Arthropods in shag (Phalacrocorax aristotelis) nests FROM th e Nationa l Park of th e Atlantic Islands (NW Spain): occurrence and abundance at different breeding phases

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ARTHROPODS IN SHAG (*PHALACROCORAX ARISTOTELIS)* NESTS FROM THE NATIONAL PARK OF THE ATLANTIC ISLANDS (NW SPAIN): OCCURRENCE AND ABUNDANCE AT DIFFERENT BREEDING PHASES

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PHALACROCORAX ARISTOTELIS
ARTHROPODS
MITES
SPIDERS
BEETLES
FLIES
FLEAS
SHAG NEST
NATIONAL PARK OF THE ATLANTIC ISLANDS

ABSTRACT. – The paper deals with the composition of the arthropod fauna in nineteen shag (*Phalacrocorax aristoteli* Linnaeus, 1761) nests collected in two sampling sites from the National Park of the Atlantic Islands: in the Cíes and Ons Islands located in the NW of the Iberian Peninsula during 1997. The occurrence and abundance of arthropods in the nests have been studied in three different breeding phases: nests with eggs, nests with broods and empty nests. In these nineteen nests, the authors found 25 families of acari (92.1 % of the total fauna), 14 families of Diptera (98 % were in a saprophagous larval stage), 8 families of Hymenoptera, 16 families of Coleoptera and 5 families of spiders. The ecological and the trophic relations of these families have been studied. A large proportion of arthropod families found in the nests occur there occasionally. Furthermore, the nests provided few groups with the right conditions to develop and complete their biological cycle. Only saprophagous mites, fly larvae and predator beetles found suitable conditions to survive in the nests. Saprophagous arthropods were the most abundant, independently of the nest occupation phase. The difficult access to the cliffs along with the necessity to transport the nests into the laboratory hampered the sampling process and consequently made this study the first about entomological fauna in shag nests.

INTRODUCTION

Bird nests and mammal burrows are an interesting material for arthropods study, since a great number of them develop totally or partially their life cycle on these constructions. Thus, bird nests provide an approximate idea of the edaphic fauna of the area of study (Kristofik *et al*. 1993, 1995, Vidal 1995).

Previous researches carried out on bird nests are mainly focused on ticks (Acari, Ixodida) (Danchin 1991, Mašán & Kristofik 1993, Kuliŝić *et al*. 1995), on lice (Order Mallophaga) (Martín-Mateo 1988, Tendeiro & Méndez 1994, Ròzsa 1996, Martín-Mateo & Blasco-Zumeta 1996, Rózsa *et al*. 1996, Rekasi *et al*. 1997), on ectoparasitic larvae of Diptera (Hurtrez *et al*. 2000) and on the acari Mesostigmata (Kristofik & Mašán 1996, Kristofik *et al*. 1996, Gwiazdowicz *et al*. 1999, 2005, Bloszyk *et al*. 2005, 2006, Bloszyk & Gwiazdowicz 2006, Bajerlein *et al*. 2006). In some of these studies, authors analysed the effects of acari and lice populations on the reproductive success of the birds (Clayton & Tompkins 1995), the changes in the population's structure during the breeding period (Kristofik & Mašán 1996) and the relationship between feather mite abundance and bird body mass (Rózsa 1996). There are also studies that referred mainly to the presence of ectoparasitic mites on the nests (Gallego *et al*. 1992, Mašán & Kristofik 1995, Bloszyk *et al*. 2005, Gwiazdowicz *et al*. 2006).

Some studies analyze the structure of the arthropod community or the microhabitat preference (Choe & Kim 1987b, 1988), others treat the effect of climatological factors on arthropods abundance (Merino & Potti 1996), or the relationship between the arthropod abundance and preference and the nest age (Rendell & Verbeek 1996).

Some authors studied the preferences of birds for hangers free of ectoparasites (Merilä & Allander 1995) and the effect of hematophagous mites and parasitic diptera larvae on the growth and survival of broods (Merino & Potti 1995). The various ways of transmission from some individuals to others according to space availability in the colony were also studied by Tompkins *et al*. (1996).

Unfortunately, the rest of the non-hematophagous arthropod fauna was secondarily treated (Kristofik *et al*. 1996) or the researches that existed were either focused on only one group (Mašán & Kristofik 1995) or based on research results of another kind (Kristofik *et al*. 1993, 1995). Consequently, no researches that dealt in details with these groups constituted mainly by arthropods were carried out.

So far, the only studies on parasites in shag nests have been done on ectoparasites (Choe & Kim 1987a).

This work emerges from preliminary studies conducted on the colonies of shags from the islands of Cíes and Ons (Pontevedra, N.W. Península Ibérica) (Velando

1997). These studies show that the colonies of shag are second in size to the yellow-legged gull (*Larus michahellis*).

Besides, nesting in remote areas like inaccessible and isolated islands makes these arthropod communities acquire an original character.

The aim of this study is to characterize the arthropod fauna that occurs in shag nests of the Cíes and Ons Islands, analyze the trophic structure of the community and relate it with the occupation of the nests that is with eggs, broods and empty nests.

Shag is a colonial bird that builds voluminous nests on the rocks. They occupy hollows on the cliffs and places of difficult access. The nests are long lasting and can be re-occupied through the subsequent seasons. The construction or re-occupation of nests occurs during the breeding phase, which goes from the end of February to the beginning of June (Velando 1997).

It is important to emphasize that this study is the first acknowledged about arthropod fauna that occurs in shag nests, not only due to the difficulty to sample the fauna, as it is essential to transport a part or the complete nests to the laboratory, but also because of the difficult access to the cliffs where nesting occurs.

MATERIAL AND METHODS

Nineteen shag (*Phalacrocorax aristotelis* L.) nests were collected in two islands that belong to the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula): Cíes and Ons Islands. The nests were collected in May and July 1997. This sampling method was the occasion for studying two different breeding phases: May samples provided eggs or chicks (Cíes Island only), and July samples gave the opportunity to analyze empty nests (from both islands)

Collections on Cíes Island were timed to coincide with the period when chicks begin to be independent, but have not left the nest yet. Therefore, the absence of this construction poses no risk to their survival. In this group of nests, three of them had no fertile eggs, in another one the chicks had already flown, and in the others chicks were still in the nest.

The second sampling was conducted two months later and included six nests. The nests were already abandoned by the offsprings and showed visible signs of deterioration due to the constant activity and trampling of the chicks.

At Ons Island, the approach was similar to the Cíes Island. The aim was to conduct a survey for each phase of occupation. However, the weather conditions hampered the sampling of all the nest occupation phases, leaving data only from nests already abandoned by the chicks.

The Cíes Islands, with a 434 ha of total surface, are located in the entrance of the Ria of Vigo (42°15’04” N, 8°53’30” W). They form an archipelago of three main islands (Monteagudo or North Island, Faro Island and San Martiño or South Island) and other small islands. The Ons Island is located in the entrance of Ria of Pontevedra (42°21’05” N, 5°15’35” W) and it occupies 402 ha (Fig. 1). The shags breed on the western face of both archipelagos were the coast is abrupt with strong differences, and the erosive action of the sea builds cliffs.

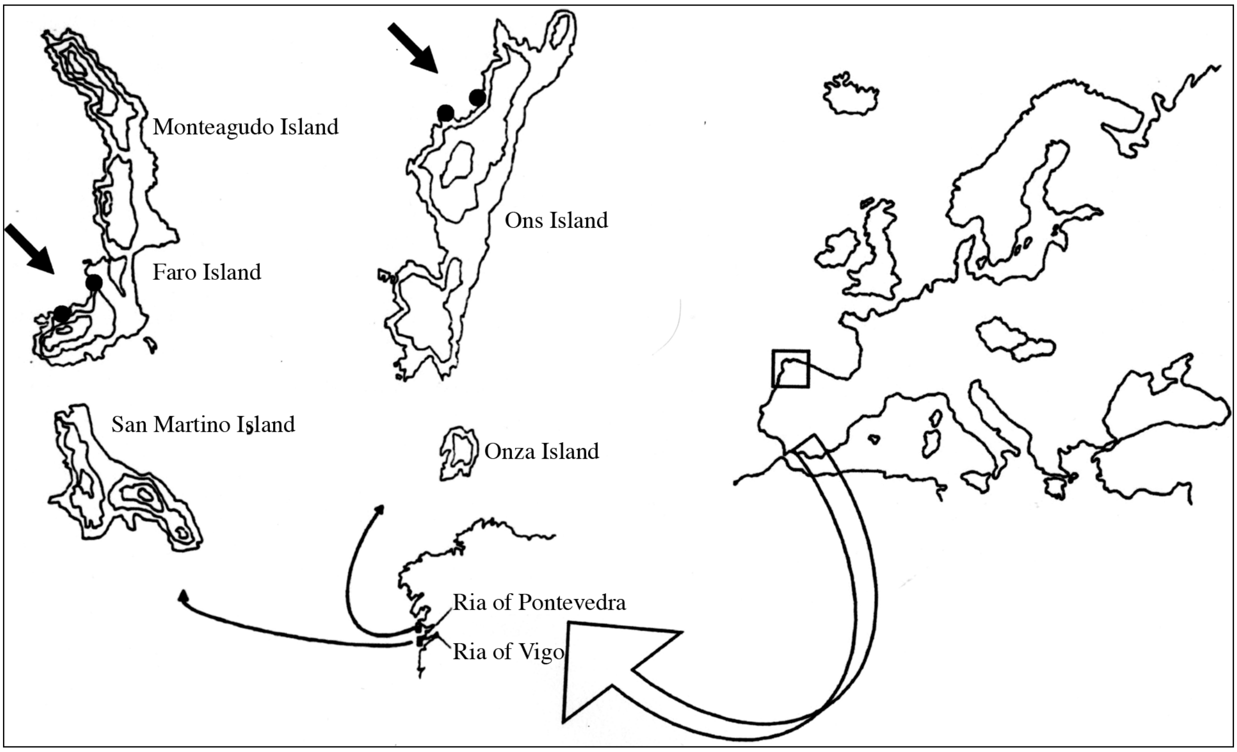

Fig. 1. – Geographical situation of Cíes Islands (Ría of Vigo) and Ons Island (Ría of Pontevedra) in the National Park of the Atlantic Islands (NW of the Iberian Peninsula), showing the location of the nests under study.

Nests were taken with a long hook, transported to the laboratory in labelled plastic bags, and kept in a cold chamber at 4° C until the extraction of the arthropod fauna. The arthropods were extracted using a Tullgren apparatus, and then samples were preserved in alcohol 70°.

Fauna was identified by means of suitable keys (Barrientos 2004, Dindal 1990, McDaniel 1979, Pérez Iñigo 1993, 1997) and classified into eight trophic groups: phytophagous (Ph), fungivorous (Fg), saprophagous (S), predators (Pr), coprophagous (Cp), omnivorous (Om), parasites (P), and parasitoids (Pa). The abundance and diversity (Shannon-Wiener Index) at various occupation stages were calculated. Moreover, the frequency of occurrence of each family at each occupation stage was calculated (three nests with eggs, three nests with broods and thirteen empty nests).

Changes in number of individuals of each family, and diversity were analyzed using a one-factor ANOVA analysis (nests with eggs *vs* nests with broods from Cíes, and empty nests from Cíes *vs* empty nests from Ons). In addition, non-parametric multivariate analyses of variance (PERMANOVA, Anderson 2001) were used to test hypotheses about differences among assemblages on different nests (nests with eggs *vs* nests with broods from Cíes and empty nests from Cíes *vs* empty nests from Ons).

RESULTS

A total of 313525 arthropods were registered in all nests belonging to 85 arthropod families. The most abundant group was the Acarina represented by 25 families and 288417 individuals, followed by Diptera (13601 individuals and 14 families), the Hymenoptera (956 individuals and 8 families), the Coleoptera (619 individuals and 16 families) and the Araneae (121 individuals 5 families). Furthermore, there were 9422 more individuals distributed among 17 families that belonged to different orders. Faunistic groups are described below.

Acari (Subclass Acarida). Altogether 288417 individuals of 25 acari families were found in the shag nests (Table I). The high number of mites found in shag nests represents 92.1 % of the total fauna. The average number of acari in each nest was 15189.8 ± 14698 individuals, this high deviation must be due to the great difference that exists between the number of individuals of the present families in each nest. This number ranges from 52484 individuals of the Uropodidae family present in one of the empty nest to the absolute absence of individuals of the rest of acari families (Table I). The total number of acari is 84645 individuals, with an average of 28215 ± 25642.5 in nests with eggs. In nests with broods, the number of individuals is 51430 (with an average of 15143.3 ± 12147.1). Lastly, when the nests are empty, the acari number reaches the 152342 individuals with an average of 11718.6 ± 11552.4. The total and average number of mites in each nest, in the different breeding phases is represented in Fig. 2. The phase of empty nest shows the highest number of individuals. The average number of acari and the standard deviation in each nest are low because of the distribution of individuals in the nests.

Sampled mites were included in the following trophic groups: parasites (P), saprophagous (S), phytophagous (Ph) and predators (Pr).

Parasites (P), hematophagous mites of the family Argasidae. When the nests are empty, argasids resist long starving periods. They represent 0.65 % of all acari. Argasids are also present in the nests with eggs and broods (with a 100 % appearance frequency). However, the highest number of individuals is counted in the first occupation stage, when adult birds they feed on spend more time incubating.

Saprophagous (S) mites are the most abundant trophic group. They include the Uropodidae, Parasitidae, Acaridae and Anoetidae families. The Uropodidae and Parasitidae, with a 100 % appearance frequency, are edaphic mites able to survive and reproduce that colonize the nests during the building phase. The highest number of them was counted in empty nests (Table I). The Uropodidae family represents 76.9 % of all acari (Fig. 2). Their behavior is similar to the general distribution of acari. The Parasitidae (8.6 %) prefer nests in which the degradation processes have already started. The Acaridae (9.5 %) and the Anoetidae are related to decomposed material and for this reason they occupy mainly empty nests.

Other groups of acari like the Galumnatidae, Oribatellidae, Xenillidae and Epilomannidae families do not survive long periods in the nests. They stay temporarily feeding on construction material like phytophagous (Ph) mites that feed on the partially degraded vegetables remains, or like predators (Pr) mites (families Cheyletidae, Bdellidae, Eupodidae and Erythraeidae among others). Fourteen families of phytophagous mites that feed on dead vegetable remains were identified (Table I). Their number and presence is higher in empty nests because they do not feed on fresh vegetable material but on material that has been partially degraded.

Finally, six families of predator (Pr) mites were identified. They represent 1.87 % of all acari and they come into the nest looking for food and refuge. Their abundance is higher during the empty nest phase when the number of mites is higher.

The order Diptera represents 4.26 % of the arthropods sampled (Table II) and 98 % of them are at the saprophagous (S) larval stage. An average of 726.31 ± 2533.38 individuals per nest was found. The high deviation is due to a high abundance of certain families like Milichiidae. Regarding the breeding phase, 1016 individuals (338.67 ± 275.2 per nest) were found in nests with eggs, 473 (157.67 ± 123.14) individuals were found in nests with broods and 12311 (947 ± 3072.57) individuals were found in empty nests. In all phases, the most abundant and frequent family was Milichiidae (Table II).

Attending to the feeding preferences, the dipterous

Table I. –Acari abundance and diversity in different occupation stages of shag nests. Trophic group (T. G.): P - Parasites; S - Saprophagous; Pr - Predators and Ph - Phytophagous. Total number of individuals, average and standard deviation (dt); appearance frequency (A. F.) of each of them in the different occupation stages: with eggs, with broods and empty nests in the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula).

	Family	T.G.	with eggs			with broods			empty nests		
			Total ind.	$\overline{X}$ ± dt	A. F.	Total ind.	$\overline{X}$ ± dt	A. F.	Total ind.	$\overline{X}$ ± dt	A. F.
Or. Parasitiformes	Argasidae	P	771	257± 373.94	100.0	404	134.67 ± 59.79	100.0	711	54.69 ± 67.10	84.6
	Uropodidae	S	81814	27271.33 ± 24803.65	100.0	49748	16582.67 ± 11775.37	100.0	90452	6957.85 ± 9036.26	100.0
	Parasitidae	Pr	2044	681.33 ± 549.05	100.0	1240	413.33 ± 475.69	100.0	21567	1659 ± 2000.40	100.0
Or. Acariformes	Acaridae	S	7	2.33 ± 4.04	33.3	3	1 ± 1.73	33.3	2999	230.69 ± 247.02	100.0
	Anoetidae	S	0	0	0	0	0	0	27541	2118.54 ± 4958.84	92.3
	Cheyletidae	Pr	0	0	0	0	0	0	115	8.85 ± 17.83	46.2
	Bdellidae	Pr	0	0	0	1	0.33 ± 0.58	33.3	27	2.08 ± 4.92	23.1
	Eupodidae	Pr	0	0	0	0	0	0	17	1.31 ± 4.71	7.7
	Pachygnathidae	Pr	0	0	0	0	0	0	5187	399 ± 700.11	76.9
	Erythraeidae	Pr	1	0.33 ± 0.58	33.3	0	0	0	5	0.38 ± 0.96	15.4
	Johnstonianidae	Pr	0	0	0	0	0	0	17	1.31 ± 3.35	15.4
Or. Oribatei	Galumnatidae	Ph	1	0.33 ± 0.58	33.3	3	1 ± 1.73	33.3	29	2.23 ± 6.08	23.1
	Oribatellidae	Ph	0	0	0	0	0	0	22	1.69 ± 6.10	7.7
	Xylobatidae	Ph	0	0	0	0	0	0	29	2.23 ± 6.25	15.4
	Oribatulidae	Ph	2	0.67 ±1.15	33.3	3	1 ± 1.73	33.3	548	42.15 ± 73.73	69.2
	Haplozetidae	Ph	3	1 ± 1.73	33.3	0	0	0	111	8.54 ± 16.42	38.5
	Cymbaeremaeidae	Ph	0	0	0	0	0	0	45	3.46 ± 9.11	30.8
	Damaeidae	Ph	0	0	0	1	0.33 ± 0.58	33.3	45	3.46 ± 12.48	7.7
	Belbidae	Ph	0	0	0	0	0	0	11	0.85 ± 3.05	7.7
	Eremaeidae	Ph	1	0.33 ±0.58	33.3	4	1.33 ± 1.53	66.7	2762	212.46 ± 380.18	69.2
	Zetorchestidae	Ph	0	0	0	0	0	0	14	1.08 ± 2.66	15.4
	Xenillidae	Ph	0	0	0	0	0	0	2	0.15 ± 0.55	7.7
	Carabodidae	Ph	1	0.33 ± 0.58	33.3	20	6.67 ± 7.64	66.7	32	2.46 ± 5.33	30.8
	Oppiidae	Ph	0	0	0	3	1 ± 1	66.7	48	3.69 ± 8.60	23.1
	Epilomannidae	Ph	0	0	0	0	0	0	6	0.46 ± 1.66	7.7

found in shag nests take the organic matter as basic feeding source, thus a high number of larvae of saprophagous habits were found in nests with eggs, in which the organic matter contribution is very high. On the other hand, dipteran adults like Sciaridae and Milichiidae visit the nests to oviposit and others such as the predators (Pr) or the hematophagous parasites (P) (Ceratopogonidae, Simuliidae and Dolichopodidae families) are found sporadically. Fungivorous (Fg) also appear sporadically (Mycethophilidae, Phoridae and Sphaeroceridae families) and they feed

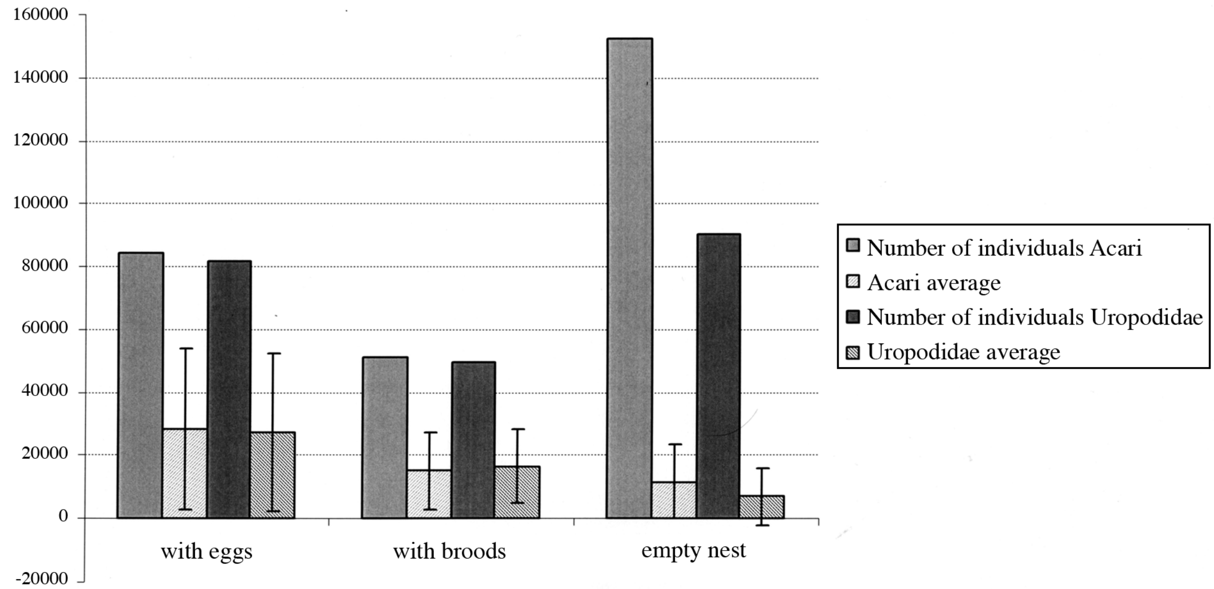

Fig. 2. – Total number of individuals and average for nests of the Acari and family Uropodidae present in the shag nests of Cíes Islands (Ría of Vigo) and Ons Island (Ría of Pontevedra) in the National Park of the Atlantic Islands (NW of the Iberian Peninsula).

Table II. – Diptera abundance and diversity in different occupation stages of shag nests. Trophic groups (T.G.) for the adults (A) and larvae (L): P - Parasites; S - Saprophagous; Pr - Predators; Ph - Phytophagous; Fg – Fungivorous and Cp - Coprophagous. Total number of individuals, average and standard deviation (dt); appearance frequency (A. F.) of each of them in the different occupation stages: with eggs, with broods and empty nests in the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula).

	T. G.		with eggs			with broods			empty nests		
Family	A	L	Total ind.	$\overline{X} \pm$ dt	A. F..	Total Ind.	$\overline{X} \pm$ dt	A. F.	Total ind.	$\overline{X} \pm$ dt	A. F.
Chironomidae	Ph	S	10	3.33 ± 4.93	66.7	3	1 ± 1.73	33.3	7	0.54 ± 1.94	7.7
Ceratopogonidae	Pr,P		0	0	0	1	0.33 ± 0.58	33.3	7	0.54 ± 1.94	7.7
Simuliidae	P		1	0.33 ± 0.58	33.3	0	0	0	2	0.15 ± 0.55	7.7
Mycetophylidae	Fg		0	0	0	0	0	0	4	0.31 ± 1.11	7.7
Sciaridae	Ph	S	1	0.33 ±0.58	33.3	4	1.33 ± 2.31	33.3	208	16 ± 28.65	53.8
Cecidomyiidae	Ph		4	1.33 ± 1.53	66.7	0	0	0	16	1.23 ± 2.20	30.8
Scatopsidae		S	0	0	0	0	0	0	100	7.69 ± 21.98	15.4
Psychodidae	Ph		2	0.67 ± 1.15	33.3	4	1.33 ± 1.15	66.7	24	1.85 ± 3.24	30.8
Phoridae	Fg		0	0	0	0	0	0	8	0.62 ± 2.22	7.7
Milichiidae	Ph	S	866	288.67 ± 323.58	100.0	236	78.67 ± 125.96	100.0	11926	917.38 ± 3070.13	76.9
Sphaeroceridae	S,Cp		3	1 ± 1.73	33.3	0	0	0	0	0	0
Chloropidae		Fg	110	36.67 ± 63.51	33.3	0	0	0	0	0	0
Dolichopodidae	Pr		1	0.33 ± 0.58	33.3	0	0	0	0	0	0
Muscidae		S	16	5.33 ± 2.52	100.0	28	9.33 ± 6.81	100.0	9	0.69 ± 2.50	7.7

on vegetal decomposed material, excrements and even fluids. Others, like the Psychodidae family, present a low number of individuals and inhabit the nest sporadically, looking for fresh, humid, and dark ambience.

The order Hymenoptera represents the third group in order of abundance (Table III) with 956 individuals (0.29 % of the total arthropod fauna). They are distributed into eight families, from which seven were parasitoids (Pa). The average number of individuals per nest was 50.3 ± 67.9 and most of them were found in empty nests (904 individuals; average 69.54 ±75.12). Nests with eggs presented 24 individuals (8 ± 4.58 individuals per nest) and nests with broods showed 28 (9.33 ± 7.73) individuals. Diapriidae, Braconidae and Cynipidae visit nests already occupied by other dipteran hosts. The Ceraphronidae, Ichneumonidae, Encyrtidae and Eulophidae families par-

Table III. – Hymenoptera abundance and diversity in different occupation stages of shag nests. Trophic groups (T. G.): Pa. – Parasitoids; Om.- omnivorous. Total number of individuals, average and standard deviation (dt), appearance frequency (A. F.) of each of them in the different occupation stages: with eggs, with broods and empty nests in the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula).

		with eggs			with broods			empty nests		
Family	T.G.	Total ind.	$\overline{X} \pm$ dt	A. F.	Total ind.	$\overline{X} \pm$ dt	A. F..	Total ind.	$\overline{X} \pm$ dt	A. F.
Diapriidae	Pa	8	2.67 ± 2.08	100.0	2	0.67 ± 1.15	33.3	824	63.38 ± 68.94	92.3
Ceraphronidae	Pa	0	0	0	1	0.33 ± 0.58	33.3	28	2.15 ± 6.08	23.1
Braconidae	Pa	0	0	0	0	0	0	4	0.31 ± 1.11	7.7
Ichneumonidae	Pa	0	0	0	2	0.67 ± 0.58	66.7	0	0	0
Cynpidae	Pa	0	0	0	2	0.67 ± 1.15	33.3	26	2 ± 4.18	38.5
Encyrtidae	Pa	0	0	0	1	0.33 ± 0.58	33.3	4	0.31 ± 1.11	7.7
Eulophidae	Pa	1	0.33 ± 0.58	33.3	0	0	0	0	0	0
Formicidae	Om	15	5 ± 5.29	100.0	20	6.67 ± 8.33	66.7	18	1.38 ± 3.01	23.1

Table IV. – Coleoptera abundance and diversity present in shag nests. Trophic group (T.G.): Fg.- Fungivorous; Pr.- Predators; Cp.- Coprophagous; S.- Saprophagous and Ph.- Phytophagous. Total number of individuals, average, standard deviation (dt), appearance frequency (A. F.) of each one of them in the different occupation stages: with eggs, with broods and empty nests in the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula).

		with eggs			with broods			empty nests		
Family	T.G.	Total Ind.	$\overline{X} \pm$ dt	A. F.	Total ind.	$\overline{X} \pm$ dt	A. F.	Total ind.	$\overline{X} \pm$ dt	A. F.
Ptiliidae	Fg	0	0	0	0	0	0	25	1.92 ± 6.09	15.4
Staphylinidae	Pr	5	1.67 ± 1.15	100.0	14	4.67 ± 7.23	66.7	58	4.46 ± 10.27	38.5
Aleocharidae	Pr	2	0.67 ±1.15	33.3	2	0.67 ± 1.15	33.3	15	1.15 ± 2.82	15.4
Trogidae	Cp, S	22	7.33 ± 5.03	100	56	18.67 ± 31.47	66.7	53	4.08 ± 10.10	38.5
Aphodidae	Cp,S	1	0.33 ± 0.58	33.3	0	0	0	0	0	0
Curculionidae	Ph	3	1 ± 1	66.7	11	3.67 ± 2.52	100.0	4	0.31 ± 1.11	7.7
Chrysomelidae	Ph	1	0.33 ± 0.58	33.3	0	0	0	0	0	0
Histeridae	Pr	38	12.67 ± 10.07	100.0	29	9.67 ± 9.07	100.0	220	16.92 ± 35.65	61.5
Dermestidae	S	0	0	0	1	0.33 ± 0.58	33.3	0	0	0
Rhizophagidae	Pr	10	3.33 ± 3.06	66.7	1	0.33 ±0.58	33.3	27	2.08 ± 7.49	7.7
Lathridiidae	Fg	0	0	0	1	0.33 ±0.58	33.3	2	0.15 ± 0.55	7.7
Coccinelidae	Pr	1	0.33 ± 0.58	33.3	1	0.33 ±0.58	33.3	0	0	0
Nitulidae	Fg	0	0	0	0	0	0	3	0.23 ± 0.83	7.7
Anthicidae	Fg	1	0.33 ± 0.58	33.3	1	0.33 ±0.58	33.3	3	0.23 ± 0.83	7.7
Micetophagidae	Fg	3	1 ± 1	66.7	0	0	0	0	0	0
Lagriidae	Fg	0	0	0	0	0	0	5	0.38 ± 1.39	7.7

asite many orders. The only non-parasitoid hymenopterans found were Formicidae, which visit the nests in search of food.

The Order Coleoptera included 619 individuals distributed in 16 families (Table IV). The average number of individuals per nest was 32.6 ± 47.5 and the highest abundance was found in empty nests with 415 individuals (average 31.9 ± 54.5). Nests with eggs had 87 (average 29 ±13.1) coleopterans and in nests with broods the number was 117 (39 ± 47.6). Coleopterans found in shag nests include all trophic groups, the most abundant being the predators (families Histeridae and Staphylinidae), followed by coprophagous (Trogidae) that presented the highest appearance frequency. The presence of larvae and adults of these families indicates that they develop in the nests. Predators are more abundant in empty nests where the number of preys is higher (larvae of dipterous, mites, etc).

The rest of the families are present in the nests sporadically and come up to it from the surroundings seeking for refuge and food.

Order Araneida. The 121 individuals of spiders pres-

Table V. – Abundance of the families the order Araneida present in shag nests. Trophic groups (T.G.): Pr.- Predators. Total number of individuals, average, standard deviation (dt), appearance frequency (A. F.) of each of them in the different occupation stages: with eggs, with broods and empty nests in the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula).

Family	T.G.	with eggs			with broods			empty nests		
		Total ind.	$\bar{X}$ ± dt	A. F.	Total ind.	$\bar{X}$ ± dt	A. F.	Total ind.	$\bar{X}$ ± dt	A. F.
Clubionidae	Pr	0	0	0	0	0	0	17	1.31 ± 3.20	15.4
Linyphiidae	Pr	0	0	0	4	1.33 ± 2.31	33.3	71	5.46 ± 4.93	69.2
Agelenidae	Pr	0	0	0	0	0	0	14	1.17 ± 2.89	23.1
Oonopidae	Pr	0	0	0	0	0	0	6	0.46 ± 1.66	7.7
Dysderidae	Pr	0	0	0	3	1 ± 1	66.7	6	0.46 ± 1.66	7.7

Table VI. – Abundance of the different families present in shag nests. Trophic groups (T.G.): P. - Parasites; S. - Saprophagous; Pr. - Predators; Ph. - Phytophagous; Fg. - Fungivorous; Om. - Omnivorous; Cp. - Coprophagous. Total number of individuals, average, standard deviation (dt), appearance frequency (A. F.) of each of them in the different occupation stages: with eggs, with broods and empty nests in the National Park of the Atlantic Islands (N.W. of the Iberian Peninsula).

Family	T.G.	with eggs			with broods			empty nests		
		Total ind.	$\bar{X}$ ± dt	A. F.	Total ind.	$\bar{X}$ ± dt	A. F.	Total ind.	$\bar{X}$ ± dt	A. F.
Pulicidae	P	0	0	0	0	0	0	7	0.54 ± 1.94	7.7
Leptosyllidae	P	63	21 ± 14.73	100.0	38	12.67 ± 14.57	100.0	32.56	2.50 ± 5.04	38.5
Lepidoptera		34	11.33 ± 18.77	66.7	8	2.67 ± 4.62	33.3	310.58	23.89 ± 74.38	53.8
Chernetidae	Pr	1	0.33 ± 0.58	33.3	7	2.33 ± 2.52	66.7	54	4.15 ± 14.39	15.4
Oniscidae	S, Om	12	4 ± 2.65	100.0	12	4 ± 6.93	33.3	185	14.23 ± 29.66	46.2
Lithobiidae	Pr	0	0	0	0	0	0	34	2.62 ± 7.81	15.4
Geophilidae	Pr	0	0	0	2	0.67 ± 1.15	33.3	11	0.85 ± 1.72	23.1
Julida	Ph	0	0	0	2	0.67 ± 1.15	33.3	2	0.15 ± 0.55	7.7
Polyxenidae	Ph	0	0	0	0	0	0	3	0.23 ± 0.83	7.7
Hypogastruridae	S	10	3.33 ± 5.77	33.3	0	0	0	7447	572.85 ± 1438.12	30.8
Entomobryidae	S	0	0	0	0	0	0	1052	80.92 ± 228.70	30.8
Isotomidae	S	0	0	0	0	0	0	3	0.23 ± 0.83	7.7
Psocoptera	Fg., S	0	0	0	0	0	0	64	4.92 ± 10.63	30.8
Cicadidae	Ph	0	0	0	0	0	0	7	0.54 ± 1.94	7.7
Philopteridae	P	3	1 ± 1	66.7	5	1.67 ± 0.58	100.0	2	0.15 ± 0.55	7.7
Lygaeidae	Ph	0	0	0	0	0	0	4	0.31 ± 1.11	7.7
Thripidae	Ph	0	0	0	0	0	0	7	0.54 ± 1.94	7.7

ent in the shag nests belong to five families (Table V). The average number of individuals per nest was 6.38 ± 7.14. Empty nests presented the almost totality of spiders (114 individuals) (average 8.77 ± 7.42 individuals). All spiders are predators and present differences in their techniques of capture, for instance, the Linyphiidae family uses the wind as means of dispersion. It is the most abundant since it has been found in a high number of nests.

The preference for empty nests could be due to the search for food and refuge. Although they were at immature stages, the spiders did not develop in the nest but came from the surroundings.

Other groups. Besides the groups mentioned above, we can find a wide number of arthropods that are less represented in shag nests (Table VI). Collembolans (Hypogastruridae, Entomobryidae and Isotomidae families) inhabit nests occasionally and their distribution is conditioned by the degree of humidity. Psocopterous and isopods have saprophagous (S) habits. The pseudoscorpions and centipedes (Lithobiidae and Geophilidae families) are predators (Pr) and the millipedes (order Julida) are phytophages (Ph).

Other individuals like the Cicadidae, Lygaeidae and Thripidae families are phytophagous and transported to the nests by birds or together with the construction material.

Other groups represented by a smaller population like the flea larvae (Pulicidae and Leptosyllidae), including the Mallophaga (Philopteridae) families and fleas, develop feeding on detritus deposited in the nests.

Predators (Pr) like pseudoscorpions have an unequal distribution for they are concentrated on a scarce number of nests.

Diversity and number of individuals of each family did not show significant differences between nests with eggs and nests with broods from Cíes. Abundance of three families (Oribatulidae, Milichiidae and Sciaridae) showed significant differences in empty nests from Cíes and Ons.

There were no significant differences in assemblage between nests with broods and eggs from Cíes ($F_{1,4} = 0.42$; $P > 0.05$). Neither there were significant differences in assemblages between empty nest from Cíes and Ons ($F_{1,10} = 1.42$; $P > 0.05$).

Finally, a Trophic Network has been elaborated from these results (Fig. 3). It is an attempt to represent a schematic way of the energy flow in the shag nests. It is observed, with the exception of a small number of families, that the contributions of organic matter are the main power supply. Although the nest has been left, the nutritional rest and the excrements deposited by broods continued to supply the processes developed in the nest.

DISCUSSION

The fauna present in shag nests comes fundamentally from the surroundings, and is mainly edaphic. It is not homogeneously distributed in the nests due to factors such as the accessibility of the nests, exposition (cavern or caves), and the proximity to other nests. The main source of food for the arthropods is the organic matter at various decomposition stages, and for this reason, the highest abundance of arthropods is counted in the phase of empty nests.

Acari are the most abundant group of the nest fauna. The saprophagous preference of the Uropodidae family must be emphasized. Most of saprophagous mites are present in empty nests where, due to their nutritious habits, they find the most favorable conditions. Concerning other acari families, the number of individuals in each nest is highly variable, even during the same phase of occupation. The greatest abundance of mites is presumably the result of a great variability in the strategies of life history, as well as the capacity of dispersion of the acari species, already observed in other bird species nests (Bloszyk *et al.* 2006).

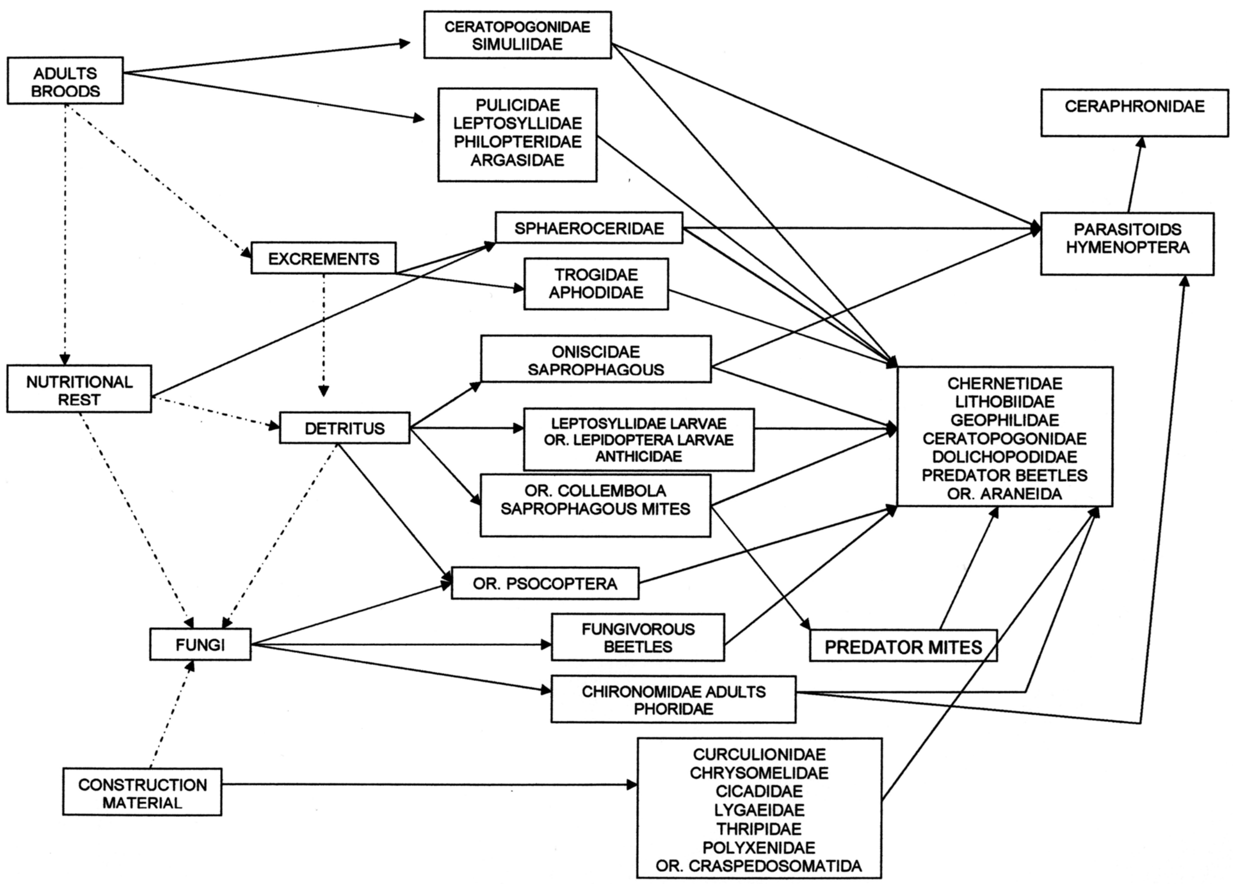

Fig. 3. – Trophic network showing a schematic way of the flow of energy in the shag nests of Cíes Islands (Ría de Vigo) and Ons Island (Ría de Pontevedra) in the National Park of the Atlantic Islands (NW of the Iberian Peninsula).

Diptera are fundamentally present at larval stage with saprophagous preferences. The Miliciidae family was the most abundant and found the best conditions for their development in empty nests. This great abundance of dipterous in empty nests is related to the high number of hymenopteran parasitoids found since these larvae are their principal host.

On the other hand, coleopterans showed a great variety of trophic preferences. Predators (Histeridae and Staphilinidae families) were the most abundant group as they are able to develop in the nests, while the coprophagous group (Trogidae family) showed a very low abundance.

Spiders are almost exclusively in empty nests, where they seek for refuge and food. Other arthropod groups were found, some of them brought into the nests by birds together with the construction material (Cicadidae, Lygaeidae and Thripidae families) and others that abandon their hosts like the hematophagous parasites (Pulicidae, Leptosyllidae).

Saprophagous arthropods are the most abundant, independently of the nest occupation phase, followed by the parasites in nests with eggs and predators and parasitoids in empty nests. The fungivorous, phytophagous and coprofagous arthropods are less abundant.

From the rest of the groups, some of them use the nest as a diurnal or nocturnal refuge or a shelter for hibernation. Others are introduced accidentally with the construction material of the nest or transported by other animals. That explains why their presence in the colony is scarce. A great proportion of species are occasional and appeared only in one, two, or three nests; parasitic groups are brought into the nests secondarily.

Certain groups of mites (Uropodidae, Parasitidae), some dipterous (Milichiidae) and some coleopterans (Staphylinidae and Histeridae) find suitable conditions for developing their biological cycle in shag nests. Other groups are attracted to the nests in search of food, shelter or they are simply transferred accidentally to the nests with the construction material.

In contrast with other researches on nidicolous fauna (Kristofik *et al* 1993), the hematophagous mites (Argasidae) are not the most abundant group.

In our study it is necessary to emphasize, compared to other researches about bird nests (Kristofik *et al*. 1993, 1995, 1996, Mašán & Kristofik 1993, 1995, Mašán *et al*. 1994, Vidal 1995) and burrows (Blasco-Zumeta 1995, Carrió *et al*. 1997), the high abundance and richness of arthropods in each nest. These shag nests are structures that show microhabitats of great entomological interest. Moreover, the cleaning processes of nests carried out by saprophagous can also contribute to make the nests long lasting and consequently re-occupied by other shags. In this study, we found more coleopteran and dipteran families together with predators mites than in other studies. In contrast, there were less spider families. For the first time, we have found a greater number of families belonging to acari (Argasidae, Anoetidae, Cheyletidae, Eupodidae, Pachygnathidae, Erythraeidae and Johnstonianidae), spiders (Agelenidae and Oonopidae), coleopterans (Ptiliidae, Aleocharidae, Aphodidae, Mycetophagidae, Anthicidae and Lagriidae), dipterans (Chironomidae, Simuliidae and Sphaeroceridae) and parasites hymenopterans (Proctotrupoidea) than those found in nests of *Parus major* (Merilä & Allander 1995), *Lanius* sp. (Vidal 1995), *Merops apiaster* (Kristofik *et al*. 1996), *Remiz pendulinus* (Kristofik *et al*. 1993, 1995, Mašán & Kristofik 1995) and *Riparia riparia* (Mašán & Kristofik 1993). We have not found individuals belonging to Laelapidae, Aranaeidae (Dyctinidae and Thomisidae) or Drosophilidae. Within parasitic insects, only the order Siphonaptera (due to life cycle) is common in nests and burrows.

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