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Sexual differences in bill shape and external measurements of Crested Auklets.—Most alcids are sexually monomorphic in plumage, ornaments, and body size and consequently cannot easily be sexed in the field (Bédard 1985). In a few species, external measurements can provide clues about the sex of a bird in the hand. For example, sex can be determined with 95% certainty from bill depth for 94% of individual Cassin's Auklets (*Ptychoramphus aleuticus,* Nelson 1981), for 70% of individual Ancient Murrelets (*Synthliboramphus antiquus,* Gaston 1992), and from an index combining bill depth and culmen length for 65% of individual Atlantic Puffins (*Fratercula arctica,* Corkhill 1972). Discriminant function analyses utilizing additional characters have not proved to be any better at identifying males and females (Nelson 1981, Gaston 1992). The only method for determining the sex of individual alcids by observation alone has been by their position during mounting or by observing marked individuals performing sex-limited displays (Jones 1992, Jones et al. 1989).

Bédard and Sealy (1984) reported sexual differences in external measurements of Crested Auklets (*Aethia cristatella*), but a sexing technique based on external appearance has not been published for any member of the genus *Aethia.* Nevertheless, observation of color-banded Crested Auklets at nesting colonies has led several researchers to tentatively identify the sex of some individuals by behavior. For example, individuals exhibiting an advertising display in which all feathers on the nape and hindneck are erected and the head is brought into a vertical position during a trumpeting vocal display have been assumed to be males (Flint and Golovkin 1990, Kharitonov 1980, Zubakin 1990, I. L. Jones, pers. obs.). These putative males are aggressive and attack other displaying individuals and other male-like birds that approach them. In contrast, female-like individuals do not exhibit the trumpeting display, are attracted to male-like individuals, are socially subordinate to these putative males, and rarely engage in aggressive behavior. Furthermore, courting pairs show stereotyped behavior in which the putative female adopts a crouched posture and nibbles at the bill of the putative male. These supposed males and females differ in bill-shape, as do specimens of known sex that have been examined (R. H. Day, pers. comm.; N. B. Kon-

yukhov, pers. comm.; I. L. Jones, pers. obs.). Putative males tend to have a bill that appears deeper than its length, their culmen is strongly de-curved, and the tip of the upper mandible overlaps the lower mandible to form a distinct hook; putative females tend to have bills that appear longer than their maximum depth, have an almost straight culmen, and lack the pronounced hook on the bill tip. In this paper I evaluate whether these bill shape differences are reliable characteristics for determining the sex individual Crested Auklets in the field.

Methods.—I collected 27 adult Crested Auklets and salvaged an additional nine fresh carcasses that had been predated by Glaucous-winged Gulls (*Larus glaucescens*) at a large auklet colony at Buldir Island, Aleutian Islands, Alaska (52°2'N, 175°5'E, Byrd and Day 1984) during May and June 1992. Before measurement, each specimen was held in a natural posture and the sex inferred using the bill shape characteristics described above. Then I measured bill depth, culmen length, rictal plate height, tarsus length, crest length, and plume length to the nearest 0.1 mm, using calipers, and flattened wing length to the nearest 1 mm, using a wing rule. Culmen was measured from the bill tip to the edge of the feathering at the bill base; bill depth from the proximal base of the culmen to the angle of the gonys on the underside of the bill; rictal plate from its mid-point along the cutting edge of the bill to its highest point; and tarsus from the mid-point of the tibiotarsal joint on the back of the leg to the blunt end of the tarsometatarsal joint on the underside of the foot. The length of the auricular plume on either side of the head was measured as the distance from the exposed distal end of the plumes (just below and behind the eye) to the proximal end of the longest plume. Crest length was measured as the length of the longest feather shaft in the crest. Each individual was then dissected to determine its sex (confirmed by an assistant). To test the reliability of the technique of determining sex by bill shape, I estimated the sex of 11 museum specimens from which sex was later determined from the specimen label. During observations at the colony, I used bill shape to guess the sex of color-marked auklets whose bill I was able to see clearly on 244 occasions over a ten-week period. This produced multiple (2–6) records of sex inferred by bill-shape for 47 individuals, from which the repeatability of this technique could be inferred. Multiple estimates of sex of these individuals based on bill depth were likely to be independent because of the large number (284) of color-marked birds present on the study plot, which precluded remembering the previously inferred sex of any individual.

Results and discussion.—Males and females differed significantly for four of the external measurements: bill depth, culmen length, mean plume length and wing length, with bill depth and culmen length showing the greatest sexual dimorphism (Table 1). These results differ from Crested Auklet measurements from St. Lawrence Island (Bédard and Sealy 1984) where crest length was found to differ significantly between the sexes (DI = 1.10), but bill-length (culmen length) did not (DI = 1.02). At Buldir, there was considerable overlap between males and females in both bill depth (11.1–11.9 mm) and culmen length (11.7–12.8 mm), so these univariate measures are not likely to be useful for sexing all captured individuals (Fig. 1). For example, among Crested Auklets caught, measured and released after banding at Buldir during 1990–1992, 104/504 (21%) lay in the overlap zone (within the range of both sexes) for bill depth and 181/296 (61%) lay in the overlap zone for culmen. Discriminant function analysis with all characters included was no more effective in sexing Crested Auklets than bill depth considered alone. Moreover, geographic variation in size among different colonies is significant, further reducing the usefulness of measurements.

Among the 15 male and 21 female Crested Auklets collected at Buldir, I used observed bill shape characteristics to attempt to estimate the sex of 33 specimens; the remaining three specimens (8%) were judged to be unsexable because their bill shape was of intermediate appearance. Among the specimens sexed by bill shape, the correct sex (confirmed by dissection) was inferred in all except one individual (32/33 sexed correctly). An additional ten

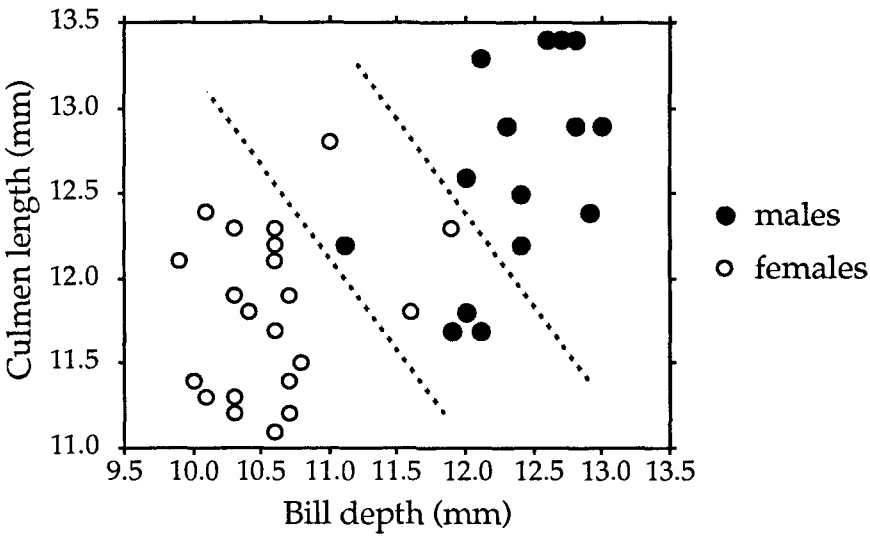

FIG. 1. Bill depth and culmen length of 36 specimens from Buldir. About 20% of individuals lie in a zone of overlap between the sexes (between dashed lines fitted by eye; individuals lying in this area could be of either sex). Sex was inferred correctly from bill shape before dissection for all but one individual (indicated by an arrow).

TABLE 1

MEASUREMENTS OF ADULT MALE AND FEMALE CRESTED AUKLETS FROM BULDIR ISLAND

Character	Males N	Males Mean ± SE (Range)	Females N	Females Mean ± SE (Range)	DI[a]	t[b]	P
Bill depth (mm)	15	12.3 ± 0.1 (11.1–13)	19	10.6 ± 0.1 (9.9–11.9)	1.16	10.7	<0.0001
Culmen (mm)	15	12.6 ± 0.2 (11.7–13.4)	19	11.8 ± 0.1 (11.1–12.8)	1.07	4.4	<0.0001
Rictal plate (mm)	15	5.0 ± 0.3 (3.3–6.6)	18	4.9 ± 0.2 (3.9–6.4)	1.02	0.4	0.7
Tarsus (mm)	14	29.3 ± 0.3 (28–31.9)	19	28.9 ± 0.3 (26.4–30.8)	1.01	1.3	0.2
Crest length (mm)	15	38.2 ± 0.8 (34.5–45.3)	19	37.9 ± 1.2 (28.4–44.4)	1.01	0.2	0.9
Plume length (mm)	10	35.5 ± 0.7 (29.9–38.2)	18	31.8 ± 0.9 (24.6–39.5)	1.12	2.9	0.007
Wing length (mm)	9	143.0 ± 0.8 (140–148)	15	140.3 ± 0.6 (136–143)	1.02	2.7	0.01

[a] Sexual dimorphism index, expressed as mean male size/mean female size.
[b] t-test of difference between male and female values.

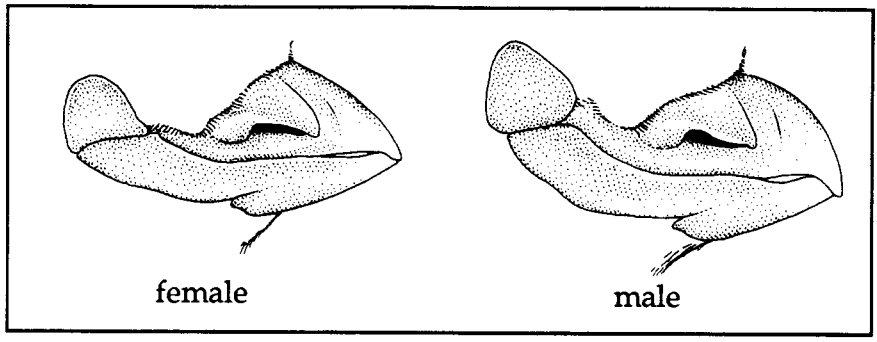

FIG. 2. Characteristic bill shapes of male and female crested auklets (drawn from photographs).

museum specimens (6 males and 4 females) were sexed correctly, while one museum specimen was judged to be intermediate in bill shape. Thus bill shape differed sufficiently between the sexes to infer a 'most likely sex' for 91% (43/47) of individuals, and these estimations proved correct for 98% (42/43) of the individuals that were sexed using the method. The bill shape characteristics were readily apparent in birds observed with binoculars at a distance of 10–15 m at the colony. Of 47 color-marked individuals whose sex was estimated more than once during observations at the study plot at Buldir, sex determinations based on bill shape were consistent for all but one individual (98%), indicating that this technique is repeatable. All sub-adults (two-year-olds, identified by their extensively worn remiges) observed or captured at Buldir had female-like bills, indicating that bill shape is not useful for determining the sex of young birds, as in Cassin's Auklets (Nelson 1981). However, these results confirm that readily observable bill shape characteristics can be used to identify the sex of adult Crested Auklets with a high degree of reliability. The typical bill shapes of males and females (Fig. 2) can, with practice, be used to identify about 90% of adults seen well in the field. Based on examination of museum specimens from other areas, and of live birds in the Pribilof Islands (I. L. Jones, pers. obs.), sexual differences in bill shape appear to be present throughout the species' range.

Crested Auklets may thus be the only alcid species in which males and females can easily be distinguished in the field by observation of external morphology. This may prove valuable for understanding sexual differences in behavior of this unusual species. For example, 11 marked individuals that were seen performing the trumpeting display were independently judged to have a male bill shape, confirming earlier suggestions (Flint and Golovkin 1990, Kharitonov 1980, Zubakin 1990) that this display is restricted to males. It is likely that the hooked bill shape of male Crested Auklets is favored by intra-sexual selection because of its use in fights between males for access to mates and nest-sites.

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American Redstarts using Yellow Warblers' nests.—Among passerines, heterospecific nest use is common in cavity nesters, with overlap between species in the use of individual cavities dependent upon the degree of nest site limitation and preferred cavity characteristics (e.g., Kerpez and Smith 1990). Among open-cup nesters, however, the use of nests built by other species is rare (see Skutch 1976:127). This may be due to the availability of sites suitable for building relative to suitable nesting cavities, the relatively lower costs of building a cup nest compared to excavating a cavity, more rapid loss of structural integrity of cup nests, and/or the species-specific nature of cup nests which are not easily modified. Extensive observations indicate open nesting passerines seldom use nests built by other individuals (Bent 1953). Here I report a notable exception: an American Redstart (*Setophaga ruticilla*) pair using a Yellow Warbler (*Dendroica petechia*) nest.

On 23 May 1992, I observed a female Yellow Warbler building a nest, which she completed on 25 May. The first of three eggs was laid on 27 May. When I checked the nest on 16 June and 18 June, both the male and female Yellow Warblers, as well as a male and female American Redstart alarm called and performed distraction displays, apparently in response to my presence. The three Yellow Warbler offspring fledged on 18 June. On 1 July, I found a female American Redstart incubating a complete clutch of three eggs in this same nest.