ANALYSIS OF THE DRUMS OF RUFFED GROUSE[1]

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MANY bird studies have shown individual differences in vocalizations within one species. For the most part such spectrographic studies deal with passerine songs, but some work with game birds has been done. Beightol and Samuel (1973) recently completed an analysis of American Woodcock (*Philohela minor*) vocalizations and showed that individual birds were readily identified by their voice prints. Williams (1971) also found individuality in calls of Bobwhite (*Colinus virginianus*). If identification of the drums of individual Ruffed Grouse (*Bonasa umbellus*) were possible then it could be used as a new "tool" for study of longevity and movements of this bird.

The drum of the Ruffed Grouse is a nonvocal sound produced by rapid wing strokes (for an exact description of this display, see Hjorth 1970: 225–232). Aubin (1972) examined this nonvocal form of communication and concluded that Ruffed Grouse "answer drumming sounds" of nearby birds, and that the number of wing strokes and the duration of each drum were variable for an individual bird.

In our study of the drums of Ruffed Grouse, we were interested particularly to learn if individuals were recognizable by their drumming.

METHODS

We recorded 150 drums from 10 birds between 13–27 April 1971 near Morgantown, West Virginia, and over 40 drums from 5 birds in May 1972 near Englehart, Ontario, Canada. The number of drums recorded per bird varied from 1 to 15. As all recordings were not of good quality most analyses are based on 115 drums from 13 birds. In an effort to determine day to day variation one paint-marked (tips of two outer primaries) bird was recorded on three mornings in May 1972.

Norelco Carry-Corder Cassettes were put in plastic bags, camouflaged with leaves, and placed near active drumming logs. The microphone was placed 3 feet in front of the drumming location and covered with leaves. Recorders were placed near logs in the evening, and switched to the record position. A 180-foot lead wire ran from the microphone to an off-on switch. If a bird was drumming on the log one-half hour before sunrise, the recorder was turned on for 1 hour. In most instances, tapes represent drums recorded during a single morning.

The length of the drum and the low frequency made spectrographic analysis difficult. Oscillograms were prepared of 190 drums of 15 grouse. Only 115 drums were of good enough quality (minimum noise) to be analyzed. Oscillograms were made by connecting the recorder to a Tektronix Type 565 Dual

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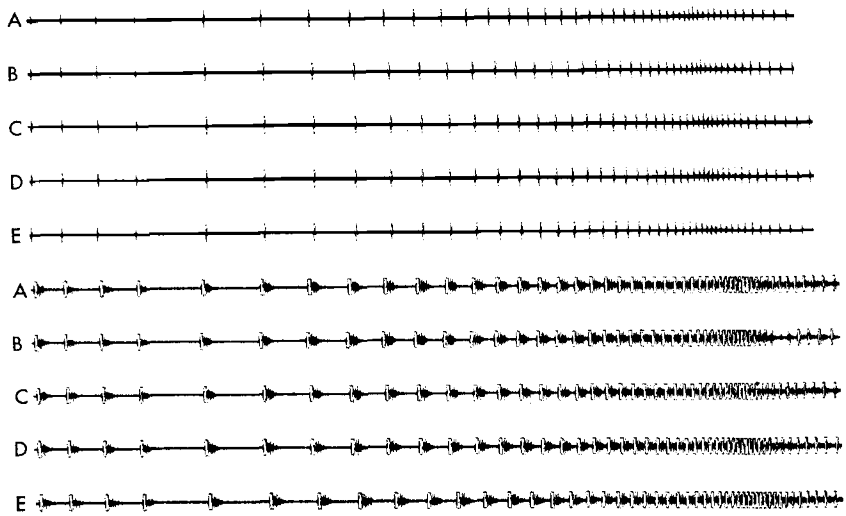

Figure 1. Oscillograms of five consecutive drums from two different Ruffed Grouse recorded in April 1971. Variation in appearance of the oscillograms is a function of recording distance. Preliminary wingbeats were removed so that each drum would have a uniform initial point.

Beam Oscilloscope, and photographs were taken with a Kymograph Oscilloscope Recording Camera, model C4N set at a film speed of 50 mm/second at F16. From the oscillograms (see Figure 1), line drawings of all drums were prepared (Figure 2). Three parameters were measured from each of these line tracings; total drum duration (to the nearest 0.1 seconds), duration of intervals between wingbeats (to nearest 0.1 seconds), and the number of beats per drum. Statistical analyses were carried out in the West Virginia University Computer Center.

RESULTS AND DISCUSSION

The drum.—Hjorth (1970) and Aubin (1970, 1972) charted the wingbeats of drumming birds. Because the authors differed as to what was the initial wingbeat in a drum, comparisons of lengths were not possible. Aubin (1970) noted "two preliminary wing-strokes" that "did not register on the recorder." Hjorth (1970: 223) indicated that the drum lasts 11 seconds if measured from the first regularly appearing wingbeat, and the first measured beat for Aubin's study was the second beat for Hjorth. The problem arises because of preliminary, barely audible wingbeats.

We noted as many as three preliminary wingbeats occurring irregularly before a quartet of regular wingbeats (Table 1). Such beats were recorded at times when they were inaudible to humans 180 feet from the bird. They were not always given (or possibly not recorded), and the number

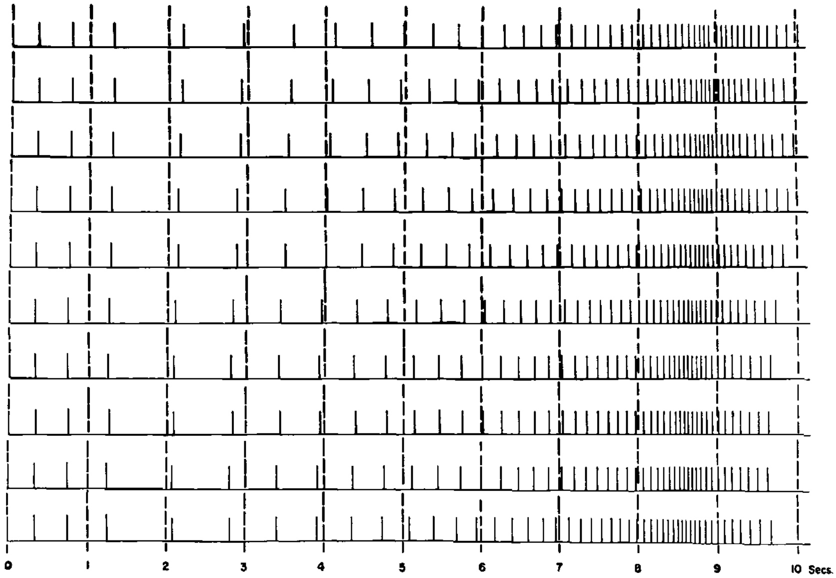

Figure 2. The rhythm of wingbeats for bird 6 recorded in April 1972; ten consecutive drums. Each drum is a tracing made from the oscillograms. To facilitate comparisons between drums, the preliminary wingbeats were deleted and the first regular wingbeat arranged at 0 seconds.

varied for some individuals in two consecutive drums. Bird 9, for example, gave two preliminary beats on each of 13 drums but only one beat on the 14th drum (Table 1). We recorded one marked bird on three separate mornings in 1972 (11,13, 18 May). Each time the microphone was placed in the same spot in front of the log. Even so, the visibility of the preliminary wingbeats on our oscillograms varied from one day to the next. Thus the bird either deleted these beats or moved slightly from his drumming spot. Our experience showed a move of only 3–4 inches in any direction could be enough to change the microphone's ability to pick up these early wingbeats.

All birds gave the initial quartet of beats at the beginning of each drum, and thus we used this point as reference for the beginning of each drum (see Figure 2).

Wingbeats.—One obvious place to begin when trying to determine if individuals have characteristic drums is the number of wingbeats per drum (Table 1). Hjorth (1970) indicated that each series of drums from one bird in Alberta and one in Ohio had the same number of beats (47 and 51, respectively). Aubin (1970) noted a variation in the number of wingbeats per drum in three of six birds studied.

TABLE 1

CHARACTERISTICS OF THE DRUMS OF 12 RUFFED GROUSE[1]

Bird		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	NOB	43	42	44	44	45	44	44	44	44					
	TOT	9.29	9.58	9.46	9.65	9.81	9.41	9.49	9.52	9.59					
	EWB	2	1	2	1	0	0	0	0	0					
2	NOB	46	45	46											
	TOT	10.13	9.78	9.66											
	EWB	1	1	1											
3	NOB	49	48	49											
	TOT	10.41	10.25	10.31	10.36	10.29	10.32	10.35[2]							
	EWB	0	0	0	0	0	0	1	0	0[2]					
4	NOB	46													
	TOT	9.91	9.94	10.01[2]											
	EWB	3	3	2	3	2	2[2]								
5	NOB	45	46	47	45	45	46	45							
	TOT	9.06	9.67	9.26	9.51	9.62	—	9.46	9.28	9.26	9.32	9.25[2]			
	EWB	0	0	0	0	0	0	0	0	0	0	0	0		
6	NOB	47	47	47	47	47	47	47	47	47	48				
	TOT	10.03	10.00	9.96	9.88	9.81	9.71	9.65	9.64	9.63	9.66				
	EWB	2	2	2	2	2	2	2	2	2	2				

TABLE 1 CONTINUED

7	NOB	48	47	48	48	48	48	48	48	48	48				
	TOT	10.13	9.89	10.02	10.02	10.03	10.00	10.01	9.99	10.01	10.01				
	EWB	1	1	0	1	1	1	1	1	1	0				
8	NOB	48	48	48	48	47									
	TOT	9.71	9.75	9.81	9.71	9.54									
	EWB	0	1	1	1	0									
9	NOB	46	46	46	46	46	46	46	46	46	46	46	46	46	46
	TOT	10.28	10.24	10.22	10.21	10.19	10.17	10.21	10.14	10.17	10.09	10.15	10.12	10.31	10.29
	EWB	2	2	2	2	2	2	2	2	2	2	2	2	2	1
10	NOB	49	48	49	49	49	48	49	50	49	49	49	49		
	TOT	10.41	10.43	10.45	10.45	10.54	10.32	10.48	10.58	10.46	10.29	10.53	10.49		
	EWB	2	2	2	2	2	2	2	2	2	2	2	2		
11	NOB	45	46	46	46	46	46	45	45	45	44	44	45	44	
	TOT	9.86	10.22	10.20	10.23	10.20	10.20	10.01	10.02	10.01	9.89	9.96	10.16	10.07	
	EWB	2	2	2	2	1	2	1	1	0	1	0	1	1	
12	NOB	46	48	49	47										
	TOT	9.83	10.06	10.62	10.40										
	EWB	0	0	0	0	0	0	0							

[1] NOB = number of wingbeats per drum, TOT = total length of each drum, EWB = number of early wingbeats in each drum.
[2] For some birds the oscillograms were blurred, thus preventing complete data for each drum. For example, we could count beats for only three drums of bird 3, but measured total length in seven drums, and early wingbeats for nine drums.

TABLE 2

CHARACTERISTICS OF DRUMS FROM ADJACENT RUFFED GROUSE[1]

Bird	Wingbeats[2]	Length[3]
9	46 ± 0.00 (14)[4]	10.08 ± 0.04 (14)[4]
11	———	10.38 ± 0.14 (16)
13	48.5 ± 1.66 (4)	10.19 ± 0.31 (4)
4	46 (1)	9.95 ± 0.01 (3)
5	45.57 ± 0.39 (7)	9.37 ± 0.01 (10)
6	47.10 ± 0.10 (10)	9.80 ± 0.05 (10)
7	47.90 ± 0.10 (10)	10.01 ± 0.02 (10)
12	45.15 ± 0.36 (13)	10.08 ± 0.14 (13)
1	43.78 ± 0.09 (9)	9.53 ± 0.05 (9)
2	45.67 ± 0.15 (3)	9.86 ± 0.15 (3)
3	48.67 ± 0.12 (3)	10.33 ± 0.01 (7)
8	47.80 ± 0.07 (5)	9.72 ± 0.05 (5)
10	48.92 ± 0.29 (12)	10.46 ± 0.03 (12)

[1] Adjacent birds (on adjacent logs) within hearing distance are grouped. These are birds 9, 11, and 13; birds 4 and 5; and birds 6, 7, 12. Birds 1, 2, 3, 8, and 10 were from various areas and were not within hearing distance.
[2] Mean (± 1 SE) number of wingbeats per drum.
[3] Mean duration in seconds (± 1 SE).
[4] The sample size is given in parentheses.

Of 11 of our birds 4 used the same number of wingbeats in each drum with a range for all birds of 42 to 50 (Table 1). The average number of wingbeats per drum for most birds was between 45.5 and 49.0 (Table 2).

Two unmarked birds (7 and 12) in 1971 were recorded on successive days. A comparison of the number of wingbeats on these 2 days showed no significant difference ($P > 0.05$). Also the one marked bird was recorded on 11, 13, and 18 May in 1972 (Table 3). A comparison of the mean number of wingbeats showed no significant difference ($P > 0.05$). Thus the number of beats did not change significantly over a period of a few days for three birds. Even so, overlap would prevent definite identification of all individuals in one area (see birds 4 and 5 or 6 and 7, Tables 1 and 2).

Length of drum.—A second variable is the length of the drum, which ranged for all birds from 9.06 to 10.62 seconds (Table 1). A comparison of the mean lengths of drums for birds 7 and 12 for 2 successive days on

TABLE 3

CHARACTERISTICS FOR DRUMS OF ONE GROUSE RECORDED ON 3 DIFFERENT DAYS IN 1972[1]

Date	Wingbeats[2]	Length[3]	N
11 May	44.29 ± 0.64	9.60 ± 0.04	21
13 May	44.32 ± 0.18	9.66 ± 0.01	19
18 May	44.82 ± 0.13	9.63 ± 0.02	11

[1] N is the number of drums per day.
[2] Mean (± 1 SE) number of wingbeats per drum per day.
[3] Mean duration in seconds (± 1 SE).

which they were recorded showed no significant difference for one (bird 12, $P > 0.05$) and a significant difference for another (bird 7, $P < 0.05$). A comparison of the mean lengths of one marked bird recorded on 11, 13, 18 May 1972 showed a significant difference (11–13 May, $P < 0.05$) (Table 3). Thus the lengths of drums may vary from one day to the next.

Statistical analyses.—As the data on wingbeats per drum and lengths of drum did not reveal any clearcut methods for identifying birds, we ran statistical analyses on 115 drums of 13 birds. The 19 variables analyzed were: the total number of beats for each drum, the total length of each drum in seconds, and the intervals in seconds of wingbeats 1 through 17 for all drums.

A multivariate analysis of variance on these 19 variables showed highly significant differences between birds: the Hotelling-Lawley's trace, the Pillai's trace, the Wilks' criterion and Roy's Maximum Root criterion all showed $P < 0.0001$. Univariate analyses of variance for each of these 19 variables also showed highly significant differences between birds ($P < 0.0001$). Thus when considering these 19 variables as a group, differences among birds are discernible, but this does not imply that birds can be distinguished individually.

The next analysis centered on the comparison of correlations of beat intervals from drums of the same bird versus correlations from drums of different birds with higher correlations expected from the drums of the same bird. For this analysis only three drums from each bird were considered, but as almost all of the correlations were very high there was no clue as to which drums belong to the same bird.

A matrix of geometric distances for all of the 115 drums was computed in regard to the 19 variables mentioned above. We expected drums from the same bird to show smaller distances than drums from different birds. Again this was not true.

Finally a sequential cluster analysis technique was run on the 115 drums of the 13 birds. This technique employs a Chi-square statistic which is the same as that used for tests about mean vectors from multivariate normal distributions with a known variance-covariance matrix (Morrison 1967: 129). Basically the technique is as follows: (1) The drum farthest from all others (on the basis of the above statistic) was selected first. The same statistic was then used in a stepwise fashion to order the remaining drums in a sequence such that those drums with small distances were placed together or fairly close in the sequence. This sequence was then split in two at the point of maximum distance between the two arms of the sequence. (2) The entire procedure described in the previous step was repeated for each arm or subgroup of drums in a sequential fashion, until the maximum distance observed in any given arm or subgroup fell

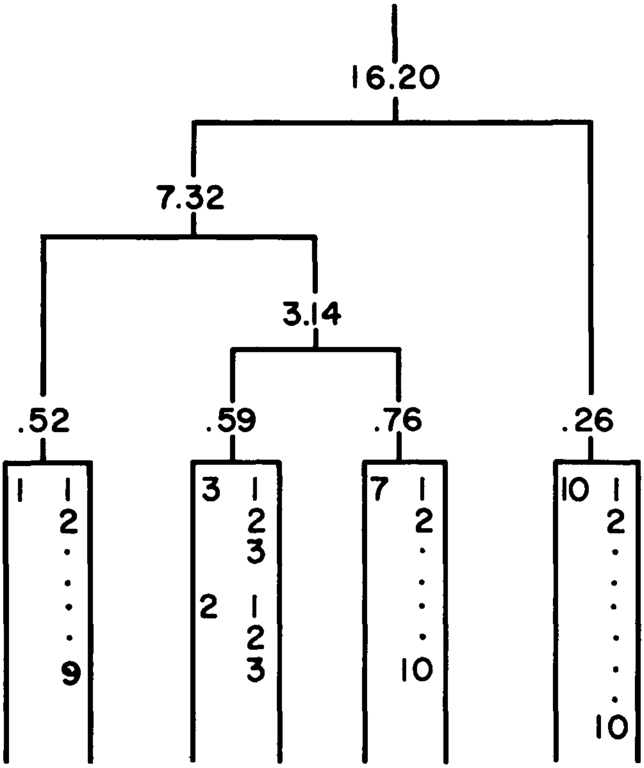

Figure 3. A dendrogram with the stepwise separation of 35 drums for five birds.

beyond a given point. This sequential cluster analysis technique applied to the 115 drums of the 13 birds yielded 12 clusters.

Two similar analyses were run, one on all drums of five birds, and the other on all drums of seven birds. In the former only four clusters were obtained. Birds 2 and 3 were not separable at the cutoff point level used (Figure 3). In the latter 8 clusters of 57 drums were obtained.

The function of the drum.—Aubin (1970) considered various aspects of the basic question, what is the function of the drum? Allen (1934) first suggested that the drum was an "announcement to females, and a challenge to males," and Gullion (1967) has since agreed with this interpretation. Aubin, after watching several males from blinds, gave support to the theory that drumming was a threat signal. As further evidence, Aubin removed a drumming male from his log. He then played artificial drums from that log for 8 days. The nearest neighbor was captured twice at the log, once before and once after the drums were played.

Aubin concluded that this neighboring bird moved into the area only when no drums could be heard, thus suggesting a threat function for the drum.

If an individual bird could recognize drums of other birds, we might expect adjacent birds to have different drums, but this is not always true (Table 2). Adjacent birds 9 and 13, 4 and 5, and 6 and 7 did not have a significantly different ($P > 0.05$) number of wingbeats per drum, while birds 7 and 12 did ($P < 0.05$). Adjacent birds 4 and 5, 9 and 13, and 7 and 12 did not have a significantly different ($P > 0.05$) length of drums (Table 2). Gullion (1967) found that perennially used logs had the highest rate of turnover and that older males changed primary logs one or more times in their life. If birds could be readily identified by drums, it would facilitate study of these factors, but apparently unless one considers a complex computer analysis of many variables, the use of drums cannot be used to identify individual birds.

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Summary

Oscillograms of 115 drums from 13 Ruffed Grouse were analyzed from tapes recorded in April 1971 and 1972. As many as three barely audible, preliminary wingbeats were noted, but the occurrence of these varied for bird from day to day. Four of 11 birds used the same number of wingbeats in each drum; the range of the number of beats per drum for all birds was 42–50. No significant difference in the number of wingbeats occurred for three birds from one day to the next.

The range of the length of drums for all birds was 9.06 to 10.62 seconds. Mean lengths were significantly different for three birds from one day to the next.

Multivariate and univariate statistical analyses of 19 variables (total length, wingbeats, and time interval of beats 1 through 17) showed that drums of birds could be clustered, but no practical and rapid methods for individual identification were found useful for the field biologist because of the variation and overlap within birds.

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