

## A REVIEW OF THE MORPHOLOGY AND TAXONOMY OF STELLER'S JAYS (*CYANOCITTA STELLERI*) IN BRITISH COLUMBIA

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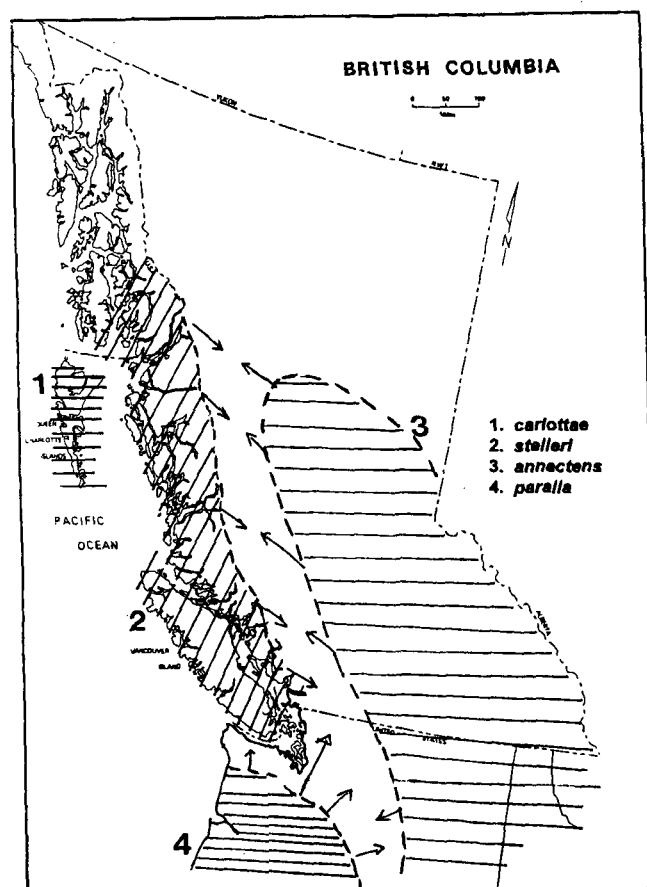
**Abstract** — A quantitative analysis of specimens is used to describe each subspecies and intergrade of Steller's Jay known from British Columbia and to review their distributions. Steller's Jays resident in the southwestern mainland are probably intergrades between *Cyanocitta s. stelleri* and *C. s. paralia*, rather than pure *C. s. stelleri*, pure *C. s. paralia* or intergrades between *C. s. stelleri* and *C. s. annectens*, all of which have been proposed previously as the local subspecies.

**Key words:** British Columbia, *Cyanocitta stelleri*, plumage, size dimorphism, Steller's Jay, subspecies, taxonomy.

The Steller's Jay (*Cyanocitta stelleri*) inhabits coniferous and mixed forests west of the Rocky Mountains from southern Alberta to Mexico. Within this range, body size and plumage colour vary so that at least 13 subspecies have been described in North America (Phillips 1986) and ten in Mexico (Browning 1993). Four of these subspecies (and possibly intergrades between them) are believed to occur in British Columbia: *C. s. stelleri*, *C. s. carlottae*, *C. s. annectens* and *C. s. paralia* (Godfrey 1986), of which *C. s. paralia* is included within *C. s. stelleri* by some authorities (e.g. American Ornithologists' Union 1957, as followed by Campbell *et al.* 1997). Although major flights of this species sometimes occur in British Columbia (Bent 1946; Stewart and Shepard 1994; Campbell *et al.* 1997) and elsewhere (Morrison and Yoder-Williams 1984), each subspecies is normally resident where found (Goodwin 1976; Morrison and Yoder-Williams 1984). The systematics of Pacific Coast crested jays was first examined by Fisher (1902), and then Mailliard (1922), who gave detailed descriptions of the colour of subspecies from Alaska to California. A review by Stevenson (1934) focused on five Californian subspecies with the aim of mapping their distributions accurately. Brown (1961) measured crest lengths and plumage markings of several subspecies, but did not address taxonomy directly.

In 1987, Steller's Jay was designated "British Columbia's Provincial Bird" (Campbell *et al.* 1997), yet quantitative differences among subspecies and their ranges within this province have not been examined closely. There is confusion about the identity of jays in the extreme southwestern corner of British Columbia, where three of the subspecies converge (Figure 1). These southwestern birds were all classified as *C. s. stelleri* by the American Ornithologists' Union (1957), although Munro and Cowan (1947) had classified them as *C. s. paralia*. Stevenson (1934) believed that no typical *C. s. paralia* occur north of Grays Harbor County, Washington and called the southwestern British Columbia jays "*stelleri-annectens* hybrids;" however, he did not do a quantitative analysis to support this conclusion.

The objectives of this study were to describe subspecies of Steller's Jay in British Columbia quantitatively, to map their distributions, and to measure sexual size dimorphism in each population.



**Figure 1:** Approximate distribution of four subspecies of Steller's Jay believed to occur in British Columbia and adjacent Washington. Modified from maps in Stevenson (1934) and Munro and Cowan (1947).

## METHODS

In 1987, 1990 and 1995, I examined a total of 328 study skins from the Royal British Columbia Museum, University of British Columbia Vertebrate Museum, Simon Fraser University Museum, and the Burke Museum of the University of Washington. I measured eight continuous variables to the nearest 0.5 mm.: total body length, flattened wing chord, tarsus, culmen length, culmen depth (at the anterior edge of the nostril), crest length (the length of the longest feather -see Brown 1961), frontal streak length, and superciliary spot length (Figure 2). Differences in the way museum skins are prepared may cause biased measurements. Seven of the eight variables are unlikely to be affected by skin preparation because they are measurements of hard body parts or small patches of feathers on the head. Total body length is less reliable. To reduce bias, I excluded skins that appeared oddly shaped and assumed that any remaining biases would be evened out among collections. I also did not measure wing and crest lengths from birds taken in June or July because moult occurs during that time (Pitelka 1958).

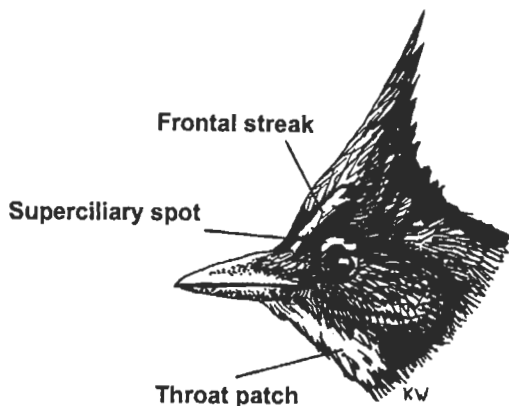


Figure 2: Plumage markings on the heads of Steller's Jays.

Colour and plumage patterns were quantified by ranking jays on a scale. To minimize subjectivity, all the birds were compared to the same four "standard" skins while being ranked. For frontal streak colour, a scale from 1-4 was used: 1 = white to very light blue, 2 = medium blue, 3 = dark blue, 4 = black (the same colour as the rest of the crest so that the bird, in effect, had no streaks). The scale for throat colour was: 1 = throat patch large with most of a single feather white, 2 = patch of moderate size with single feathers partly white and partly dark, 3 = throat almost entirely dark with only the shafts of some of the feathers white. Because of confusion with the names of back and breast colours used by different researchers, I described colours on the basis of standard colour charts of Smithe (1974). Breast colour was quantified as: 1 = "light cerulean blue" with "turquoise blue" on the flanks, 2 = "cerulean blue," 3 = between "cerulean

blue" and "spectrum blue." The back colours were: 1 = "plumbeous" -a greyish-brown, 2 = "fuscous" -a dark, rich brown, 3 = "dusky brown" -almost black. Black barring on the tail feathers were ranked as: 0 = no bars visible to 3 = numerous and distinct tail bars.

To be conservative, only the jays collected south of Seattle, Washington were classified as *C. s. paralia* initially, as recommended by Stevenson (1934). Jays from northern Washington and the lower Fraser River Valley of British Columbia from Hope to Vancouver were classified as "unknown" to compare them with the other subspecies. Statistical tests were performed using SAS [Statistical Analysis Software] (1988). I used ANOVA [Analysis of Variance] (continuous variables) and Chi-square tests (ranked variables) to compare univariate means among groups. To determine the identity of the "unknown" jays from the mainland near Vancouver, I used a Discriminant Function Analysis (Canonical Variates Analysis in SAS) that weights characters to maximize the separation among groups, and then uses these criteria to classify unlabelled individuals into the "best" group.

Because male and female birds often differ in body size, each sex should be analyzed separately across subspecies. To do this for each continuous morphometric variable, I performed a 2-way ANOVA with sex and subspecies as main effects. To test whether there were significant differences in size among the subspecies, Scheffé's multiple-comparison tests were performed for each variable. For each subspecies, Chi-square tests were used to test for differences in the proportion of males and females within each plumage colour category.

## RESULTS

## Univariate Analyses

Most jays were collected during fall and spring. There was a slight bias towards males in the sample (58%). For all the variables except frontal streak length, males were significantly larger than females ( $p < 0.01$  in all cases; Table 1, page 9). However, for *Cyanocitta stelleri carlottae* considered in isolation, the sexes did not differ in size for any variable ( $T$ -tests, all  $ps > 0.1$ ). In general, *C. s. carlottae* and *C. s. annectens* were the largest subspecies (Table 2, page 10), followed by *C. s. stelleri* and *C. s. paralia*. Although *carlottae* and *annectens* had similar wing length and body length, *carlottae* had longer and thicker bills and longer legs. Specimens of *annectens* had longer crests than those of other subspecies in British Columbia, although their crests are considerably shorter than those of southern subspecies in Mexico (Browning 1993). Overall, the greatest differences in size occurred between *annectens* and *stelleri* and between *carlottae* and all other B. C. subspecies. No statistically significant differences in size were found between *paralia* and the unidentified class of jays (Table 2).

My tests showed that within a subspecies, males and females did not differ in the colour of the breast or back ( $p > 0.1$  in all cases). With the sexes combined, there were significant differences among subspecies in the amount of tail barring and the colour of the back, breast, throat and frontal streak (Chi-square tests:  $p < 0.0001$  in all cases; see Figure 3). *Carlottae* generally had the darkest colouration and the least tail barring, followed by *stelleri*, *paralia* and *annectens*. Most *annectens* had superciliary spots, but 15% did not. These birds without spots were collected in various locations in British Columbia, including Vaseux Lake, Lumby, Enderby, and Lytton.

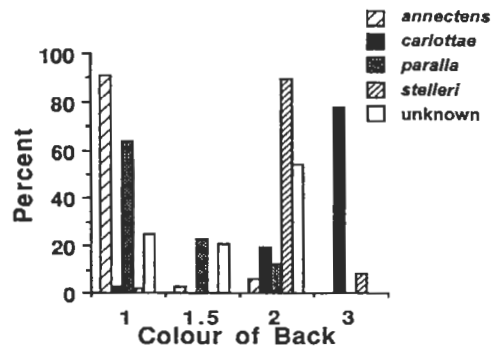


Figure 3c: Colour of Back.

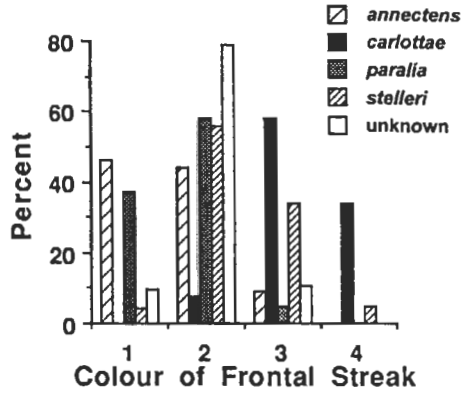


Figure 3a: Colour of Frontal Streak.

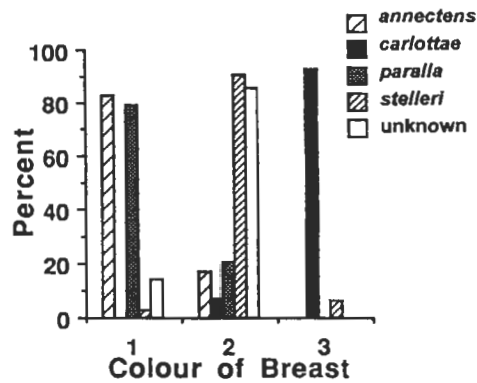


Figure 3d: Colour of Breast.

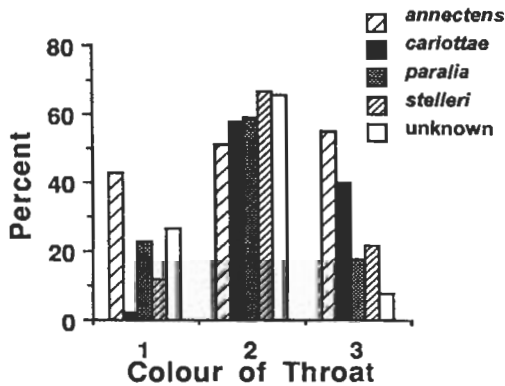


Figure 3b: Colour of Throat.

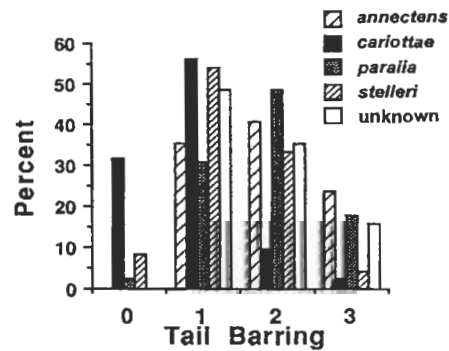


Figure 3e: Tail Barring.

Figure 3a-e: The proportion of the subspecies within various plumage colour categories. The lower the number, the lighter the colour (see definitions in METHODS). Both sexes are combined.

Multivariate Analyses

Discriminant Function Analyses were performed initially on each sex separately, but because the canonical structures of the axes and resulting plots were similar, the sexes were combined in a single analysis for simplicity (Figures 4a,4b). The first canonical variate (pooled within-class) ranked subspecies according to plumage characteristics (such as body colour and superciliary spot) and tarsal length. The second axis was a combination of wing and body length, and the length of the frontal streak and superciliary spot. The third canonical variate represented bill size (Table 3, page 10). The discriminant function classified 20.5% of the unknown class

birds as *paralia*, 13% as *stelleri*, and 1.5% as *annectens*. Interestingly, all the unknown birds classified as *stelleri* were individuals from southwestern mainland British Columbia collected before 1946. In contrast, nine of 11 Steller's Jays collected in Vancouver during 1993 were classified as *paralia*, while the other two remained in the "unknown" class. To distinguish the unidentified class of jays better, *carlottae* was excluded and a second discriminant analysis was performed on a data set with the 20.5% and 13% unidentified jays newly classified as *paralia* and *stelleri*, respectively. This ordination placed the unknown jays about evenly between *stelleri* and *paralia* (Figure 5).

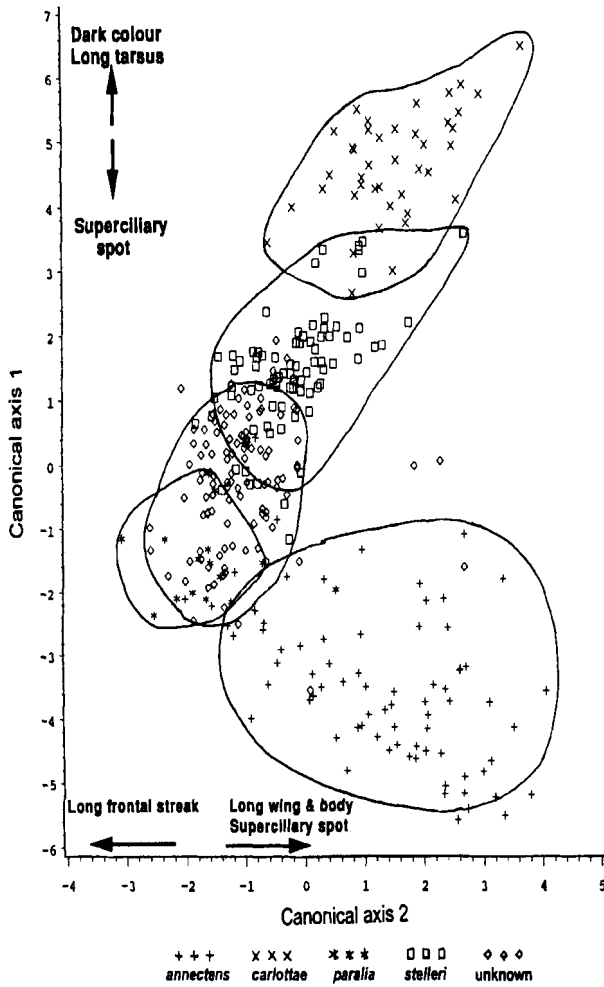


Figure 4a: Ordination of the five groups of Steller's Jays based on discriminant function analysis. Both sexes are combined and the circles are drawn by hand to include most individuals within a group. The greater the overlap between circles, the more similar the groups. Traits that increase or decrease along the axes are shown by arrows. The subspecies are indicated at the bottom of the graph. Canonical 1 compared with Canonical 2.

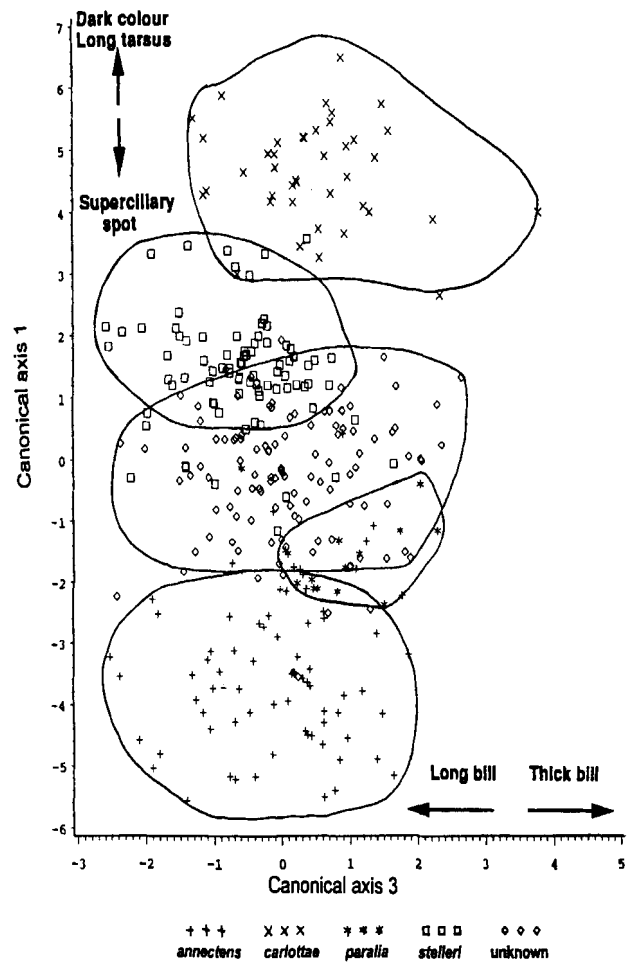


Figure 4b: Ordination of the five groups of Steller's Jays based on discriminant function analysis. Both sexes are combined and the circles are drawn by hand to include most individuals within a group. The greater the overlap between circles, the more similar the groups. Traits that increase or decrease along the axes are shown by arrows. The subspecies are indicated at the bottom of the graph. Canonical 1 compared with Canonical 3.

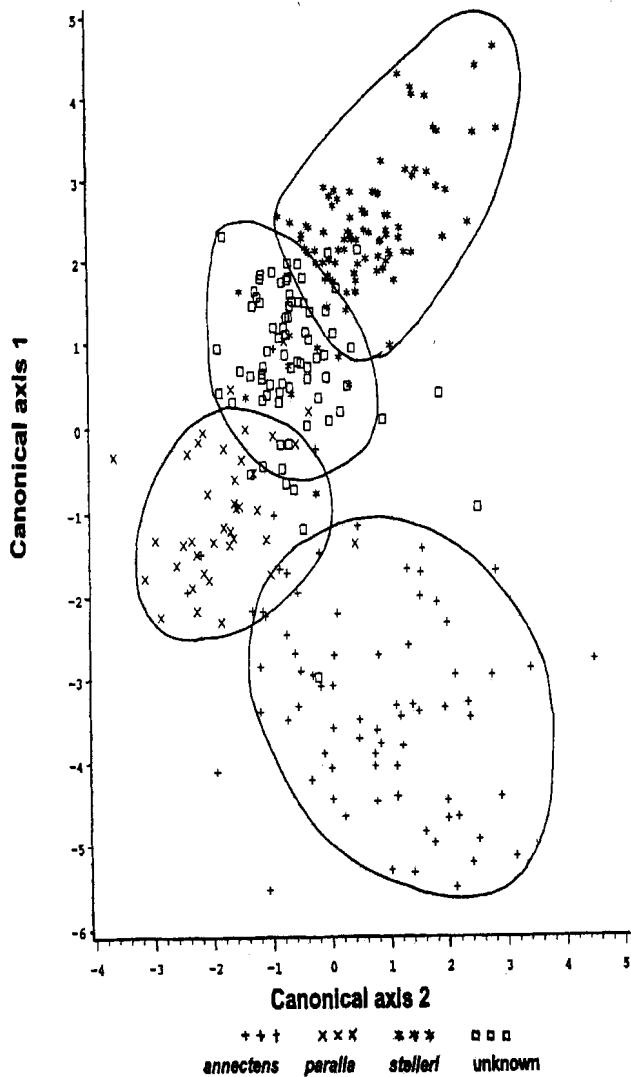


Figure 5: A second ordination performed on data with some "unknown" jays reclassified and *carlottae* removed for clarity (see METHODS). Both sexes are combined, and the circles enclosing the groups are drawn by hand.

## DISCUSSION

The slight male bias of Steller's Jays within museum collections was interesting, since the sexes do not differ in plumage characteristics. Therefore, specimen collectors would presumably not have been able to select males consciously. Whether there is, in fact, a male bias in natural populations is unknown, but territorial behaviour of males may make them more aggressive or more conspicuous, and thus more likely to be taken by collectors. While incubating and raising young, jays are unusually quiet and secretive (Angell 1978), possibly explaining why fewer were collected during summer. The following is a brief summary of the characteristics of the four subspecies of Steller's Jay in British Columbia.

### *Cyanocitta stelleri stelleri* (Gmelin)

First described from a specimen taken at Nootka Sound on Vancouver Island (American Ornithologists' Union 1957). The colour of the breast is cerulean blue, lighter than *carlottae*, but darker than *annectens* and *paralia*. The back is fuscous, a dark, rich, slightly reddish brown. The frontal streaks are relatively short and usually medium- to dark-blue in colour, although a few on Vancouver Island are light blue (Andrew C. Stewart personal communication to M. K. McNicholl 20 February 1996). The superciliary spot is absent except in a few intergrades with *annectens*.

### *Cyanocitta stelleri carlottae* (Osgood)

The darkest of all Steller's Jay subspecies; breast plumage is spectrum blue tending to a dark purplish blue, and the back is dusky brown (near black). Body and wing lengths are larger than *stelleri* or *paralia*, but similar to *annectens*. This Queen Charlotte Islands race tends to have long tarsi and a long, thick bill. The superciliary spot is never present, and frontal streaks are absent in about one-third of the population. When present, the streaks are short and dark blue. The black bars on the tail tend to be less distinct than in other subspecies.

### *Cyanocitta stelleri annectens* (Baird)

The breast is light cerulean blue and the back is "plumbeous," a light greyish-brown. *Annectens* is larger than *stelleri* or *paralia* in total length and wing length, but has proportionately short tarsi and a short, narrow bill. The superciliary spot is present in 85% of individuals and the frontal streaks are long and light blue.

### *Cyanocitta stelleri paralia* (Oberholser)

Pure *paralia* appear to have similar breast and back colour compared to *annectens*, while the individuals in extreme southwestern mainland British Columbia (intergrades with *stelleri*) are slightly darker. *Paralia* are smaller than *annectens* in terms of body length and wing length and smaller than all subspecies in tarsal and culmen lengths. They have long and light blue frontal streaks.

### Body Size

The size of jays in British Columbia (Table 1), falls within the ranges reported for the population by Godfrey (1986), but clearly there is significant variation in body size among the sexes and subspecies. The overall size of subspecies follows Bergmann's ecogeographic rule for size in that the northern races are larger than the southern race, *paralia*. However, a single measurement of body size can be misleading. For example, *carlottae* and *annectens* were similar in wing and body length, but *annectens* had shorter legs and bills. A multivariate measure of body size is thus preferable to a univariate measure (Rising and Somers 1989). Whether, and

how, differences in body size are adaptive for Steller's Jays is not clear. Bill size and shape affects food choice and handling ability in other seed-eating species, such as finches (Abbott *et al.* 1975), but it is not known whether differences in food or foraging methods can explain proportional differences in size of the bill, legs or wings among subspecies of jays in British Columbia.

Most male passerines are larger than females, presumably because they must defend territories and compete with other males for mates (Jehl and Murray 1986). An alternate idea is that sexes are competing for a limited food supply and thus diverge in morphology to occupy different ecological "niches" (Rothstein 1973). In this study, I found less dimorphism among island-dwelling *C. s. carlottae* than among subspecies on the mainland. Food may be relatively more abundant on the Queen Charlotte Islands, or else there may be less inter-sexual competition. Future studies comparing levels of competition for mates and food between island and coastal jays are needed to explain these patterns of size dimorphism.

### Plumage Colour

The colour and plumage of Steller's Jays throughout their range has been described previously by Stevenson (1934) and Phillips (1986). These reviews showed that subspecies in warm and moist coastal areas were darker in colour than subspecies in the dry interior, conforming to Gloger's ecogeographic rule for colour. My finding that *carlottae* and *stelleri* on the coast of British Columbia had darker breast, throat and back colours than *annectens* jays from the interior (Figure 3) is consistent with this trend. The adaptive significance of plumage colour is unknown. Huxley (1942) found that humidity could act directly on the development of feather pigmentation, having a darkening effect, which suggests that differences in colour need not be genetically based. The fact that many coastal bird and mammal species are dark, and have not evolved to counteract a darkening effect of humidity, if it exists, suggests that there may be a selective advantage to being dark on the coast. Perhaps dark plumage is more cryptic in dark, dense coastal forests, reducing the risk from such visual avian predators as accipiters, falcons and owls. Alternatively, dark plumage might be an advantage for jays when they prey on the eggs and young of other birds by reducing the chance of their being detected by the parents of such potential prey.

Dense forests also limit contact among individuals and reduce the effectiveness of plumage patterns and crests as visual signals to conspecifics (Brown 1961). This may explain

why *carlottae* and *stelleri* on the coast have no superciliary spots, short, dark frontal streaks and little tail barring. In contrast, *annectens* from the more open interior habitat (albeit with the interior wet belt providing habitat similar to dark coastal forests) had the longest crests and most prominent plumage markings. Rand (1948) reported that the *annectens* without superciliary spots came from the far eastern part of the province, but I also found examples of such birds in the central interior.

### Distribution of Subspecies

*Carlottae* is resident on the Queen Charlotte Islands, and no specimens were collected on the mainland of British Columbia (see Figure 1). *Annectens* is found in the interior of the province from the Cascade Mountains in the west to the Rocky Mountains in the east, north to Hazelton (Munro and Cowan 1947). Phillips (1986) suggested that some *annectens* might also be resident on the coast. Indeed, some of the museum specimens from Prince Rupert were *annectens* (as also found by Munro and Cowan 1947), and *stelleri-annectens* intergrades (with superciliary spots) were found at Bella Coola, but whether the subspecies actually breeds there still needs to be confirmed. Steller's Jays intermediate between *stelleri* and *annectens* have been collected at Hazelton in northern British Columbia (Taverner 1919), at Alta Lake (Racey 1948), and at Huntington in the eastern Fraser Valley. Thus, there appears to be a zone of intergrades along the Cascades where the two subspecies meet. *Stelleri* are resident on Vancouver Island and the coast, and a few "pure" individuals were also collected from the extreme southwest corner of the mainland, near Vancouver, but only before 1946.

Jays in the southwestern mainland of British Columbia show a confusing mix of characteristics, but are definitely not the same as pure *stelleri* of Vancouver Island, as implied by the American Ornithologists' Union (1957) classification. Neither are they pure *paralia*, as suggested by Munro and Cowan (1947). The portion of the "unknown" jays between *paralia* and *stelleri* on the ordination (Figures 4 and 5) means that these birds are probably intergrades between *stelleri* and *paralia*, not *stelleri* and *annectens* as claimed by Stevenson (1934). The fact that nine of 11 recently collected (1993) jays from Vancouver were classified by the discriminant function as "*paralia*" supports Munro and Cowan's (1947) idea that the *paralia* subspecies is gradually extending its range northward and supplanting *stelleri* on the south coast of British Columbia. More research on behaviour and ecology of the subspecies is needed to determine if, and how, differences in plumage and size are adaptive and why the ranges of subspecies may be changing over time.





