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UROPYGIAL GLAND SIZE AND AVIAN HABITAT

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Resumen. El papel fisiológico de la glándula uropigia es hasta ahora una controversia. Algunos autores afirman que su función podría estar estrechamente vinculada con las propiedades hidrofóbicas de su secreción, que puede ser esencial para impermeabilizar el plumaje. Por consiguiente podría esperarse que el grado de desarrollo de esta glándula debe ser mayor en aves acuáticas que en especies terrestres. Con el objeto de validar esta hipótesis, se determinó el peso de la glándula (GW) relativo al peso corporal (BW) expresando los resultados como porcentajes (GW x 100/BW). Se analizaron los datos de 1164 individuos de 126 especies de aves adultas de 49 familias. Los resultados mostraron la ausencia de una clara correlación entre el índice calculado y el grado de contacto de las aves con el agua. No se observó correlación filogenética derivada de la presencia de la glándula uropigia.

Abstract. The physiological role of the uropygial gland is still controversial. Certain authors state that its function could be closely connected to the hydrophobic properties of its secretion, that may be essential for plumage waterproofing. Therefore, it could be hypothesized that the degree of this gland's development should be greater in aquatic birds than in terrestrial species. In order to validate that hypothesis, gland's mass (GW) relative to body weight (BW) was determined, expressing the results as percentages (GW x 100/BW). Data of 1164 adult individuals from 126 bird species from 49 families were analysed. Results showed the absence of a clear cut correlation between the calculated index and the degree of birds' contact with water. No phylogenetic correlation was observed derived from the presence of the uropygial gland. *Accepted 15 June 2000.*

Key words: Uropygial gland, habitat, aquatic birds, terrestrial birds.

INTRODUCTION

The uropygial gland, may be considered as the only organized tegumentary structure of external secretion typical of birds, is always found in embryonic stages, while in adults of some species it may be vestigial or absent (Rheidae, Psittacidae and Columbidae) (Johnston 1988). It is a holocrine gland that secretes a complex and variable mixture of substances formed greatly of aliphatic monoester waxes, formed of fatty acids (with various degree of methyl branching) and monohydroxy wax-alcohols. However, some types of diester waxes containing hydroxyfatty acids and/or alkane-diols exist in the secretions of the uropygial gland of some groups of birds (Jacob & Ziswiler 1982, Downing 1986, Jacob 1992) and is highly specialized in lipid synthesis (Kolattukudy & Rogers 1978, Urich 1994).

Morphological descriptions of the gland

of different taxa and systematic classifications based on its morphology and chemical nature of secretory lipids have been reported (Jacob & Ziswiler 1982, Johnston 1988). Information on the uropygial gland's histology, secretion chemistry, and possible physiological functions has been recorded (Elder 1954, Lucas & Stettenheim 1972, Jacob & Ziswiler 1982, Montalti *et al.* 1994). It is interesting to mention that Jacob *et al.* (1979) demonstrated sexual differences in the chemical composition of the secretion in domestic ducks. The extirpation of the uropygial gland did not reveal any serious consequence for the survival of pigeons (Montalti *et al.* 1999), hens, and passerine birds (Jacob 1976).

The physiological function of this gland has not been studied extensively. Many workers hold that this gland's function is closely connected with the hydrophobic properties of its secretion, which would have an essential role in plumage waterproofing. It is also possible that the gland could play a role in plumage hygiene against microflora and/or in supplying provitamin D and repository and excretory function for several pesticides and pollutants (Johnston 1975, 1976, 1978, Jacob & Ziswiler 1982, Quay 1986, Kozulin & Pavluschick 1993, Pilastro *et al.* 1993, Jacob et al. 1997, Gutiérrez *et al.* 1998, Bandyopadhyay & Bhattacharyya 1996, 1999). We undertook this study in order to check this point of view. Our hypothesis was that adult birds'gland size, considering its weight relative to the body weight, should be related to the bird's habitat, being relatively greater in species that are in permanent or temporary contact with water than in terrestrial species.

MATERIALS AND METHODS

Data used in this work came from two sources. Some of them were taken from Jacob & Ziswiler (1982) and Johnston (1988). Most of them came from measurements carried out at our laboratory between 1985 and 1995. In the latter case, birds were captured in different places of the Buenos Aires province, Argentina; penguins (Spheniscidae), petrels (Procelariidae and Hydrobatidae), cormorants (Phalacrocoracidae), sheathbills (Chionidae) and skuas (Stercorariidae) came from King George Island (South Shetland Islands) and from Laurie Island (South Orkney Islands), Antarctica. A few samples were provided by the La Plata Zoo.

Some 1164 individuals from 126 species and 49 families were studied in total. Body weight was determined in the field or at the laboratory, using a dynamometer balance (± 1 g accuracy); glands were removed according to the technique developed by Montalti *et al.* (1998) and weighed with an electronic balance (± 0.01 g accuracy). These values were used to calculate the gland's mass as percentage in relation to body weight (GW x 100/BW) for each one of the considered species. Following Johnston's procedure (1988), data were grouped in families and a mean gland weight (as %) for each species was calculated. When the number of data was higher than two, results were expressed as means ± SD; otherwise individual values were shown. Data were evaluated statistically by one-way analysis of variance and the Tukey test.

RESULTS AND DISCUSSION

The Appendix shows the results ordered according to the systematic sequence of Morony *et al.* (1975). We found the largest mean relative gland weight in the Sternidae (S*terna trudeaui*, mean = 0.522), Podicipedidae (*Podylimbus podiceps*, 0.418–0.556) and Procellariidae (*Daption capense*, mean = 0.426). These findings are coincident with those of Jacob & Ziswiler (1982) and Johnston (1988) who also found the largest gland's weight in other species of the same families.

Among the Passeriformes, the greatest

relative weights were recorded in the Furnariidae (*Phacellodomus striaticollis*, mean = 0.363), Tyrannidae (*Serpophaga subcristata*, mean = 0.359), and Emberizidae (*Poospiza nigrorufa*, 0.280–0.320). Kennedy (1971) and Jacob & Ziswiler (1982) recorded the largest value in Passeriformes in Troglodytidae (*Troglodytes troglodytes*, 0.561 and 0.580) whereas, in a larger sample of *Troglodytes aedon*, we found a much lower value (mean = 0.245).

The smallest glands proportional to body weight were found in Ardeidae (*Bubulcus ibis*, mean = 0.014), and in Columbidae (*Columba picazuro*, mean = 0.016). Other authors (Kennedy 1971, Jacob & Ziswiler 1982, Johnston 1988) have reported similar results in Columbidae. The small size of the gland in these families may be attributed to the presence of the powder down; it is known that some birds such as herons, pigeons and kagus possess a rudimentary preen gland whose function may be fulfilled by powder down (Jacob 1976). Thus, the well developed powder down production may explain their reduced uropygial glands or absence of it (Johnston 1988).

In this study, it came out that there was no clear cut correlation between gland's size and the bird's exposure to water. It is accepted that species that plunge into the water to capture their prey would require larger glands than species that pick their prey from the water surface, almost without contact with water (see Jacob & Ziswiler 1982). However, the relative gland weight appeared without a clear relationship with the degree of aquaticity of the considered species. In spite of their condition of being fully aquatic species, the relative size of Sternidae resulted one of the largest among the species we studied; similar findings were reported by Johnston (1988) for *S. albifrons*.

On the other hand, birds living in aquatic environments not always have a more developed gland than non-aquatic birds. If we compare the size of glands of aquatic vs landbirds, it will come out that both show comparable values in spite of their different habitats; for instance, *Anas georgica* (mean = 0.306) vs *Guira guira* (mean = 0.296); *Pygoscelis adeliae* (mean = 0.159) vs *Colaptes campestroides* (mean = 0.174).

When comparing the gland size among landbird species, we found great variability. That is the case of fully terrestrial species as *Zonotrichia capensis* (mean = 0.198), *Milvago chimango* (mean = 0.143), *Athene cunicularia* (mean = 0.090) and *Zenaida auricularia* (mean = 0.026). On the other hand, it is interesting that if we compare the glands'size of aquatic species, but of dissimilar degree of aquaticity, it can be noted the existence of peculiar differences. *Pygoscelis papua,* which is a pursuit diving species, has a gland size of 0.132 %, while in *Daption capense*, a surface filterer bird, the size is 0.426 %. The size of the glands of these seabirds seems to be in the opposite direction of the expected values, i.e., the gland size of *P. papua* might be larger than the gland of *D. capense* because their feeding behaviour involves a different degree of contact with water. A similar trend is observed when the comparison between freshwater species is done; that is the case of *Fulica rufifrons* (mean = 0.168) and *Anas versicolor* (mean = 0.342).

Several authors have reported differences in relative gland weights, attributing them to seasonal variations (Kennedy 1971), habitat (Jacob & Ziswiler 1982), body weight (Johnston 1979), individual variation, and sex (Johnston 1988). In our case, no difference was found in the gland relative size between males and females.

Analysis of birds' phylogenetic classification (according to Morony *et al.* 1975) shows that despite the fact that the number of our samples may be considered small, the trend of the development of the gland was independent from the lineage of the birds. Thus, the uropygial gland is present in birds phylogenetically distant (Tinamidae-Hirundinidae) or, on the contrary, absent in phylogenetically close taxa (some Psittacidae and Columbidae).

In summary, if we assume that the gland's mass constitutes a valid parameter to quantify its degree of gland development, our results indicate that the physiological role of the gland does not depend upon gland mass. Chemical composition of the secretion may be involved in this (Jacob 1978). The role could be more complex than a feather waterproofing function.

There is no evidence that glands of similar mass produce comparable quantities of secretion. Consequently, we cannot disregard the possibility that the degree of contact with water might rather be associated with adaptive changes in the composition of the secretion, involving the biosynthesis routes of the gland's lipids.

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APPENDIX. Uropygial gland weight relative to body mass (gland weight x 100/ body weight). Data as percentage (mean ± SD). Species listed according to Morony *et al.*(1975).

FAMILY/Especies[1,2]	Mean	SD	n[3]
TINAMIDAE			
Rhynchotus rufescens	0.080	0.017	6
Nothura maculosa	0.141	0.042	41
SPHENISCIDAE (A)			
Pygoscelis papua	0.132	0.015	10
Pygsocelis adeliae	0.159	0.042	16
Pygoscelis antarctica	0.217	0.070	6
GAVIIDAE (A)			
Gavia stellata **	0.190	0.016	3
Gavia immer **	0.103	0.009	3
PODICIPEDIDAE (A)			
Podilymbus podiceps	0.418-0.556	—	2
Rollandia rolland	0.428	0.107	10
PROCELLARIIDAE (A)			
Macronectes giganteus	0.191-0.437	—	2
Daption capense	0.426	0.047	5
Halobaena caerulea	0.212-0.332	—	2
HYDROBATIDAE (A)			
Oceanites oceanicus	0.445	0.055	16
Fregetta tropica	0.459	0.079	5
PELECANIDAE (A)			
Pelecanus occidentalis **	0.373	0.045	3
FREGATIDAE (A)			
Fregata magnificens **	0.067	0.005	3
PHALACROCORACIDAE (A)			
Phalacrocorax olivaceus	0.279	0.066	6

APPENDIX. Continuation.

FAMILY/Especies[1,2]	Mean	SD	n[3]
Phalacrocorax bransfieldensis	0.154	0.041	3
Phalacrocorax georgianus	0.191-0.194	—	2
ANHINGIDAE (A)			
Anhinga anhinga **	0.152	0.017	5
SULIDAE (A)			
Sula bassana *	0.350	—	2
ARDEIDAE			
Syrigma sibilatrix	0.025	0.006	4
Egretta alba	0.029	0.006	7
Egretta thula	0.029	0.013	8
Bubulcus ibis	0.014	0.007	3
Nycticorax nycticorax	0.031-0.041	—	2
CICONIDAE			
Ciconia maguari	0.051-0.074	—	2
Ciconia ciconia	0.077-0.082	—	2
THRESKIORNITHIDAE			
Plegadis chihi	0.208	0.043	31
Platalea ajaja	0.148-0.190	—	2
PHOENICOPTERIDAE			
Phoenicopterus chilensis	0.181	0.043	12
ANHIMIDAE			
Chauna torquata	0.063	0.016	3
ANATIDAE (A)			
Dendrocygna viduata	0.263	0.035	8
Cygnus melanocorypha	0.152	0.012	3
Coscoroba coscoroba	0.234	0.057	4
Chloephaga picta	0.063-0.095	—	2
Cairina moschata	0.242	0.065	5
Anas flavirostris	0.382	0.066	8
Anas georgica	0.306	0.120	9
Anas versicolor	0.342	0.108	5
Netta peposaca	0.408	0.134	4
CATHARTIDAE			
Coragyps atratus **	0.043	0.004	4
ACCIPITRIDAE			
Elanus leucurus	0.094	0.015	3
Rostrhamus sociabilis	0.097	0.020	11
Circus buffoni	0.065	0.013	4
Buteo magnirostris	0.044	0.011	4
FALCONIDAE			
Polyborus plancus	0.060	0.018	6
Milvago chimango	0.143	0.033	17
Falco sparverius	0.082	0.022	6
PHASIANIDAE			
Gallus gallus	0.094	0.041	3

APPENDIX. Continuation.

FAMILY/Especies[1,2]	Mean	SD	n[3]
ARAMIDAE			
Aramus guarauna	0.141	0.020	4
RALLIDAE (A)			
Aramides ypecaha	0.114	0.020	6
Pardirallus maculatus	0.294-0.342	—	2
Pardirallus sanguinolentus	0.281-0.316	—	2
Gallinula chloropus	0.222	0.033	6
Gallinula melanops	0.296	0.091	4
Fulica armillata	0.111-0.219	—	2
Fulica rufifrons	0.168	0.048	4
GRUIDAE			
Grus canadensis **	0.045	0.009	4
JACANIDAE (A)			
Jacana jacana	0.157	0.032	6
ROSTRATULIDAE			
Nycticryphes semicollaris	0.191	0.017	3
RECURVIROSTRIDAE			
Himantopus himantopus	0.088	0.006	4
CHARADRIIDAE			
Vanellus chilensis	0.096	0.023	51
SCOLOPACIDAE			
Tringa flavipes	0.231	0.031	8
Calidris fuscicollis	0.251	0.036	22
CHIONIDAE			
Chionis alba	0.202	0.029	6
STERCORARIIDAE (A)			
Catharacta maccormicki	0.211	0.053	17
Catharacta antarctica	0.172	0.049	35
LARIDAE (A)			
Larus dominicanus	0.174	0.058	13
Larus cirrocephalus	0.232	0.043	6
Larus maculipennis	0.225	0.042	23
STERNIDAE (A)			
Sterna trudeaui	0.522	0.031	3
RHYNCHOPIDAE (A)			
Rynchops niger **	0.200	—	6
ALCIDAE (A)			
Uria algae *	0.170	—	2
Alca torda *	0.220	—	3
COLUMBIDAE			
Columba livia	0.026	0.012	50
Columba picazuro	0.016	0.005	9
Columba maculosa	0.022	0.006	7
Zenaida auriculata	0.026	0.010	26
Columbina picui	0.069	0.016	5

APPENDIX. Continuation.

FAMILY/Especies[1,2]	Mean	SD	n[3]
PSITTACIDAE			
Melopsittacus undulatus	0.207	0.023	5
Ara macao	0.057-0.097	—	2
Nandayus nenday	0.084	0.004	3
Cyanoliseus patagonus	0.094-0.117	—	2
Myiopsitta monachus	0.094	0.033	12
CUCULIDAE			
Guira guira	0.296	0.111	35
TYTONIDAE			
Tyto alba	0.121	0.033	3
STRIGIDAE			
Asio flameus	0.068-0.089	—	2
Athene cunicularia	0.090	0.028	10
Bubo virginianus **	0.038	0.004	4
APODIDAE			
Apus apus *	0.050	—	7
TROCHILIDAE			
Chlorostilbon aureoventris	0.286-0.288	—	2
ALCEDINIDAE (A)			
Chloroceryle americana	0.415-0.510	—	2
RAMPHASTIDAE			
Ramphastos toco	0.065-0.071	—	2
PICIDAE			
Colaptes campestroides	0.174	0.021	10
Colaptes melanolaimus	0.108	0.027	11
Melanerpes carolinus **	0.117	0.02	3
FURNARIIDAE			
Cinclodes fuscus	0.223	0.033	11
Furnarius rufus	0.125	0.045	29
Phacellodomus striaticollis	0.363	0.083	5
Schoeniophylax phryganophila	0.309	0.049	5
Anumbius annumbi	0.240	0.094	9
Lessonia rufa	0.121	0.020	3
TYRANNIDAE			
Machetornis rixosus	0.150	0.007	5
Tyrannus savana	0.103	0.032	19
Tyrannus melancholicus	0.104	0.045	8
Pitangus sulphuratus	0.124	0.037	25
Pyrocephalus rubinus	0.143	0.046	7
Serpophaga subcristata	0.359	0.183	3
Serpophaga nigricans	0.248	0.083	4
Satrapa icterophrys	0.089-0.178	—	2
Xolmis coronata	0.053-0.083	—	2
Hymenops perspicillatus	0.161	0.022	4
PHYTOTOMIDAE			
Phytotoma rutila	0.111	0.023	10

APPENDIX. Continuation.

FAMILY/Especies[1,2]	Mean	SD	n[3]
HIRUNDINIDAE			
Phaeoprogne tapera	0.076	0.016	6
Tachycineta leucorrhoa	0.125	0.032	4
MOTACILIDAE			
Anthus hellmayri	0.257	0.043	3
TROGLODYTIDAE			
Troglodytes aedon	0.245	0.067	13
POLIOPTILIDAE			
Polioptila dumicola	0.153	0.085	9
MIMIDAE			
Mimus saturninus	0.134	0.026	9
Mimus triurus	0.074	0.017	3
TURDIDAE			
Turdus rufiventris	0.129	0.027	3
Turdus amaurochalinus	0.064-0.093	—	2
Turdus migratorius **	0.100	0.014	3
EMBERIZIDAE			
Sicalis flaveola	0.101	0.028	5
Zonotrichia capensis	0.198	0.084	35
Paroaria coronata	0.093	0.022	4
Poospiza nigrorufa	0.278-0.323	—	2
Donacospiza albifrons	0.366-0.620	—	2
Embernagra platensis	0.275	0.079	26
Cardinalis cardinalis **	0.083	0.009	3
ICTERIDAE			
Molothrus bonariensis	0.116	0.042	6
Molothrus badius	0.262	0.076	27
Molothrus rufoaxilaris	0.143	0.012	3
Icterus cayanensis	0.140	0.013	3
Agelaius thilius	0.212	0.054	31
Pseudoleistes virescens	0.246	0.051	13
Sturnella superciliaris	0.242	0.056	27
FRINGILLIDAE			
Carduelis magellanicus	0.122	0.032	16
Serinus canarius	0.151-0.186	—	2
STURNIDAE			
Sturnus vulgaris **	0.117	0.009	3
CORVIDAE			
Corvus corax *	0.120	—	6
Corvus corone *	0.100	—	8
Pica pica *	0.090	—	5
Cyanocitta cristata **	0.127	0.052	3
PARIDAE			
Parus major *	0.140	—	12
Parus ater *	0.150	—	11

APPENDIX. Continuation.

FAMILY/Especies[1,2]	Mean	SD	n[3]
AEGITHALIDAE			
Aegithalos caudatus *	0.210	—	2
ESTRILDIDAE			
Padda oryzivora	0.111-0.136	—	2
PLOCEIDAE			
Passer domesticus	0.171	0.061	22

[1](A) means aquatic bird.

[2]Asterisks indicate the source of information: * = from Jacob & Ziswiler (1982), ** = from Johnston (1988).

[3]n = number of specimens of each species.