GEOGRAPHIC VARIATION IN THE PIGEON GUILLEMOTS OF NORTH AMERICA

By ROBERT W. STORER

A comparative study of the murres and guillemots now in progress by the writer has brought to light geographic trends in wing, tarsal, and culmen lengths in the populations of the Pigeon Guillemot (*Cepphus columba*) on the Pacific coast of North America. These trends are shown in table 1. Wing length decreases from California to Washington and British Columbia and increases from there to northern Alaska. Trends in tarsal length vary in the same directon but are not so marked. Culmen length varies clinally, decreasing from south to north. Thus, there is a long-winged, long-billed population inhabiting California, a short-winged, moderately long-billed population in Washington and British Columbia, and a long-winged, short-billed population in northern Alaska and eastern Siberia. At present all three are included within the form known as *Cepphus columba columba* Pallas.

Two other races of the Pigeon Guillemot are currently recognized, *Cepphus columba kaiurka* Portenko, the small, short-billed form of the Commander and outer Aleutian (Kiska and Atka) islands, and *Cepphus columba snowi* (Stejneger), of the Kurile Islands, a form in which the white in the speculum is reduced or absent.

The type locality of *Cepphus columba* is given by Pallas (Zoogr.-Rosso-Asiatica, II, 1811:348), as Kamtschatka and Bering Strait. The Pigeon Guillemots inhabiting both these areas belong to the long-winged, short-billed form which therefore must be called *Cepphus columba columba*. As there are no names available for the two forms to the south, I propose that they be named.

Cepphus columba adianta, new subspecies

Type.—No. 101,528, Mus. Vert. Zool., male in breeding plumage, collected by Allan Brooks, March 24, 1926, at Nanaimo, Vancouver Island, British Columbia.

Diagnosis.—Wing short, nearly as short as in *C. c. kaiurka;* bill moderately long, but shorter than in Californian birds. Wing length, 171 to 191 mm. (180.2 ± 0.4, $\sigma = 4.42$); tarsal length, 31.5 to 37.5 (34.57 ± 0.10, $\sigma = 1.08$); culmen length, 31.0 to 38.5 (34.61 ± 0.13, $\sigma = 1.44$). This short-winged form with a moderately long bill is best distinguished from the nominate race and from the Californian birds by a combination of wing and bill lengths, and from *kaiurka* of the outer Aleutian and Commander islands by its longer bill. No sexual differences in measurements have been found and accordingly data for the sexes are combined.

Range.—The coasts of Washington, British Columbia and southern Alaska, from the mouth of the Columbia River north to and including the Alaska Peninsula and the Aleutians at least as far west as Unmak Island.

The guillemots of southern Alaska and the eastermost Aleutians are included in this form although intermediate between it and the nominate race. The population of the central Aleutians is presumably intermediate between *adianta* and *kaiurka* but may further approach *columba*. At present too few specimens are available to clear up this point.

The differences in wing length and bill length in the various populations of the Pigeon Guillemot are suggested by the measurements of Ridgway (Birds N.M. Amer., pt. 8, 1919:741).

The name is derived from the Greek, *a,* the privative, plus *diantos* = capable of being wet and alludes to the dense, water-proof plumage of these birds.

Cepphus columba eureka, new subspecies

Type.—No. 31,462, Mus. Vert. Zool., male in breeding plumage, collected by W. H. Osgood, June 19, 1894, on the Farallon Islands.

Diagnosis.—Wing long as in *C. c. columba* from Siberia and the islands of Bering Sea. Bill longer than in any other race of *columba*. Wing length, 176 to 197 (187.5 ± 0.3, $\sigma = 4.04$); tarsal

length, 32.5 to 39.0 (36.13 ± 0.10, $\sigma = 1.27$); culmen length, 33.5 to 39.5 (36.57 ± 0.12, $\sigma = 1.40$). This form is best distinguished from *adianta* by a combination of bill and wing lengths and from *columba* by its much longer bill.

Range.—The coasts of California and Oregon from San Clemente Island north to the mouth of the Columbia River.

The Oregon population is intermediate between the Californian one and *adianta,* but perhaps is nearer the former. Until a larger series from Oregon and the west coast of Washington can be examined, it seems best to set the boundary between the two subspecies arbitrarily at the Columbia River. The few specimens from the coast of Washington, south of Cape Flattery, are closest to *adianta* and lend support to the adoption of this boundary.

That the Californian and Alaskan birds should belong to different subspecies was suggested by Grinnell (Univ. Calif. Publ. Zool., 5, 1910:367) who noted that Alaskan specimens were "decidedly blacker than specimens from the coast of California. There appear to be differences in proportions also; but the inadequacy of the available material does not warrant conclusions as to their constancy." I have been unable to verify Grinnell's statement regarding the greater intensity of the black of the Alaskan birds by examination of the series in the Museum of Vertebrate Zoology; but it is possible that this difference may be more evident in fresh material.

The name, *californica,* was not used for this form as it has already been applied to the California Murre with which the guillemots are still considered congeneric by a few people. I see no justification for this view; but in order to prevent possible nomenclatorial complications, I have used the name *eureka,* which is the motto of the state of California.

Table 1

Geographic Variation in *Cepphus columba*

	Wing length[1]				Tarsal length				Culmen length			
Population	No.	Mean ± σm	σ	V	No.	Mean ± σm	σ	V	No.	Mean ± σm	σ	V
California	172	187.5 ± 0.32	4.01	2.14	157	36.13 ± 0.10	1.27	3.52	161	36.53 ± 0.11	1.35	3.69
Oregon	18	187.2 ± 0.94	4.00	2.13	18	35.39 ± 0.29	1.25	3.53	18	35.19 ± 0.25	1.06	3.01
Washington and British Columbia	118	180.2 ± 0.41	4.42	2.45	118	34.57 ± 0.10	1.08	3.14	129	34.61 ± 0.13	1.44	4.15
Alaskan coast from Alaska Peninsula southward	93	183.2 ± 0.44	4.12	2.30	105	34.64 ± 0.13	1.28	3.69	102	33.97 ± 0.13	1.32	3.89
Islands of Bering Sea[2] and Siberia	46	186.3 ± 0.57	3.84	2.06	41	34.76 ± 0.18	1.17	3.35	41	32.35 ± 0.21	1.37	4.22
Outer Aleutian and Commander islands	19	177.2 ± 0.88	3.82	2.16	27	33.72 ± 0.23	1.19	3.53	25	31.20 ± 0.26	1.32	4.24

[1] Wing length was measured with the wing straightened along the measuring device. It is therefore several millimeters longer than the chord of the closed wing.

[2] St. Matthew, St. Lawrence, the Diomedes, Sledge and King islands.

Owing to the difficulty of assembling adequate series of birds as large as guillemots, it seems worth while to present the statistical data which have indicated to me the desirability of recognizing the various races of the Pigeon Guillemot discussed in this paper.

In forms which differ in one mensural character, the standard deviation (σ) of that character is usually the best means of estimating the number of individuals of one form which can be separated from those of other forms. Approximately two-thirds of a normal curve lie within one standard deviation to each side of the mean, and it follows that approximately five-sixths (83 per cent) will lie below the mean plus one standard deviation or above the mean minus one standard deviation. Thus if in two populations the difference between the means for a character is greater than the sum of the standard

deviations, more than 83 per cent of one population will be distinguishable from 83 per cent of the other on the basis of that character. This test has been applied to the subspecies *columba, kaiurka, adianta,* and *eureka* in table 2, from which it will be seen that more than 83 per cent of *kaiurka* are distinguishable from more than 83 per cent of *columba* on the basis of wing length, from more than 83 per cent of *adianta* on the basis of culmen length, and from more than 83 per cent of *eureka* on the basis of both characters. *Cepphus columba columba* is similarly distinct from *eureka* on the basis of culmen length. The differences between *adianta* and *columba* and *eureka* are not so great in either wing or culmen length.

Table 2

The Difference between Means and the Sum of the Standard Deviations for Wing Length and Culmen Length of Pairs of Races of *Cepphus columba* (calculated from the data in Table 1)

		Wing		Culmen	
		m_1-m_2	$\sigma_1+\sigma_2$	m_1-m_2	$\sigma_1+\sigma_2$
kaiurka	*eureka*	*10.3*	7.8	*5.33*	2.67
kaiurka	*columba*	*9.1*	7.7	1.15	2.69
kaiurka	*adianta*	3.0	8.2	*3.41*	2.76
columba	*eureka*	1.2	7.9	*4.18*	2.72
adianta	*eureka*	7.3	8.4	1.92	2.79
adianta	*columba*	6.1	8.3	2.26	2.81

One might then question the desirability of recognizing *adianta.* Were this form in the center of a cline in wing length as well as one in culmen length, I would not consider naming it. However, since it is shorter-winged than the two adjacent races, *columba* and *eureka,* there is a point in separating it if a sufficient proportion of its members is distinguishable. As *adianta* differs from both adjacent forms in two mensural characters, the lengths of the wing and culmen, discriminant functions can be used to combine the length of the wing (w) with that of the culmen (c) into one figure (x) which will maximize the differences between adjacent forms. The formula will be $x = aw + bc$ where a and b are the discriminant functions obtained as described by Mather (Statistical Analysis in Biology, 1947:152-159). These functions will be different for each pair of populations compared.

The results of these calculations for the values of x for comparing the specimens of *adianta* with those of *columba* and *eureka* are shown in table 3 from which it will be seen that the difference between the means is greater than the sum of the standard deviations in both instances.

Table 3

The Values of aw + bc for *C. c. adianta* as Compared with *C. c. eureka* and *C. c. columba*

	Number	Mean $\pm\sigma m$	σ
adianta versus *eureka* $a = 1.59, b = 3.54$			
adianta	100	407.8±0.9	9.1
eureka	179	427.4±0.7	8.7
adianta versus *columba* $a = 6.5, b = -8.5$			
adianta	100	882.0±3	28
columba	40	940.0±4	24

As a check, the wing and culmen lengths of the specimens of each race were compared with the mean and standard deviation of each other race. The results of these comparisons are shown in table 4 and will be found to agree with the estimates indicated by tables 2 and 3.

Table 4

The Percentage of Individuals of One Race Distinguishable from 83 Per Cent of Another Race

Per cent of	Distinguishable from 83 per cent of	Using individual characters				Characters combined using discriminant functions	
		Both wing and bill	Wing only	Bill only	Not distinguishable	on the basis of x	Not distinguishable
kaiurka (18)[1]	*eureka*	100.0	0.0	0.0	0.0	....	....
eureka (179)	*kaiurka*	92.7	0.0	7.3	0.0	....	....
kaiurka (18)	*columba*	33.3	61.1	0.0	5.6	....	....
columba (40)	*kaiurka*	42.5	45.0	2.5	10.0	....	....
kaiurka (20)	*adianta*	.....	....	100.0	0.0	....	....
adianta (100)	*kaiurka*	.....	....	90.0	10.0	....	....
columba (40)	*eureka*	.....	....	97.5	2.5	....	....
eureka (179)	*columba*	.....	....	99.4	0.6	....	....
adianta (100)	*eureka*	62.0	14.0	17.0	7.0	89.0	11.0
eureka (179)	*adianta*	50.8	26.3	14.5	8.4	88.8	11.2
adianta (100)	*columba*	46.3	21.5	19.0	13.2	88.0	12.0
columba (40)	*adianta*	50.0	27.5	22.5	0.0	85.0	15.0

[1] The numbers in parentheses are the numbers of specimens of each race used in the analysis.

Although the method of using standard deviation is useful in determining the distinctness of adjacent forms, I am opposed to the use of it or of any other arbitrary rule for determining the validity of subspecies. The line between what is to be or not to be recognized as a subspecies is an artificial one drawn for the convenience of systematists and as such, to be of most value, should be flexible enough to cover the variety of different situations which arise.

Discriminant functions have been used to advantage in a number of biological fields and should prove of considerable assistance in the taxonomy of birds. Their principal drawback is the length of the calculations involved. Their use in separating *C. c. adianta* from *C. c. columba* and from *C. c. eureka* is a good example of how they may be used in practice. I am indebted to Dr. R. R. Ronkin of the University of Delaware for pointing out the value of these functions and to him and to Dr. C. C. Craig of the University of Michigan for assistance in working out the formulas.

Museum of Vertebrate Zoology, Berkeley, California, and University of Michigan Museum of Zoology, Ann Arbor, Michigan, July 28, 1949.