AN ATTEMPT TO MEASURE STATISTICALLY THE DIFFERENCES BETWEEN EASTERN AND WESTERN SUBSPECIES OF THE SAME SPECIES.

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THE amateur bird student whose observations have been confined to a relatively small area, finds himself continually amazed by the apparent likenesses yet important differences in closely related birds, when he first invades an entirely new region. Such was the writer's experience when, after a lifetime spent in the southern New England states, circumstances permitted an extended stay in northern California. So deep an impression did these similarities and dissimilarities make, that after consultation with an ornithologist and a statistician, the writer decided to attempt the statistical measurement of these deviations.

The first problem which arose was that of limiting the study to the most nearly related birds. It was decided to include only subspecies whose eastern and western representatives bred in as nearly comparable regions as possible, thus eliminating to some extent the environmental factor. Since most of the New England states are included in that area enclosed by 40° North Latitude and from 67°–80° West Longitude, an approximately equal area was found in the Western states above 40° North Latitude and from 115°–124° West Longitude. The western region includes northern California, much of Oregon and Washington, and parts of Idaho, Montana, and Utah. A map of the Life Zones in the United States, which may be found in the American Ornithologists' Union 'Check-List' for 1931, shows that these two regions are made up chiefly of the Canadian and Transition Zones. The final decision was that the study would include only those species which had subspecies in each of the two regions, the presence of such subspecies being based on the fact of their breeding, at least partly, in these areas, using the A. O. U. List of 1931 as authority, and limiting the species to the order Passeriformes.

The final list of subspecies to be used, twenty pairs, was as follows:

Eastern	*Western*
Empidonax trailli trailli	Empidonax trailli brewsteri
Corvus b. brachrhynchos	C. b. hesperis
Penthestes a. atricapillus	P. a. occidentalis
Sitta c. carolinensis	S. c. aculeata
Certhia familiaris americana	C. f. occidentalis
Troglodytes a. aedon	T. a. parkmani
Nannus h. hiemalis	N. h. pacificus
Telmatodytes p. palustris	T. p. paludicola
Turdus m. migratorius	T. m. propinquus
Hylocichla guttata faxoni	H. g. nanus

Eastern	*Western*
Hylocichla f. fuscescens	H. f. salicola
Vireo s. solitarius	V. s. cassini
Vireo g. gilvus	V. g. swainsoni
Vermivora r. ruficapilla	V. r. ridgwayi
Agelaius p. phoeniceus	A. p. caurinus
Carpodacus p. purpureus	C. p. californicus
Spinus t. tristis	S. t. salicamans
Passerculus sandwichensis savanna	P. s. bryanti
Pooecetes g. gramineus	P. g. affinis
Spizella p. passerina	S. p. arizonae

The second major problem to be solved was that of finding characteristics to be compared which were capable of being worked on statistically. The writer would have liked to make comparisons of such traits as color, song, nesting habits, eggs, etc., but soon found that the data available were very meager, especially for the western subspecies. Therefore, the study resolved itself into an intensive comparison of the sizes of the subspecies. Here Ridgway's 'Birds of North and Middle America,' Volumes I to IV, were of great value, since they contain measurements of skins collected for both eastern and western subspecies. The measurements available were these: length of the dried skin, wing length, tail length, length of the exposed culmen, depth of the bill at the base, length of tarsus, length of the middle toe.

As no listing of the actual measures of the individual birds was given, but only the maximum, minimum, and average measures of each characteristic, a modified method for deriving the critical ratio was resorted to. An example of the procedure follows, taking *Vireo solitarius solitarius* and *V. s. cassini* (female) and the characteristic, "length from tip of bill to tip of tail";

10 specimens of V. s. s. measured from 118 to 131 mm. with the average at 123.6 mm.

$$\sigma_{m_1} = \frac{R}{6\sqrt{n}} = \frac{131-118}{6\sqrt{10}} = .685$$

9 specimens of V. s. c. measured from 117 to 127 mm. with the average at 121.7 mm.

$$\sigma_{m_2} = \frac{R}{6\sqrt{n}} = \frac{127-117}{6\sqrt{9}} = 555.$$

$$\sigma D_{m_{12}} = \sqrt{\sigma_1^2 + \sigma_2^2} = .882$$

$$D_{m_1-m_2} = 123.6 - 121.7 = 1.9$$

$$\frac{D}{\sigma D_{12}} = \frac{1.9}{.882} = +2.15 \text{ (critical ratio)}$$

For purposes of this study, it was decided to put the minimum critical ratio which would be accepted as significant, at 3. This would raise to a

high degree the chances that future measurements of these twenty pairs of subspecies would give similar differences in the characteristics measured. Thus we see that the + 2.15 critical ratio for females of *Vireo solitarius solitarius* and *Vireo solitarius cassini* in the characteristic "length" cannot be considered here as statistically significant, since it does not meet the minimum critical ratio set up. The list which follows later presents the results of the application of this statistical procedure giving subspecies which possess a critical ratio from 3 to 10 as unstarred, and those with a ratio of ten and above, as starred. The list is divided as to sex and as to Eastern and Western subspeccies. In all cases, the Eastern subspecies is used as the standard, from which the Western, by being larger, gives the ratio a minus quality, and by being smaller, gives it a plus quality. Thus, if *Penthestes atricapillus atricapillus* is listed under the Eastern Male heading for Total Length, this placement is to be interpreted to mean that the specimens of male *Penthestes a. atricapillus* for which measurements are available have been found to show a distinct difference in this characteristic when compared statistically with the specimens of *Penthestes atricapillus occidentalis* for which measurements are available, a difference which is described by a critical ratio of from 3 to 10; in this particular case, of + 6.036.

This procedure was used for each of the characteristics for which measurements were available, treating male and female measurements separately, in each of the twenty pairs of subspecies. It is obvious that twenty pairs is not a large enough number from which to draw definite conclusions as to the probability of western subspecies in general being larger or smaller than eastern subspecies in general. Also, the statistical method used was not all one could wish, but notwithstanding these and other limitations of the study, the writer feels that certain interesting facts were brought out, and that this type of procedure has possibilities for future work in bird ecology.

The following table gives the subspecies showing the significant ratios (3 and above) for each characteristic measured, taking males and females separately: (* means ratios 10 or above)

MALE

Eastern	*Western*
Total Length	
*Hylocichla guttata faxoni	*Spizella passerina arizonae
Corvus b. brachyrhynchos	Troglodytes aedon parkmani
Penthestes a. atricapillus	Nannus hiemalis pacificus
Vireo s. solitarius	Turdus migratorius propinquus
Passerculus sandwichensis savanna	Vermivora ruficapilla ridgwayi
Pooecetes g. gramineus	Agelaius phoeniceus caurinus
Wing Length	
*Penthestes a. atricapillus	Troglodytes a. parkmani
*Hylocichla g. faxoni	Turdus m. propinquus
*Carpodacus p. purpureus	Spizella p. arizonae

MALE—*Continued*

Eastern		*Western*
	Wing Length	
Corvus b. brachynchos		
Sitta c. carolinensis		
Certhia familiaris americana		
Hylocichla f. fuscescens		
Vireo s. solitarius		
Vireo g. gilvus		
Spinus t. tristis		
Passerculus s. savanna		
Pooecetes g. gramineus		
	Tail Length	
*Spinus t. tristis		Troglodytes a. parkmani
*Penthestes a. atricapillus		Turdus m. propinquus
Corvus b. brachyrhynchos		Vermivora r. ridgwayi
Hylocichla g. faxoni		Carpodacus purpureus californicus
Vireo g. gilvus		Spizella p. arizonae
Pooecetes g. gramineus		
	Exp. Culmen	
*Hylocichla g. faxoni		Empidonax trailli brewsteri
*Vireo g. gilvus		Penthestes a. occidentalis
Telmatodytes p. palustris		Certhia f. occidentalis
Pooecetes g. gramineus		Vireo s. cassini
		Agelaius p. caurinus
		Passerculus s. bryanti
		Spizella p. arizonae
	Tarsus Length	
*Corvus b. brachyrhynchos		Penthestes a. occidentalis
*Hylocichla g. faxoni		Turdus m. propinquus
Sitta c. carolinensis		Vireo s. cassini
Troglodytes a. aedon		Vermivora r. ridgwayi
Nannus h. hiemalis		Carpodacus p. cassini
Telmatodytes p. palustris		Spizella p. arizonae
Hylocichla g. faxoni		
Vireo g. gilvus		
Passerculus s. savanna		
Pooecetes g. gramineus		
Agelaius p. phoeniceus		
	Middle Toe Length	
*Sitta c. carolinensis		Certhia f. occidentalis
Corvus b. brachyrhynchos		Spizella p. arizonae
Hylocichla g. faxoni		
Vireo g. gilvus		
Pooecetes g. gramineus		
	Depth of Bill at Nostrils	
*Corvus b. brachyrhynchos		
*Vireo g. gilvus		
	Depth of Bill at Base	
*Agelaius p. phoeniceus		
*Pooecetes g. gramineus		
Carpodacus p. purpureus		

FEMALE

Eastern	*Western*
Total Length	
*Hylocichla g. faxoni	*Telmatodytes palustris paludicola
Corvus b. brachyrhynchos	Turdus m. propinquus
Vireo g. gilvus	Sitta c. aculeata
Passerculus s. savanna	Nannus h. pacificus
Pooecetes g. gramineus	Agelaius p. caurinus
	Spizella p. arizonae
Wing Length	
*Penthestes a atricapillus	Turdus m. propinquus
*Hylocichla g. faxoni	Hylocichla fuscescens salicola
Corvus b. brachyrhynchos	Agelaius p. caurinus
Certhia f. americana	Spizella p. arizonae
Vireo s. solitarius	
Vireo g. gilvus	
Vermivora r. ruficapilla	
Carpodacus p. purpureus	
Pooecetes g. gramineus	
Tail Length	
*Penthestes a. atricapillus	Troglodytes a. parkmani
Corvus b. brachyrhynchos	Nannus h. pacificus
Sitta c. carolinensis	Telmatodytes p. paludicola
Certhia f. americana	Turdus m. propinquus
Hylocichla g. faxoni	Hylocichla f. salicola
Vireo g. gilvus	Agelaius p. caurinus
Vermivora r. ruficapilla	Spizella p. arizonae
Exp. Culmen	
*Telmatodytes p. palustris	*Sitta c. aculeata
Corvus b. brachyrhynchos	Penthestes a. occidentalis
Hylocichla g. faxoni	Troglodytes a. parkmani
Vireo g. gilvus	Nannus h. pacificus
Vireo s. solitarius	Agelaius p. caurinus
	Passerculus s. bryanti
	Spizella p. arizonae
	Carpodacus p. californicus
Tarsus Length	
Corvus b. brachyrhynchos	Vireo s. cassini
Penthestes a atricapillus	Agelaius p. caurinus
Telmatodytes p. palustris	Pooecetes g. affinis
Hylocichla g. faxoni	Spizella p. arizonae
Vireo g. gilvus	
Passerculus s. savanna	
Spinus t. tristis	
Middle Toe Length	
Sitta c. carolinensis	Penthestes a. occidentalis
Troglodytes a. aedon	Nannus hiemalis pacificus
Hylocichla g. faxoni	Telmatodytes p. paludicola
	Hylocichla f. salicola
	Agelaius p. caurinus

FEMALE—*Continued*

Eastern	*Western*
Depth of Bill at Nostrils	
*Vireo g. gilvus	
*Corvus b. brachyrhynchos	
Depth of Bill at Base	
Pooecetes g. gramineus	

From the data contained in these tables, it seems safe to draw the following conclusions:

1. The outstanding male birds, judged by the size of the critical ratios and the number of characteristics superior in, are: the Eastern Warbling Vireo (*Vireo gilvus gilvus*), the Eastern Hermit Thrush (*Hylocichla guttata faxoni*), the Eastern Vesper Sparrow (*Pooecetes gramineus gramineus*), the Eastern Crow (*Corvus brachyrhynchos brachyrhynchos*), and the Western Chipping Sparrow (*Spizella passerina arizonae*).

2. The outstanding female birds, judged on the above standard, are: the Eastern Crow, Eastern Hermit Thrush, Eastern Warbling Vireo, Northwestern Red-wing (*Agelaius phoeniceus caurinus*), and the Western Chipping Sparrow.

3. If we were to select the birds most apt to show the same superiority in the majority of its characteristics measured, both male and female, we would choose the Eastern Warbling Vireo, Eastern Hermit Thrush, Eastern Crow, and the Western Chipping Sparrow.

4. The general superiority in measurements of all characteristics seems to go to the Eastern subspecies, in about the ratio of ten to four.

5. It seems likely that should measurements be made of additional birds of the subspecies starred to show critical ratios of ten or more, the same superiority would be found over its eastern or western mate, as the case might be.

As has been suggested previously, it would be of value if some method of comparing and contrasting color variations, songs, nesting habits, egg color and number, etc., of subspecies could be devised. Perhaps a color card with a numerical value for each shade could be used for feathers and eggs, and the number of eggs could be used in the same manner as the measurements of body, wing, tarsus, etc. In any case, there exists a distressing lack of data on these and other characteristics of subspecies, particularly the western ones. It is the writer's hope that this article may point out the lack of information, and that competent ornithologists will seek to remedy it.

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*Should any reader wish further details on the statistical procedure used or the means of arriving at the results, the writer will be glad to furnish them.