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IDENTIFICATION OF HUNGARIAN MUSTELIDAE AND OTHER SMALL CARNIVORES USING GUARD HAIR ANALYSIS

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The characteristics of the guard hairs of all the mustelids in Hungary and *Vulpes vulpes* and *Felis silvestris* were examined for diagnostic characters. The analysis of hair samples taken from guts, scats, burrows, nests and bait sites can serve as an easy and quick method for faunistic research. The difficulties of hair determination are the similar appearance, overlapping characters and often the low number of samples, but some relevant characters of hair could be used to develop more detailed and specific identification. Otter and Badger differ markedly from the other mustelids while separating the hair of the other six species living in Carpathian Basin (Polecat, Steppe Polecat, Stoat, Weasel, Pine Marten and Stone Marten) demanded statistical analysis. Separating the two "twin-pairs" of species (Stoat and Weasel, Polecat and Steppe Polecat) is not probable by this technique.

Key words: small carnivores, Mustelidae, hair, identification, Carpathian Basin

INTRODUCTION

There are eight species of Mustelidae in the Carpathian Basin, all indigenous: Weasel (*Mustela nivalis*), Stoat (*Mustela erminea*), Polecat (*Mustela putorius*), Steppe Polecat (*Mustela eversmannni*), Stone Marten (*Martes foina*), Pine Marten (*M. martes*), Badger (*Meles meles*) and Otter (*Lutra lutra*). The European Mink (*Mustela lutreola*) is only a rare, lonely rambling (UJHELYI 1994). Mustelids are regarded as important top predators, because the Wolf (*Canis lupus*) and Lynx (*Lynx lynx*) are scarce, though their gradual return to the fauna is occurring through to their natural re-expansion. Although these sympatric carnivores prefer different habitats and foods, they often share the same area. Earlier publications have shown a lack of reliable information about the occurrence, home range, the population dynamics, distribution trend of these species (BÁLDI *et al*. 1995, DEMETER 1984). It is also important to note that the ecological drivers change for these species, as does the extent and general perception of damage caused by them. In recognition of these problems monitoring projects were initiated with the objective of facilitating the development of appropriate protection and management practices. The gradation of some Rodentia may cause the increase of small carnivores (SZEMETHY *et al*. 2000). The proceeding surveys used the methods of live-trapping with the food

analysis from scats and stomach contents (LANSZKI *et al.* 1999). Valuable information obtained from hunters in the study region was also incorporated. Preliminary results indicate an increase in the number and range of *Meles meles* and *Martes foina*. Both of them frequent the rural as well as the urban environment. Badgers will steel eggs and chickens of partridges and pheasants fledglings and often rifle the maize-fields (SZEMETHY *et al*. 2000). Stone Martens find its food and make dens in urban environment perfectly (TÓTH 1998, 2000). Data are most limited and inconclusive on the *Mustela eversmanni, M. erminea* and *Martes martes*. All of them have disjunct populations within Hungary area. Their damage caused is rather neglible, even though Pine Marten often pillage the nest of protected tree nesting birds. *Mustela eversmanni, M. erminea* and *Martes martes* are protected. *Lutra lutra* has strictly protected status in Hungary. Thanks to successful protection and management programs and natural distribution, the number of Otters has been increasing (Gera 1998). Other Hungarian small carnivores populating the Carpathian Basin are Red Fox (*Vulpes vulpes*), Jackal (*Canis aureus*), Racoon Dog (*Nyctereutes procyonides*) and Wild cat (*Felis silvestris*). They often occupy each others' abandoned burrows. Hair traces and other tracks left behind can reveal the identity of the occupants. Jackal, Racoon Dog and the recently emerging, adventurous Racoon have coarse, long guard hair with black or dark brown marks at the tip and the base. Thus this study only covered the comparative analysis of the Wild Cat and Red Fox, and does not address the problem of incorrect identification as a result of mistaken domestic cat (*Felis catus*), dog (*Canis familiaris*), feral (*Mustela furo*) or their hybrids.

The three layers of the hair are the cuticula, cortex and the medulla. Their morphological characters may provide data for statistical analysis. Intact guard hair can yield a lot of valuable information. According to international experience it is the adults' dorsal guard hair that reveal the most clues. There can be, however, significant variations that occur as a function of the age of the hair sample, the part of the body the sample originates from, the age and condition of the animal and season. As a consequence, analysis based on one or a few samples will only provide a limited level of confidence. It is still being debated whether hair characteristics are distinct enough to play a role in taxonomy. It is recognised however that some parameters or their combinations show specific or generic trends and often reveal genetic, phylogenetic and other morphometric information (KENNEDY 1982, CHAKRABORTY 1998, MCDANIEL 2000, MOWAT & STROBECK 2000). The objective here is to develop keys to the identification of mustelids living in the Carpathian Basin through hair analysis, while also identifying overlapping characters which may lead to the incorrect identification of species.

MATERIALS AND METHODS

Hairs were gathered mainly from specimens deposited in the Department of Zoology of the Hungarian Natural History Museum. The fundamental selection criteria were species identity and source of collection. Specimens derived from different parts of Hungary. The study series included a minimum of five individuals of each species with 20 randomly selected guard hair samples taken from each individual. This brought the number of samples for each species to 100.

The samples were cleaned in 60% alcohol then ether to free them of grease and dust. The cuticular preparations were made in about 20% gelatine with thymol preservative. Canada balm was used for the permanent medullar slides. The applied methods and the nomenclature of cuticular, medullar and cross-section patterns were based mainly on TEERINK (1991). Some relevant expressions were also adopted from MOORE *et al*. (1974).

Macro- and microscopic investigations were carried out on the samples using sections and impressions. The standard magnification of photographs was 400 times. The measurements were taken by ocular micrometer or using Windows Winimag in order to get more precise results in micrometer. The resulting data were then used to develop quantitative and qualitative keys of identification.

Due to the relatively small number of samples, the frequent occurrence of extreme values and high variances it was decided to use SPSS Non-parametrical, independent statistics. The SPSS Hierarchical Cluster Analysis was used to develop Dendrograms representing Average Linkage as a function of length (l), maximal diameter (d), medulla/total, maximal diameter ratio at thickest part of shield (m/d) between the ten small carnivore species investigated. The Mann–Whitney statistical test was used to compare the mean value of characters.

Qualitative analysis of characteristics

Qualitative data descriptive characteristics were used:

- The colour of the tip: MOORE *et al* (1974) defined the tip as the opposite of the basal part of hair, KENNEDY (1981) interpreted it as the region most distal from the basal part of the hair and has one proximal colour demarcation. TEERINK (1991) used the expression 'tip' mainly for the most distal zone from the base without medulla. The exact measurement of length of this region is difficult, because it often shows a gradual transition, nevertheless, colour is regarded important.
- The number of bands. MOORE *et al*. (1974) defined the band as the region of the hair that shows distinct proximal and distal colour bands.
- The pattern of cross- section of thickest part of shield. The methods were given previously (MATHIAK 1938, KENNEDY 1981, TEERINK 1991). Making cross-sections is a problem since the exquisite fixation of hair is difficult. Hair often curve, giving deformed contours, so require a lot of samples and cutting. Another method was probed fitting the hair in the middle of elderpith or other flexible twigs. After freezing (or without it) samples were cut by razors. This method has the same problem but easy to apply for field works.
- The pattern of cuticula and medulla of shaft (the proximal part of the hair = near to the base of hair).
- The pattern of cuticula and medulla in the transitional part between the shaft and shield.
- The pattern of cuticula and medulla in the shield (the distal part of the hair = near to the tip of hair).

Table 1. Descriptive characteristics of hair of mustelids and mistakable species (Red Fox and Wild Cat). (The denomination of "Brown" mean the different tints of this colour may occur at every species included: the greyish, reddish and tawny tints)

Species	Colour of the hair	Colour of tip	Colour of base	No. bands	Cuticula of shaft	Cuticula of transitional part	Cuticula of shield	Medulla of shaft	Medulla of transitional part	Medulla of shield	Medullar margins	Cross-section
1. *Mustela erminea*	Brown	Brown	Brown	0	Pectinate and diamond petal	Regular distant wave and mosaic (Fig. 3)	Close, regular wave	Unicellular ladder (Fig. 5)	Irregular unicellular ladder	Cloisonné	Scalloped	Oval or oblong
2. *Mustela nivalis*	Brown	Brown	Brown	0	Pectinate and diamond petal	Mosaic and elongate petal	Irregular or regular wave	Unicellular ladder	Unicellular, irregular ladder	Cloisonné	Scalloped (Fig. 6)	Oval or oblong
3. *Mustela eversmanni*	Brown	Black, dark brown	Yellow, white, light-brown	0	Pectinate (Fig. 1) and diamond petal	Mosaic	Irregular or regular wave	Unicellular ladder	Irregular uni-, or multicellular	Cloisonné	Scalloped	Oblong
4. *Mustela putorius*	Brown	Black, dark-brown	White, light-brown	0	Diamond petal	Mosaic	Irregular or regular wave	Unicellular ladder	Irregular multicellular	Cloisonné	Scalloped	Oblong
5. *Martes martes*	Brown	–	–	0	Diamond petal	Mosaic	Mosaic and close, regular wave	Unicellular ladder	Irregular multicellular	Cloisonné	Scalloped	Oval or oblong
6. *Martes foina*	Brown	Brown	Brown	0	Diamond petal	Mosaic and regular wave	Close, regular wave	Unicellular ladder	Multicellular	Cloisonné (Fig. 7)	Scalloped	Oval or oblong
7. *Meles meles*	White with black or dark-brown band	White	White	1	Intermediate regular wave	Regular wave and mosaic	Close, regular and irregular wave	Amorphous	Amorphous	Amorphous with differently shaped cells	Straight or fringed-like	Oblong

Table 1 (continued)

Species	Colour of the hair	Colour of tip	Colour of base	No. bands	Cuticula of shaft	Cuticula of transitional part	Cuticula of shield	Medulla of shaft	Medulla of transitional part	Medulla of shield	Medullar margins	Cross-section
8. *Lutra lutra*	Brown, rarely white or light-brown with a brown band in the shield	Light-brown, rarely white	Light-brown, rarely white	0–1	Pectinate and diamond petal (Fig. 2)	Broad petal, irregular wave and mosaic	Close, regular wave (Fig. 4) and petal	Irregular unicellular ladder	Unicellular ladder with wide cells	Wide unicellular	Straight or scalloped	Elongated oblong
9. *Vulpes vulpes*	Brown with white band	Fulvous, brown	Black, dark-brown	0–1	Broad petal and mosaic	Irregular wave	Close, irregular wave	Multicellular ladder	Irregular multicellular ladder	Cloisonné-like with rounded or oval cells (Fig. 9)	Straight,or fringed	Rounded
10. *Felis silvestris*	Brown with bands, bands are white, yellow or brown	Dark-brown	Dark-brown	0–1–2	Regular wave and mosaic	Mosaic and regular wave	Close, irregular wave	Irregular, uni-multi-cellular	Irregular uni-multi-cellular	Irregular mulicellular with narrow spindle-like or large cells	Fringed (Fig. 10) or scalloped	Rounded or oblong

Table 2. The length (l), maximal diameter at shield (d) and ratio of medulla and diameter at shield (m/d) of the studied small carnivores (the given l, d and m/d values are mean value of 20 hairs of the same specimens)

Mustela	*erminea*	*nivalis*	*erminea*	*nivalis*	*erminea*	*nivalis*
	l	l	d	d	m/d	m/d
1.	15	7	110	110	0.7	0.8
2.	22	6	115	92.5	0.787	0.772
3.	9.5	9	117.5	87.5	0.79	0.71
4.	9	8	92.5	92.5	0.804	0.78
5.	14	10	97.5	100	0.77	0.7
Mean	13.9	8	106.5	96.5	0.7702	0.7524
Variance (sd)	5.24880	1.58113	10.9829	8.76783	0.04106	0.04459
Mustela	*eversmanni*	*putorius*	*eversmanni*	*putorius*	*eversmanni*	*putorius*
	l	l	d	d	m/d	m/d
1.	35	45	82.5	120	0.742	0.71
2.	38	37	112.5	130	0.69	0.7
3.	36	30	100	90	0.7	0.785
4.	45	40	115	142.5	0.91	0,.6
5.	42	41	87.5	135	0.8	0.78
Mean	39.2	38.6	99.5	123.5	0.7684	0.747
Variance (sd)	4.20713	5.59464	14.5129	20.4328	0.09023	0.03962
Martes	*martes*	*foina*	*martes*	*foina*	*martes*	*foina*
	l	l	d	d	m/d	m/d
1.	35	40	80	120	0.6	0.6
2.	37	45	90	90	0.878	0.71
3.	45	50	120	125	0.628	0.753
4.	38	45	82.5	125	0.86	0.69
5.	40	38	112.5	120	0.875	0.7
Mean	39	43.6	97	116	0.7682	0.6906
Variance (sd)	3.80788	4.72228	18.1486	14.7478	0.14127	0.05605
Meles/Lutra	*M. meles*	*L. lutra*	*M. meles*	*L. lutra*	*M. meles*	*L. lutra*
	l	l	d	d	m/d	m/d
1.	60	28	250	120	0.6	0.56
2.	86	26	200	70	0.45	0.6
3.	90	20	167.5	160	0.45	0.68
4.	45	18	175	110	0.43	0.66
5.	60	25	187.5	90	0.46	0.694
Mean	68.2	23.4	196	110	0.478	0.6388
Variance (sd)	19.1363	4.21900	32.6247	33.9116	0.06906	0.05680

Vulpes/Felis	*V. vulpes*	*F. silvestris*	*V. vulpes*	*F. silvestris*	*V. vulpes*	*F. silvestris*
	l	l	d	d	m/d	m/d
1.	55	45	85	100	0.7	0.72
2.	37	52	90	60	0.82	0.7
3.	60	35	120	120	0.78	0.73
4.	25	60	120	92.5	0.75	0.75
5.	50	30	117.5	80	0.65	0.7
Mean	45.4	44.4	106.5	90.5	0.74	0.72
Variance (sd)	14.2583	12.2188	17.4642	22.3886	0.06670	0.02121

All the descriptive characteristics of the ten species investigated necessary for further identification are included in Table 1.

Quantitative analysis of characteristics

Quantitative data, statistical characteristics were used:

- The length of guard hairs (l), the mean of length and the variance of length.
- The diameter (d) of thickest part of shield (distal part of the hair = toward the tip), the mean and the variance of it.
- Medullary index: the ratio of medulla (m) and total diameter (d) in the thickest part of shield (m/d), the mean value and variance. TEERINK (1991) used the CC/TW (cuticle-cortex/total width) ratio, but instead of this I use the medullary index (medulla/ total width) as DEBROT (1982) and CHAKRABORTY *et al.* (1999), because the width of cuticula-cortex may vary around the given section of the medulla.

All the necessary data that were measured are in Table 2. These data served the base matrix of non-parametrical statistical tests, and the results of these tests are shown in Table 3. These test were made on the easily confused species, like the Stoat and Weasel, the Polecat and Steppe Polecat, the Stone Marten and Pine Marten.

Table 3. Results of non-parametric Mann–Whitney test on the basis of pairs of species have overlapping characters

	l: Mu.er.-Mu.ni.	d: Mu.er.-Mu.ni.	m/d: Mu.er.-Mu.ni.	l: Mu.ev.-Mu.pu.	d: Mu.ev-Mu.pu.	m/d: Mu.ev.-Mu-pu.	l: Ma.ma. - Ma.fo.	d: Ma.ma. -Ma.fo.	m/d: Ma.ma. -Ma.fo.
Mann–Whitney U	2.50	5.50	9.50	12.50	3.00	12.50	5.00	3.50	8.50
Wilcoxon W	17.5	20.5	24.5	27.5	18.00	27.50	20.00	18.50	23.50
Asymp. sig. (2-tailed)	0.036	0.138	0.53	1.00	0.047	1.00	0.110	0.055	0.402
Exact sig. [2*(1-tailed sig.)]	0.032	0.151	0.548	1.00	0.056	1.00	0.151	0.056	0.421

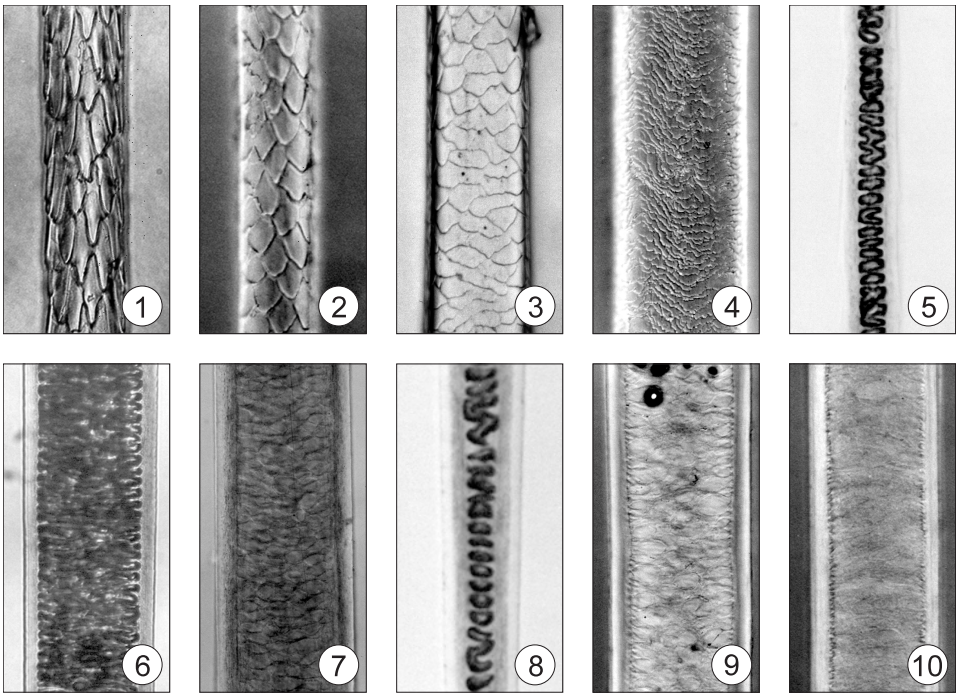
Results show that significant differences (at p = 0.05) are very rare. *Mustela erminea* and *M. nivalis* show significant differences only in length, the Stoat's guard hair being longer. *Mustela putorius* and *M. eversmanni* show some differences at maximum diameter: wider in Polecat. The *Martes foina* and *M. martes* differ in maximum diameter, the Stone Marten having a wider diameter at the thickest part of the shield. Cluster analysis of length, maximum diameter and medullary index of all species shows, that even these little differences can give some points of branching that may be used for identification.

DISCUSSION

Previous publications (MOORE *et al*. 1974, DEBROT 1982, BLAZEJ 1989, TEERINK 1991) have indicated the most important features of hairs that are required for identification but they used often a different nomenclature for patterns and did not give statistical descriptions. Some deviations of quantitative characteristics may be connected with the different geographic habitat within the area of the given species. CHAKRABORTY *et al.* (1999) could use the differences in Side-to-side cuticular scale length (SS) and Proximo-distal cuticular scale length (PD) for segregating the lesser Indian cats, the genus *Panthera* and Mongoose species. These measurements were carried out for Mustelidae, but in this case the variance and overlap were too high to use them as identification keys. Measurements on length, diameter and ratio of medulla-maximal diameter have shown high variance, and may vary within the same individual. Multiplying the samples could not reduce the high variance while the mean value proved to be standard, so these parameters were not relevant for distinguishing mustelids. TEERINK (1991) described the so-called mustelid-like characters as it having diamond petal cuticula (Fig. 2) of shaft, cloisonné (Fig. 7) pattern of medulla and scalloped margin of medulla (Fig. 6) of shield region. These patterns appear in Red Fox while they are absent in Badger and Otter. Analysis has shown that only the combinations of certain sequences and ratios are relevant for identification. The "mustelid-like" characters considering only the subfamily of Mustelinae are:

- hairs have no bands;
- medullary index: m/d = 0.7–0.8;
- the sequences of cuticular patterns from the base to the tip: transitional, regular mosaic – pectinate (Fig. 1) – diamond petal (Fig. 2) – mosaic (Fig. 3) – regular or irregular wave (Fig. 4),
- the sequences of medullar patterns from the base to the tip: unicellular ladder (Fig. 5) – unicellular, irregular ladder – cloisonné (Fig. 7) – fragmented (Fig. 8).

Mustela erminea and *M. nivalis*: TEERINK (1991) distinguished *M. erminea* and *M. nivalis* based on differences of the total length and the different number of bulges protruding into the cortex within a certain section. Stoat and weasel cannot be distinguished with a high level of confidence, except maybe on the basis of the length of hair. The mean length of Stoat's hairs are about 14 mm (sd = 5.2), Weasel's hairs are about 8 mm (sd = 1.6). All other qualitative or quantitative data show total overlap as shown in Table 3. Meanwhile they compose an isolated group within the mustelids, because of short, homogenous brown hairs (not including the white, winter hairs of Stoat) and the shield region of hair is markedly widened after the narrow shaft while smoothly thicken of other mustelids. *Martes foina* and *M. martes* have the same patterns but guard hairs are much more longer. Some shorter hairs of *Lutra lutra* may be similar to these species, but the medullar characters are different.



Figs 1–10. Photographs of small carnivores guard hairs: 1 = pectinate pattern of cuticula (*Mustela eversmanni*); 2 = diamond petal pattern of cuticula (*Lutra lutra*); 3 = mosaic pattern of cuticula (*Mustela erminea*); 4 = regular, close wave pattern of cuticula (*Lutra lutra*); 5 = unicellular ladder pattern of medulla (*Mustela erminea*); 6 = scalloped margin of medulla (*Mustela erminea*); 7 = cloisonné pattern of medulla (*Martes foina*); 8 = fragmented medulla (*Mustela erminea*); 9 = cloisonné-like medulla with straight medullar margin and large, oval cells (*Vulpes vulpes*); 10 = multicellular medulla with fringed medullar margin and spindle-like cells (*Felis silvestris*)

Martes foina and *M. martes:* We can separate *Martes foina* and *M. martes* on the basis of the structure of medulla. As described by TEERINK (1991), the medullar cells lie perpendicular to the cortex in the case of Pine Marten, but lie obliquely Stone Marten. This mark is not always visible, statistically the mean value of length, maximal diameter and medullary index have shown some differences (Table 3). Stone Marten has significantly wider diameter at the shield, d = 116 (sd = 15), while d = 97 (sd = 18) of the Pine Marten. The mean value of medullary index, m/d = 0.6–0.75 of the Stone Marten, but m/d often exceeds the 0.8 of the Pine Marten.

Mustela putorius and *M. eversmanni*: Previous publications did not give a description of hair of *M. eversmanni*. This study has pointed out that *Mustela putorius* and *M. eversmanni* can only be distinguished statistically based on the value of the diameter: Polecat's diameter significantly wider at the shield, mean value d = 124 (sd = 20), while mean value of maximal diameter, d = 100 (sd = 15) of the Steppe Polecat (Table 3). The basal and shaft part of hair more often yellow than white in case of Steppe Polecat.

Lutra lutra: The fine, thin homogenous brown hair has a lighter zone at the base and at the tip, some guard hairs may have bands as brown hairs with one white band or light-brown, white hairs with one brown band. The mean length about 23 mm (sd = 4.22). The medullary index about 0.6–0.7. Medulla at shield has cells reaching across the total width, so instead of the mustelid-like cloisonné we find mainly the unicellular unbroken pattern and straight or scalloped margins. The cross-section is elongated oblong. The cuticular patterns are regular and close. Some shorter guard hairs of Stone Marten may resemble Otter's hair but the medullar configurations have relevant differences.

Meles meles: Badger is unique among the Mustelidae, significant characters give keys for identification. The long, straight, strong hairs have a white tip and base, so even the external characters make exact identification possible. Otherwise, every internal characters are different. The mean length 68 mm (sd = 19). The mean maximal diameter of shield 196 μm (sd = 33). The medullary index about 0.5. That value show significant deviation from the other small carnivores where m/d values are about 0.7. "Mustelid-like" diamond petal of cuticle at shaft section, the cloisonné pattern and scalloped margins of medulla at thickest part of shield are absent. The cuticular patterns are mostly transverse, regular waves, margin of the medulla mostly straight or rarely fringed, the medulla is amorphous, with some large, rounded or oval cells.

Mistakable characters of hair of *Vulpes vulpes* and *Felis silvestris*: There are some brown hairs which have light-yellow or brown or fulvous shaft and dark-brown shield with overlapping parameters: the length (approximately 40 mm), diameter (approx. 100 μm) and medullary index (approx. 0.75). These hairs may orig-

inate from the coat of Martens, Polecats, Red Fox or rarely the Wild Cat. Important factors distinguishing these species are the characters of medulla. The medullar margin at the shield is straight or fringed in Red Fox; fringed (Fig. 10) or rarely scalloped in Wild Cat, but typically scalloped (Fig. 6) in Polecats, Martens. The cloisonné pattern of medulla is typical in Polecats and Martens. The multicellular, "cloisonné-like" pattern of Red Fox and Wild Cat are really similar, but the medulla of Red fox (Fig. 9) contains rounded or oval cells against the mostly spindle-like or large cells in Wild Cat. Taking into consideration that most of the Wild Cat's guard hairs have at least one band and the petal pattern of shaft is absent, this species differs significantly from the other investigated small carnivores.

IDENTIFICATION KEYS TO GUARD HAIRS OF MUSTELIDAE LIVING IN CARPATHIAN BASIN AND TO RED FOX AND WILD CAT

1a Hair have bands 2

1b Hair homogenous brown, or show a gradual transition from light to dark shades 6

2a The colour of the tip and base are white or light 3

2b The colour of the tip and base are dark, brown or black, the number of light (white, yellow) bands one or two 4

3a The colour of the tip and base are white, the colour of the band is black or dark-brown. The length of hairs are 60–90 mm. The mustelid-like diamond petal-pectinate scale pattern at the shaft and the medullary cloisonné pattern at shield region are absent. The medullary index (m/d) about 0.5 *Meles meles*

3b The colour of the tip and base are white or light-brown, the colour of the band is brown, reddish. The length of hair is 18–28 mm. The cuticular pattern of base are regular, close diamond petal and pectinate but cloisonné pattern of medulla at shield is absent *Lutra lutra*

4a The length of hair is 18–28 mm, only one band counted. The medullary index mainly about 0.6. Cross-section of hair is elongated-oblong *Lutra lutra*

4b The mean length of hair about 45 mm (sd = 12–14). Number of bands one or two. Medullary index about 0.6–0.7. Cross-section often rounded or oblong 5

5a Banded hair are tricoloured: the base often fulvous, the middle part yellow or white and the shield and tip regions are black, dark-brown. The cuticle of shaft has broad petal or mosaic pattern. The margin of medulla at thickest part straight or fringed, the medullar pattern cloisonné of shield, the cross-sections of hair rounded at total length. Guard hair without band are brown or fulvous at base and than turn into black markedly, the base never white or yellow (as Polecats) *Vulpes vulpes*

5b There are two type of banded hair. Hair with one band are black or dark-brown with a yellow or white section in the middle part. Hair with two bands has a white or yellow base, then a black, then a white section towards the black tip. The cuticular pattern of the base is mainly mosaic or regular wave. The margin of the medulla at thickest part of shield is fringed or scalloped. The cross-section is rounded or oblong. Medullar configuration at shield is cloisonné-like or unbroken, with spindle-shaped or wide cells *Felis silvestris*

6a Colours of hair show a gradual transition from light to dark tints, the colour of base and tip are different. Usually the transitional, middle part yellow at Steppe Polecat while white or grey-yellow at Polecat. Significant differences derive only on the diameter of these species

6a.1 Mean value of maximal diameter d = 123.5 (sd = 20.4) *Mustela putorius*

6a.2 Mean value of maximal diameter d = 100 (sd = 14.5) *Mustela eversmanni*

6b Hair homogenous brown, or have only slight difference 7

7a Length of hair usually not longer than 15–20 mm, but often shorter. The shaft thin, light, the shield widening-flat. These species are Stoat and Weasel. It has significant differences only at mean length of hair

7a.1 Mean value of length l = 14 (sd = 5.2) *Mustela erminea*

7a.2 Mean value of length l = 8 (sd = 1.6) *Mustela nivalis*

7b Length of hair about 35–50 mm. Medullary index about 0.7. Hairs are brown, fulvous or rarely dark-grey 8

8a Mean value of maximal diameter d = 97 (sd = 18), the medullary index m/d = 0.77 (sd = 0.14), often bigger than 0.8. Hair are mainly brown or fulvous *Martes martes*

8b Mean value of maximal diameter d = 116 (sd = 15), the medullary index m/d = 0.7 (sd = 0.05), not exceed 0.8. Hairs are mainly brown, dark grey- or brown, rarely fulvous *Martes foina*

CONCLUSION

Hair investigation methods require exact identification keys. The qualitative and quantitative characters often show high variance and overlap but statistical analysis may give significant values for identification. Mean values of length, maximal diameter and medullary index show enough consistency to be used for distinguishing Mustelidae. Homogenous brown hairs may belong to almost any of the studied species, excluding the Wild Cat. Its guard hair always has at least one light band, so it could resembles only the Red Fox. Cross-sections are required for separating similar hair of Red Fox and Wild Cat. Two species of mustelids, Badger and Otter can be identified by just a few hairs. Species specific identification is possible in a case of the Stone Marten and Pine Marten, but the investigation demands at least 10–20 or more intact guard hairs. Stoat and Weasel, Polecat and Steppe Polecat compose so called "twin-pairs" where only one significant deviation would help, but it is not enough for exclusive identification. The employment of genetic methods may be necessary for the segregation of these species. The practical application of this method form an integral part of ecological and faunistical research like food-analysis from scats, track-analysis, collecting hairs from baiting-sites, burrows, traps and hair-capture methods.

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