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Information on Waterfowl Feather Characteristics

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ABSTRACT

Information on feather numbers and weights as well as dietary protein ingestion values for feather synthesis are fundamentally important to taxonomic and nutritional studies of waterfowl. In order to compare species-specific plumage characteristics in waterfowl, ten species of *Anatinae* (*Anas platyrhynchos, Anas strepera, Anas americana, Anas crecca, Anas discors, Aix sponsa, Aythya affinis, Aythya collaris, Aythya americana,* and *Mergus cucullatus*) were collected in the central Illinois River Valley during 1991 and 1992. Variations were found in total feather number, weight and estimated dietary protein requirements between species and sexes. Male and female plumage weight was positively correlated to body mass. Plumage weight was consistently greater in males than females and tended to be related to total body mass but was found not to be significant. Further investigations into waterfowl plumage characteristics and body surface area are recommended in order to elucidate potential physiological, behavioral or habitat related functions of waterfowl plumage.

INTRODUCTION

Feathers are the most distinctive feature of avian anatomy (Gill, 1989) and alone distinguish birds from all other animals (Van Tyne and Berger, 1976). As independent structures, feathers are extremely complex integumentary derivatives capable of providing multiple functions (Lucas and Stettenheim, 1972). However, according to Pettingill (1985) and subsequent review of available literature, no attempt to thoroughly investigate the number and weight of feathers within a species has been conducted. Previous plumage studies of North American Anatidae have primarily examined chronological development or molting dynamics of feathers (e.g. Billard and Humphrey 1972, Palmer 1972, Paulus 1984, Wishart 1985, Miller 1986). Consequently, information on the actual number and weight of feathers within this group of birds is deficient. In addition, outside of the work of Heitmeyer (1988) and Bellrose and Holm (1994) no information on amount of dietary protein required by waterfowl to synthesize feathers has been published.

Knappen (1932) was the first to provide data on feather numbers for waterfowl when she enumerated 11,903 feathers from an adult female Mallard (*Anas platyrhynchos*) that was collected on 19 March. Since that time relatively little information has accrued. Amman (1937) counted 25,216 contour feathers that weighed 621.0g. from a Whistling Swan (*Cygnus columbianus*) that was collected 5 November. Brodkorb (1951) counted contour feathers from one female Green-winged Teal (*Anas crecca*) and one male Northern Pintail (*Anas acuta*) that were collected 28 January that had 11,450 and 14,914 feathers respectively. Turcek (1966) calculated weights of plumage as expressed in percentage of total body mass for 91 species of birds representing 34 families, including one Green-winged Teal, one White-fronted Goose (*Anser albifrons*) and five Mallards. The average plumage weight of these seven waterfowl was 7% of their total body mass. More recently, while studying nutritional requirements of molting Mallards Wielicki (1986) estimated the body region of male Mallards in definitive alternate plumage to average 54.7g. Investigating protein costs of molting Mallards, Heitmeyer (1988) determined that the feathers of adult females in basic plumage averaged a dry mass of 72.7g. Bellrose and Holm (1994) examined an adult male Wood Duck (*Aix sponsa*) collected in early November and counted 8, 216 contour feathers, weighing 38.9g. and calculated it would require 67.9g. of ingested protein to synthesize the feather coat (excluding sheath and down feather synthesis). Hohman et al. (1997) presented a comparison of mean plumage weight to body mass in adult male waterfowl and provided the following species accounts; Blue-winged Teal (*Anas discors*) Basic plumage - 19.5g., Alternate plumage - 21.0g., Cinnamon Teal (*Anas cyanoptera s.*) Alternate - 20.5g., Mallard Basic - 56.6g., Alternate - 77.0g., Ring-necked Duck (*Aythya collaris*) Alternate - 30.5g., Canvasback (*Aythya valisneria*) Alternate - 59.7g., and Ruddy Duck (*Oxyura jamaicensis*) Alternate - 24.9g.

In order to compare species-specific plumage characteristics in waterfowl this investigation examines 10 species of Anatinae and provides additional information on total feather numbers, weight, and protein requirements for synthesis.

STUDY AREA AND METHODS

Wood Duck, Green-winged Teal, Gadwall (*Anas strepera*), American Wigeon (*Anas americana*), Mallard, Ring-necked Duck, Lesser Scaup (*Aythya affinis*), Redhead (*Aythya americana*) and Hooded Merganser (*Mergus cucullatus*) were collected in central Illinois, November 1991 and November 1992. Blue-winged Teal were collected in early September 1992. Wood Duck, Blue-winged Teal and Green-winged Teal were examined for total contour feather numbers. Birds were weighed on an electronic precision balance to the nearest 0.1g. Cloacal characteristics were used to distinguish adults from juveniles (Hochbaum, 1942). Contour feathers were removed from 33 delineated feather tracts within 3 major plumage regions: head – base of bill to base of hind-neck and throat, body – that portion excluding the head and innermost wing feathers, and wings – all feathers of wing including axillars and alula region) and allowed to air dry before being weighed to the nearest 0.01g. Feathers were not subjected to any cleaning or artificial drying process prior to weighing. Because criteria for demarcation of tract boundaries was not always well defined, minor variations between individuals undoubtedly occurred (see Bellrose and Holm, 1994). Feathers within each plumage tract were individually counted except for the crown, side of head and chin/throat areas. Because of the abundance of small feathers in these tracts, samples of feathers were counted and weighed and total feather numbers for these regions were estimated. The methodology described by Bellrose and Holm (1994) was followed to determine amount of dietary protein required by waterfowl to synthesize feathers. To ascertain an approximate weight and calculate dietary protein requirements for down feather synthesis, ≥95% of the down feathers were removed from six Wood Ducks, five Blue-winged Teal and four Green-winged Teal and ≥95% of the down feathers from one adult male and one adult female of seven additional duck species.

RESULT

Male and female plumage mass was positively correlated ($P < 0.01$) to body mass (Figure 1.). Plumage weight was consistently greater in males than females and tended to be related to total body mass (Table 1.) but was not statistically significant ($P > 0.10$, CI –9.16, 20.08). Plumage weight calculated as percentage of total body mass for all male species varied from 4.5% in the Lesser Scaup to 6.9% in the Green-winged Teal and averaged 5.7% as a group. Female plumage weight averaged 5.3% of total body mass and ranged from a low of 4.2% in the Lesser Scaup to 6.5% in the Gadwall.

Total mean contour feather numbers for male Green-winged Teal were significantly greater ($P < 0.01$, CI 1479, 3415, df = 5) than for male Wood Ducks or Blue-winged Teal. Total mean contour feather numbers for male and female Green-Winged Teal as a group was significantly greater ($P < 0.01$, CI 1105, 2414, df = 20) than for male and female Wood Ducks and Blue-Winged Teal as a group. Total contour feather numbers expressed as percentage of total feather coverage by body region for all male and female species examined was: head - 54%, body - 29%, and wings - 17%. Mean plumage weight expressed as percentage of total feather mass by region for all species examined was: body - 55.5%, wings - 28% and head - 5.5%. Male and female down feathers comprised an additional 11% of total plumage weight.

DISCUSSION

Minor variations in total contour feather numbers between individuals and sexes collected during the same season have been reported by Wetmore (1936), Staebler (1941), and Korelus (1947). This scenario was also prevalent in the examination of Wood Ducks, Blue-winged Teal and Green-winged Teal (Table 2). Comparison of three species of waterfowl examined in this study revealed that male and female Green-winged Teal as a group had significantly ($P < 0.01$) more feather numbers relative to either Blue-Winged Teal or Wood Ducks. Although Hutt and Ball (1938) determined that smaller species tended to have a greater amount of total feather numbers in relation to body surface area than large birds, the number of feathers found on Green-winged Teal was disproportionately more ($P < 0.01$) than that counted on Blue-winged Teal or Wood Ducks. At this time the correlation of body surface area to total feather numbers and weight in waterfowl is unknown. The mean calculation of 8,975 feathers on female Green-winged Teal in this study is fewer than the 11,450 feathers reported by Brodkorb (1951). This discrepancy may reflect a temporal difference in collection dates or comparative difficulties due to small sample size.

Data collected on Blue-winged Teal may be bias in respect to timing of molt. Birds collected in Illinois in September are still retaining basic plumage. All other species examined were tentatively classified as near completion of full alternate plumage, although no exact determination of the extent of molt was ascertained. Molt terminology follows Humphrey and Parkes (1959).

The calculated 5.5% mean plumage weight to total body mass value from 10 species of Anatinae in this study is consistent with the findings of Turcek (1966) who determined that the amount of plumage weight delineated as percentage of total body mass for aquatic birds is less than the mean value of 6.3% determined for all birds. However, his formulation that for each 1% increase in body mass, plumage weight increased 0.95% was not applicable in this study. For example, an adult male Lesser Scaup had a mean body mass 7% less than an adult male American Wigeon but possessed a plumage weight 23% less. Similarly, the mean body mass of an adult female Ring-necked Duck was nearly equal to an adult female Gadwall yet their plumage weight was 27% less. I found that in general for each 1g. increase in body mass plumage mass increased by approximately 0.06g. These discrepancies in the relationship between body mass and plumage weight were also found by Hohman et al. (1997) in their attempt to predict waterfowl plumage weight based on the formula presented by Turcek (1966). Individual variation in waterfowl body weights (Bellrose, 1980) presents an important variable in estimating percent plumage mass to body weight. Results of this study on total contour feather numbers and weights are comparable to the results of Bellrose and Holm (1994) on the Wood Duck, data reported by Hohman et al. (1997) on male Blue-winged Teal, Ring-necked Duck and Mallards, and the results of Wielicki (1986) on male Mallards.

Dietary protein ingestion values required for feather synthesis in waterfowl may be proportional to feather weight (Heitmeyer, 1988). For example, the mean amount of protein necessary for male and female Mallards to synthesize feathers (147.4g.) is 3.1 times the amount that would be required for Green-winged Teal (47.7g.). This does not imply that dietary requirements are greater or lesser than the proportional body mass presented by individual species. Molt and associated feather synthesis induce essential nutritional conditions in waterfowl (Heitmeyer, 1988, Bellrose and Holm, 1994, Hohman et al., 1997). However, the costs of molt are directly related to the duration of feather replacement and may be offset by temporal acquisition (Ankney, 1979, Hohman, 1993, and Hohman et al., 1997). These costs would be most pronounced when rapid sequential molting of feathers is required such as acquisition of juvenile plumage or during annual wing molt for adults. Estimated protein costs for feather synthesis in waterfowl are not solely obtained from dietary sources. Hohman (1993) determined that a small proportion of endogenous protein may be catabolized by Ruddy Ducks to synthesize feather acquisition, thus offsetting potential dietary restraints.

In comparison to terrestrial birds, down feathers in aquatic birds are thought to be highly developed (Van Tyne and Berger, 1976). In particular, waterfowl are especially noted for their abundance of down feathers and the functions they provide in thermoregulation and female nest ecology. Of the ten species examined, down feather mass averaged 11.0% of total feather mass and 9.1% of the dietary protein necessary for complete plumage synthesis. The relative value of down feathers necessitates further inquiry into the potential cost/benefit ratio of their production as compared to total feather synthesis.

Finally, although this study provides only minimal baseline data on waterfowl feather characteristics, it does present some comparative difficulties in relating species specific plumage patterns to body mass. I would suggest a more comprehensive comparison of feather numbers and weight as well as physical properties of feathers (e.g. length, width, weight of contained biochromes etc.) in relation to body surface area in order to elucidate potential physiological, behavioral, or habitat-associated functions of waterfowl plumage.

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Table 1. Contour and down feather weights (g.) and protein (g.) required for feather synthesis for adult Wood Duck, Mallard, Gadwall, American Wigeon, Blue-winged Teal, Green-winged Teal, Redhead, Ring-necked Duck, Lesser Scaup and Hooded Merganser.

Tribe/ Species[a]	Body Mass	Plumage Mass					
		Body	Head	Wings	Down	Total	Protein[b]
CAIRINI							
Wood Duck							
Male	692.0	21.16	2.17	10.26	3.74	37.33	78.19
Female	629.1	17.61	1.04	9.92	4.38	32.95	69.00
ANATINI							
Mallard							
Male	1,238.3	43.66	4.12	20.48	6.77	75.03	157.12
Female	1,104.6	34.27	3.02	20.24	8.20	65.73	137.66
Gadwall							
Male	762.2	27.74	1.48[c]	15.70	4.94	49.86	104.44
Female	710.0	25.69	2.14	13.64	5.01	46.48	97.34
American Wigeon							
Male	880.8	25.70	3.03	14.54	4.78	48.05	100.63
Female	678.9	21.39	1.79	12.96	4.18	40.32	84.44
Blue-Winged Teal							
Male	375.1	12.05	0.87	7.17	1.78	21.87	45.82
Female	330.5	9.65	0.64	6.06	2.50	18.85	39.49
Green-Winged Teal							
Male	358.9	14.27	1.79	6.18	2.43	24.67	51.66
Female	336.2	8.81	1.14	4.90	2.22	17.07	35.76
AYTHYINI							
Redhead							
Male	1,093.9	35.33	3.84	15.10	5.79	60.06	125.80
Female	946.9	27.90	2.17	12.18	5.42	47.67	99.83
Ring-necked,Duck							
Male	728.2	21.50	3.47	9.70	4.50	39.17	82.03
Female	720.1	18.64	2.02	8.64	4.85	34.15	71.51
Lesser Scaup							
Male	819.0	20.86	2.20	9.96	4.13	37.15	77.80
Female	757.9	17.89	1.93	9.08	3.31	32.21	67.45
MERGINI							
Hooded Merganser							
Male	657.0	19.65	2.73	7.76	4.30	34.44	72.12
Female	579.5	16.26	1.64	7.30	3.80	29.00	60.73

[a] n=1, except for Wood Duck male and female (*n*=2), Blue-winged Teal male (*n*=3).

[b] Dietary protein amount required to synthesize total contour and down feathers. Calculation based on 96% protein content of feathers (i.e. 96% feather weight) times 55% efficiency of conversion (times 1.818) plus 20% of total protein requirement for sheath production.

[c] This value may represent an individual anomaly.

Table 2. Mean regional and total contour feather numbers on adult and juvenile Green-winged Teal, Wood Duck and Blue-winged Teal.

Male	Head	Body	Wings	Total
Green-Winged Teal				
	6599	2348	1551	10588
n=2	*r*(6568-6630)	*r*(2176-2700)	*r*(1548-1554)	*r*(10298-10878)
Wood Duck				
	4416	2607	1259	8282
n=5	*r*(4181-4612)	*r*(2420-2733)	*r*(1104-1390)	*r*(7908-8732)
Blue-Winged Teal				
	3822	2395	1515	7731
n=5	*r*(3676-3935)	*r*(2316-2589)	*r*(1352-1648)	*r*(7500-8059)

Female	Head	Body	Wings	Total
Green-Winged Teal				
	4958	2408	1609	8975
n=2	*r*(4855-5060)	*r*(2404-2412)	*r*(1578-1640)	*r*(8907-9042)
Wood Duck				
	4420	2611	1405	8346
n=5	*r*(4136-4581)	*r*(2536-2736)	*r*(1336-1476)	*r*(8148-8699)
Blue-Winged Teal				
	3558	2428	1422	7409
n=3	*r*(3425-3641)	*r*(2400-2462)	*r*(1370-1466)	*r*(7314-7473)

Figure 1. Relationship of plumage mass to body mass for 10 species of adult male and female (n=20, p<0.01, df 19) waterfowl.