USE OF TOE AND SHANK LENGTHS AS SEX DETERMINANTS IN WOODCOCK

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Abstract: From 1965-1970, toe and shank lengths of 509 woodcock (*Philohela minor*) banded in Canaan Valley, WV were measured to determine if these characteristics could be used as age and sex determinants. Test results from analysis of variance, Duncan's multiple range test and stepwise discriminant analysis determined toe and shank lengths can be indicators of sex. However, results from stepwise discriminant analysis suggest that toe and shank lengths should be used in conjunction with bill lengths.

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Several sexing techniques have been developed for woodcock (*Philohela minor*), including measurements of bill length (Tufts 1940), 3 outer primaries (Greeley 1953), size and weight (Sheldon 1967), and total wing length (Artmann and Schroder 1976). Aging methods of woodcock include examination of the bursa of Fabricius (Mendall and Aldous 1943), and examination of secondary feather color pattern (Martin 1964). Aging of chicks by measuring bill length is described by Ammann (1970).

This paper reports on the correlation of toe and shank lengths with sex and age of woodcock. Data were collected from the Canaan VAlley woodcock study (1964-1972).

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STUDY AREA

The study area was located at Canaan Valley, a scenic region of Tucker County in northeastern West Virginia. Canaan Valley lies within the Allegheny Plateau Province of the Central Appalachian Mountains. The valley has been described as a "cigar-shaped" basin composed primarily of smooth hills, and wide stream bottoms surrounded by steep, rocky mountain slopes (Goudy et al. 1970). Average elevation is approximately 900 m above sea level. Canaan Valley is completely surrounded by mountains except for a narrow gap at the northwest perimeter between Canaan and Brown Mountains where the Blackwater River leaves the valley. Poorly drained soils occupy the northern half of Canaan Valley, while well-drained soils predominate in the southern region.

Mountainsides surrounding Canaan Valley are primarily second growth hard-wood forest, a result of lumbering operations and subsequent uncontrolled fires during the early 1900's. Well drained soils occupy gentle sloping regions occurring throughout Canaan Valley in a mixed pattern. Canaan Valley is in early stages of succession, held in this condition by past farming operations, recently discontinued grazing, and a healthy beaver (*Castor canadensis*) population which has helped maintain boggy conditions of the valley floor (Sepik 1975).

Canaan Valley's climate and frequent changes in weather are due to the valley's elevation, geographic location, prevailing winds, and frequent alteration of air masses originating in the Gulf of Mexico and Canada (Weedfall and Dickerson 1965). Canaan Valley's climate has been classified as cold and humid; slightly warmer than Thorwaite's (1948) tundra classification. Canaan Valley, as all of West Virginia, lies in a cloudy belt and summer showers are due mostly to currents of moist tropical air sweeping northeastward from the Gulf.

MATERIALS AND METHODS

Information on woodcock banded in Canaan Valley was initially put on field cards and later, punched on computer data cards. Eventually, these data were programmed and stored on computer tape. Measurements were taken from 509 captured woodcock of determined age and sex. Toe measurements were made from the third toe (digit 3), and shank measurements were taken from the posterior edge of the flexed tarsometatrsus to the end of the third toe (Kletzly, pers. comm.).

Bill, toe, and shank measurements were subjected to stepwise discriminant function analysis, a multivariate statistical technique. Discriminant function analysis was used to analyze age and sex class response to all variables simultaneously, to determine which variables are important in age and sex separation. Data were analyzed using the BMD-07M stepwise discriminant analysis program (Dixon 1968). One-way analysis of variance (ANOVA), and Duncan's multiple range test using Statistical Analysis Systems (Barr et al. 1976) were used to analyze bill, toe, and shank measurements together to determine statistical differences between age classes. In using Duncan's multiple range test, Kramer's adjustment was applied to adjust for unequal cell frequencies (Barr et al. 1976).

RESULTS

Toe and shank lengths for each age and sex class showed distinct separation between male and female measurements (Table 1). Distribution of toes measurements from woodcock of predetermined age and sex indicated toe measurements less than 36 mm were from males in 99% of all cases (Table 2). Measurements greater than 38mm were from females in 90% of all cases. Analysis of variance of toe measurements between age and sex classes proved statistically significant ($P < 0.05$) (Table 3). Differences between males and females were found to be statistically significant ($P < 0.05$; df: 505). Significant differences were also found between adult males and immature males.

Distribution of shank measurements showed 95% of measurements greater than or equal to 78mm were males (Table 4). Analysis of variance revealed the difference between sexes to be significant ($P < 0.05$) (Table 5). Duncan's multiple range test showed significance between males and females ($P < 0.05$; df: 505). No significant differences ($P > 0.05$) were found in shank lengths between age classes within each sex.

Stepwise discriminant analysis yielded high F values in toe and shank measurements between males and females (Table 6, 7). No significant differences were found between age classes within each sex. Discriminant analysis was computed using bill lengths as an additional parameter. From these computations, bill length was found to be the most discriminating characteristic (Table 8).

Table 1. Means of toe and shank lengths (mm) of woodcock for each age and sex.

	Variable	*Mean*	*Variance*	*Confidence limits*
Immature male	Toe	35.11	1.90	34.92-35.30
	Shank	71.61	5.49	71.29-71.93
Adult male	Toe	35.47	2.31	35.18-35.78
	Shank	72.12	5.35	71.67-72.65
Immature female	Toe	38.66	2.73	38.35-38.97
	Shank	78.44	8.40	77.92-79.01
Adult female	Toe	39.11	2.90	38.76-39.45
	Shank	78.33	8.86	78.22-79.43

Table 2. Toe measurements (mm) from woodcock of predetermined age and sex.

Toe Length	*Males*		*Females*	
	Immature	*Adult*	*Immature*	*Adult*
32	4	2	1	
33	16	7		
34	52	19		
35	56	26	1	
36	47	23	7	7
37	21	16	15	8
38	8	5	28	21
39	1	3	24	18
40	1		20	19
41			9	14
42			3	4
43			1	1
44				1
Total	206	101	109	33

Table 3. Analysis of variance summary table for toe measurements of woodcock age and sex classes.

Source	*DF*	*Sum of squares*	*Mean squares*	*F values*
Model	.3	1628.22*	1628.88*	231.78*
Error	505	1182.99*	2.34	
Corrected total	2811.86*			

* Significant at P >= 0.05.

Table 4. Shank measurements (mm) from woodcock of predetermined age and sex.

Shank Length	*Male*		*Female*	
	Immature	*Adult*	*Immature*	*Adult*
64	1			
65	2			
66	2			
67	2		1	
68	12	4		
69	15	8		
70	26	12	4	2
71	28	17		2
72	52	25	1	2
73	34	7	3	2
74	19	10	1	
75	4	12	8	3
76	6	2	10	6
77	1	2	5	4
78	1		13	13
79		1	16	11
80	1	1	25	17
81			11	18
82			5	10
83			4	3
84			2	
Total	206	101	109	93

Table 5. Analysis of variance summary table for shank measurements of age and sex classes.

Source	*DF*	*Sum of Squares*	*Mean Squares*	*F Values*
Model	3	5749.36*	1916.45*	286.17*
Error	505	3381.89*	6.70	
Corrected total	508	9131.25*		

*Significant at $P > 0.05$

Table 6. F matrix for shank length measurements.
DF: 3,504.

	Immature male	*Adult male*	*Immature female*
Adult male	1.61		
Immature female	374.44*	240.12*	
Adult female	353.44*	233.49*	.58

*Significant at P > 0.05

Table 7. F. matrix for toe length measurements.
DF: 3,503.

	Immature male	*Adult male*	*Immature female*
Adult males	1.55		
Immature females	265.91*	168.19*	
Adult females	261.25*	170.20*	1.56

*Significant at P > 0.05

Table 8. Summary table for discriminant analysis of bill, toe, and shank lengths of woodcock.

Step number	*Entered variable*	*F value*
1	Bill	305.22
2	Shank	40.95
3	Toe	11.01

DISCUSSION

All toe and shank measurements were greater in females than in males. No distinct differentiation could be detected in age groups within each sex class. Results from previous studies involving measurements also yielded greater lengths in females (Tufts 1940, Mendall and Aldous 1943, Greeley 1953).

In toe measurements, a definite separation between sexes was found at 37mm. Measurements less than 37mm were mostly males. The break-off region for sexes in shank measurements fell between 75-77mm.

Although statistical testing confirmed the validity of using toe and shank lengths as sex determinants, they should not be used by themselves. Results from stepwise discriminant analysis suggest that toe and shank measurements should be used in conjunction with bill lengths and primary feather widths. Measurements of toe and shank should increase accuracy in sexing woodcock and decrease the number of unknowns in a sample. Measuring toe and shank lengths are rather simple and accurate procedures, since inaccuracies due to stretching are eliminated. However, human error can still be a factor. Results of these methods show that bill measurements are most reliable (smaller variances and small amount of overlap). Toe and shank measurements did not overlap appreciably, but their variances were rather high.

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