ISSN 1995-4255, Contemporary Problems of Ecology, 2011, Vol. 4, No. 4, pp. 451–456. © Pleiades Publishing, Ltd., 2011.
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Size Structure of Introduced and Native Populations of Sable in Yakutia

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Abstract—Skull dimensions of nine sable populations in Yakutia (n = 1230 ind.) were studied. Differentiation in the size structure between autochthonous left-bank (large skull) and introduced right-bank (small skull) population groups was revealed. Allochthonous groups occupy an intermediate position between the founders (Vitim, Bureya, Kamchatka) and left-bank aboriginals exhibiting morphological trends that lead to the appearance of new forms of the species.

DOI: 10.1134/S1995425511040187

Keywords: sable, morphology, craniometry, autochthones, translocation, introduced groups, structure

The problem on interrelations of adjacent populations of animals that have different origin is an important aspect of biology. Such situations occur at expansion of species and populations owing to outbreaks, migrations and introductions. It was noted [1, 2] that often zoological problems arise due to colonization of animals of one subspecies to the areal of another one in the result of translocations of animals. This happened in the middle of the past century at the mass sable introductions [3–9]. New populations with their own morphological and ecological peculiarities have been formed in these introduction sites. One of the regions where sables of different subspecies have colonized in the 1950s [10] is Yakutia.

MATERIAL AND METHODS

In this paper the problem of formation of size sable morphs in nine (n =1230) Yakutian species populations in the postintroduction period is considered using craniometry. The studied craniological material is given in the Table 1. To measure 18 skull dimensions we used animals older that one year. To determine the age we used the methods of V. V. Timofeev and V. N. Nadeev [3], V. S. Smirnov [11], G. A. Klevezal' and S. E. Kleinenberg [12].

The craniometric characteristics of every population group is formed by 18 characters [14]: (1) basal length; (2) condylo-basal length; (3) profile length; (4) braincase length; (5) facial length; (6) upper teeth length; (7) upper molar length; (8) diameter of foramen magnum; (9) length of tympanic bullae; (10) braincase width; (11) greatest skull width; (12) width of occipital condyles; (13) choanal width; (14) facial width in the line between zygomatic foramina; (15) width of upper incisor row; (16) width of tympanic bullae; (17) height at tympanic bullae; (18) height at interorbital narrowing [3, 8, 18].

To reveal the total (integral) index of sizes (dimensions) we used the value of the first principal component (PC 1) which was calculated by the method of the principal components in the *Statistica 5.5 (Statsoft)* packet.

RESULTS AND DISCUSSION

As shown in the Table 2, the PC1 integrates 94.6% of dispersion of characters and it is rightfully to use its score as an index of common sizes of males and females.

Dimensional interrelations of nine Yakutian populations are shown in the Fig. 1. The most similarity is shown in two groups: Vilyui–Zhigansk–Olenek and Upper Aldan–Maya–Yana–Olekma. The first group is formed by aboriginal left-bank populations of big sables, condylo-basal length (CBL) of which is more than 84 mm (males) and 77 mm (females) (Fig. 2). The second group presents introduced populations of the right-bank Lena River, skull dimensions of which are the least in the region (CBL of males is less than 83 mm and that one of females—76 mm, see Fig. 2).

The other two populations take an intermediate position between two first groups. However, the re-acclimatized populations of the Aldan lower reach are closer to small forms and have the CBL 83.1 mm (males) and 75.2 mm (females). The most close to native forms in skull dimensions the animals of the Middle Kolyma River are. Into the component analysis we have also in-

Table 1. The material used for characterizing skull dimensions

Samples	Males	Females	Years (collections of museums)
Lower Aldan	41	30	2002–2005 (A)
Upper Aldan	83	43	1958–1960 (B); 1990, 2004–2006 (A)
Vilyui	30	24	1971–1973 (C); 2002 (A)
Yana	116	91	1962–1964, 1969–1973 (A); 2004–2006 (A)
Zhigansk	36	23	1942 (C); 1970 (A)
Middle Kolyma	105	102	1967–1973 (B); 1972–1978 (A)
Maya	98	91	1959–1960, 1972–1973 (B); 1991, 2005–2006 (A)
Olekma	72	56	1959–1962, 1974–1975, 2002–2003 (A)
Olenek	99	70	1959, 1968–1974, 1989, 2003–2006 (A)
Total	680	550	

Note: (A) the Institute of Biological Problems of Cryolitic Zone of SB RAS, Yakutsk; (B) the All-Russian Research Institute of Hunting and Fur Farming, Yakutsk; (C) Zoological Museum of the Moscow State University, Moscow.

Table 2. Result of analyzing the skull sizes of males and females in Yakutia by the method of the principal components

Character	Factor loadings of 1–4th principal components (PC)			
	PC 1	PC 2	PC 3	PC 4
1	0.996	–0.07	–0.06	0.02
2	0.994	–0.09	–0.05	0.01
3	0.993	–0.06	–0.09	0.03
4	0.999	–0.02	–0.02	–0.03
5	0.997	–0.16	–0.09	0.06
6	0.996	–0.03	–0.01	0.04
7	0.997	0.00	0.04	0.02
8	0.934	0.25	0.08	0.22
9	0.974	–0.19	–0.04	–0.09
10	0.951	0.28	0.04	–0.07
11	0.954	0.07	0.20	0.01
12	0.977	–0.18	–0.04	–0.01
13	0.856	0.48	–0.17	–0.10
14	0.995	–0.01	–0.03	–0.02
15	0.971	–0.08	0.16	–0.06
16	0.963	–0.01	0.14	–0.11
17	0.987	0.03	–0.04	0.06
18	0.984	–0.12	–0.05	0.01
Explained dispersion of characters, %	94.60	2.80	0.86	0.56

cluded sampling data related to the Upper Kolyma (CBL of males is 84.8 mm and that one of females—77.7 mm) from Magadan oblast (n = 62 animals [9]), which is located from the group of the Middle Kolyma River at the distance 200–220 km. As it is seen from the Fig. 2 the sables of the Upper Kolyma region are much larger ($p_{♂} = 0.0245$, $p_{♀} = 0.0008$) than animals from the Middle Kolyma region.

By the data of V. V. Timofeev and M. P. Pavlov [10] the translocations of animals to the Kolyma basin (n = 548) within Yakutia were realized using both small animals from Bureya basin (CBL of males is 80.15 and females—73.63 mm [9])—which make 38% from the number of animals released, also from Vitim basin (CBL of males is 81.49 and females—74.31 mm)—they make 52.7%—and large Kamchatka sables (CBL

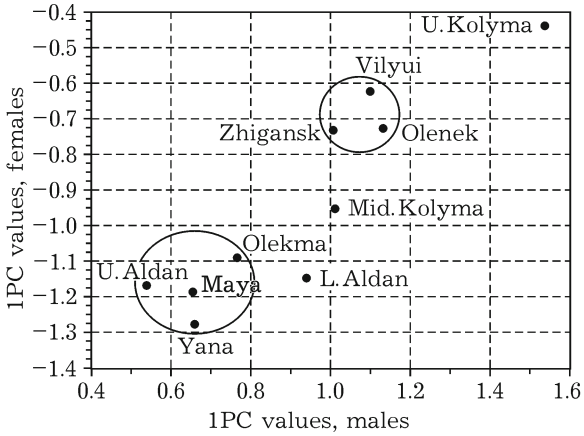

Fig. 1. Location of studied samples in 1PC area for males and females.

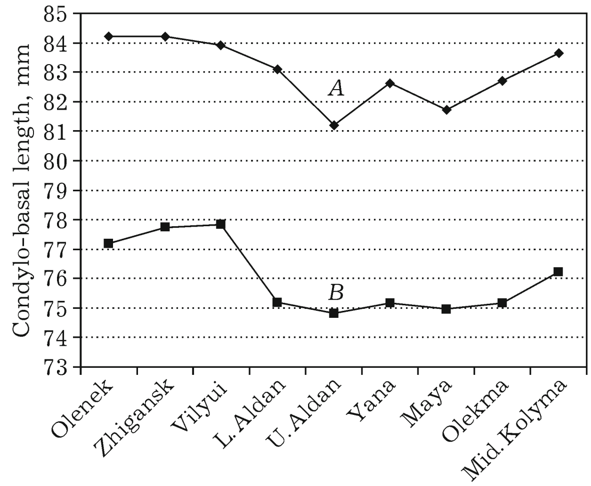

Fig. 2. Condylo-basal skull length of sable males (*A*) and females (*B*) in Yakutia.

of males is 87.86 and females—80.97 mm)—they make 9.3% from animals let out [9]. According to the same information [10] only sables from Bureya basin (n = 361) were released to the Upper Kolyma region. Probably, the main role in livestock formation in the Middle and Upper Kolyma regions was played by setting sables free in 1951–1952 from Yakutian area earlier than translocations to the upper reaches of the basin from the Magadan side in 1953–1958.

Thus, the formation of dimensional structure of Yakutian sable populations took place in the second half of XX century in accordance with origin of animals which took part in their formation. Since the depression period of XIX–XX centuries the left- bank indigenous groups of this species restored their number based on local residual habitation [10, 13]. They remained their morphological appearance which is close to that one of sables from the Yenisei region [9].

The right-bank species populations were formed by large-scale (more than 5 thousand of animals) translocations of sables from the Vitim, Bureya and Kamchatka regions in the middle of XX century which were let go to the free habitats [10]. Their size structure, typical of sables from the Vitim, i.e., the main group of founders-invaders, didn't practically undergo any changes. Groups, consisting of animals of comparatively large size which are close in craniometric parameters to autochthonous sables residing in the left-bank of Yakutia and Kamchatka, have been formed only in the Kolyma River basin under influence of Kamchatka resettlers.

At the same time the animals in introduced populations became somewhat larger than the founders for the time period 30–40 years. By data of V. G. Monakhov [9] the males in the Upper Yana basin exceed in CBL the males from the Vitim basin by 0.27 mm, the males from Maya basin by 0.40 mm, those ones from Olekma—by 0.68 and from the Kolyma—by 3.32 mm, showing a directed morphological trend. It means that rapid changes of morphological and epigenetical structure (in this case the size one) in populations of mammals under anthropogenic impact is a real process what is quite confirmed by effects of the postintroduction period of sables in different regions of the species areal [7, 9, 15, 16], also by formation of races of population-subspecific level. It should be noted that the relative isolation of Yakutian populations surely contributes to the formation of contemporary peculiarities of size structure of native and reintroduced populations.

The analysis of craniometric relations of Yakutian sables has also another aspect, and namely, clearly pronounced sexual distinctions, and especially a sexual dimorphism in size of a skull.

A great number of species of Mustelidae family and *Martes* genus [17, 19–24, 38] was found to have a sexual size dimorphism. In many available publications

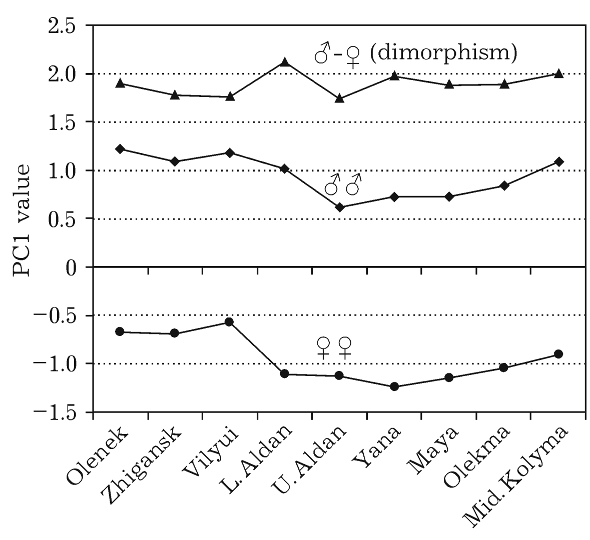

Fig. 3. Distinctions in skull size (PC1) of Yakutian sable males and females.

concerning sables this aspect was touched on only at interpreting the geographical variability and taxonomy [15, 26, 27] as well as in summary reports [5, 28]. Special papers were not devoted to this problem and, possibly, therefore the references to the data on sexual dimorphism of sables are absent in publications of the latest years.

For assessing the degree of distinctions between males and females the formula was used, suggested by O. L. Rossolimo and I. Ya. Pavlinov [29]:

$$I_{SD} = 100\,(X_{♂} - X_{♀})/X_{♀},$$

where I_{SD}—a value (index) of a sexual dimorphism, %; $X_{♂}$ and $X_{♀}$— mean values of characters for males and females. The similar indicator (given sometimes in parts of an unity but not in a percent) is also used in papers of Holmes and Powell [30], A. V. Abramov and I. L. Tumanov [25], V. V. Rozhnov and A. V. Abramov [31]. This indicator as distinct from the other used ones (*t*-criterion, CV) has a small dependence on sampling value. The PC1 score was used also for revealing the distinctions in the complex of characters.

The distinction between sexual groups in the integral characteristics (PC1 score) varied from 1.74 (the Upper Aldan) to 2.12 (the Lower Aldan). Dimorphism indicator was higher than the average one also in the Kolyma region (2.00) and in the Yana river basin (1.97).

The most geographical distinctions in the sexual dimorphism index (Table 3) were found in sables of the Lower Aldan, Kolyma, and Yana regions. Therewith the distinctions were maximum (12% and more) in the facial length (no. 5), teeth length (no. 6), and molar length (no. 7). Distinctions at the level 10–11% were revealed in characters 1, 2, 3, 14, 18. The minimum (6–7%) distinctions between sable males and females proved to be in diameter of foramen magnum (no. 8), width of tympanic bullae (no. 16), braincase width (no. 10) and length of tympanic bullae (no. 9).

Direct estimations of sexual dimorphism of Yakutian sables were absent in the papers of other researchers, however according to the data of V. A. Tavrovskii [13] we have computed I_{SD} using condylo-basal length for three populations in the region: "southern Yakutian" (8.09%), "acclimated" (8.86%) and "western Yakutian" (9,52%) (all these names were given by V. A. Tavrovskii). According to the data from the monograph of G. I. Monakhov and N. N. Bakeev [5] the computed estimations of I_{SD} by the same character (no. 2) proved to be, %: for the Olenek 7.96, the Yana—10.79, the Maya—8.87 and they differed little from the characteristics which we have revealed (Table 3).

The mean level of distinctions for Yakutian sables made 7.99% (see Table 3) what is lower than that one for the Urals populations (9.03) [32]. The average I_{SD} for indigenous Yakutian groups turned to be lower (7.53%) than that one for introduced groups (8.22%).

Table 3. Distinctions between the Yakutian sable males and females (I_{SD}). %

Character	L. Aldan	U. Aldan	Vilyui	Yana	Zhigansk	Mid. Kolyma	Maya	Olekma	Olenek	*X*
1	10.9	8.9	8.6	10.2	8.6	10.1	9.3	10.1	9.4	9.6
2	10.5	8.5	7.8	9.9	8.4	9.7	9.0	10.0	9.1	9.2
3	10.8	8.8	8.4	10.4	8.5	10.3	9.5	10.3	10.2	9.7
4	9.3	7.8	7.9	9.0	8.3	8.8	8.6	9.1	8.5	8.6
5	12.5	8.9	9.4	11.2	9.0	11.0	10.0	10.7	10.4	10.3
6	12.5	9.3	8.4	10.7	10.0	11.1	10.9	11.0	10.2	10.5
7	12.0	8.9	7.7	11.2	9.4	11.3	9.9	10.2	10.3	10.1
8	6.1	3.6	2.7	4.9	2.5	4.7	2.9	2.7	4.0	3.8
9	6.3	6.1	6.6	7.4	6.8	7.2	6.6	7.5	6.4	6.8
10	7.2	6.0	7.2	6.7	6.2	6.7	6.1	6.0	5.7	6.4
11	5.6	5.0	6.4	5.1	5.2	6.4	7.6	6.0	8.0	6.2
12	7.2	6.7	6.9	7.0	7.3	8.2	7.1	8.3	8.0	7.4
13	6.6	5.7	9.5	7.2	5.1	6.1	7.1	6.0	6.8	6.7
14	10.3	8.2	8.2	8.9	7.0	9.1	8.6	8.2	8.6	8.6
15	6.0	7.7	6.0	7.1	9.3	7.2	6.5	6.9	5.3	6.9
16	7.1	5.7	4.4	6.7	6.0	6.2	6.5	5.3	5.9	6.0
17	9.4	7.7	6.3	7.7	7.0	6.8	7.5	8.2	5.9	7.4
18	11.2	9.0	8.7	9.6	8.6	10.5	11.1	9.6	9.1	9.7
X	9.0	7.4	7.3	8.4	7.4	8.4	8.0	8.1	7.9	7.99

We suppose that the sexual dimorphism value can reflect in dynamics the adaptive activity of the population: where it is higher there the "animals–environment" interaction proceeds more intensively. This supposition requires an experimental confirmation.

There are, mainly, two hypotheses concerning the origin of this phenomenon: sexual selection and separation of trophic niches [20, 33–35]. However, their discussion is the subject of a special talk. Nevertheless the differentiation in sizes is a necessary and sufficient result of phylogenesis of mammals, particularly of the *Martes* genus. Such a phenomenon of mammals as sexual dimorphism in sizes enables the populations of the species to respond promptly to habitation changes by adaptive rearrangements in morphology and to use more fully the resources of habitat and life area through the group behaviour [5, 20, 28, 30, 31, 36, 37], also the resource of adaptation at the population level.

This work has been supported by the Siberian Branch and the Urals Branch of the Russian Academy of Sciences (the Integration project 5.20) and the Russian Foundation of Fundamental Research (the Project 07-05-00298).

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