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Abundance and habitat use by herons (Ardeidae) in the Axios Delta, northern Greece

SAVAS KAZANTZIDIS[1*] and VASSILIS GOUTNER[2]

[1] *National Agricultural Research Foundation*, *Forest Research Institute*, *57006 Vassilika*, *Thessaloniki*, *Greece*
[2] *Department of Zoology*, *School of Biology*, *Aristotle University of Thessaloniki*, *54124 Thessaloniki*, *Greece*

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Habitat use, abundance and changes in number of herons were studied in the Axios Delta during a year cycle. At least seven different man-made and natural habitat types were distinguished in an area of 99.06 km^2; rice fields (44.5% of the study area), seacoast (20.6%), salt marshes (19.0%) and fresh water habitats (2.5%). Nine heron species were recorded (five breeding, two wintering and two staging). Little egret was the most opportunistic species using almost equivalently all habitat types. Great white and grey herons mostly exploited the salt marshes and seacoast. Squacco, purple and night herons exploited rice fields, especially during the chick-rearing period (May-June). Fresh water marshes were valuable for almost all species, particularly during the breeding season. Canals were occasionally attractive to heron species, especially in the spring. Interspecific competition may occur in the feeding areas and especially in the freshwater marshes, but both, biological and behavioural segregation among the species probably reduced the negative effects. The conservation of freshwater habitats alongside the enforcement for less intensive agricultural practices at rice fields is considered essential for heron protection in the Axios delta.

Key words: herons, egrets, habitat use, Axios delta, Greece.

INTRODUCTION

Herons are wading birds of considerable importance, because they constitute indicator species in wetlands. Therefore, they have been the object of a considerable number of studies regarding their distribution, habitat use, breeding biology, foraging habits and as indicators of pollution (Fasola, 1986; Tsachalidis, 1990; Kushlan, 1993; Kazantzidis & Goutner, 1996; Kazantzidis, 1998; Kushlan & Hafner, 2000; Goutner *et al*., 2001a, b).

In Greece, as likewise in Europe, nine species of herons have been reported, most of which breed regularly (Kushlan & Hafner, 2000; Kazantzidis & Goutner, 2005). These species as well as the non-breeding ones may also occur during migration and/or wintering. Despite the wide occurrence of these birds in the Greek wetlands, only a few studies have been carried out. These mainly concerned the breeding biology of species such as the little egret *Egretta garzetta* (Tsachalidis, 1990; Kazantzidis, 1998), the black-crowned night heron *Nycticorax nycticorax* (Kazantzidis *et al.*, 1997; Birtsas, 2002) and the squacco heron *Ardeola ralloides* (Papakostas, 2002), as well as the foraging ecology of the little egret (Kazantzidis & Goutner, 1996; Dimalexis *et al.*, 1997), the great white heron *Ardea alba,* the grey heron *Ardea cinerea* (Dimalexis & Pyrovetsi, 1997; Dimalexis *et al.,* 1997) and the squacco heron (Papakostas *et al.,* 2005). Additionally, species such as those previously mentioned have been studied as bioindicators of mercury (Goutner & Furness, 1997; Goutner *et al.,* 2001a) and organochlorines (Albanis *et al.,* 1996). Little effort has been made to study the distribution, abundance and habitat use of herons during their annual cycle of occurrence in Greek wetlands, despite the usefulness of this information on the conservation and manage-

* Corresponding author: tel.: +30 2310 461173 (ext. 214), fax: +30 2310 461341, e-mail: savkaz@fri.gr

ment of their populations and of that of the wetlands.

All nine heron species recorded in Europe and Greece were present in the study area. Little egrets, black-crowned night herons, and squacco herons form a mixed colony on tamarisks along a bank of the lower Axios river where spoonbills *Platalea leucorodia*, great cormorants *Phalacrocorax carbo* and occasionally pygmy cormorants *Phalacrocorax pygmaeus* and glossy ibises *Plegadis falcinellus* also occur. Purple herons *Ardea purpurea* breed separately in a monospecific colony in reed beds (Kazantzidis, 1998).

Regarding the rest of the colonially breeding species, the great white heron breeds in small numbers and the cattle egret *Bubulcus ibis* was recorded to breed only once (Goutner *et al.*, 1991). The grey heron, although present in the area throughout the whole year, has never been reported to breed. Among the non-colonially breeding herons, only the little bittern *Ixobrychus minutus* breeds in reed beds, while the bittern *Botaurus stellaris* is only present during the staging periods in small numbers and it is assumed that it probably bred there in the past (Sladen, 1917).

The aim of the present study was to describe in the year cycle the abundance, the number changes and the habitat use of herons occurring in the Axios Delta because such information appropriately used could promote their conservation.

MATERIALS AND METHODS

The area where this study was carried out included the Axios and Gallikos river estuaries (40° 30′ N, 22° 53′ E), parts of a wetland complex of the Thermaikos Gulf, in northeastern Greece, covering an area of 68.7 km^2 (Athanasiou, 1990), and made up by the estuarine and deltaic areas of the rivers Axios, Aliakmon, Loudias and Gallikos. The complex is a wetland of international importance covered by the Ramsar Convention, a Special Protected Area, an Important Bird Area and hosts one of the biggest heron colonies in Greece (Bourdakis & Vareltzidou, 2000). In the part of the area that is most important for the heron species (99.06 km^2), the following different habitat types were distinguished from aerial photographs taken in the 1990s (provided by the Geographic Military Service, Table 1 and Fig. 1):

a) Rice fields, covering nearly half of the study area (~ 44.5%), flooded from April to July and harvested in September or October.
b) Seacoasts, making up 20.59% of the area. Only shallow areas, small islets and sand bars close to the seashore where herons can forage, were considered.
c) Salt marshes (~ 19.0% of the area), situated in the southeastern part as i) a narrow band parallel to the shore separated from the sea by a dike, and ii) spread in patches at the mouth of the delta and in some lagoons in the western part of the study area.
d) Freshwater marshes permanent or temporary (2.51% of the area) occurring mostly in the northwestern part of the area as a very narrow band parallel to the Axios river between rice fields and shrublands and at the Gallikos river as ponds (mainly).
e) Shrublands (~ 9.3% of the area) situated along both sides of the Axios river and partially of the Gallikos river. Parts of this habitat constituted an important heron nesting habitat.
f) Parts of the riverbeds of Gallikos, Axios and Loudias (3.42% or the area).
g) Canals (~ 0.3% of the area), occurring mainly in the west part of the study area.
h) Other habitats, (0.45% of the area) consisted of dirt roads made through the rice fields or on the coastal embankments separating salt marshes from the sea, and two landfill areas.

TABLE 1. Habitat types and extent in the study area

Habitat type	Size (km^2)	% of the total area
Ricefields	44.07	44.49
Seacoast	20.40	20.59
Saltmarsh	18.80	18.98
Shrubland	9.19	9.28
River	3.39	3.42
Freswater marsh	2.48	2.51
Canal	0.28	0.28
Other	0.45	0.45
Total	99.06	100.00

Human presence is intense in the biggest part of the area. Apart from extensive rice fields, there are also mussel-cultures on the seacoast, fishery and stock breeding in the zone between the sea and the rice fields, while recreation activities have been initiated in the last decade.

During the study period (from January to December 1990), the numbers of all heron species were counted 1-3 times monthly. The herons occurring in the habitats were counted using telescopes or binoculars along a pre-arranged route of approximately 100 km, being the same in all counts starting from the

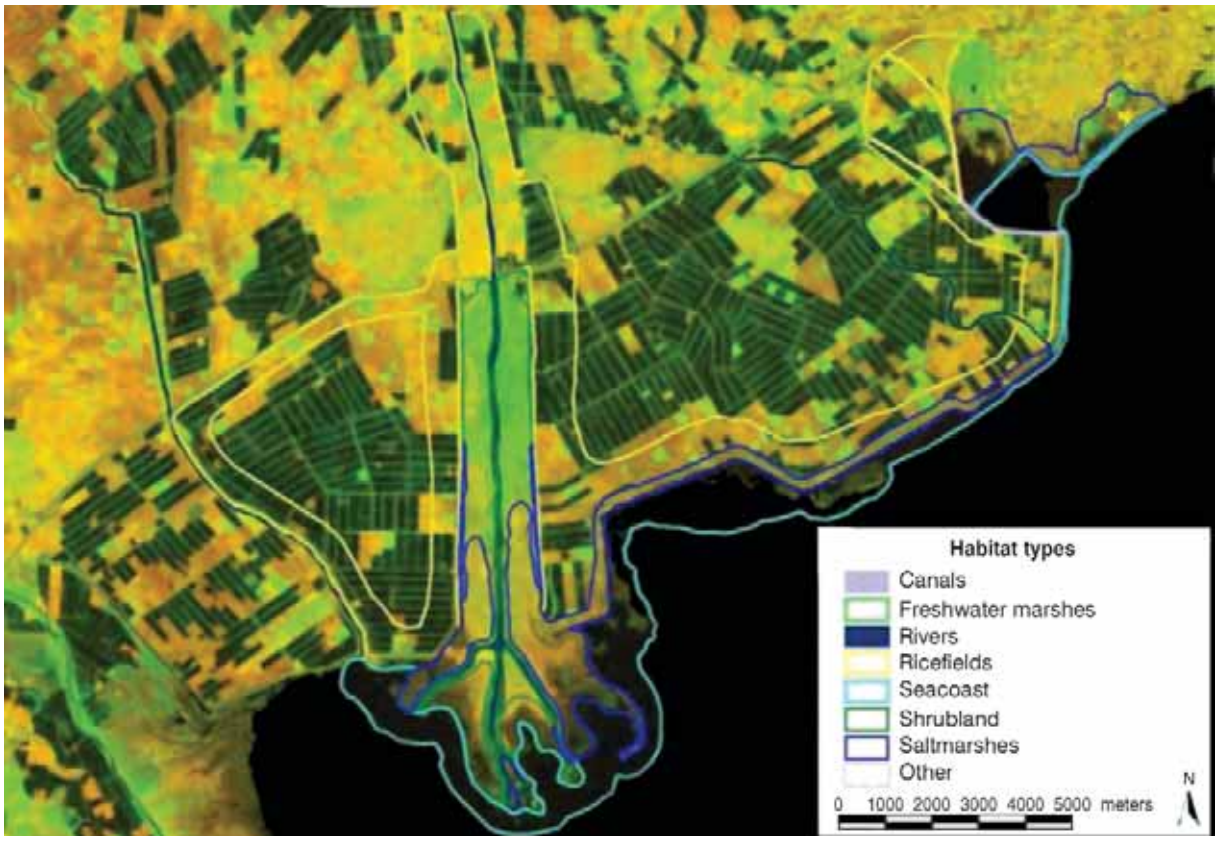

FIG. 1. The study area of the Axios Delta including the Gallikos (on the right) and the Loudias (on the left) estuaries. The habitat types involved are also indicated.

east part of the area and finishing in the west. Each count lasted from early morning to late afternoon. The route was designed in such a way as to include all available habitat types used by all heron species. Special attention was paid in order to avoid the same individuals being counted twice in case they flew from one site to another. Species distribution was recorded on 1:10000 maps. Breeding populations were estimated by counting directly the number of active nests in their colony (Kazantzidis, 1998). In this study, the birds counted were those present in habitats other than the breeding ones. The size of each habitat type was calculated using satellite images and the GIS ArcView software. The coefficient of variation (CV $= \frac{S}{X} \times 100$, where "S" is the standard deviation and "X" is the mean) was used in order to compare the relative dispersion of the studied bird species among the habitats. The selection index w_i (Krebs, 1999) was used to evaluate the preferred habitats of herons in relation to their extent ($w_i = o_i / p_i$, where o_i is the proportion of the mean number of individuals of a studied species at the i habitat and p_i is the proportion of the habitat extent in the study area).

RESULTS

Little egret (Egretta garzetta)

Low numbers of little egrets occurred in the study area during the winter and early spring (January to mid-March) and at the end of autumn (end of October to December). Numbers increased from late March, reached a maximum of *ca* 540 in end of July, and declined gradually in late summer and autumn. Population levels of little egrets were the highest among heron species (Fig. 2).

Little egrets were observed in most habitat types, but habitat use varied during the year. The seacoast and salt marshes were used during most of the year. Bird numbers, especially in the latter habitat, varied considerably. The largest numbers usually occurred when their population levels were the highest, that is in the post breeding period (in July). Rice fields were mostly used in the spring and early summer (nestling rearing period), being available during this period due to flooding. Freshwater marshes were occasionally used in considerable numbers from April to October (Fig. 2). Overall, number proportions of little

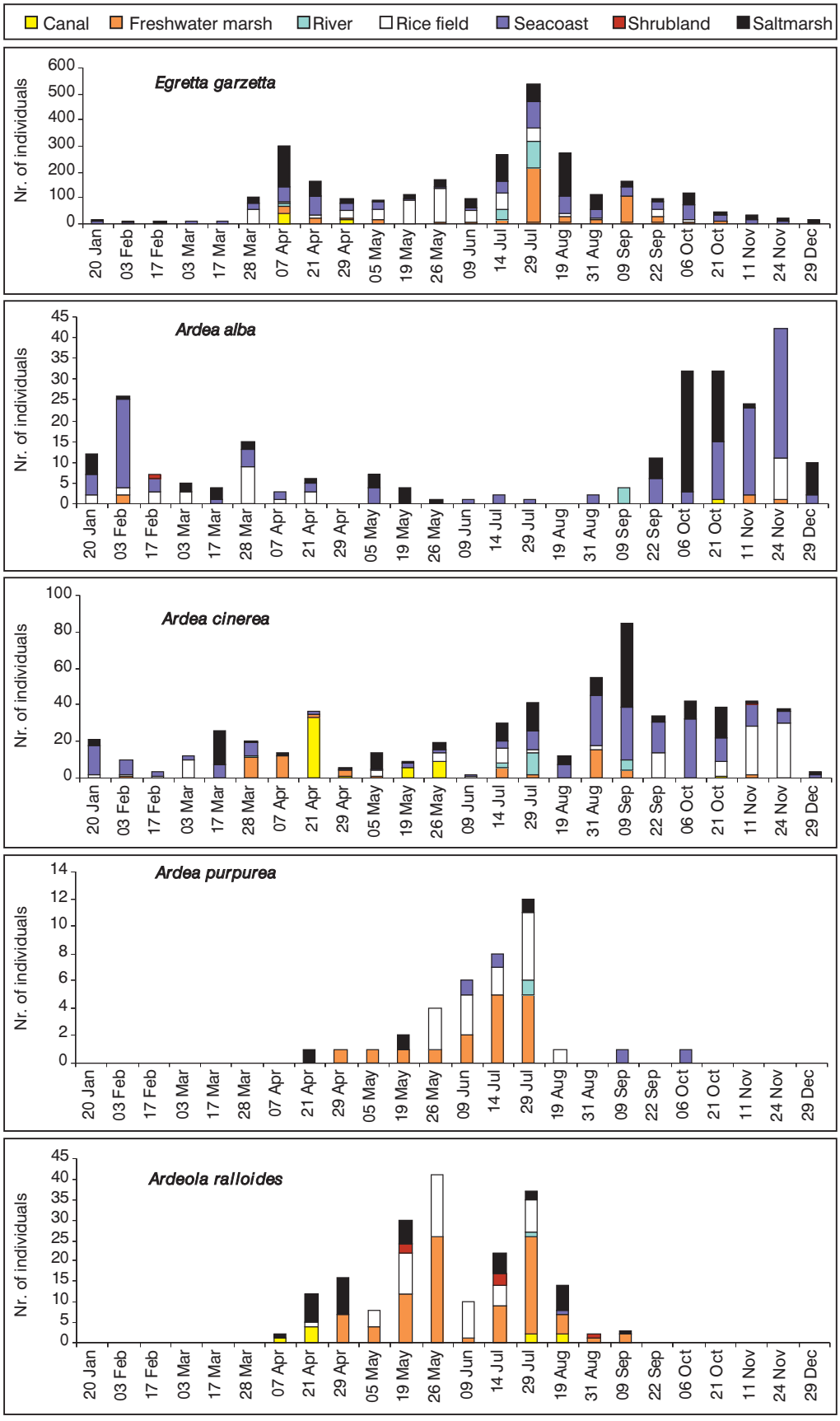

FIG. 2. Habitat use and changes in numbers of the commonest heron species in the Axios Delta (1990).

TABLE 2. Mean number of herons per visit (MEANV) and standard deviation (s.d.) in each habitrat in the Axios Delta and in relation to habitat extent (birds/10 ha) (MEAN10H). w_i is the selection index (selection indices above 1 indicate preference)

	E. garzetta				*A. alba*				*A. cinerea*				*A. purpurea*				*A. ralloides*			
	MEANV	s.d.	MEAN 10H	w_i	MEANV	s.d.	MEAN 10H	w_i	MEANV	s.d.	MEAN 10H	w_i	MEANV	s.d.	MEAN 10H	w_i	MEANV	s.d.	MEAN 10H	w_i
Canal	3.17	8.56	1.130	9.30	0.04	0.20	0.015	1.35	2.08	6.93	0.744	30.00	0.00		0.000	0.00	0.38	0.97	0.135	16.30
Freshwater marsh	20.58	46.06	0.830	6.81	0.21	0.59	0.008	0.80	2.46	4.27	0.099	4.00	0.67	1.43	0.027	16.76	3.79	7.31	0.153	18.36
River	6.21	21.62	0.183	1.50	0.17	0.82	0.005	0.47	0.88	2.69	0.026	1.05	0.04	0.20	0.001	0.73	0.04	0.20	0.001	0.14
Rice fields	24.04	34.22	0.055	0.45	1.38	2.73	0.003	0.30	3.58	8.13	0.008	0.33	0.58	1.32	0.001	0.82	2.17	4.17	0.005	0.59
Seacoast	28.75	27.01	0.141	1.16	5.17	8.14	0.025	2.40	8.71	9.41	0.043	1.72	0.17	0.38	0.001	0.52	0.04	0.20	0.000	0.02
Shrubland	0.13	0.34	0.001	0.01	0.04	0.20	5×10^{-4}	0.04	0.04	0.20	0.001	0.02	0.00		0.000	0.00	0.25	0.74	0.003	0.33
Saltmarsh	37.21	44.67	0.198	1.63	3.42	6.63	0.018	1.72	6.67	10.17	0.035	1.72	0.13	0.34	0.001	0.43	1.54	2.77	0.008	0.98
Total	120.08	123.66	0.121		10.46	11.90	0.011		24.42	19.69	0.005		1.58	3.02	0.002		8.21	12.50	0.008	
Coefficient of Variation (CV) %	102.98				113.76				80.63				191.13				152.25			

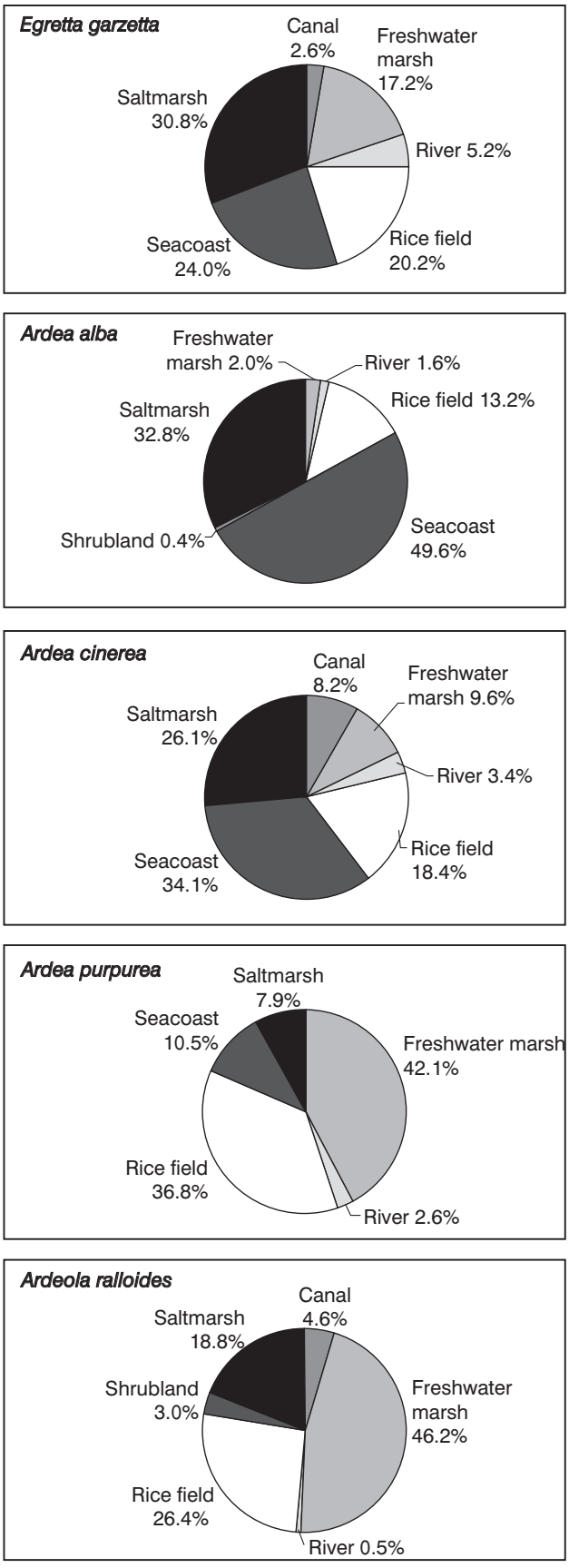

FIG. 3. Percentages of the total heron population in habitat use in the Axios delta (1990).

egrets in the four habitats (namely salt marshes, seacoast, rice fields and freshwater marshes) made up the greatest part of the total (Fig. 3). The highest mean number of little egrets per visit was recorded in the salt marshes (37.21), but, in relation to the habitat extent, this number was the highest in the canals (1.13 birds per visit/10ha) (indicating the importance of this habitat type) followed by the freshwater marshes (0.83), and was much lower in the other habitats (Table 2).

Great white heron (Ardea alba)

Great white herons occurred all year long in the area but in low numbers, being most numerous in October and November, with smaller peaks in February and March, a fact that indicates it as a migrating and over wintering species (Fig. 2). Of the habitats used, seacoast and/or salt marshes attracted most birds, especially in the autumn and winter, while rice fields were used primarily in the spring and occasionally in the autumn (Fig. 2). Generally, most great white herons used mainly saltwater affected habitats such as the seacoast and salt marshes (both attracting ~82% of all birds during the study), whereas rice fields attracted much fewer birds (13%) (Fig. 3). The mean number of great white herons per visit was greatest in the seacoast (5.17). In relation to the habitat extent, this number was the highest in the seacoast (0.025 birds per visit/10 ha) followed by the salt marshes and canals (0.018 and 0.015, respectively, see Table 2).

Grey heron (Ardea cinerea)

Grey herons occurred in the study area all year long in generally low numbers, fluctuating during the year and they were more numerous in September, in the autumn migration (Fig. 2). Grey herons were found in most habitat types (Fig. 3). Habitat use varied during the study without showing any apparent pattern, although more birds used freshwater marshes and sometimes canals (in the spring), whereas salt marshes and the seacoast were mostly used in the summer and autumn months. Grey herons occurred in rice fields in a rather irregular pattern, but they visited this habitat most frequently during the autumn (Fig. 2). In general, the seacoast and salt marshes were the most preferred and frequently visited habitats (34.1% and 26.1% of the total numbers during the study period) followed by the rice fields, the fresh water marshes and the canals (Fig. 3). Whereas the mean number of grey herons per visit was greatest in the seacoast (8.71), regarding the habitat extent, this number was the highest in the canals (0.744 birds per visit/10ha) (Table 2).

Purple heron (Ardea purpurea)

Small numbers of purple herons, a migratory species breeding in the area, occurred from April to the beginning of October. Numbers peaked in June and July due to post-breeding dispersion and migration, respectively (Fig. 2). Between the end of April and the end of May, the number of purple herons using the freshwater marshes increased. Rice fields were used between the end of May and the beginning of August. Other habitats were occasionally used (Fig. 2). In general, most purple herons used mainly freshwater habitats such as freshwater marshes (42.1%) and rice fields (36.8%), whereas other habitats seemed to be of minor interest to them (Fig. 3). The mean number of purple herons per visit was the highest in the fresh water marshes (0.67), while in the rice fields it was 0.58. However, their mean number per visit (in relation to the habitat extent) was only important in the freshwater marshes (0.027 birds per visit/10ha), being negligible in the other habitats (Table 2).

Squacco heron (Ardeola ralloides)

The Squacco heron, a species breeding and migrating only in the area, was observed from the beginning of April to the beginning of September with numbers periodically peaking in May and July (Fig. 2). Between May and July (the main breeding period), numbers were the highest in the freshwater marshes and the rice fields. During most of this species period of occurrence in the area, parts of the population also used salt marshes and occasionally other habitats. Most squacco herons were observed mainly in freshwater habitats such as freshwater marshes (46.2% of all birds observed) and rice fields (26.4%), whereas lower percentages occurred in the salt marshes (18.8%) and much lower in the other habitats (Fig. 3).

The mean number of squacco herons per visit was greatest in the freshwater marshes (3.79) followed by the rice fields (2.17). Regarding the habitat extent, this number was also the highest in the freshwater marshes (0.153 birds per visit/10 ha) followed by the canals (0.135) indicating that these two habitats were the most preferred (Table 2).

TABLE 3. The occurrence of little bittern (*Ixobrychus minutus*, IM) and black-crowned night heron (*Nycticorax nycticorax*, NN) in the Axios Delta. Dates before April and after August were ommited, since both species were not recorded during this period

	Canal		Freshwater marsh		Ricefields		River	Saltmarsh
	IM	NN	IM	NN	IM	NN	NN	NN
21 Apr	–	–	–	–	1	2	–	–
29 Apr	–	–	1	–	–	–	–	–
05 May	–	1	1	–	2	2	–	–
19 May	–	–	–	1	–	3	–	–
26 May	–	1	–	–	–	11	–	–
09 Jun	–	–	–	1	1	11	–	–
14 Jul	–	–	–	–	1	11	–	4
29 Jul	1	–	–	5	–	–	17	9
19 Aug	–	–	–	8	–	–	–	–
31 Aug	–	–	–	1	–	–	–	–

Other heron species

Of other ardeid species, the little bittern, a secretive species not easily detected, was occasionally observed from April to July in rice fields, freshwater marshes and canals (Table 3). The black-crowned night heron, a nocturnal species, inactive during the daylight (apart from the period of chick rearing), was observed between April and August mainly in the rice fields, the freshwater marshes, along the river, and occasionally in the canals and salt marshes (Table 3). The cattle egret was observed only once (3 birds on 14 July) in the rice fields. The bittern, another secretive species, was heard once in late April in the fresh water marsh. Habitat use and abundance of species, which are secretive or inactive during the daylight, may not be accurately represented.

DISCUSSION

The Axios Delta is among the most important wetlands for herons in Greece due to the occurrence of a variety of both natural and man-made habitats. Herons exploit these habitats throughout the year in different patterns according to the species. The highest number of herons was recorded after the completion of the breeding season when the birds (both, adults and fledged juveniles) left their nests and dispersed throughout the study area. The little egret was by far the most abundant foraging species in the area under study, although its breeding population was similar to that of the black-crowned night heron, which was rarely recorded in the foraging areas (Kazantzidis, 1998). The lowest number of herons recorded occurred during the winter (from December to mid March) and only three species were present in the wetland. Generally, the numbers of wintering herons in Greece are small due to the low temperatures, especially in northern Greece (Naziridis *et al.,* 1992).

Although each species used a variety of aquatic habitats for feeding, it was also found to prefer specific habitat types. Thus, the purple and squacco herons (species with higher coefficient of variation in relation to the others), the little bitterns, the black-crowned night herons and the bitterns all seemed to be highly dependent on freshwater habitats, especially freshwater marshes. By contrast, the great white heron was depended mostly on salt-water affected habitats. It appears that the little egret and the grey heron were the most opportunistic species (species with lower coefficient of variation in relation to the others), exploiting a variety of habitats.

Freshwater marshes, although of limited extent, supported a high number of herons (27.11 of herons per visit; density, 1.117 herons/10 ha). Probably, the heron species of the area established their colony near the freshwater marshes (less than five km) due to the prey richness and availability found there. Furthermore, the reeds that grow in freshwater marshes constituted breeding grounds for the purple heron and the little bittern and also provided cover for secretive species such as the black-crowned night heron, the bittern and the squacco heron (Kazantzidis, 1998; Papakostas, 2002).

Rice fields are a man-made habitat that replaced the marshes that where present before land reclamation occurred in the area (Athanasiou, 1990). Rice fields were commonly exploited by all species during a specific period (late spring and summer). This habi-

tat seems to play a crucial role for all breeding heron species as an important food source during the very critical chick-rearing period (Hafner & Fasola, 1992). The mean prey biomass consumed by the little egret in the rice fields of the Axios Delta was higher than that consumed in the salt- and fresh water marshes (Kazantzidis, 1998). Rice fields are of great importance in other wetlands too. They are considered to be the most important artificial heron habitat worldwide and the distribution of heronries in Italy is related to the area of rice fields (Fasola *et al.,* 1996; Marques & Vicente, 1999; Kushlan & Hafner, 2000; Maeda, 2001). Non-breeding species such as the grey and the great white herons, used rice fields mostly during the winter and autumn months when these fields are dry and ploughed.

Numerous canals crossing the rice fields for irrigation purposes occasionally play an important role as feeding sites for herons, especially during April when they are filled with water from the Axios river. These canals are attractive to herons providing them with small fish, amphibians and insects (Kazantzidis & Goutner, 2005).

Salt-water affected habitats (the seacoast and salt marshes), being extensive in the study area, were exploited mostly by the great white herons, the grey herons and the little egrets almost throughout the whole year. Little egrets used them only when there was a reduction in the fresh water marshes due to drying and when the rice fields were no longer available because the plants had increased in height.

The riverbank was used by "stand and wait" foragers only, such as black-crowned night herons and squacco herons using overhanging branches and shrubs as look-out posts for prey acquisition.

An overlap in habitat use and interspecific competition is likely to marginally occur in the rice fields and in the freshwater marshes among two or three species (the little egret and the black-crowned night heron or the squacco heron). Nevertheless, differences in choice of microhabitat features (such as water depth, vegetation density, substrate, etc.) may minimize conflicts of this type (Fasola, 1986). Additionally, differences in feeding techniques (little egrets forage actively while squacco herons wait for prey or walk slowly, Papakostas *et al.*, 2005) and feeding time (night herons are active mostly after dusk) may also reduce interspecific competition. Prey type and size also play an important role in habitat segregation among heron species (Fasola, 1986). Prey size has been found to differ considerably among the heron species in the Axios Delta as well as elsewhere in Europe (Fasola, 1994; Kazantzidis & Goutner, 2005).

Herons are among the top predators in the Axios Delta aquatic habitats and the conservation of these habitats must be a major target in this wetland. Within this framework, emphasis should be given to the protection of herons freshwater feeding habitats (especially the freshwater marshes) that are limited in the study area and most valuable for herons. Many species and especially the purple heron, the squacco heron and the bittern, would benefit from enhancement of shallow freshwater marshes. Wintering herons would benefit the most from the provision of additional freshwater wetlands. Flooding harvested rice fields in winter have proved to be a valuable foraging habitat for herons and other waterbirds (Elphic & Oring, 2003). The agricultural practices in the rice fields and the extensive use of insecticides and pesticides (Albanis *et al*., 1996) need to be reconsidered.

Accumulation of organochlorine insecticides in the eggs, body tissue and prey of herons primarily originates from the rice fields and the river water. At present, contaminant concentrations in herons and in their prey are still low (Albanis *et al*., 1996) but the constant use of insecticides in rice fields could gradually lead to a reduction in their value as an important feeding habitat (Hafner & Fasola, 1992; Ruiz *et al*., 1992). Conservation of the seacoast and the salt marshes, which are likewise important foraging habitats, especially for the great white heron, the grey heron and the little egret, should involve reducing disturbing activities by stopping the building of fishing huts.

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