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A method for rapid identification of the murres *(Uria lomvia* and *Uria aalge)* based on tibiotarsus and phalanges

F.G. Cooch[1] and B. Collins[1]

Abstract
A procedure has been developed using measurements of the tibiotarsus and phalanges to distinguish between Thick-billed Murres *(Uria lomvia)* and Common Murres *(Uria aalge)* taken by subsistence hunting in coastal waters off Newfoundland-Labrador. Both discriminant function and manual techniques were tested. The results produced by the former technique led to misidentification of 6.9% of *U. aalge* and 6.7% of *U. lomvia,* while the latter yielded misidentification of 6.9 and 11.7% respectively. This procedure is preliminary and requires field testing with an independent sample.

Introduction

Each year an estimated 4 million Thick-billed Murres *(Uria lomvia),* from the Canadian eastern Arctic and western Greenland, migrate south and winter in the waters around Newfoundland and southern Labrador (Gaston 1980). There they join an estimated 1.5 million Common Murres *(Uria aalge)* that breed in the region. During winter, the two species are partially synheimic in distribution with a broad zone of overlap off the northeast and southeast coasts of Newfoundland.

Large numbers of the birds are taken in nets during the summer peak of gill-net fishing in Newfoundland, especially Common Murres (Tull *et al.* 1972), or are killed by oil, or taken by subsistence and recreational hunters (Wendt and Cooch 1982). Both species are under increasing pressure from human exploitation, industrial activities such as fishing and hydrocarbon emissions, and perhaps a depleted food resource (Brown and Nettleship, in prep.). Thick-billed Murres in the Canadian arctic colonies have declined by 30-50% (Gaston and Nettleship 1981) while Common Murres have shown significant increases at breeding sites such as Cape St. Mary's and Witless Bay islands.

According to preliminary field checks of hunting zones and various oil spills in the wintering period, Thick-billed Murres appear to suffer most of the hunting pressure in West Greenland and Newfoundland, as well as oiling during autumn, winter, and spring. The major Common Murre wintering zones appear to be more southerly, perhaps largely confined to the Gulf Stream rather than to the Labrador Current. Because of these factors and increasing pressure on both species, it is important to measure the absolute and relative mortality being suffered by *U. lomvia* and *U. aalge* and to know their seasonal changes in distribution along the coast of Newfoundland. The use of recoveries of standard US Fish and Wildlife Service (USFWS) bands was insufficient for this purpose. Because many of the bands do not survive as long as the birds wearing them, relatively small numbers have been banded in recent years, and recovery and reporting rates are low.

A modified species composition survey (SCS), patterned after that used for ducks and geese, is probably the best way to collect material permitting specific identification on a regular and stratified basis. We considered requesting hunters to send in wings or mandibles for identification, but rejected the first of those proposals when we found that no distinction between the species could be made on the basis of wings. Furthermore, mandibles proved too difficult to remove cleanly from shot birds and, in their shipment by mail, it seemed likely that postal workers would object to blood oozing from the packed mandibles. The only other appendages readily available for easy removal and cheap transport were the tibiotarsus and foot. But, since the number of those parts submitted was likely to be very large, we needed to develop a method of species discrimination which was quick and involved a minimum of precise measurements.

Material and methods

We based this study initially on 98 specimens in the National Museum of Canada, plus 118 fresh feet from Digges Island, Northwest Territories and coastal Newfoundland. An additional 175 fresh specimens were used to test the methodology in preliminary stages of the investigation. We restricted the use of museum study skins to standard measurement of the tibiotarsus. The bones in the phalanges were measured individually, but the procedure was too time-consuming and subject to considerable error. Thus tibiotarsi and phalanges were measured only on fresh specimens. For these measurements, we abandoned such devices as dial vernier calipers and dividers in favour of a 20-cm standard flanged ruler used by bird-banders to record wing lengths.

We made the following measurements (to the nearest millimetre):

(1) the total length to the distal tip of the nail, with the posterior edge of the cnemial process abutted against the flange, and the tarsus and mid toe pressed flat;
(2) the mid, outer, and inner toes from the proximal point of articulation to the distal tip of the nail;
(3) the tarsus from the sinovial fold to the front of the tibiotarsus.

In all cases the species involved were known, and 1st-year birds were distinguished from older one. Sexes were frequently unknown.

Frequency distribution ranges, means, and standard deviations are given in Figures 1 to 6.

[1]CWS, Ottawa, Ontario K1A 0E7.

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Table 1
Observed means, variances, and correlations separated by species

Species	Variable	Mean	Variance	Correlation			
				Mid toe	Inner toe	Outer toe	Total
U. lomvia	Tarsus	36.16	1.747	0.213	0.423	0.406	0.327
	Mid toe	59.02	3.000	—	0.784	0.255	0.762
	Inner toe	55.31	3.446	—	—	0.321	0.629
	Outer toe	43.57	2.986	—	—	—	0.231
	Total	95.09	6.782	—	—	—	—
U. aalge	Tarsus	38.38	1.766	0.205	0.155	0.351	0.515
	Mid toe	62.85	4.333	—	0.707	0.553	0.608
	Inner toe	58.63	4.783	—	—	0.539	0.559
	Outer toe	46.03	2.134	—	—	—	0.539
	Total	100.60	5.905	—	—	—	—

Results

We made the above measurements in the following sequence: (1) total length, (2) mid toe, (3) outer toe, (4) inner toe, and (5) tarsus; and undertook the subsequent analysis at three levels in order to discover the most efficient way to determine the species composition of the kill.

A discriminant function analysis was made to determine the statistical precision of the concept. This required the coding and punching of 500 measurements per 100 parts. We ran a standard discrimination analysis on these data with the SAS program package DISCRIM routine (SAS Institute 1979), which set the prior estimates of population proportions equal to 0.5. We then made a test of the homogeneity of within-species covariance matrices, and found that the hypothesis of equal within-species covariance matrices was rejected ($P < 0.10$). Our examination of the observed variances and correlations (Table 1) revealed no simple pattern to describe the significance; e.g., variances were substantially higher for either *U. aalge* mid toe or *U. lomvia* outer toe. Due to the lack of homogeneity of the covariance matrices, we based the discriminant function on the separate covariance matrices.

It is difficult to present the function in a form easy to use in hand calculations, because the procedure requires the calculation of 2 quadratic forms from 5×5 matrices, a process involving 10 subtractions, 48 additions, and 60 multiplications. The procedure, however, correctly classified 54 of 58 *U. lomvia* and 56 of 60 *U. aalge*. Since we had set the prior estimates of population proportions as equal, the resulting error rates for misclassification (4/58 and 4/60) were very nearly equal.

Once the results of the discriminant analysis had indicated that a considerable degree of segregation was possible, we introduced a stepwise discrimination based largely on a synoptic key (Table 2).

In order to reduce the amount of labour in classifying tibiotarsi, we examined several procedures by taking measurements and attempting to classify the individual on the basis of single measurements, with additional measurements only in cases of doubt.

We determined the classification key subjectively through examination of histograms. Table 3 shows several alternative stepwise procedures that are differentiated by stopping after 1, 2, 3, 4, or 5 measurements. Total length alone led to correct classification of 56 of 58 *U. lomvia* and 49 of 60 *U. aalge*, i.e., with 13 misclassified observations in all. If the discrimination was stopped after 2, 3, or 4 measurements, 10 cases would continue to be misclassified. If the complete 5-step process was used, only 9 (7.6%) observations would be misclassified, compared with the 8 (6.8%) misclassifications for the simplest discrimination procedure. The number of measurements to be taken, however, is much smaller for the stepwise than for the classical discrimination (209 vs. 590). The procedure used was as follows:

(1) We measured total lengths as defined, and assigned those falling below 96 mm to *U. lomvia*, and those above 99 mm to *U. aalge*. This procedure immediately assigned

Table 2
Synoptic key showing range of measurements used in analysis of material from *U. lomvia* and *U. aalge*

	U. lomvia (mm)	*U. aalge* (mm)
Total length	<95	>99
Mid toe	58	62
Outer toe	43	46
Inner toe	54	59
Tarsus	37	38

Table 3
Results of stepwise discrimination procedures

Proc.	Step	Meas't. taken	No. of Meas'ts.	Classification key: *U. lomvia* (mm)	Classification key: *U. aalge* (mm)	*U. lomvia* classification: *U. lomvia*	*U. lomvia* classification: Uncl.	*U. lomvia* classification: *U. aalge*	*U. lomvia* classification: Total	*U. aalge* classification: *U. lomvia*	*U. aalge* classification: Uncl.	*U. aalge* classification: *U. aalge*	*U. aalge* classification: Total	No. correct	No. uncl.	No. incorr.
1	1	Tot. lgth.	118	98	99	56	0	2	58	11	0	49	60	95	0	13
2	1	Tot. lgth.	118	95	99	30	26	2	58	1	10	49	60	79	36	3
	2	Mid toe	36	61	62	25	0	1	26	6	0	4	10	20	0	7
	Total		154	—	—	55	0	3	58	7	0	53	60	108	0	10
3	1	Tot. lgth.	118	95	99	30	26	2	58	1	10	49	60	79	36	3
	2	Mid toe	36	58	62	3	22	1	26	1	5	4	10	7	27	2
	3	Outer toe	27	45	46	21	0	1	22	4	0	1	5	22	0	5
	Total		181	—	—	54	0	4	58	6	0	54	60	108	0	10
4	1	Tot. lgth.	118	95	99	30	26	2	58	1	10	49	60	79	36	3
	2	Mid toe	36	58	62	3	22	1	26	1	5	4	10	7	27	2
	3	Outer toe	27	43	46	9	12	1	22	0	4	1	5	10	16	1
	4	Inner toe	16	58	59	11	0	1	12	3	0	1	4	12	0	4
	Total		197	—	—	53	0	5	58	5	0	55	60	108	0	10
5	1	Tot. lgth.	118	95	99	30	26	2	58	1	10	49	60	79	36	3
	2	Mid toe	36	58	62	3	22	1	26	1	5	4	10	7	27	2
	3	Outer toe	27	43	46	9	12	1	22	0	4	1	5	10	16	1
	4	Inner toe	16	54	59	2	9	1	12	0	3	1	4	3	12	1
	5	Tarsus	12	37	38	8	0	1	9	1	0	2	3	10	0	2
	Total		209	—	—	52	0	6	58	3	0	57	60	109	0	9

68% of the specimens, with an error in identification of 1.5%, and left 30.5% unclassified.
(2) We then used the 30.5% of material falling between 95 and 100 mm for each of the subsequent measurements, and for each step applied the distribution ranges given in Table 3.

In the classical discrimination procedure, one uses prior estimates of the relative population sizes as an aid to classifying the individuals, and this approach is reflected in procedures attempting to force the misclassification rates for the populations to be approximately inversely proportional to their relative sizes. In the present problem, however, the objective is to estimate the relative numbers of *U. lomvia* and *U. aalge* in the population, and the classical procedure can be reversed so that known error rates are used to improve estimates of population totals, as follows.

Let N_i denote the harvest count for species i ($i=1$ *U. lomvia*, $i=2$ *U. aalge*) with $N_1 + N_2 = N$. Assume that a simple random sample of n birds is selected, of which n_i are species i. Let p_{ij} denote the probability of classifying a bird of species i as species j, and let $\hat{n}_i$ denote the number of birds in the sample classified as species i. The expected value of $\hat{n}_i$ given n_1 observations taken from population 1 is:

$$E(\hat{n}_1/n) = n_1p_{11} + n_2p_{21}$$

and that unconditionally

$$E\left(\frac{\hat{n}_1}{n}\right) = \frac{N_1P_{11} + N_2P_{21}}{N}$$

$$= \frac{N_1P_{11} + (N-N_1)P_{21}}{N}$$

$$= \frac{N_1}{N}(P_{11} - P_{21}) + P_{21}$$

which is a biased estimator of the true population proportion unless $N_2P_{21} = N_1P_{12}$. An unbiased estimator of N_1/N is given by:

$$\left(\frac{\hat{n}_1}{n}\right) - P_{21} \;/\; (P_{11} - P_{21})$$

The two main problems with using this adjusted estimator are that: (1) the misclassification rates must be known accurately, and (2) there is a possibility that estimated proportions may be less than 0 or greater than 1.

Neither procedure permits the identification of males and females within a species. A further complication is the continuing growth of immature birds through at least the first winter. Some immature birds fall well below the lowest recorded values for adult *U. lomvia* and can be assigned without further processing; many immature *U. aalge* fall into the higher ranges of measurements of adult *U. lomvia*. Fortunately, until January, tarsi and feet of juveniles can be distinguished from those of adults of either species by a different feel and the less well defined scutellation on the tarsus. Working with material from birds that had previously been aged in the field by the flexibility of their mandibles, Cooch was able to assign 64 of 65 specimens to the correct age category. The bird which was misidentified as *U. lomvia* was actually an immature *U. aalge* taken in late February.

The degrees of overlap between adults of the two species, sexes combined, for each measurement are given in Figures 1-5, and the discriminant function analysis in Table 2.

At this stage of development, the technique still leads to misidentification of the species in 4 of 58 cases for *U. lomvia* and 4 of 60 cases for *U. aalge*. This is caused in part by a fact first noted by Storer (1952), who observed that females, while having a smaller mean tarsus than males in both *U. lomvia* and *U. aalge*, have a wider range of measurements than males. The same phenomenon was demonstrated in the present study with its larger samples.

Newfoundlanders, while shooting primarily murres, also take by accident other alcids such as Dovekies *(Plautus alle)*, Razorbills *(Alca torda)*, and Puffins *(Fratercula arctica)*. We compared the tarsal measurements of those species along with those of *U. lomvia* and *U. aalge* (this study). Because fresh material was not available, we could not measure total lengths and individual phalanges. It is clear, however, that on the basis of tarsus alone, no confusion between the two species of murres would be introduced by the accidental inclusion of material from other alcids.

Conclusion

The proposed operational technique permits species designation of 97% adult *U. aalge* and *U. lomvia*, but does not provide an accurate assessment of the sex or age ratios in the kill. In addition to the standard measurement of the tarsus, one can do all four additional primary measurements at the rate of more than two specimens per minute. Since not all measurements need be made, 200 identifications an hour are possible once the primary sorting by age and the exclusion of aberrant species have been completed.

We found that material received in Ottawa 5 days after shipping was still sufficiently pliable without further relaxing. Shrinkage of specimens left in a "ziplock" bag was less than 0.5 mm and was not a significant error factor. We hope that in 1983-84 assemblages of material from Newfoundland-Labrador can be collected at monthly intervals at varied locations from 1 September to 31 March. If this is accomplished, it should be possible to apportion the kill between species and gain further insight on geographic and temporal differences in the kill. Although *U. aalge* may constitute about 30% of the murres found at some time of the year in coastal waters, the numbers taken apparently vary throughout the season, and in our samples appear consistently in the 10-20% range. This technique may well help resolve important questions as to the distribution and kill of the two murre species in the northwest Atlantic.

It would be useful to apply the procedure to a new set of data to verify the expected performance and obtain the rates of error in a more realistic setting. The misclassification rates presented here are perhaps too low, since we used the same set of data to generate and to evaluate the procedure.

The discrimination procedure may require modification after we have studied the results of a trial run, at which time we hope that estimates of the harvest population sizes N_1 and N_2 will be available. Using the estimates $\hat{N}_1$ and $\hat{N}_2$ from the first season, we can modify the discrimination procedure so that the condition $\hat{N}_2P_{21}$ is satisfied, thereby reducing the bias in the estimator n_1/n.

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Figure 1
Interspecific variation in measurements used in this study. Ranges are indicated by single lines, means by vertical lines, standard error by inner box, and standard deviation by large box

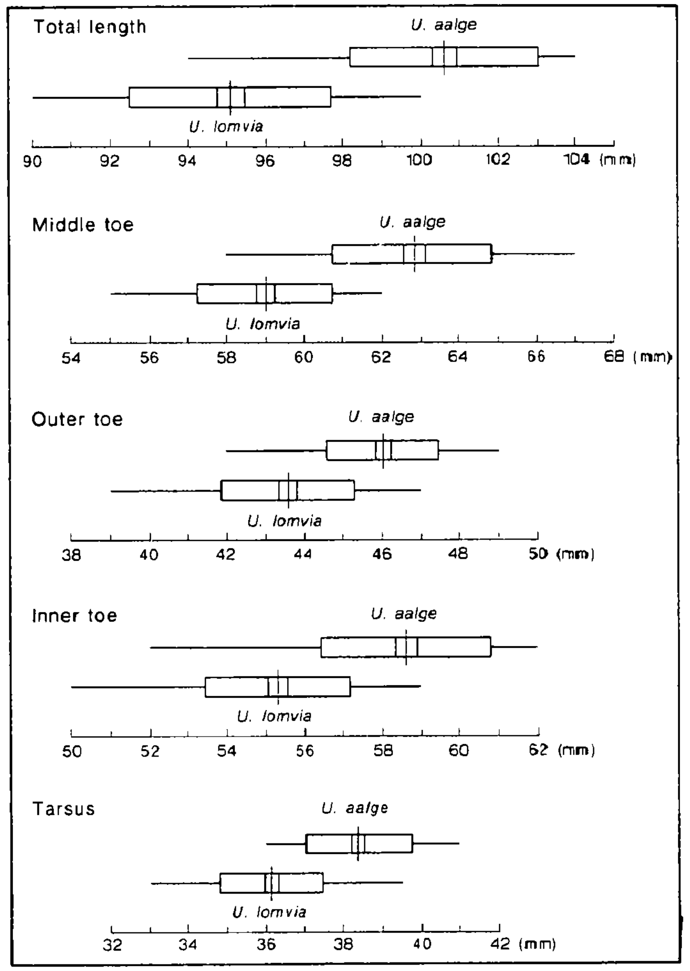

Figure 2
Frequency distribution (mm) of total length of tarsus plus mid toe

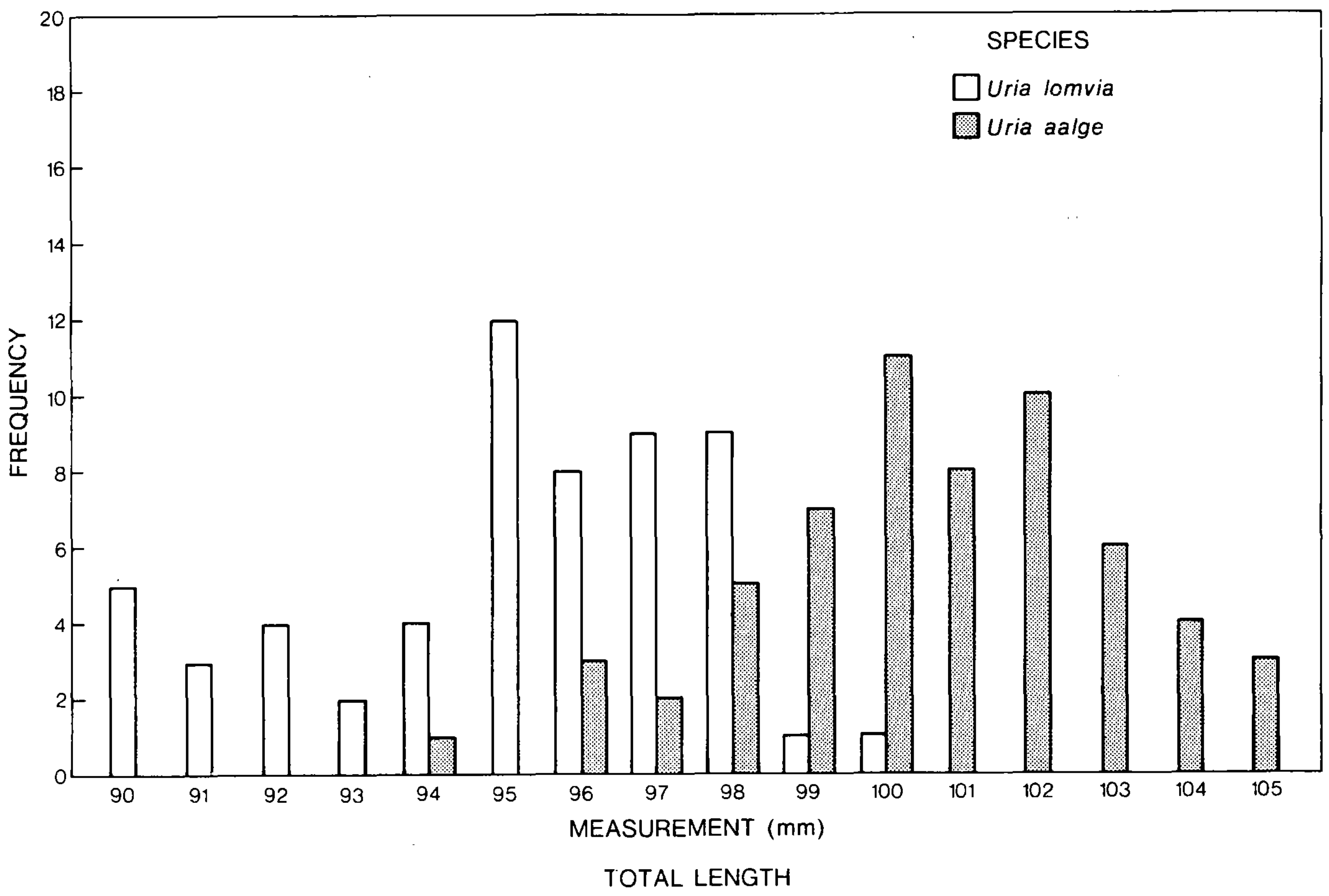

Figure 3
Frequency distribution of length of middle toe

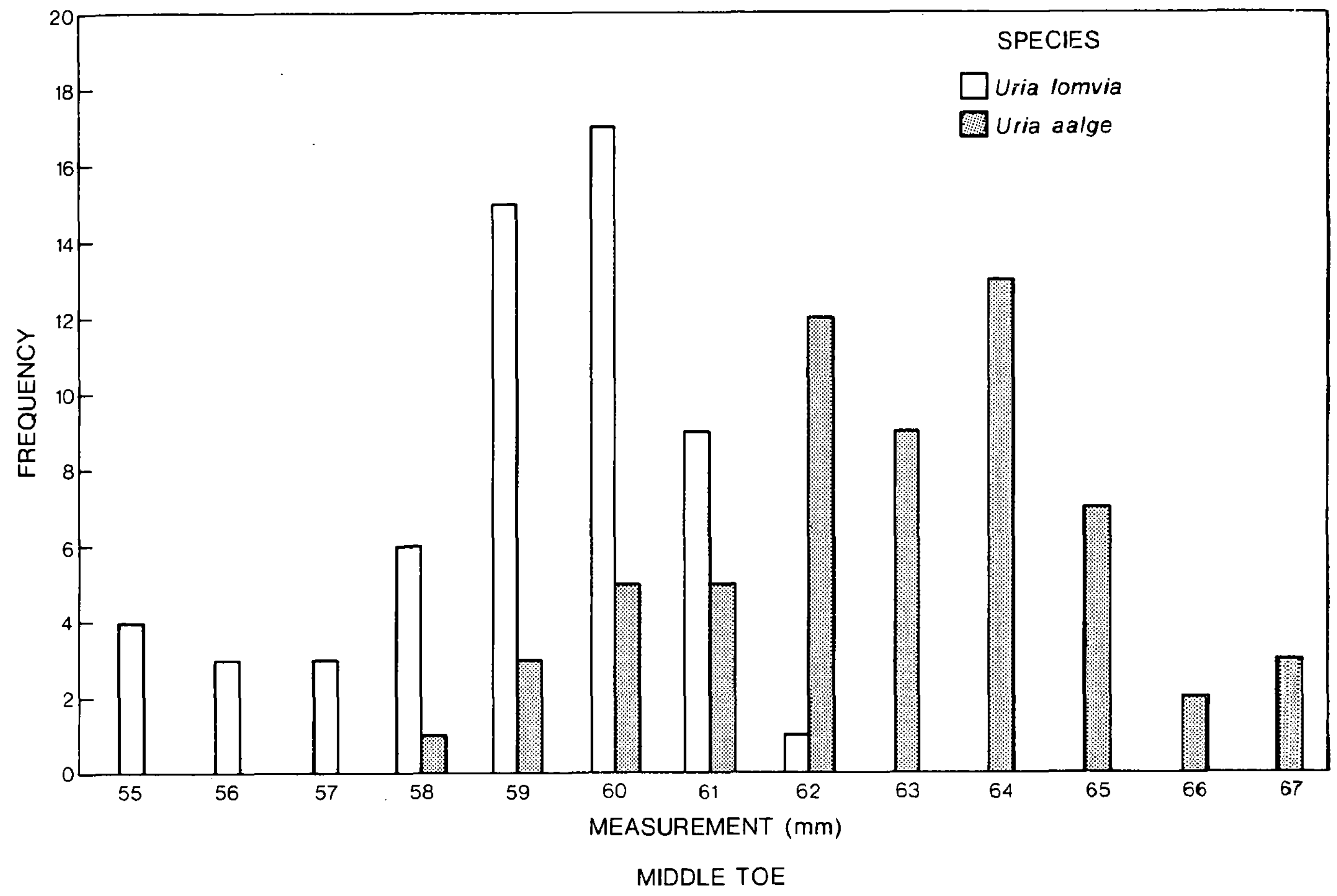

Figure 4
Frequency distribution of length of outer toe

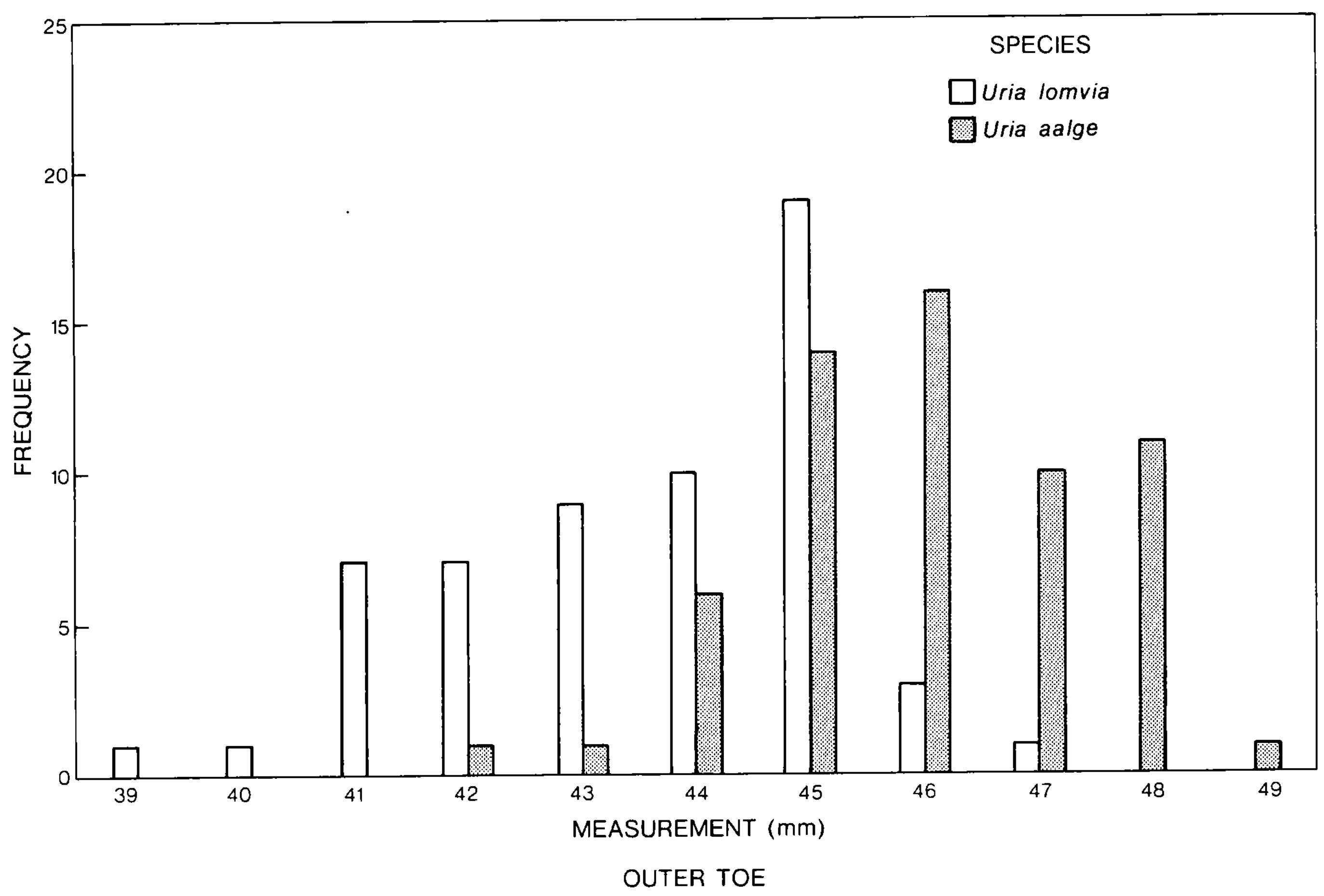

Figure 5
Frequency distribution of length of inner toe

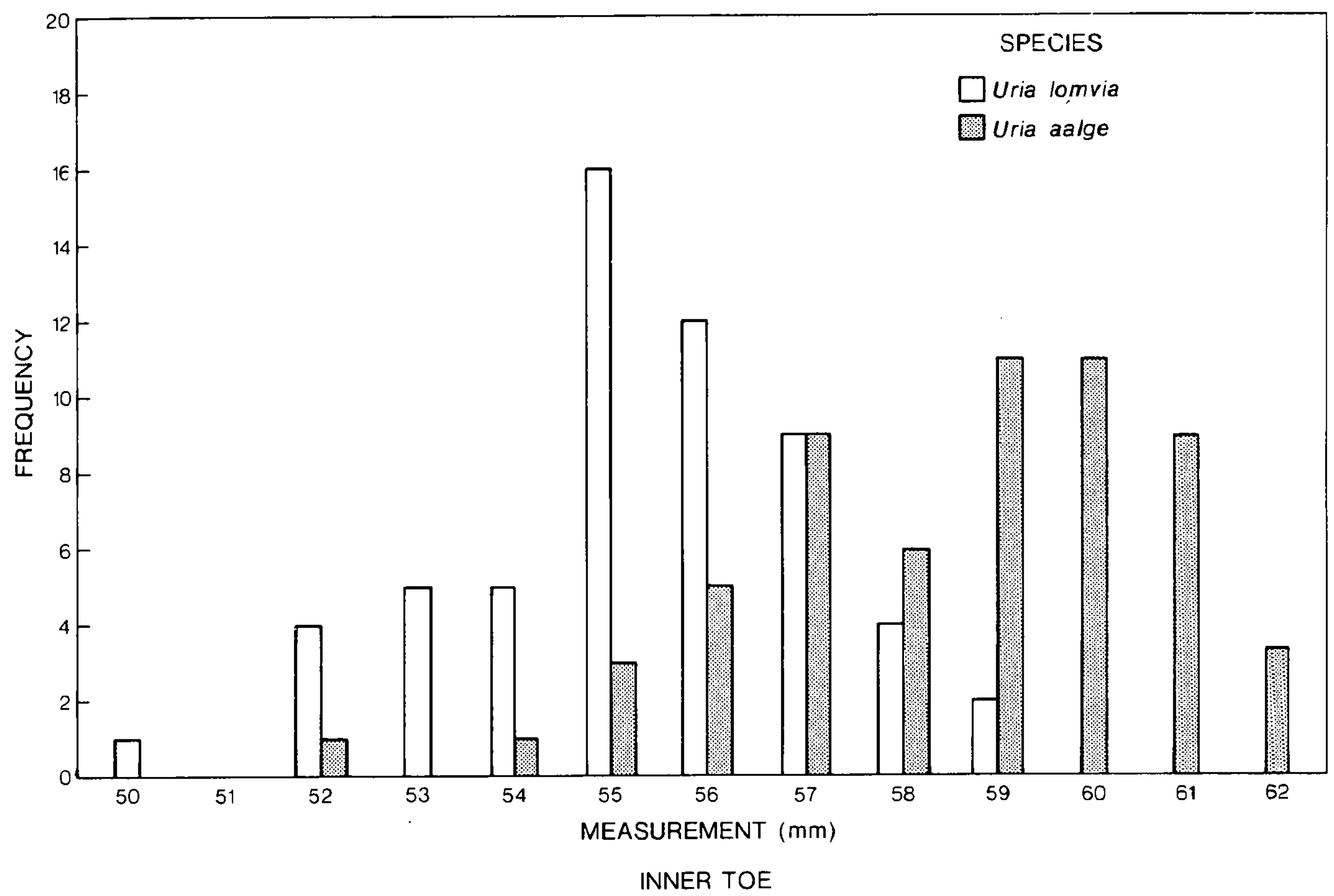

Figure 6
Frequency distribution of length of tarsus