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Identification of the Subgenus *Martes* str. Species (*Martes zibellina*, *M. martes*, *M. foina*, and *M. melampus*; Carnivora, Mustelidae) according to the Mandibular Metric Characteristics

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Abstract—A comparative analysis involving 21 mandibular metric characteristics of *Martes zibellina* (*n* = 114)*, M. martes* (117)*, M. foina* (110), and *M. melampus* (6) has been performed using a graphical method (scatter diagrams) and stepwise discriminant analysis. The best metric characteristics allowing for discrimination between the lower jaws of these species have been identified and used to plot scatter diagrams. The discriminant analysis has been conducted for three groups of characteristics, namely, those of the whole mandible, ramus ascendens, and corpus mandibulae. As a result, optimal statistical models based on the diagnostic characteristics have been constructed and tested. The corresponding classification functions for species identification of whole mandibles and their fragments have been calculated. These results can be used for species identification of the mandibles of *M. zibellina, M. martes, M. foina*, and *M. melampus*.

Keywords: *Martes zibellina, M. martes*, *M. foina, M. melampus*, mandible, morphometric characteristics, discriminant analysis, species identification

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INTRODUCTION

Several representatives of the genus *Martes* live in Northern Eurasia with their distribution areas partially overlapping. In particular, the distribution ranges of the sable (*M. zibellina* L. 1758) and pine marten (*M. martes* L. 1758) overlap in the Urals and Western Siberia; those of *M. zibellina* and the Japanese marten (*M. melampus* Wagner 1841), on the Korean Peninsula and Hokkaido Island; *M. martes* and the beech marten (*M. foina* Erxleben 1777) have a wide sympatric zone in Europe and the Caucasus (Geptner et al., 1967); and the distribution ranges of *M. zibellina* and *M. foina* overlap in Northern China (Smith and Xie, 2008). In the Holocene and historical time, the distribution ranges of part of these species have species displaying a considerable degree of overlapping (Kirikov, 1966; Kosintsev and Gasilin, 2011; Kosintsev et al., in press, 2013). Correspondingly, species identification of the fossils determined as representatives of the genus *Martes* found in potentially sympatric zones is a topical problem.

Species of the extant genus *Martes* representatives are mainly identified according to their skulls (Ognev, 1931; Gaffrey, 1953; Altuna, 1973; Gerasimov, 1985; Reig and Ruprecht, 1989; Loy et al., 2004). Several species-specific characteristics of individual *M. zibellina, M. martes,* and *M. foina* teeth have been proposed (Gimranov, 2011). As for the mandibles, relative (the position of mental foramens relative to *p3* roots; Gaffrey, 1953; Novikov, 1956) and absolute (ratio of the distance between mental foramens and diameter of the lower stomach tooth (Novikov, 1956)) characteristics are used for distinguishing between *M. martes* and *M. foina* and a species-specific characteristic—an acuminated top of the coronoid process (Paaver, 1965)—was found for *M. zibellina.* Note that fossil skulls are very rarely found, whereas mandibles are encountered quite frequently. This makes mandibles a very convenient object for species identification of the *Martes* fossils.

Researchers have already attempted to solve this problem. In particular, Paaver (1965) examined the mandibles of three species (*M. zibellina, M. martes*, and *M. foina*) aiming to find the characteristics appropriate for species identification. He analyzed extant samples and detected several absolute metric characteristics and ratios that allowed for a partial discrimination between these species using scatter diagrams. For identifying *M. martes* and *M. foina*, he used the height and relative height (calculated as the sum of the height of the articular process, *m1* length, and *p1–m2* alveolar length) of the articular process. Note also that this paper has a certain inconsistency in the definition of the relative length of the articular process, namely, the caption to Fig. 11 (Paaver, 1965, p. 123) speaks about the basal length of the coronoid process, whereas the *p1–m2* row alveolar length is indicated in the body text (Paaver, 1965, p. 120). This should be

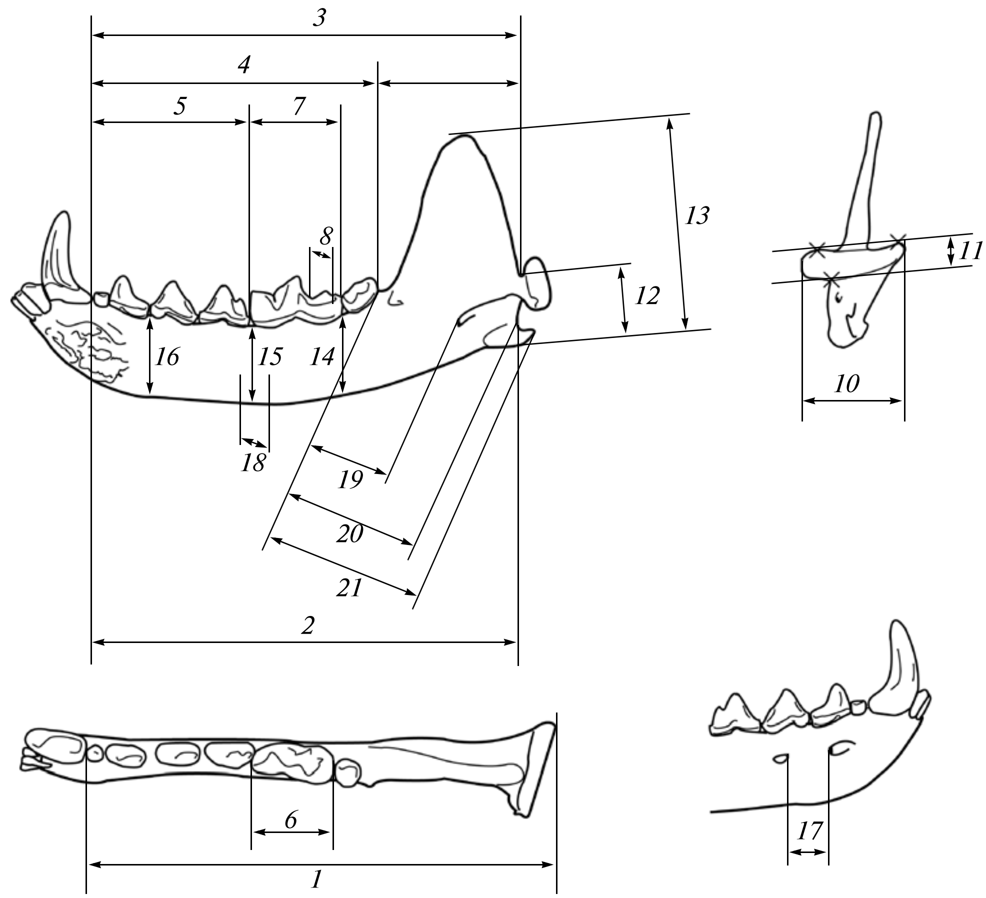

Fig. 1. Scheme of measurements of the mandible for the genus *Martes* species: (*1*) the distance from the anterior margin of the *p1* alveolus to the posterior margin of the articular process; (*2*) distance from the anterior margin of the *p1* alveolus to the posterior notch; (*3*) distance from the anterior margin of the *p1* alveolus to the top of the mandibular notch; (*4*) *p1–m2* alveolar length; (*5*) *p1–p4* alveolar length on the buccal side; (*6*) *m1* alveolar length; (*7*) *m1* crown length; (*8*) *m1* talonid length; (*9*) basal length of the coronoid process (from the posterior margin of *m2* alveolus to the top of the mandibular notch); (*10*) largest width of the articular process; (*11*) largest height of the articular process measured from the line connecting the two most distant points of the upper surface of the process to its lower margin; (*12*) the shortest distance between the top of the mandibular notch to the lower margin of the angular process; (*13*) the height of the ramus ascendens (distance from the top of the coronoid process to the lower margin of the angular process); (*14*) height of the corpus mandibulae behind *m1* on the lingual side; (*15*) height of the corpus mandibulae in front of *m1* on the lingual side; (*16*) height of the corpus mandibulae between *p2* and *p3* on the buccal side; (*17*) distance from the posterior margin of anterior mental foramen to the anterior margin of the posterior mental foramen; (*18*) thickness of the corpus mandibulae in front of *m1*; (*19*) distance from the posterior margin of the *m2* alveolus to the mandibular foramen; (*20*) shortest distance from the posterior margin of the *m2* alveolus to the posterior notch; and (*21*) distance from the posterior margin of the *m2* alveolus to the top of the angular process.

kept in mind when using the characteristic in question. To distinguish between the species *M. zibellina* and *M. martes*, the relative and absolute distances between the mandibular foramen and the posterior border of *m2* alveolus are utilized. When preparing this work, we verified the methods proposed by Paaver for species identification using more representative samples. The obtained results demonstrated the essential limitations of these methods, since the correlation plots constructed using the characteristics in question for both species pairs (*M. martes–M. foina* and *M. zibellina–M. martes*) considerably (by 50 to 80%) overlapped (Gasilin, 2009).

Later, a multivariate technique was applied to differentiate between the species *M. martes* and *M. foina* based on craniological characteristics, including mandibular measurements: they used a discriminant analysis of a set comprising seven measurements of 27 *M. martes* individuals and 27 *M. foina* individuals from Bulgaria to obtain two classification functions (Gerasimov, 1983, 1985). As we see it, other limitations in the applicability of this work are in the small sample size collected from the same geographical area; insufficient size of the initial set of characteristics; involvement of the characteristics measured from the intermaxillary, frequently damaged in subfossil specimens; and utilization of the cuspid tooth length as a diagnostic characteristics, since it is likely to be associated with sex.

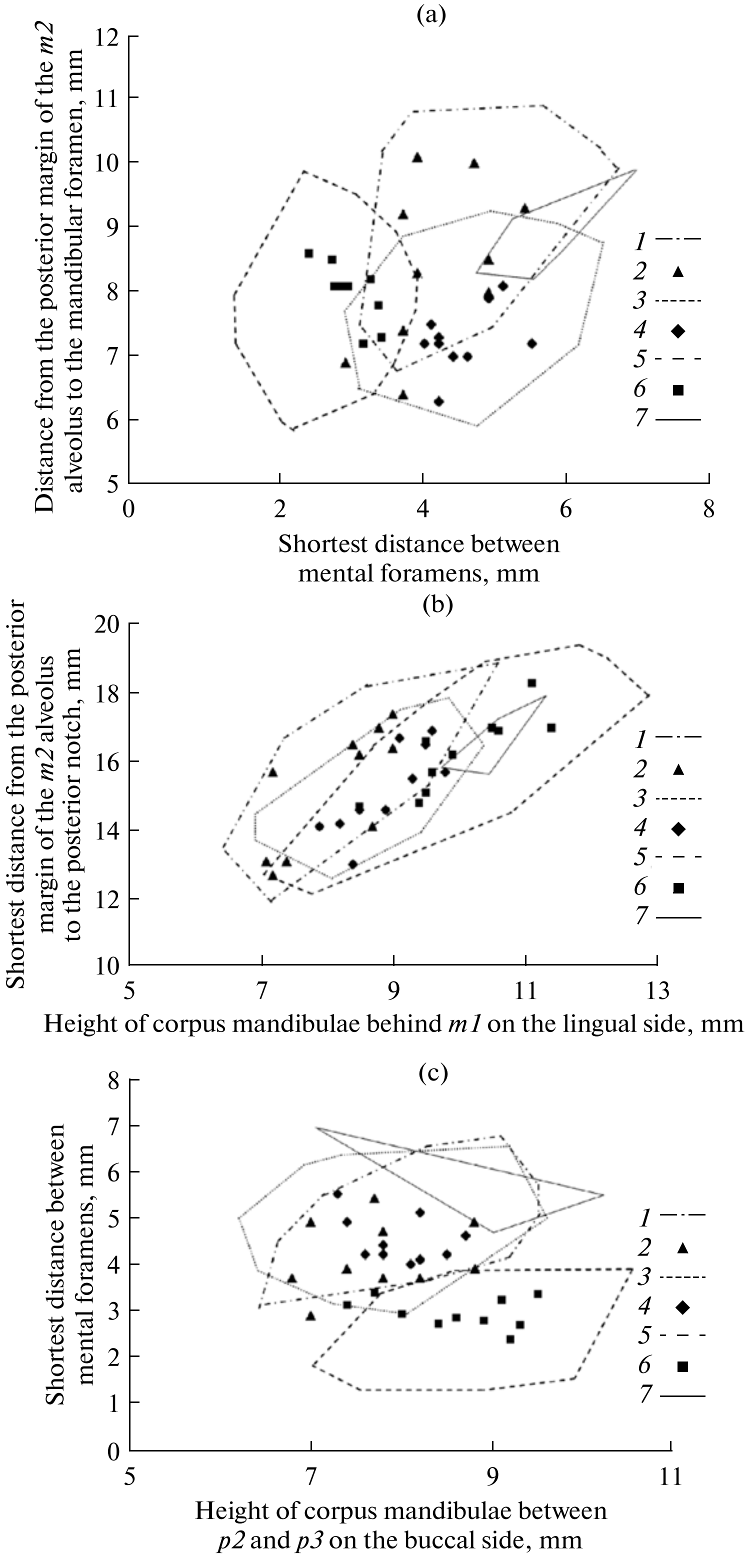

Fig. 2. Distributions of absolute values of mandibular characteristics for the genus *Martes* species: (*1*) distribution of values for *M. zibellina* characteristics; (*2*) test sample for *M. zibellina*; (*3*) distribution of values for *M. martes* characteristics; (*4*) test sample for *M. martes*; (*5*) distribution of values for *M. foina* characteristics; (*6*) test sample for *M. foina*; and (*7*) distribution of values for *M. melampus* characteristics.

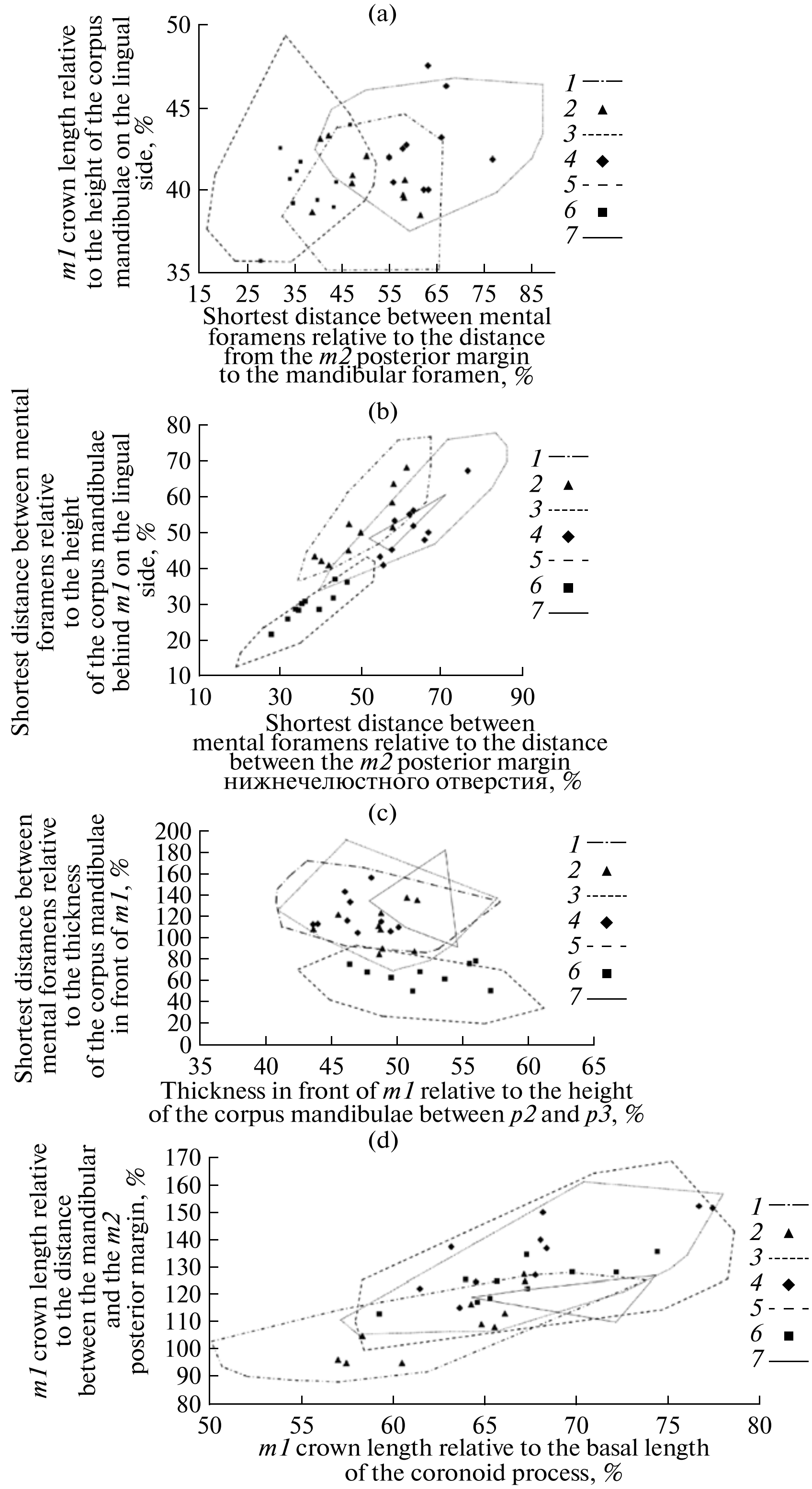

Fig. 3. Distributions of relative values of the mandibular characteristics for the genus *Martes* species; see Fig. 2 for designations.

Thus, there are currently no sufficiently reliable methods for species identification of the genus *Martes* representatives according to their fossils, including the most appropriate object for identification, their mandible. The goal of this work was to improve the method for species identification of the *Martes* representatives using metric mandibular characteristics.

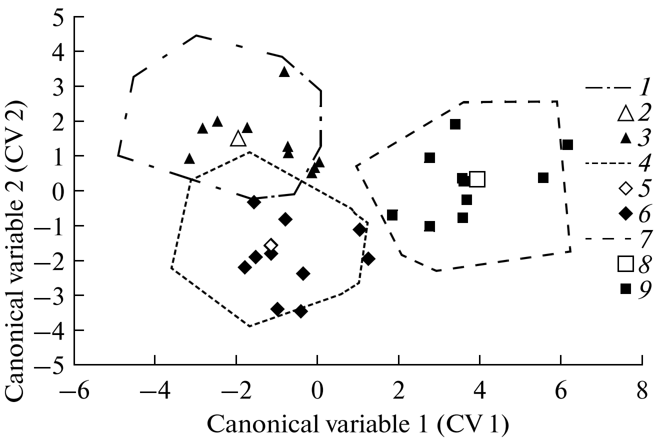

Fig. 4. Results of canonical analysis of the mandibular shape and size in the genus *Martes* species: (*1*) distribution area for *M. zibellina*; (*2*) centroid for *M. zibellina*; (*3*) test sample for *M. zibellina*; (*4*) distribution area for *M. martes*; (*5*) centroid for *M. martes*; (*6*) test sample for *M. martes*; (*7*) distribution area for *M. foina*; (*8*) centroid for *M. foina*; and (*9*) test sample for *M. foina*.

MATERIALS AND METHODS

The data obtained by measuring approximately similar samples of the right and left mandibles of extant individuals of both sexes belonging to the species *M. zibellina* from the Northern Urals and Primorye (n = 114; 54 females and 60 males), *M. martes* from Eastern Europe, the Caucasus, and the Southern Urals (n = 117; 57 females, 59 males, and one individual of unknown sex), *M. foina* from different parts of its distribution range (n = 110; 44 females, 40 males, and 20 animals of unknown sex), and *M. melampus* from Japan (n = 6; three males and three animals of unknown sex) from the collections of the zoological museums of Moscow State University (Moscow, Russia), the Zoological Institute of the Russian Academy of Sciences (St. Petersburg, Russia), and the Institute of Plant and Animal Ecology, Ural Branch, Russian Academy of Sciences (Yekaterinburg, Russia) were used in this work. All examined mandibles belonged to adult animals. The specimens with abnormalities and damage were discarded from analysis.

For each mandible, 21 characteristics were measured (Fig. 1) and an incomplete set of characteristics was measured for some *M. foina* mandibles lacking the second mental foramen. The characteristics proposed by Paaver (1965), which in our numbering are characteristics 4, 5, 7, 9, 12, 13, 15, 16, 19, and 21, as well as characteristics 17 and 10, proposed by Novikov (1956) and Gerasimov (1983, 1985), respectively, are original characteristics 1–3, 6, 8, 11, 14, 18, and 20. Characteristics 1 and 2 were measured on the lateral part of the mandible, so that the corpus mandibulae was oriented in parallel with the axis of the caliper scale, and characteristic 11 was measured with fixing of the articular process between the caliper jaws (Fig. 1).

The characteristics were measured accurate to 0.1 mm using electronic calipers. The data were analyzed with the help of the Statistica 6.0 software package.

Two main techniques—graphical and multivariate analyses—were used to estimate the species specificity of the characteristics aiming to detect those most diagnostically significant. The graphical analysis was given as scatter diagrams, and the second method was stepwise discriminant analysis with forward and backward stepping. The obtained results are intended for identification of fossil specimens; correspondingly, both whole mandibles (a complete set of characteristics) and their fragments were analyzed. The fragments were frequently represented by corpus mandibulae or ramus ascendens, for which the corresponding (incomplete) sets of characteristics were used.

Scatter diagrams for identification of the genus *Martes* species were constructed using the characteristics that could be measured in fragmented mandibles. Three plots were built for the absolute values of the characteristics. To avoid errors in species identification of fossil specimens associated with a century-scale variation in the total sizes, four plots were constructed using only absolute values (indices). The data for three samples of the *M. zibellina* (n = 10), *M. martes* (n = 10), and *M. foina* (n = 10) mandibles randomly selected from the initial samples were used as test groups for the obtained distribution areas of the values for the corresponding species. In some cases, individual specimens of test samples fell beyond the outlines of the main samples. When using these plots for species identification, the outlines should be expanded to the corresponding points of the test samples and a probabilistic character of the identification technique should be taken into account.

Three sets of characteristics were used for multivariate analysis, namely,

(1) The complete set of 21 characteristics for the whole bone;

(2) A reduced set of eight characteristics (9–13 and 19–21) for ramus ascendens; and

(3) A reduced set of ten characteristics (4–8 and 14–18) for corpus mandibulae.

The sets of characteristics were used to discriminate between species within different groups. The compositions of these groups are determined by the fact that the distribution ranges of the corresponding species are or were sympatric or parapatric. To distinguish between the three continental species (*M. zibellina, M. martes*, and *M. foina*), we used the complete set of characteristics as well as both reduced sets. The reduced sets were also used for the species pairs *M. zibellina–M. martes*, *M. zibellina–M. foina*, *M. zibellina–M. melampus*, and *M. martes–M. foina*. A sample of sables from Primor'e was used for analyzing the pair *M. zibellina–M. melampus* as the closest to the *M. melampus* distribution area.

To find the most informative characteristics and use them for classification, we applied stepwise discriminant analysis with addition of characteristics using the complete set as well as with addition and exclusion using two reduced sets. Duplication of analysis allows for a more reliable identification of the species according to mandibles. The a priori probability for discrimination was assumed equal for the groups; the lower tolerance limit was set at 0.01; and the values of F statistics for adding and excluding characteristics were assumed amounting to 1.00 and 11.00, respectively (Kim et al., 1989).

The statistical models for classification were validated with the help of test samples of mandibles (see above) initially not included into training groups. As a result, all the specimens in the test samples were identified correctly. The initial samples (training groups) for each model were randomized to obtain simple random samples amounting to 20, 30, and 40% of the initial ones. The rate of correct identification in these samples was 76–100%.

RESULTS AND DISCUSSION

The absolute values of mandibular characteristics in the studied species considerably transgressed, which hindered their application in species identification. Therefore, graphical and multivariate methods have been used for this purpose.

Graphical Methods

The characteristics selected as appropriate for distinguishing between species with the help of scatter diagrams display different "resolving power." As is evident from Figs. 2 and 3, the ranges of values for *M. zibellina, M. martes*, and *M. melampus* considerably overlap, while the range of *M. foina* is frequently considerably shifted relative to them. *M. foina* and *M. zibellina* are most pronouncedly differentiated, displaying gaps or small transgressions (Figs. 2c, 3b, 3c). The best studied characteristic appropriate for distinguishing *M. foina* is the shortest distance between the mental foramens (characteristic 17), which is minimal in this species (Figs. 2a, 2c, 3a–3c). The characteristics based on the height (characteristics 14–16) and thickness of the corpus mandibulae, which among the examined species are maximal in *M. foina*, display a lower discrimination ability (Figs. 2b, 2c, 3a–3c, respectively). The best diagnostic characteristics for *M. zibellina* are the distance from the posterior border of *m2* alveolus to the mandibular foramen (characteristic 19) and the basal length of the coronoid process (distance from the *m2* posterior border to the top of the mandibular notch; characteristic 9). The first characteristic displays its minimal absolute and relative values in the sable (Figs. 2a, 3a, 3b, respectively), and the second one, its maximal relative values (Fig. 3d). The characteristic discriminating *M. martes* well from the other species is the distance between the *m2* posterior border and the mandibular foramen (characteristic 19), which takes on the minimal relative values in the pine marten (Figs. 2a, 3a, 3b, respectively). The small size of the sample for *M. melampus* mandibles still prevents us from determining which characteristics are species-specific. However, even a small sample evidently demonstrates that some characteristics (for example, 14, 16, and 17) may have an important diagnostic value. These characteristics allow the Japanese marten to be distinguished from the sable (Figs. 2a–2c, 3b–3d), i.e., species that have overlapping distribution ranges, and from the beech marten (Figs. 2a, 2b, 3a–3c), which have adjacent distribution ranges.

Discriminant Analysis

The stepwise discriminant analysis with the addition of characteristics at a specified F value suggested excluding characters 4 and 1 from the initial set. The rate of correct identification in this case appeared to be rather high (Table 1).

The first function enhances differentiation of *M. foina* from the other species, and the second one distinguishes *M. zibellina* (Fig. 4).

Judging from the standardized coefficients (Table 1), the major contributors to the first function are characteristics 1, 19, and 20, which together describe the mandibular length, while characteristics 1, 2, 8, 10, and 13, which describe mandibular sizes in three dimensions, contribute to the second function. We have used part of these characteristics when constructing scatter diagrams (Fig. 2).

In addition to the classification functions, Table 1 lists the raw coefficients of canonical functions and the corresponding constants, which provide for calculating the coordinates for the studied specimens relative to the axes of canonical functions using the set of 19 characteristics (Fig. 4). Each of the coordinates is calculated as a sum of the constant and all products of the measured characteristics for a specimen by the raw coefficients listed in Table 1.

The significant characteristics and the corresponding classification function coefficients in the models constructed according to two reduced sets of characteristics for the mandibular fragments of the groups comprising different species are listed in Tables 2 and 3. As is evident, the probability of identification according to the corpus mandibulae is higher as compared with the ramus ascendens.

Analysis of the standardized coefficients (not shown) has demonstrated that the major contributors to discrimination between *M. zibellina, M. martes*, and *M. foina* based on the corpus mandibulae (Table 2) are the characteristics measured in all three projections; as for the identification based on the ramus ascendens, these are the characteristics associated with the length (measured from the posterior margin of the *m2* alveo-

Table 1. The coefficients for canonical and classification functions according to 19 mandibular characteristics of *M. zibellina*, *M. martes*, and *M. foina*

Characteristic	Coefficients for canonical functions				Coefficients for classification functions		
	standardized		raw				
	1	2	1	2	z	ma	f
1	**0.84**	**–1.46**	0.31	–0.53	7.39	9.30	9.81
2	–0.28	**1.49**	–0.11	0.57	5.13	3.28	3.85
3	–0.37	0.42	–0.14	0.16	–1.68	–2.27	–2.67
5	–0.59	–0.40	–0.63	–0.43	10.33	11.14	7.09
6	–0.18	–0.25	–0.20	–0.30	–2.46	–1.71	–3.32
7	0.34	–0.16	0.55	–0.27	7.96	9.26	11.54
8	–0.43	**–0.78**	–1.56	–2.84	2.89	10.42	–3.01
9	–0.62	0.23	–0.50	0.18	–0.38	–1.37	–3.54
10	–0.12	**0.87**	–0.14	1.03	1.30	–2.00	–0.71
12	0.27	–0.22	0.47	–0.37	11.50	13.04	14.71
13	0.00	**0.67**	0.00	0.41	–4.49	–5.76	–4.98
14	0.39	–0.46	0.48	–0.57	–11.99	–9.82	–8.50
15	0.32	–0.06	0.46	–0.09	–14.44	–13.76	–11.58
16	–0.02	0.45	–0.02	0.72	5.02	2.78	4.05
17	–0.62	–0.24	–0.88	–0.35	2.85	3.20	–1.96
18	0.56	0.14	1.61	0.39	1.41	1.53	10.46
19	**–0.73**	0.61	–0.92	0.76	8.96	5.82	2.65
20	0.65	–0.52	0.50	–0.40	–14.81	–13.17	–11.43
21	0.22	–0.47	0.16	–0.35	2.87	4.08	4.22
Constants			1.12	2.63	–229.02	–235.25	–229.02
Eigenvalues			6.24	1.79	Rate of correct identification, %		
Explained variance			0.78	1.00	93.1 $n = 102$	94.3 $n = 107$	98.8 $n = 80$

The highest contributions of characteristics to canonical function are boldfaced; z, *M. zibellina*; ma, *M. martes*; and f, *M. foina*.

lus) and one width characteristic (the width of the articular process). The characteristics describing the height of the corpus mandibulae also contribute to discrimination between species pairs (Table 3). This is associated with the fact that their values for *M. foina* and *M. melampus* are on average higher as compared with those for *M. zibellina* and *M. martes*. The species discrimination according to the ramus ascendens is associated with the characteristics measured from the *m2* posterior border. The differences between *M. zibellina* and *M. martes* in all groups are the least pronounced.

Species identification of a mandibular specimen using one of the sets is performed after calculating classification functions S_i (in the first case, the number of species $i = 3$ and in the remaining cases, $i = 2$), that is, the sum of the constant and products of the corresponding measured characteristics by the classification function coefficients listed in Tables 1 and 2:

$$S_i = x_1 \Sigma c_{1i} + x_2 \Sigma c_{2i} + \dots x_n \Sigma c_{ni} + C_i,$$

where x_n is the value of the nth characteristic in the studied specimen; c_{ni} is the coefficient for the nth characteristic in the studied species; and C_i is the constant for the function of the ith type. A specimen is ascribed to the species with the highest value of the S_i function.

It is recommended to identify the species of the examined mandibular specimens of the genus *Martes*

Table 2. Classification functions and the rate of correct identification according to the sets of characteristics for the corpus mandibulae and ramus ascendens of *M. zibellina*, *M. martes*, and *M. foina*

Characteristic	Forward stepwise			Backward stepwise		
Characteristic for corpus mandibulae	z	ma	f	z	ma	f
4	10.67	9.69	11.00	–	–	–
5	9.63	10.38	6.43	19.72	19.43	17.16
6	–1.21	–0.03	–0.87	1.79	2.93	2.67
7	4.61	5.64	7.56	–	–	–
8	–1.81	4.81	–7.98	14.57	21.40	11.56
14	–11.81	–11.04	–9.04	–11.20	–10.81	–7.99
15	–6.43	–7.78	–6.40	–	–	–
16	4.83	2.68	3.96	5.18	2.09	4.45
17	2.64	2.93	–2.30	3.21	3.44	–1.68
18	2.88	1.72	11.59	–2.90	–3.98	5.65
Constant	–200.26	–206.93	–201.00	–173.67	–181.58	–168.66
Rate of correct identification, %	84.3	86.9	97.6	84.3	84.1	97.6
Number of specimens, *n*	101	110	80	103	107	81
Characteristic for ramus ascendens						
9	4.00	2.68	0.98	4.95	3.74	1.96
10	5.99	4.37	6.25	6.80	5.62	7.41
11	1.34	4.17	3.93	–	–	–
12	9.13	10.15	13.29	10.41	12.35	15.34
19	1.06	–2.32	–3.72	1.70	–1.42	–2.88
20	–5.50	–3.97	–2.60	–2.33	–0.07	1.01
21	4.98	6.08	5.62	–	–	–
Constant	–102.36	–96.86	–117.84	–100.12	–93.31	–114.79
Rate of correct identification, %	82.7	78.3	82.3	81.7	74.5	84.4
Number of specimens, *n*	99	117	90	100	112	94

See Table 1 for designations.

using, to the degree possible, a number of methods, for example, scatter diagrams for the absolute and relative values of characteristics and several statistical models.

CONCLUSIONS

Mandibular morphometric characteristics of the representatives of the genus *Martes* species has been analyzed using several techniques, which has demonstrated feasibility of their species identification according to mandibles. Whole mandibles allow their species to be identified with a high probability, while fragments of mandibles provide a lower probability. The specimens displaying the sizes close to extreme values of the corresponding characteristics can be identified with a sufficient reliability. The beech marten displays the most pronounced individuality in the size and shape of its mandible and, thus, can be most reliably identified according to several absolute and relative characteristics as well as a set of characteristics. The sable and pine marten are distinguished according to most absolute and relative characteristics but to a somewhat lesser degree. The values and proportions of their mandibles display considerable transgression regions. The conducted analysis has shown the feasibility of species identification of the Japanese marten according to the mandibular measurements. However, a more distinct result is obtainable when using a larger *M. melampus* sample.

Table 3. Classification functions and the rate of correct identification according to the sets of characteristics for the corpus mandibulae and ramus ascendens in the paired samples *M. zibellina*, *M. martes*, *M. foina* and *M. melampus*

Characteristic	Forward stepwise		Backward stepwise		Forward stepwise		Backward stepwise		Forward stepwise		Backward stepwise		Forward stepwise		Backward stepwise	
Characteristic for corpus mandibulae	z	ma	z	ma	z	f	z	f	z	me	z	me	ma	f	ma	f
4	8.44	7.14	–	–	–	–	–	–	15.78	–12.42	22.52	7.58	14.19	15.29	–	–
5	9.59	10.59	–	–	20.24	17.72	15.46	13.66	16.77	29.85	–	–	8.86	4.85	21.65	19.34
6	–0.57	0.71	0.08	1.26	–3.13	–1.50	10.13	13.76	–	–	–	–	–	–	–	–
7	7.24	8.15	–	–	18.27	20.88	–	–	12.13	32.85	–	–	3.23	4.75	–	–
8	–7.12	1.79	33.05	41.11	–2.02	–7.09	–	–	–134.54	–84.11	–49.67	9.09	15.38	2.19	32.80	22.23
14	–11.74	–10.86	–	–	–12.64	–10.40	–	–	–13.87	5.01	–3.80	12.88	–8.44	–6.54	–9.00	–5.68
15	–4.18	–5.93	–	–	–	–	–	–	–10.77	–39.75	–	–	–10.35	–8.42	–	–
16	4.40	1.33	11.05	6.94	–	–	–	–	70.98	82.51	–	–	–	–	–	–
17	2.20	2.63	–	–	0.58	–5.20	0.17	–5.54	–11.16	8.42	–2.63	15.66	6.18	1.05	6.84	1.86
18	–	–	–	–	1.23	7.74	–6.70	0.00	–12.52	22.45	–	–	–5.18	4.27	–10.93	–0.97
Constant	–173.88	–179.93	–105.54	–114.77	–184.11	–189.38	–163.13	–174.69	–284.88	–379.61	–194.67	–243.07	–253.77	–235.01	–202.83	–176.25
Rate of correct identification, %	83.3	87.9	83.7	85.0	100.0	98.8	100.0	98.8	100.0	100.0	100.0	100.0	100.0	97.6	100.0	97.6
Number of specimens, *n*	98	111	103	108	103	81	103	83	17	4	17	4	109	80	109	80
Characteristic for ramus ascendens																
9	1.56	–0.26	–	–	3.24	0.55	3.93	1.20	–6.83	–23.57	–4.50	–13.43	4.19	2.44	4.36	2.69
10	4.04	2.29	4.30	3.00	–	–	–	–	2.60	–4.52	–	–	3.88	5.49	4.56	6.45
11	10.48	13.88	16.10	19.60	7.96	10.48	–	–	33.74	52.94	–	–	–	–	–	–
12	–	–	–	–	7.58	11.53	11.00	15.75	6.99	17.94	–	–	10.40	13.60	10.95	14.04
13	4.30	4.63	–	–	–	–	–	–	–9.36	–17.09	–	–	–	–	–	–
19	2.80	–0.51	2.30	–1.20	–1.06	–5.62	0.34	–3.97	–8.67	–17.59	–	–	–2.05	–3.65	–	–
20	–5.05	–3.73	–	–	–4.43	–1.66	1.45	4.88	5.57	23.15	–	–	–5.15	–3.41	–	–
21	4.17	5.78	4.80	6.40	7.45	8.16	–	–	26.79	41.16	20.83	31.53	6.67	6.00	–	–
Constant	–107.65	–101.65	–99.40	–93.40	–90.06	–106.70	–82.61	–96.95	–159.05	–256.00	–140.10	–201.26	–96.79	–115.94	–93.17	–112.20
Rate of correct identification, %	82.7	89.6	81.7	89.6	94.2	96.9	95.2	94.8	100.0	100.0	100.0	83.3	90.6	85.4	90.6	84.4
Number of specimens, *n*	97	113	96	114	101	99	104	96	17	6	17	5	110	92	111	91

See Table 1 for designations.

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