful linguistic corrections and comments on the manuscript.

REFERENCES

Athanasiou H, 1987. *Past and present importance of the Greek wetlands for wintering waterfowl*. International Waterfow Research Bureau, Slimbdridge.

Athanasiou C, 1990. *Wetland habitat loss in Thessaloniki plain, Greece*. MSc Dissertation, University College, London.

Babalonas D, 1979. Plant sociological study on the vegetation of the Evros River Delta (Aenission Delta). Ph. D. Thesis, University of Thessaloniki.

Bauer W, Helversen O, Hodge, M, Martens M, 1969. *Catalogus Faunae Graeciae, Pars II AVES*. A. Kanellis, Thessaloniki.

Cramp S, Simmons KEL, 1983. *The birds of the western Palearctic. Vol. III Waders to Gulls*. Oxford University Press, Oxford.

Davidson NC, Stroud DA, Rothwell PI, Pienkowski MW, 1998. Towards a flyway conservation strategy for waders. *International wader studies* 10: 24-44.

De Nobel WT, 1995. *Birds of the Messolonghi wetlands.* Eastern Mediterranean Wader Project, spring 1990. WIWO-report 53, Zeist.

Gill RE Jr, Handel CM, 1990. The importance of subarctic intertidal habitats to shorebirds: a study of the central Yukon-Kuskokwim Delta, Alaska. *Condor*, 92: 709-725.

Goutner V, 1983. The distribution of the waders (Charadrii) in the Evros Delta (Greece) during the breeding season. *Scientific Annals, Faculty of Sciences, Universtity of Thessaloniki*, 23: 37-78.

Goutner V, Handrinos G, 1990. The occurrence of Slender-billed Curlews (*Numenius tenuirostris*) in Greece. *Biological conservation*, 53: 47-60.

Goutner V, Papakostas G, 1992. Evaluation of the ornithological importance of the Alyki Kitrous wetland, Macedonia, Greece: a priority for conservation. *Biological conservation*, 62: 131-138.

Goutner V, Kazantzidis S, 1993. Shorebird population in the Evros Delta, Greece. *Bios*, 1: 69-98.

Grimmet RFI, Jones TA, 1989. *Important bird areas in Europe.* ICBP Technical Publication, No. 9: 271-307.

HBRC (Hellenic Bird Ringing Center), 1990. Mid-winter waterfowl census. Greece: 1990. HBRC unpublished report to IWRB.

Handrinos G, Akriotis T, 1997. *The birds of Greece*. A & C Black, London.

Kazantzidis S, 1998. Breeding ecology of the Little Egret (*Egretta garzetta garzetta* (L. 1766)) in the Axios River Delta. Ph. D. Thesis, University of Thessaloniki.

Lambeck RHD, Sandee AJJ, De Wolf L, 1989. Long term patterns in the wader usage of an intertidal flat in the Oosterschelde (SW Netherlands) and the impact of the closure of an adjacent estuary. *Journal of applied ecology*, 26: 419-431.

Makrigianni E, 2003. Breeding biology of the Spur-winged Plover (*Hoplopterus spinosus*) in the Evros Delta. M. Sc. Thesis, University of Thessaloniki.

Meininger PL, 1990. Birds of the wetlands in North-east Greece, spring 1987. WIWO-report 20, Zeist.

MEHPW (Ministry of Environment, Housing and Public Works), 1986a. *Project for delineation of Ramsar Convention wetlands. Wetland: Delta of Aliakmon - Loudias - Axios*. MEHPW, Athens (in Greek).

MEHPW (Ministry of Environment, Housing and Public Works), 1986b. *Project for delineation of Ramsar Convention wetlands. Wetland: Messolonghi Lagoon.* MEHPW, Athens (in Greek).

MEHPW (Ministry of Environment, Housing and Public Works), 1986c. *Project for delineation of Ramsar Convention wetlands. Wetland: Amvrakikos Gulf.* MEHPW, Athens (in Greek).

MEHPW (Ministry of Environment, Housing and Public Works), 1986d. *Project for delineation of Ramsar Convention wetlands. Wetland: Lake Vistonis - Porto Lagos.* MEHPW, Athens (in Greek).

Moreira F, 1993. Patterns of use of intertidal estuarine areas by feeding bird assemblages: a study in the Tagus estuary (Portugal). *Ardeola*, 40: 39-53.

Papakostas G, 1989. Evaluation of the ornithological importance of the wetland of Alyki Kitrous Pierias. Diploma Thesis, University of Thessaloniki (in Greek).

Poulos S, Papadopoulos A, Collins MB, 1994. Deltaic progradation in Thermaikos Bay, Northern Greece and its socio-economical implications. *Ocean and coastal management*, 22: 229-247.

Stroud DA, Davidson NC, West R, Scott D, Haanstra L, Thorup O, Ganter B, Delany S (compilers) on behalf of the International Wader Study Group, 2004. Status of migratory wader populations in Africa and Western Eurasia in the 1990s. *International wader studies*, 15: 1-259.