

Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State

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Patterns of pigmentation of the post dorsal fin patch, or saddle patch, were analyzed from photographs of 372 resident and 99 transient killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Of the five types of saddle patch analyzed, all were observed on residents, but only two occurred on transients. Differences in saddle patch shapes were independent of age and sex. Saddle patch pigmentation patterns were similar among clans within a community. Pigmentation patterns differed significantly between the resident and transient forms, between northern and southern residents, between northern and Alaskan residents, and between southern and Alaskan residents. As the saddle patch shape may be heritable to a large degree, these differences suggest genetic isolation of the populations. If so, this technique may be used to delineate stocks of killer whales from other areas.

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La répartition de la pigmentation dans la tache située derrière la nageoire dorsale, a été analysée par examen de photographies de 372 épaulards (*Orcinus orca*) résidents et de 99 épaulards de passage en Colombie-Britannique, en Alaska et dans le Washington. Les cinq types de taches analysés ont été observés chez les épaulards résidents, mais seulement deux existent chez les individus de passage. Les différences dans la forme de la tache sont indépendantes de l'âge ou du sexe des animaux. La répartition de la pigmentation est semblable chez tous les clans d'une même communauté. Il existe des différences de pigmentation significatives entre les épaulards résidents et les épaulards de passage, entre les résidents du nord et ceux du sud, entre les résidents du nord et ceux d'Alaska, enfin entre les résidents du sud et ceux d'Alaska. Comme la tache peut être héréditaire, ces différences semblent être le reflet d'un isolement génétique. Si tel est le cas, cette tache pourrait servir à distinguer les stocks d'épaulards les uns des autres.

[Traduit par la revue]

Introduction

Through examination of photographs, Bigg (1982) found that individual killer whales (*Orcinus orca*) can be identified from distinct pigmentation patterns and scars on the post dorsal fin pigmentation patch or saddle patch. Based on observed association patterns and ranges, three distinct communities of killer whales have been identified in British Columbia and Washington, each composed of several pods. Two of the communities are of the resident form (Bigg et al. 1987) and have largely nonoverlapping ranges that meet near the midpoint of Vancouver Island. Differentiation based on acoustics has resulted in the designation of four resident clans (Bigg et al. 1987), three of which make up the northern resident community; the three pods of the southern resident community constitute a single clan. The transient community is sympatric with the two resident communities (Bigg et al. 1985), traveling throughout most of the ranges of both resident communities, but not interacting with them. Using the same techniques, Leatherwood et al. (1984) have categorized killer whales from the eastern Gulf of Alaska as resident and transient forms. Within these two forms, however, exact pod designations are still preliminary, as more research is needed. As well, differentiation of more than one resident community in the eastern Gulf of Alaska has not been made.

Behavioral differences between residents and transients

have been noted in British Columbia, Alaska, and Washington State. Residents are found in large pods of, typically, 5–50 individuals, which rarely enter small bays and are seen predominantly in the summer months. They feed mainly on fish and share similar vocalization characteristics (Bigg et al. 1987). Transients live in smaller pods of one to seven individuals, often travel into small bays, and are present in local waters in approximately the same numbers throughout the year. They feed mainly on marine mammals and differ from residents in vocalization characteristics (Bigg et al. 1987; Morton 1987).

A morphological difference between resident and transient whales has also been noted. Bigg et al. (1987) state that the dorsal fin tip of residents tends to be rounded and positioned over the posterior insertion of the fin to the back, whereas the dorsal fin tip of transients is often pointed and positioned in the center between the anterior and posterior insertions of the fin. However, this difference has not yet been quantified. The purpose of this report is to quantitatively compare a previously unreported difference in the saddle patch pigmentation pattern between populations of killer whales, providing information on the genetic isolation of the populations and presenting a technique that may be used to delineate breeding populations of killer whales elsewhere.

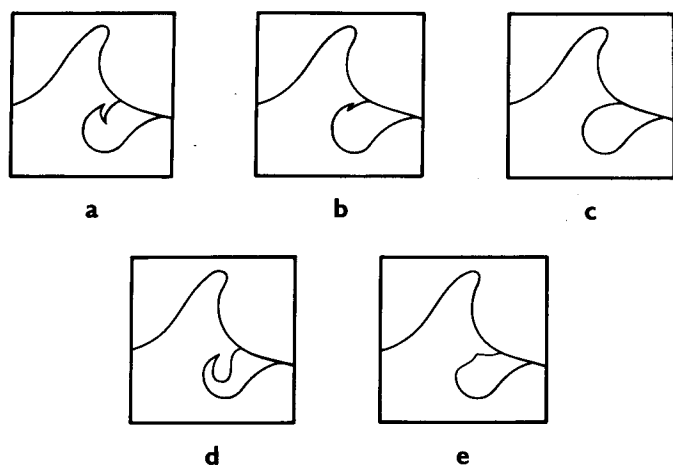


FIG. 1. Saddle patch types. Drawings by K. Uldall-Ekman (modified, with permission, from Sugarman 1984, ©1984 The Whale Museum, Friday Harbor, WA). (a) Vertical notch (residents only); (b) horizontal notch (residents only); (c) smooth (residents and transients); (d) hook (residents only); (e) bump (residents and transients).

Methods

Photographs in Bigg et al. (1987) of killer whales from British Columbia and Washington State and from Ellis (1987) of killer whales from the eastern Gulf of Alaska were used to compare the pigmentation pattern of the saddle patch. Only animals for which we had clear photographs of the saddle patch on the left-hand side were used, for a total sample size of 471. Individuals had previously been classified as resident or transient forms (Leatherwood et al. 1984; Bigg et al. 1987; Ellis 1987) based on a variety of characteristics. Designation of British Columbia clans and communities are from Bigg et al. (1987). Photographs of most calves were not used, as their saddle patches are often not distinct. Five saddle patch types were categorized after Sugarman (1984), determined by the pigmentation of the line demarcating the upper saddle patch, termed the upper saddle patch line. The types are as follows: vertical notch, horizontal notch, smooth, hook, and bump (Fig. 1). Each saddle patch was assigned to one of these categories. Whales that have been identified from both British Columbia and Alaska were only categorized in British Columbia samples. Although whales in the British Columbia transient and southern resident communities are also found in the adjoining waters of Washington State, they are sometimes referred to herein as British Columbia whales, as all whales identified from Washington have also been recorded in British Columbia.

Comparisons between males and females within communities were not possible because of inadequate sample sizes in some categories. All known males and females (Bigg et al. 1987; M. A. Bigg, personal communication) from the three communities in British Columbia were analyzed collectively using χ^2 contingency analysis. Comparisons between pods within a clan were also not possible because of inadequate sample sizes in some categories. Comparisons were made using χ^2 contingency analysis between the three clans in the northern resident community, between transients from Alaska and British Columbia, between northern, southern, and Alaskan residents, and between residents and transients.

Results

The numbers of whales with each saddle patch type in each group analyzed are presented in Table 1. Pod designations and saddle patch types for each pod are presented in Table 2. Proportions of saddle patch types between known male and female killer whales of British Columbia and Washington were similar ($\chi^2 = 8.530$, $p > 0.07$). All five saddle patch types were

TABLE 1. Numbers of whales with each type of saddle patch

	No. of individuals					Total
	a	b	c	d	e	
Northern residents						
Total	5	11	105	5	29	155
A clan	4	7	55	1	20	87
G clan	1	4	31	4	7	47
R clan	0	0	19	0	2	21
Southern residents	8	24	3	17	20	72
Alaskan residents	12	19	70	16	28	145
Transients						
Total	0	0	90	0	9	99
Alaskan transients	0	0	37	0	5	42
B.C. transients	0	0	53	0	4	57
Known B.C. males	1	7	39	6	22	75
Known B.C. females	10	19	57	13	22	121

NOTE: See Fig. 1 for definition of saddle patch types (a-e).

noted among resident whales, but only two were noted among transient whales. Of the 99 saddle patches of transients coded, 90 (91%) were of the smooth type (Fig. 1c) and the remaining 9 (9%) were of the bump type (Fig. 1e). As only two saddle patch types were noted for transients, and most were of one type, the categories a, b, d, and e were pooled in comparisons with other groups and comparisons between British Columbia and Alaskan transients. For comparisons between clans within the northern resident community these types were pooled to produce sufficient sample sizes. No differences in saddle patch pigmentation were found between clans within the northern resident community ($\chi^2 = 5.850$, $p > 0.05$). Saddle patch types of transients were similar between samples from Alaska and samples from British Columbia and Washington ($\chi^2 = 0.233$, $p > 0.60$). Comparison of saddle patch traits between northern and southern residents ($\chi^2 = 92.005$, $p < 0.0001$), between northern and Alaskan residents ($\chi^2 = 17.481$, $p < 0.01$), and between southern and Alaskan residents ($\chi^2 = 44.744$, $p < 0.0001$) all showed a significant difference in saddle patch pigmentation patterns. As saddle patch types for transients from British Columbia and Alaska were similar, all transients were combined for comparison with residents. Patterns of saddle patch pigmentation differed significantly between northern residents and all transients ($\chi^2 = 16.907$, $p < 0.0001$), between southern residents and all transients ($\chi^2 = 122.957$, $p < 0.0001$), and between Alaskan residents and all transients ($\chi^2 = 45.499$, $p < 0.0001$).

Discussion

A significant difference exists in the saddle patch pigmentation pattern between resident and transient killer whales. As this difference is not attributable to sexual dimorphism (Table 1), and the saddle patch does not change with age once it forms (Bigg 1982), it represents a quantitative difference between the two forms. As Bain (1987) has noted that saddle shape in resident killer whales may be heritable to a large degree, the difference in pigmentation of the saddle patch between resident and transient killer whales may indicate genetic isolation of the two populations, supporting Bigg and his colleagues' supposition that resident and transient killer whales do not interbreed (Bigg et al. 1987).

The differentiation between the two resident communities in

TABLE 2. Pods used in analysis

	No. of individuals					Total ^a
	a	b	c	d	e	
Northern residents						
A clan						
A1 pod	1	2	4	0	7	14
A4 pod	1	2	3	0	0	6
A5 pod	1	1	4	1	5	12
B1 pod	0	0	7	0	0	7
C1 pod	0	2	5	0	3	10
D1 pod	0	0	8	0	1	9
H1 pod	0	0	4	0	2	6
I1 pod	0	0	4	0	1	5
I2 pod	0	0	7	0	0	7
I18 pod	1	0	9	0	1	11
G clan						
I11 pod	0	0	8	1	2	11
I31 pod	0	2	3	2	0	7
G12 pod	0	0	5	0	2	7
G1 pod	1	2	15	1	3	22
R clan						
R1 pod	0	0	16	0	2	18
W1 pod	0	0	3	0	0	3
Southern residents, J clan						
J1 pod	2	7	0	2	5	16
K1 pod	2	6	0	5	1	14
L1 pod	4	11	3	10	14	42
Alaskan residents						
AF pod	4	5	3	3	2	17
AG pod	0	1	6	0	2	9
AB pod	2	4	10	6	7	29
AD pod	1	1	10	3	1	16
AE pod	1	1	7	1	2	12
AI pod	0	0	5	1	6	12
AJ pod	1	3	8	0	2	14
AK pod	2	1	1	1	0	5
AN pod	1	3	18	1	5	28
AS pod	0	0	2	0	1	3
Alaskan transients						
AA pod	0	0	4	0	0	4
AH pod	0	0	3	0	2	5
AO pod	0	0	4	0	0	4
AQ pod	0	0	3	0	0	3
AC pod	0	0	4	0	0	4
AT pod	0	0	16	0	3	19
AU pod	0	0	3	0	0	3
B.C. transients						
F1 pod	0	0	1	0	0	1
M1 pod	0	0	3	0	0	3
M3 pod	0	0	1	0	0	1
N1 pod	0	0	1	0	0	1
O2 pod	0	0	2	0	0	2
O5 pod	0	0	1	0	1	2
O10 pod	0	0	2	0	0	2
O21 pod	0	0	4	0	0	4
P1 pod	0	0	2	0	0	2
P27 pod	0	0	1	0	0	1
P10 pod	0	0	4	0	0	4
Q1 pod	0	0	3	0	0	3
Q3 pod	0	0	3	0	0	3
Q4 pod	0	0	1	0	1	2
Q9 pod	0	0	1	0	0	1
S3 pod	0	0	2	0	0	2
S8 pod	0	0	1	0	0	1
S10 pod	0	0	0	0	1	1
T1 pod	0	0	4	0	0	4

TABLE 2 (concluded)

	No. of individuals					Total ^a
	a	b	c	d	e	
U1 pod	0	0	4	0	0	4
V1 pod	0	0	2	0	0	2
V10 pod	0	0	4	0	0	4
X1 pod	0	0	1	0	0	1
Y1 pod	0	0	2	0	1	3
Z1 pod	0	0	1	0	0	1
Z50 pod	0	0	1	0	0	1
Z60 pod	0	0	1	0	0	1

NOTE: See Fig. 1 for definition of saddle patch types (a-e).

^aPod totals may be lower than actual pod numbers because of obscured saddle patches or, in the case of calves, indistinct saddles.

British Columbia has been made by a lack of observed interactions and the largely nonoverlapping ranges (Bigg et al. 1987; M. A. Bigg, personal communication). Although one pod from the northern resident community has been documented from Alaska (Leatherwood et al. 1984) it was not observed mixing with Alaskan resident whales. Similarly, although both northern and southern resident whales have occasionally been observed within each other's ranges (M. A. Bigg, personal communication), they have not been observed intermixing. However, research effort in both British Columbia and Alaska has been focused in the summer months, and research in southeast Alaska and northern British Columbia has not been intensive, so undocumented interactions may occur. In this study, from analysis of saddle patch pigmentation, differences between the northern and southern resident communities in British Columbia and between British Columbia and Alaskan residents suggest that they are genetically isolated. The similarity between clans within the northern resident community suggests that interbreeding within the community occurs.

Morphological variations between geographically separated populations of killer whales have previously been reported (Berzin and Vladimirov 1983; Evans et al. 1982). Qualitatively, Evans et al. (1982) found that geographically separated groups of killer whales appeared to be nonhomogeneous with respect to the three saddle patch variants analyzed. Their analysis of photographs from Mexico appears to fit the approximate ratios of smooth saddle patch types to other saddle patch types found in transients in this study. They also noted that the trait "c," which is the same as the smooth classification in the present study, is the only variant observed in southern hemisphere samples. This is interesting in light of the large geographical range of transient killer whales, which have predominantly smooth saddle patches, with some individuals identified from Alaska, British Columbia, and Washington State (Bigg et al. 1987). Resident whales, on the other hand, appear to have distinct and limited ranges. It is probable that the maximum limits of the geographical range of transient killer whales have not yet been determined, and individuals found from Washington, British Columbia, or Alaska may eventually be photo-identified off Oregon, California, or further afield.

In other areas, analysis of saddle patch types may be useful in determining the type of population. Comparison of saddle patch traits with those of other populations, especially the geographically adjacent populations off Oregon and California, is warranted. Also, examination of other pigmentation patterns,

such as the postocular patch, may provide further information concerning the discreteness of the populations and the validity of saddle patch pigmentation for delimiting breeding populations.

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