NEWSLETTER

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FROM THE CHAIR

MWG is looking towards the future

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In 2012, Aubry *et al.*'s (2012) new synthesis book on Martens, Sables, and Fishers was released by Cornell University Press – this resulted from our 2009 symposium in Seattle, Washington. In 2012, the *Martes* Working Group (MWG) membership also had the opportunity to voice its opinion in a questionnaire. The results are presented in this newsletter. And, in July 2014, we will meet once again to discuss various aspects of the biology of *Martes* species in Krakow, Poland. The *Martes* Working Group definitely is a dynamic organization and we always have something interesting to discuss among ourselves.

MWG is also a progressive organization. On the basis of our members' responses to the questionnaire, we will now invite wolverine (*Gulo gulo*) and tayra (*Eira barbara*) biologists to join our group. From systematic and ecological points of view, these species have their place in our group. Including wolverine and tayra researchers and managers will only better our organization in our efforts to facilitate communication among scientists with common interests – our knowledge and understanding of small carnivores will simply grow to a new dimension. Some of our members already work on wolverine and will certainly play an important role in recruiting *Gulo* scientists.

Have you ever wondered how one could reach a unique group of scientists working on *Martes*, *Gulo*, and *Eira*? Many specialists likely belong to umbrella organizations – *e.g.*, The Wildlife Society, The American Society of Mammalogists, The Society for Conservation Biology – there is no doubt that such professional organizations allow us to be in touch with recent research findings and conservation concepts. However, MWG has most of the specialists working on martens, fishers, and sables. We can easily reach any of them to discuss issues and concerns regarding a particular species. In fact, although there are many international groups dealing with small carnivores and musteloids, none of them has a track record as good as MWG to deal with *Martes* species. Hopefully, we will succeed in bringing wolverine and tayra biologists into our group and improve our communications with these people.

Although the scientific activities of the working group will now include more species, there is no simple way to change the name of our organization to reflect this new focus. For now, we should retain the name that has served the group so well for the last 20 years: the *Martes* Working Group.

We are living an exciting period in our MWG history. Our organization is still meeting the expectations of its membership while continuing to produce unique scientific works and expanding its horizons – this is extraordinary!

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FROM THE TREASURER AND MEMBERSHIP DIRECTOR

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I have been thinking about change a great deal lately. Major changes in one's life can be a scary proposition. A new job, selling or buying a home, or moving one's family can all be daunting propositions. These same changes can also come with excitement and rewards.

The *Martes* Working Group is about to undergo some significant changes that should land us squarely in the 'rewarding' category. As you know, we have invited additional species experts (*Gulo* and *Eira*) to join our group. This will broaden our network of passionate professionals interested in a species guild that share similarities with their taxonomy, ecological breadth, and conservation concern around the globe. To facilitate communication among old and new colleagues we will be reinvigorating our website, and of course we have another fantastic symposium approaching in Krakow in 2014!

One thing that cannot change, however, are the accomplishments of the *Martes* Working Group as it begins its second decade as an active and dynamic professional organization. Four international symposia and four highly regarded and referenced books top the list, but countless professional contacts, communications, and collaborations should not go unrecognized.

However, we can continue to be a top-notch organization only through your active participation. Help mold the next 20 years of the *Martes* Working Group by keeping your membership active and by remaining engaged in group communications. Membership rates are $18 USD for one year, $30 USD for two, or $40 for three years. Until our new website is up and running, please just email me directly (jscottyaeger@gmail.com) your interest in the group and your desired number of years (1, 2, or 3). I will promptly send you an invoice via PayPal to allow you to conveniently pay with a credit card.

Please let your interested colleagues know of our group, and I challenge you all to recruit a young professional or student this year. To encourage participation, we waive fees for

students or any *Martes* enthusiast who feels the dues are a financial burden. I look forward to hearing from you all in the years to come!

FULL SURVEY RESULTS: WHAT DOES THE MWG MEMBERSHIP WANT?

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In April 2013, I surveyed the *Martes* Working Group (MWG) membership to know what our group needed to do in order to remain an effective professional group. It was an opportunity for all of us to review our objectives, communication tools, and future endeavours. I sent a questionnaire to the 44 people who had paid their dues and were officially registered as members of the group in 2013. Nineteen (43%) members responded. In the following, I review and analyse the members' responses, clarify some ambiguities, and draw some conclusions, which hopefully will help us remain dynamic and productive.

The majority (95%) of respondents believed that MWG is still needed today (Table 1) and members raved about MWG accomplishments. Here are two comments that summarize well the general members' opinion:

> *"I can think of no other group of which I am a member which includes such a high percentage of experts and so much experience on a group of wildlife."*

> *"I am surprised and impressed by how relevant the organization is today. Its primary contribution seems to be the meetings and proceedings, but that has had a real impact on the field…"*

The original objective of the MWG (to facilitate communication among scientists with an interest in martens, fishers, and sables) still meets membership expectations (Table 1). However, there is an interest in seeing our group becoming involved in the production of educational material, including position statements on population and habitat management. In this respect, I believe that the proceedings and syntheses that MWG has published in previous years have certainly helped in educating members of the scientific community. However, we should consider producing special publications on the conservation of habitats and populations, which could be distributed to government agencies and conservation groups. These publications would allow us to meet the expectations of some members who would like to see our group recognized and consulted by governments to deal with management issues.

Respondents also indicated that they would welcome a forum for members to discuss research and management issues. Although increased communication among members certainly could be enhanced, I think that managing this forum may be taxing for the few of us who are actively involved in MWG. The reality is that many members enjoy playing a passive role in MWG; they receive the information but do not provide feedback. The best example is the relatively low number of respondents to this questionnaire.

The Newsletter is well received by the great majority of our members (Table 1). An interesting point was made, however, about newsletter contents. The newsletters should include information that is not necessarily acceptable in journals but could still be of interest to the membership. It should not be an outlet for abstracts of scientific publications; most MWG researchers have likely read these abstracts. The newsletter should inform people about new research and conservation programs that are being implemented in different regions, special meetings, etc. I think that these are constructive comments that we need to consider in the future. Our newsletter must provide news, not already published material. Nevertheless, people are still pleased with the current product. Although one member would prefer that we abandon the newsletter altogether and focus instead on an interactive website, the majority of our members find the service provided by our Editor is adequate.

The majority of the respondents were not in favor of a peer-refereed *Martes* journal (Table 1). Many comments related to the fact that it might be difficult to receive enough material to maintain the journal. Furthermore, because of its specialized forum, the journal may fail to reach the scientific community and promote new findings.

The great majority (84%) of respondents believed that one symposium every 4-5 years was adequate (Table 1). However, more than 50% of the respondents would welcome regional meetings every 2 years. Some members suggested that such regional symposia be included in larger conferences (*e.g.*, TWS, International Mammalogical Conference, etc.). Video conferences did not appeal to the respondents. Most of them did not have a strong opinion on the subject. This is something that we may want to re-visit only once we have resolved other pressing issues I discuss below.

The majority (68%) of respondents believed that MWG should not be restricted to martens, fishers, and sables (Table 1). These respondents also believed that we should include wolverine researchers in the MWG. Also, 60% of the respondents indicated that tayra researchers should be invited to join the group. The majority of respondents (70%) did not suggest other species. However, a few members pointed out that the composition of our group should not be based only on taxonomy; it should also consider the ecology of the species. For example, members working on American marten may welcome the input of researchers who work on small carnivores inhabiting structurally complex forests.

The great majority (80%) felt that we needed a greater online presence and that we needed a new website (Table 1). The majority (70%) would agree with hiring a professional company. It is interesting to note, however, that nearly one-third of the respondents would prefer that we do it in-house. Unfortunately, this is easier said than done. Most of us do

not have the skills to produce high-quality, dynamic websites. The website has been a source of frustration for many members because it was not updated on a regular basis and it did not reflect the dynamism of our organization. This is my point: scientists who are busy teaching and conducting research are not necessarily good volunteers to manage a professional website. Some members suggested that our website should be more interactive. However, integrative websites probably require a substantial number of volunteer moderators. Again, we may not have enough active members to implement such an initiative. Some recommended that we get Facebook and Twitter accounts. Others suggested that a blog account be attached to the website.

Most respondents would like to see our funds used for symposia, publications, and the production of a new website (Table 1). About 60% supported the idea of helping students to join our group or attend MWG symposia. Two members suggested that small grants be made available to students. Of course, our funds are very limited due to the size of our membership and the low subscription fees. A few members thought that it would be interesting to see MWG become involved in research, but funding would be restrictive. On the other hand, they suggested that some of the money should be used to identify research needs.

Fifty percent of the respondents think that they will attend the next symposium, in 2014 in Poland. This is good news because some of the insights discussed above need to be further discussed at the symposium.

One member made the comment that in order to recruit more members, MWG needed to become more dynamic, by holding regular elections of the Chair and other functions. The fact that the current Chair had served since 1995 was a red flag to him, and he did not recall the last time officers were elected in this organization. The truth is that elections have been held at each symposium and people do not rush in to submit their name for any position. Another member made the point that, sociologically, we had entered a period characterized by lack of motivation to volunteer and significant concern about personal wealth. In light of this trend, that we have maintained our core membership is a sign that we are reasonably healthy as an organization. I agree with this comment. Nevertheless, members should know that there will be elections in Poland in 2014 and if people are interested in becoming part of the Executive, they should put their names forward.

I believe that MWG is still a top-notch professional organization that meets the needs of its membership. Yet, there is room for improvement: we should consider developing educational material, organizing regional/continental symposia, and most importantly, developing a professional website to show people what MWG is all about. In order to stay in line with recent scientific findings and enlarge our horizons, we must invite scientists with an interest in wolverine, tayra, or other species that play similar ecological roles to join our group.

The current and future executives will have to pursue these objectives. This year, I will contact wolverine and tayra scientists and invite them to join us in Krakow, in 2014. I am grateful to Keith Aubry who helped me develop a contact list of wolverine researchers. I

will also initiate a discussion with my Executive to determine how we will approach the development of a professional website. With an international symposium scheduled for 2014, I cannot foresee any regional/continental symposium in the near future. However, after 2014, we may discuss with our regional representatives the possibility of organizing such meetings.

I think that it is important that our membership knows that if there is something that they want to discuss, develop, or recommend, they should not hesitate to contact their Executive. Even though some of us have been around for a while, we are truly committed to MWG and its future. To conclude, I would like to thank Editor Bill Adair and Treasurer Scott Yaeger for their comments on the questionnaire and this report. I am really thankful to all the members who took the time to respond to the questionnaire and share their thoughts with me.

Table 1. Responses (n = 19) to questionnaires sent to the MWG membership (n = 44) in April 2013.

	Responses (%)		
Questions	**Yes**	**No**	**Not sure**
1. Is MWG needed today?	18 (95)	-	1 (5)
2. What should be MWG's objective?			
• To facilitate communication among people	19 (100)	-	-
• To become involved in research	9 (47)	7 (37)	3 (16)
• To become involved in management	12 (63)	4 (21)	-
• To produce educational material	17 (89.5)	2 (10.5)	3 (16)
3. Is the MWG Newsletter meeting our needs?	16 (84)	2 (11)	1 (5)
4. Should we produce more than one newsletter per year?	5 (26)	13 (69)	1 (5)
5. Should MWG produce a peer-reviewed scientific journal specific to *Martes* researchers?	2 (10)	15 (80)	2 (10)
6. Is a symposium every 4-5 years sufficient?	16 (84)	3 (16)	-
7. Should we organize regional or continental symposia?	10 (52)	8 (42)	1 (5)
8. Should we consider video conferences?	7 (37)	9 (47)	3 (16)
9. Should we restrict MWG to martens, fishers, and sables?	6 (32)	13 (68)	-
10. Should we include wolverine in MWG?	13 (68)	6 (32)	-

Table 1, continued. Responses (n = 19) to questionnaires sent to the MWG membership (n = 44) in April 2013.

	Responses (%)		
Questions	**Yes**	**No**	**Not sure**
11. Should we include tayra in MWG?	12 (63)	5 (27)	2 (10)
12. Should MWG look into a greater online presence?	15 (79)	3 (16)	1 (5)
13. Would you welcome the production of a new website?	15 (79)	3 (16)	1 (5)
14. Would you agree that we hire a professional company to produce the new website?	13 (68)	5 (27)	1 (5)
15. How should we use our money? (18 respondents)			
• Symposia	17 (94)	-	1 (6)
• Publication of books and newsletters	16 (88)	-	3 (12)
• New website	15 (83)	2 (11)	1 (6)
• Research activities	7 (39)	8 (44)	3 (17)
• Student deferment (*i.e.*, help with participation at conferences, membership, etc.)	11 (61)	5 (28)	2 (11)
16. Will you attend the next symposium?	10 (53)	7 (37)	2 (10)

6TH *MARTES* WORKING GROUP SYMPOSIUM

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Dear colleagues,

We are delighted to invite you to Krakow, Poland, for the 6th International *Martes* Symposium, to be held from 21-24 July 2014. This meeting will bring together researchers, practitioners, and educators from around the world engaged in *Martes* species research and conservation.

The theme of this symposium is:

Ecology and Conservation of Martes Without Borders:
Common Denominators and Regional Differences Across Countries and Continents

One of the objectives of this gathering will be to present similarities and differences between *Martes* species from different continents, their adaptations related to climate and habitat, and consequences for conservation issues. The main theme concerns *Martes* species biology, management, and conservation, but papers on interactions with other carnivore species, especially at larger geographical scales and in different communities (*e.g*. habitat and prey requirements), will also be presented. We welcome either original contributions or comprehensive reviews.

The symposium will be a great opportunity to establish collaborations, deepen friendships, and further international understanding of *Martes* issues. The social events and congress tours will provide opportunities to network with colleagues from around the world in a pleasant environment. We also hope you will enjoy Poland, especially the many sights in and around Krakow.

You can find more information at the official conference website:
http://www.martes2014.com.pl

We look forward to seeing you at the Symposium!

On behalf of the Organizing Committee,

Dr. Izabela Wierzbowska
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WESTERN NORTH AMERICA

A note on standardization of reproductive and survival rates for populations of *Martes*

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Estimating and understanding population vital rates are important to those managing and conserving populations of *Martes* species. Population vital rates are commonly used to estimate population growth rates, conduct population viability analysis, or to model the potential effects of different management decisions (Caswell 2001, Morris and Doak 2002, Buskirk 2012). Published, or otherwise reported, population vital rates are also important for comparison among sites (*e.g.*, estimating variability) and for syntheses, such as those found in meta-analyses. Consequently, if vital rates are collected and reported with

different, or nebulous, standards there may be important consequences on accuracy and applicability for use of the information by managers and biologists.

In the last decade much effort and expense has been focused on collecting and understanding vital rates for fishers (*Pekania* [*Martes*] *pennanti*), particularly in the western portion of their range. Several independent studies have employed similar field methods (*e.g.*, VHF telemetry) and collected data on the number and percent of females that den, average litter size, and age- and sex-specific survival for fishers in California and Washington (*e.g.*, Matthews *et al*. 2013). As a result, we are now much closer to being able to describe and understand factors that limit populations and develop empirically driven models of long-term population persistence for the conservation of fishers.

Despite the large amounts of information coming from these studies, no standard procedures exist for collecting, analyzing, or reporting data. We acknowledge that individual research projects have different goals and interests that require specific protocols and reporting standards. Yet, much of the information on vital rates is requested, and usually provided, to state and federal agencies as well as private organizations with little regard, or explanation, for the disparities found among the different research projects. In particular, we note that many issues arise because juvenile fishers are dependent on their mother for a large portion of the year, and we observe relatively high numbers of adult females that die during this dependent period (Higley *et al.* 2013, Sweitzer *et al.* in preparation).

In this update we discuss several considerations for vital rates related to denning, estimates of litter size, and survival, and the potential for different approaches to estimation and reporting key demographic parameters. We provide several examples of potential pitfalls that we have encountered in individual projects (Sierra Nevada Adaptive Management [SNAMP] Fisher Project, Northern Sierra Fisher Reintroduction Project, and Hoopa Valley Tribe [HVT] Fisher Project) and as part of collaborative efforts.

"Adult" Defined

To model populations using vital rates, one must be able to define an "adult" or other important stages in the animal's life. Female fishers breed on or near their birthdays at age 1 but do not give birth until a year later, when they turn age 2. Consequently, female fishers are sexually mature at age 1 but cannot be modeled as "adults" that produce offspring until age 2. Researchers must always define what they mean by "adult" and "juvenile" to avoid confusion.

Male fishers appear to be unable to breed before age 3 but may not become effective breeders until they reach large sizes at older ages (Lewis *et al*. 2012). Consequently, male fishers are sexually mature at age 3 but cannot be modeled as "adult" until probably age 4 years. Researchers must also define "adult" for males to avoid confusion.

Denning Rate

A common metric reported by studies on fishers, and other species of *Martes*, is denning rate (an index of birth or reproductive rate). Our respective projects often rely on VHF

telemetry to observe patterns in individual female movement prior to denning, and then to identify denning behavior when her movements become restricted. Thus, an obvious estimate of denning rate is to take the number of adult-age females that denned and divide by the number of adult females monitored.

Some females, however, exhibit denning behavior for a brief period (several days or weeks), and then return to non-denning movement patterns. Researchers can often identify a putative "natal" den tree, but are unable to verify long-term use of the tree, or other "maternal" den trees. We are then left to wonder if (1) the female denned and then abandoned her litter, (2) if the litter died in the den cavity, possibly due to cold weather or starvation, or (3) if there was some coincidental circumstances that gave the appearance of denning when it did not actually occur. We hypothesize that female fishers might use denning-type structures to control the timing of copulation and otherwise avoid males during the mating season, which corresponds with the onset of denning (Powell 1993). Unfortunately, nothing conclusive can be determined among these scenarios and researchers may be tempted to report a female as having denned even if she exhibited the behavior for a short time.

On the Stirling reintroduction project we have reported only initial denning rates (though we have not observed abandoned dens), whereas Matthews *et al*. (2013) reported for the HVT Fisher both initial denning plus the number of dens that were active until a weaning period (presumed to be around May 31st). On the SNAMP study site we are now reporting data similarly to Matthews *et al*. (2013), after realizing that denning rates were often overestimated when "denning" females ceased denning, or perished before kits were weaned. Across all 3 study sites the initial denning rate for adult females was on average 83% (SD ±9%); however, an average of only 66% (SD ±15%) of monitored females exhibited denning behavior until weaning (weaning rate). Reporting both rates provides information on the number of females that initially denned, successfully weaned a litter, and those that may have lost or abandoned litters. Thus, we recommend that both initial denning and weaning rates be reported as well as the time when litters were, or might have been, lost. Ideally, researchers would observe kits in the den or detect them on cameras placed at den trees to ensure that a female actually gave birth. We acknowledge documenting kits may not always be possible.

Litter Size and Recruitment

Litter size and survival estimates are also potentially problematic because female fishers often die while kits still depend on them. Across our 3 studies, we tracked an average of 13 ± 3.5 females per study site per year, and an average 2.3 ± 1.4 of those females died while kits presumably depended on them.

For our respective studies, cameras placed at the bases of den trees provide minimum estimates of litter sizes. Camera-based surveys have the greatest chance of observing females and kits relatively early in the denning season (early April to early June) when den trees are easiest to find and observe. As the denning season progresses into summer, females move their kits more often compared to earlier in the spring, making finding and confirming dens more difficult. For the SNAMP and HVT projects, we do not attempt to

locate "den" trees after mid-June because the structures are typically not used for more than a few days before the adult female transits to other areas of her home range with trailing kits. Consequently, counts of litter sizes are biased towards this early time period. Yet, reproductive females often die later in the summer when kits are still dependent on them. Thus, we should presume that these females' kits have also died.

If researchers report mean litter sizes based on the earlier cameras surveys, the possibility exists of over-estimating the mean number of juveniles available for recruitment per female. Additionally, even if mean litter size per female remains the same, the absolute numbers of juveniles contributed to the next generation decreases. On average, and across our 3 field sites, a mean of 14 ± 7 kits were counted each year. After accounting for females that died, we conservatively estimate that 3 ± 2 kits are lost per study site per year, dropping mean litter size from 1.6 ± 0.3 to 1.5 ± 0.3.

We emphasize that litter size counts from early in the year are important metrics because they inform us about possible environmental limitations that are reducing overall reproductive rate, and thus they have value. However, we suggest researchers also report the number of females that died and an estimate of number of kits lost as a result.

Juvenile Independence

Another consideration that affects estimates of litter size and recruitment is juvenile independence and the timing of kit survival after a mother dies. In many instances, females with kits die late in the summer when the kits are nearly as large and mobile as their mother. Thus, when a female dies in late July or August, we wonder if the kits will survive. On the Stirling reintroduction project we observed kits that were mobile and alive several days after confirming that their mother had died in late July. When we inspected the maternal den tree we never found dead kits and we assume they left the tree after their mother failed to return. Perhaps these kits survived, but we cannot confirm that they did.

Currently, no information exists to suggest that juveniles can survive without their mother prior to early autumn (Powell 1993). Juveniles that are weaned are still dependent on their mothers to bring them prey, and perhaps to demonstrate hunting skills or foraging locations. Indeed, the late summer period may be a crucial period in a young fisher's life for acquiring information relevant to their survival later; however, most of our knowledge related to juvenile fishers during this time remains anecdotal. Moreover, an exact date of independence is largely unknown and may vary among study sites and years, sexes, and individual fishers. We hypothesize that kits will not survive if their mother dies prior to mid-July and then will have only a small likelihood of survival thereafter. We also hypothesize that kit survival increases the later in the summer and autumn a mother dies.

Information from both SNAMP and HVT projects indicate that juveniles may become independent from their mothers in early September. We hypothesize that kits orphaned in early September may survive similarly to kits whose mothers live. Unfortunately, we cannot offer, or substantiate, a standard date for when kits should be considered dead or truly independent following a maternal death, but we suggest that projects include dates

when females die and the latest known litter size of that female. Kit survival and independence remain important information gaps.

Juvenile Survival after Independence

Estimating juvenile survival in the first year is particularly challenging and introduces a source of potential misinformation. For most studies on *Martes*, definitively documenting the number of kits born to a mother requires finding a den(s), and extracting and marking kits with either via passive integrated transponder (PIT) tags or by taking genetic material to identify them later (Matthews *et al*. 2013). Currently, very young juveniles (< 6 months) cannot be ethically collared with radio-transmitters. Thus, recapturing juveniles that were initially marked in the den during the fall remains the most practical approach for estimating juvenile survival for the first 4-6 months of their lives. Yet, this approach has pitfalls because the period when fall trapping takes place corresponds with timing of when we think the earliest dispersal events take place, thus confounding dispersal and death of a juvenile as potential explanations for not capturing an individual. In any case, these types of information are difficult to acquire and, thus, most projects cannot estimate true juvenile survival over the entire first year.

Generally, we do not encounter a kit until its first fall, when we capture it during trapping efforts. Therefore, little information is available on kit survival until they are greater than 6 months old. Consequently, most projects can only estimate survival for the last half of a fisher's first year. Among our 3 study sites, juvenile survival during this period is relatively high (0.85 – 0.95). While it is possible that juvenile survival is truly over 85%, it may also be true that significant mortality occurs among juvenile-age fishers during the first 6 months after parturition (for example, when mothers die). The juveniles we do capture in the fall may be high-quality juveniles that have a high likelihood of survival, and therefore, by estimating only their survival we may overestimate juvenile survival for the year and may underestimate the overall impact on population dynamics (see Buskirk *et al*. 2012). Alternatively, the juveniles we catch in autumn may be the most in need of food, and hence easiest to catch, leading us to underestimate true survival. In lieu of being able to collect, and estimate, survival for the first 6 months of a fisher's life, we suggest that reports of juvenile survival be specific to the appropriate timeframes. Combining information from kits that were known and lost (*e.g.*, mothers that that died with litters of known size) and those captured and that survived might provide a minimum estimate of kit survival.

Concluding Remarks

We wish to reiterate that we have written this note with no intention of influencing the objectives of other research projects. Rather, we wish to update others about some of the issues that we have encountered in the course of collecting, sharing, and compiling demographic data from published sources. We recognize that we are part of a larger community of researchers, managers, resource agencies, and concerned citizens that use and interpret these data. Therefore, it is important to represent these data in ways that are consistent in their approach and interpretation when possible or when they are used in direct comparison. Though we have focused this note on fishers, other species of *Martes* stimulate similar needs for reporting results clearly. We encourage all researchers to consider that their research will be used in important ways, and that they should think

about how to present their data as transparently as possible, so that they are easily interpreted and compared among studies.

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Fisher denning ecology in the southern Sierra Nevada

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Understanding the reproductive ecology of a rare species in a given area is an essential step in creating an effective conservation plan. The fisher (*Pekania pennanti*) is considered a species of conservation concern in the southern Sierra Nevada; however, until recently information on basic aspects of reproductive ecology, such as litter size and tree species used as dens, has been unavailable for this geographic area. As part of a broad study of fisher ecology being conducted on the Sierra National Forest in California, we monitored adult female fishers during the spring and summer from 2008 through 2013 to collect data on basic reproductive parameters and identify natal and maternal den structures. We present here some preliminary results and highlights from our work to date.

Reproductive Parameters

The percent of adult female fishers that were reproductive each year was high, with a mean of 86% across years and a range from 77% to 100%. We followed from 6 to 19 females each year, with reproductive dens located for a total of 34 individuals. Litter size was measured using a combination of tree climbs to peer into den chambers and remote cameras at the base of den trees to photograph females moving kits. The mean number of

kits per female across years was 1.6, with a range of 1 to 3. Of note, only 1 female in our study was known to have 3 kits, although she did maintain this litter size in 2 consecutive years. Den initiation dates ranged from 23 March to 11 April, with the earliest known move from a natal to a maternal den occurring on 6 April.

Structures used as Natal and Maternal Den

We located at total of 222 reproductive dens, including 67 natal dens, 148 maternal dens, and 7 dens that apparently failed early in the season. Female fishers selected California black oaks (*Quercus kelloggii*) as both natal (48%) and maternal (50%) den structures more than any other available tree species. Other trees used as reproductive dens included white fir (*Abies concolor*), incense cedar (*Calocedrus decurrens*), ponderosa pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), and canyon live oak (*Quercus chrysolepis*). All den microsites were in cavities of tree boles accessed through broken limbs, broken trunks, scars, cracks, or woodpecker holes, with the exception of 2 maternal dens in hollow logs.

Females generally moved from their initial natal den to one or more maternal dens, although occasionally a female stayed in 1 structure for the duration of the denning season. The total number of dens used by individual females in a given year ranged from 1 to 6.

In addition to locating reproductive dens, we also identified rest sites used by females with older kits (3-6 months) during the summer and fall. These "maternal rest sites" were often in hollow logs or trees with relatively low cavities and appeared to provide refuges where females could leave young while hunting, were easily accessible by kits that were still improving their climbing skills, and had chambers large enough to hold an adult female and 1 or more large kits.

Conservation Implications

Although the proportion of females that reproduced each year in our study area was relatively high, mean litter size was slightly lower than reported in other geographic areas. This relatively low reproductive rate suggests that fishers in the southern Sierra Nevada may have a limited capacity to recover following a major perturbation.

Characterization of the structures used by female fishers as reproductive dens should help facilitate the identification and conservation of suitable reproductive habitat in this geographic area. Further analysis of reproductive den habitat at several spatial scales will be forthcoming and should help to clarify additional aspects of habitat selection by reproductive female fishers relative to available forest habitat in this part of the Sierra Nevada. Last, the somewhat unique rest sites being used by females with kits in the summer and early fall may play a role in facilitating kit survival during this critical life stage. We plan to compare the characteristics of these structures with those of other rest and den sites to see if they represent a distinct seasonal subset of the larger pool of fisher resting structures; if they are distinct, it may be important to conserve other potentially suitable maternal rest structures to promote successful kit rearing in this geographic area.

Female fisher with kit at natal den (live black oak).

Female fisher with kit at maternal den (live white fir).

Fisher kit at maternal rest site (incense cedar log).

Influence of satellite information on performance of miniature global positioning system collars (<60g) in a forested ecosystem

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The following abstract summarizes a manuscript currently in review.

Miniaturization of GPS components allows studying movements of animals <1kg. However, GPS units suffer from non-random data loss and measurement error. GPS units use memory of satellite configuration to improve accuracy, including both almanac data reflecting satellite positions at weekly temporal scales and ephemeris data reflecting precise locations valid for 2-4 hours.

Using the smallest GPS collars available for mammals (45-51g, Telemetry Solutions, Concord, CA), we evaluated how satellite data and environmental conditions affected the performance of test GPS units in 27 mobile trials and 56 deployments on Pacific marten (*Martes caurina*). We programmed the test GPS unit to retain or remove (continuous or cold start mode) satellite data before attempting a location (fix), thereby mimicking short (<2-4 hour) and long (>4 hours) fix intervals. We used generalized linear mixed models to identify factors that predicted fix success and measurement error in each mode.

In continuous mode, overall fix success was 8.2 times higher, was not strongly influenced by environmental conditions, and improved after a location with ≥ 4 satellites (3-D fix) was obtained. In cold start mode, fix success was negatively correlated with vegetation cover. Censoring fixes with 3 satellites (2-D) decreased measurement error from 300 ± 58m to 27 ± 5m in cold start mode. Censoring 2-D locations prior to the first 3-D fix decreased measurement error from 101 ± 16m to 46 ± 10m in continuous mode. Only 66% of 56 miniature GPS units functioned upon delivery. Once tested and deployed, <30% failed.

Although we could not isolate the influences of ephemeris versus almanac data, the influence of previous fix success underscores the importance of ephemeris data. For fine-scale analyses requiring < 50m accuracy, we recommend 1) removing all 2-D fixes for fix intervals > 3 hours, and 2) removing all 2-D locations prior to the first 3-D location for fix intervals < 3 hours.

When is a barrier a barrier? Scale, incentive, and behavior influence movement thresholds

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The following summarizes a manuscript currently in progress – Do not cite!

A key factor driving population dynamics in fragmented landscapes is the ability of animals to move from one patch of habitat to another. Habitat fragmentation and loss can restrict individual movements, however, little is known about what constitutes a barrier for many species.

We explored movement thresholds for a forest specialist, Pacific marten (*Martes caurina*), using experimental food-titration treatments and locations obtained from VHF and GPS telemetry. We used food titration experiments, or a linear array with bait incentive, to coax martens from dense forested stands into openings that varied in overstory and understory cover. We evaluated the martens' willingness to move into stand types (*i.e.*, open, simple/thinned, and complex (the control)) and used fine-scale vegetation data to specify which features within a stand increased likelihood of movement.

We evaluated incentive-based movement thresholds and compared results from our experiment with habitat selection derived from passively collected data (*e.g.*, telemetry locations). First, we evaluated whether marten movement thresholds differed by season (summer, winter) and patch type. Martens raise kits and breed during summer months and can experience thermal stress and food-limitations during winter, potentially influencing willingness to travel through risky patches. Second, we tested whether movement thresholds were influenced by landscape composition and configuration. We

predicted that martens residing in a diverse matrix of patch types would be more willing to travel through potentially risky patches. While accounting for landscape-level effects, we evaluated whether movement thresholds were influenced by micro-site features (*e.g.*, sapling cover).

Ultimately we aimed to identify features that facilitated marten movement through managed stands. Following these analyses, we compared incentive-based movement thresholds with marten habitat-selection to elucidate potential costs of traveling into patches with reduced forest cover.

EASTERN NORTH AMERICA

Population ecology of American marten in New Hampshire: Impact of wind farm development in high-elevation habitat

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The following is a summary of a M.Sc. Thesis completed at University of New Hampshire, Durham, New Hampshire, USA, in June 2013.

Introduction

American marten (*Martes americana*) is a state-threatened species in New Hampshire and predicted to decline regionally due to climate change (Carroll 2007) and shifts in forest practices (Simons-Legaard *et al*. 2013). Occurrence models predict that marten prefer high-elevation mixed and coniferous stands in northern New Hampshire where deep snow exists (Kelly 2005). Further, seasonal use patterns indicate that they require forests with either greater canopy cover (Buskirk and Ruggiero 1994, Hodgman *et al*. 1997, Fuller and Harrison 2005) and/or enhanced structural complexity during winter months, and these habitat conditions exist at high elevation in New Hampshire (Kelly and Foss 2005).

Much of the current and proposed wind farm development in the northeastern United States occurs along high-elevation ridgelines where measureable disturbance could destabilize the fragile forest community. In New Hampshire, wind farm development is identified as the greatest immediate threat in high-elevation habitat (WAP 2005). Further, spruce-fir forest is predicted to decline and become reduced in northern New Hampshire and northwestern Maine (Tang and Beckage 2010). This region is considered a critical

linkage for marten in northern New England (Jensen 2012), yet is largely unprotected (Publicover and Kimball 2012). It is critical then to understand the importance of this habitat at finer scales and the potential influence of wind farm construction on marten populations.

Methods

This study examined marten ecology relative to wind farm development using radio-marked marten, camera trapping, remote telemetry monitoring, and snow track surveys. The 100-km^2 study area was located in Coos County, New Hampshire, specifically within the townships of Millsfield, Dixville, Odell, and Ervings Location (Fig. 1). Mt. Kelsey, Owlhead Mountain, and the surrounding lowlands delineated the core study area. Trapping occurred seasonally to maintain an adequate sample size (~10) of radio-collared marten and to compare with a photographic-mark-recapture (PMR) technique. The distinct ventral patches (throat and chest) of uncollared animals and artificial markings placed on radio-collars were used to identify individual marten for PMR analysis (Fig. 2).

Telemetered animals were located weekly to obtain ≥48 annual locations (24 per leaf-off [16 November-15 May] and 24 per leaf-on season [16 May-15 October]) to measure intersexual home range overlap, home range size, movements, seasonal home range overlap, and habitat use. The use of high-elevation habitat on Kelsey and Owlhead Mountains was continuously monitored by 3 ATS 4500S receiver/dataloggers, which detected and stored radio signals of marked marten within a prescribed area of ~8 km^2 (Fig. 1; inset map) to evaluate seasonal use patterns and/or effects of wind farm development.

Snow tracks and/or trails of marten and competing carnivores (fisher [*Martes pennanti*], coyote [*Canis latrans*], red fox [*Vules fulva*], and bobcat [*Lynx rufus*]) were counted during winter 2011-2012 to compare their relative use of 3 high-elevation survey route types (roads, snowmobile, and snowshoe trails). Snowpack measurements were taken to determine potential influence of mobility on these survey species.

Results

The population was mostly breeding adults (>1 yr old: 15 M, 13 F; <1 yr old: 2 M, 4 F) and was considered near carrying capacity (PMR 2-year average density = 52 marten/100 km^2). Mortality (predation) was biased towards females (5 M, 12 F) and young (1.5 ± 0.3 yr).

Overall, male (n = 21, $\bar{x}$ = 2.95 ± 0.27 km^2) and female (n = 6, $\bar{x}$ = 1.55 ± 0.20 km^2) home ranges (HR) were small; HR was largest during summer and when marten used more regenerating and softwood forest. The overall mean HR overlap (HRO) between consecutive seasons was 66 ± 6%, and between corresponding seasons was 57 ± 10%. Selection at the landscape scale was more pronounced than at the stand scale; regenerating forest was selected against year-round. Stand selection for mature mixed-wood and softwood occurred in winter. Remote monitoring indicated that the highest use of high-elevation habitat occurred in winter, and disturbance from wind farm construction resulted in less use and periodic displacement of marten, although marten maintained presence in the study area throughout the study.

Temporal clusters of photographs aided in the identification of individuals (Mendoza *et al*. 2011) for the PMR method. Radio-collared marten visited camera traps for 12 ± 1 min (11 ± 1 videos) in 2011 and 17 ± 3 min (84 ± 17 photos) in 2012. The time between visits at the same trap was 1048 ± 163 min for both years, providing ample opportunity for identification.

The camera trapping method improved with a modified design (Fig. 2; right picture). Marten were identified in 82% (202 of 247) of the photo-captures in 2011 and 90% (130 of 144) in 2012. The 2012 PMR density estimate was more accurate and precise (61 ± 15 marten/km^2) compared to live-trapping (41 ± 23 marten/km^2); the discrepancy was likely due to reduction in trap shyness and increased effort (Wegge *et al*. 2004).

The snowpack was shallow and more supportive along survey routes (P <0.0001). The deepest and least supportive snowpack was found at higher elevations, in mixed-wood stands, and along snowmobile trails, whereas hardwood stands had the shallowest and most supportive snowpack.

Use of survey routes differed among species (χ^2 <0.0001). Red fox were encountered along roads more than along snowmobile trails (P <0.01) and snowshoe trails (P <0.0001). Coyotes were not encountered along specific survey routes more than expected; however, roads and snowmobile trails were used 4x more than snowshoe trails. Marten were encountered more often along interior forest snowshoe trails than along roads (P <0.0001) and snowmobile trails (P <0.0001).

Discussion

The study area supported a high-density population of breeding adults with spatial ecology similar to that measured in core marten range in the northeastern United States. Home range fidelity (HRO) was considered high compared to other studies (O'Doherty *et al*. 1997, Payer *et al*. 2004, Hearn 2007). Marten in New Hampshire selected strongly against regenerating forest at the home range scale during both seasons, and past studies clearly identify selection against regenerating forest and that it is the least suitable (used) during winter (Thompson *et al*. 2012). The higher selection we observed at large spatial scales is consistent with research across marten range (Thompson *et al*. 2012), especially when landscapes are managed for timber production (Chapin *et al*. 1998, Hargis *et al*. 1999, Payer 1999, Potvin *et al*. 2000, Cheveau *et al*. 2013). Of concern, the sampled landscape was comprised of 25% regenerating forest, which was close to the 30% threshold where occupancy sharply declines (Bissonette *et al*. 1997, Fuller 2006).

Interestingly, we detected stand-scale avoidance of the high-elevation ridgeline during wind farm construction using remote dataloggers, yet this avoidance was not detected using telemetry locations and resource selection functions. This period was characterized by obvious disturbance and habitat conversion. Although use returned to levels measured during pre-construction, it is reasonable to assume that disturbance and open habitat (roads and wind turbine pads) shifted proximal use of the ridgeline, caused behavioral disturbance, and lowered habitat quality, as marten avoid treeless areas (Thompson *et al*.

2012). Habitat loss along high-elevation ridgelines might be additive to the effects of forest fragmentation occurring elsewhere on the landscape, and the footprints associated with wind farm development may reduce the long-term value at the local stand scale (Harrison 2011).

The habitat conversion from wind farm development is likely the greatest long-term impact. Species adapted to edge environments and generalist species will presumably capitalize on the road habitat required for wind farm construction and maintenance, providing the potential for a broader predator community. For example, birds of prey not typically associated with contiguous forests (*e.g.*, red-tailed hawks [*Buteo jamaicensis*]) and coyotes were observed travelling and resting in high-elevation habitat during summer following the post-construction period, and 5 marten mortalities (4 fox, 1 coyote) were documented within 200 m of the road in high-elevation habitat. Such community shifts might reduce the resiliency of specialized high-elevation forest communities that are typically associated with relatively undisturbed conditions.

High-elevation habitat is believed important for marten because such areas are contiguous, roadless, and have a deeper and less supportive snowpack. Indeed, this study provided evidence for habitat partitioning at a local level during winter. The roads required for wind farm construction and maintenance provide year-round access to competing predators, create edge habitat, and remove habitat; combined, these factors increase the likelihood of competition and predation, which has the potential to reduce marten fitness over time.

Boreal forest is predicted to decline regionally due to climate change and to be limited locally to the mountainous region of northwestern Maine and northern New Hampshire; deciduous forests are predicted to expand northward (Tang and Beckage 2010). While deciduous forests are important for marten (Payer *et al*. 2003, Poole *et al*. 2004, Dumyahn *et al*. 2007, Jensen 2012, this study), occupancy increases with a higher percentage of mixed-wood and conifer forest at the ecoregional scale (Jensen 2012), and stands with a conifer component were important during winter. The aforementioned region is considered vital for providing connectivity from source populations in Maine to New Hampshire and Vermont (Jensen 2012), and could play an important role in maintaining local source populations if the recent trend of reduced snowfall persists (Carroll 2007).

Wind power development creates high-contrast edges along ridgelines, which contributes to direct habitat loss and provides increased access for predators and competitors. Because this habitat is rare and important for marten long-term, maintaining the contiguous nature of this habitat is recommended. A balanced approach is encouraged to minimize developmental impacts in prime, high-elevation habitat of recovering marten populations.

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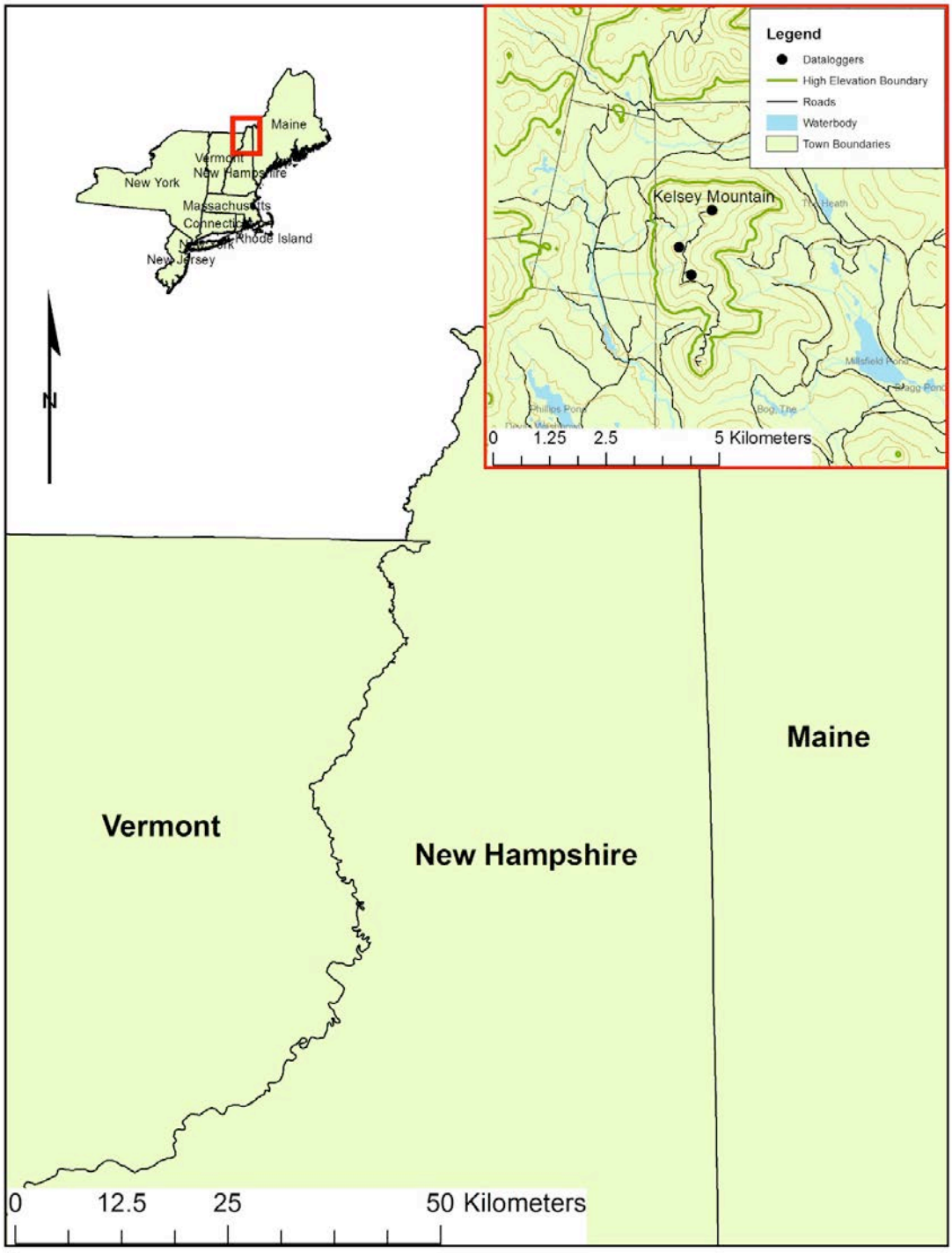

Figure 1. Kelsey Mountain Study Area (~100 km^2), in the towns of Millsfield, Dixville, Odell, Ervings Location, Colebrook, and Columbia in Coos County, New Hampshire, USA.

Figure 2. Ventral patches of collared (including unique artificial markings on collars) and uncollared marten. Trap on the left was used during PMR 2011 and trap on the right was used for PMR 2012.

25 years post reintroduction: Serosurveys of select pathogens in a population of American marten in Michigan

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The following is an abstract of a presentation given at The 62nd International Conference of the Wildlife Disease Association (WDA) on July 31, 2013.

American marten (*Martes americana*) were reintroduced into the Upper Peninsula (UP) and Northern Lower Peninsula (NLP) of Michigan during the 20th century. While the marten population in the UP has grown, marten in the NLP are regionally rare. There are no studies examining pathogen exposure in martens in Michigan. This study examines the seroprevalence to canine distemper virus (CDV), *Toxoplasma gondii*, and *Leptospira* spp. in the NLP American marten population. Serum and urine samples from 22 live-trapped American marten from the Manistee National Forest (MNF) were obtained between May 2011 and December 2012. Overall, 9% (*n*=2) were seropositive for CDV, 50% (*n*=11) for *T. gondii*, and 0% for *Leptospira*. In addition, urine samples from 18 marten were negative for *Leptospira* spp. using real-time polymerase chain reaction or indirect fluorescent antibody. Nine marten were recaptured and tested for *T. gondii* and 8 for CDV. Six recaptured marten

seropositive for *T. gondii* at the initial exam remained positive 4 to 12 months later. One marten seroconverted during the study and 2 marten were consistently seronegative for *T. gondii* 8-12 months later. Two martens seropositive for CDV had persistent titers 4-7 months later. Thus, marten in the MNF are exposed to CDV and *T. gondii*, while exposure to *Leptospira* spp. was not detected in this study. These results indicate that further testing of both the UP and NLP marten populations is warranted to determine if disease is limiting the NLP population and to evaluate the risk of disease introduction in any future reintroduction.

EUROPE

Habitat selection by two predators in an urban area: The stone marten and red fox in Wrocław (SW Poland)

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The following is the abstract of a paper published in Mammalian Biology – Zeitschrift für Säugetierkunde (online) (DOI 10.1016/j.mambio.2013.08.001)

We analyzed the habitat use of stone martens and red foxes based on incidental observations within the urbanized zone of Wrocław, SW Poland. We compared proportional habitat use at observation sites with randomly selected points and evaluated differences in distance to the water sources and to urban boundaries. Habitat use by both species was different from what we had expected from random points. Stone martens used high-density housing more frequently than red foxes and that expected from random points and avoided open and industrial areas, whereas red foxes used housing estates significantly more often than expected and avoided high-density housing. Both species used the other habitats according to their availability. Stone martens often selected habitats located closer to the city centre, whereas red foxes often selected habitats closer to urban borders than expected. The distribution of red foxes and stone martens is influenced by several factors including the availability of shelter and food, as well as the opportunity to move around undetected. Interspecific competition may also play an important role in habitat selection. Stone martens seem to be better adapted to urbanized areas than red foxes.

Socio-spatial ecology of pine marten (*Martes martes*) in conifer forests, Ireland

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The following is an abstract of a paper published in Acta Theriologica (2013) (DOI: 10.1007/s13364-013-0167-4).

Abstract – Understanding the social organisation and spacing patterns of wildlife populations is an important aspect of conservation management and applied science. The present study investigated the spatial ecology of pine marten (*Martes martes*) inhabiting conifer forests in Ireland, the largest habitat resource available for the species. It represented the first study of pine marten spacing patterns in Irish conifer forests. Pine marten (*n* =7; 5 males and 2 females) were live-trapped and radio-tracked for between 4 and 10 months from March 2008 to March 2009. Mean annual home-range estimates (95 % fixed kernel) for males (150.7 ha) were generally larger than those of females (90.2 ha). There was considerable inter-seasonal overlap in home ranges (approx. 85 %) with less inter-sexual (12.0 %) or intra-sexual (11.8 %) overlap, although the sample size of individuals for comparison was small. Pine marten home ranges were stable from season to season. Core ranges varied in size from 10.6 to 104.1 ha, and as a mean percentage of home-range area were 22.9 and 42.5 % for males and females, respectively. In terms of forest management, potential under-occupancy of available space by pine marten and vulnerability of very small core ranges to clear-felling practices needs further research to determine any impacts on individuals and populations.

Non-invasive multi-species monitoring: real-time PCR detection of small mammal and squirrel prey DNA in pine marten (*Martes martes*) scats

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Abstract – DNA identification of mammal species occurring in the diet of a predator is potentially a useful approach to remotely monitor the distribution of multiple species. This is important in Ireland, where it has been shown that the combined presence of the introduced bank vole and greater white-toothed shrew impact the distribution of the indigenous small mammals, the wood mouse and pygmy shrew. Direct monitoring of these species and their interactions requires trapping, a labour-intensive and costly approach. In this study, we applied an indirect method by genetically testing the presence of small mammals in pine marten scats collected during the National Pine Marten Survey (2005–2007) to map their distribution. We also included additional scats to investigate if less common prey items, the red squirrel and grey squirrel, could also be detected. This study demonstrates that all target species were genetically detected from pine marten scats. This strategy could be implemented as a monitoring programme for indigenous and introduced mammal species.

RUSSIA

Contemporary status of sable and European pine marten resources in the Mid-Urals Region

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The Ural region is special because 2 *Martes* species occur here – sable (*Martes zibellina*) and European pine marten (*Martes martes*). Here the western part of the sable's geographic range and the eastern part of the pine marten's geographic range overlap. In recent years, a multiple increase in marten and sable numbers has been observed for all natural hunting areas and districts of the Middle Urals (Korytin 2011, Monakhov 2011). We consider a significant reduction in hunting removal to be the most probable factor, and concomitant is global warming and loading decrease on agricultural lands.

These observations aroused interest in these questions: what are the current relationships in the geographic ranges of these 2 species, their resources, and population densities? We have carried out similar studies before (Monakhov 2005a, 2005b). It is important to assess the current status of these species in the Urals, and in particular, in the Sverdlovsk province.

Here we analyze population data for spring 2013 for these 2 species of *Martes* provided by the Department of Natural Resources of the Sverdlovsk province. To describe the distributions of these species, we use the natural-hunting zoning scheme based on game-economy counties (GEC), as described previously (Monakhov 2011).

When we estimate the number of sable dwelling within the region, we observe that the species' geographic range has not changed. As described previously, sables occupy the northeast part of the Sverdlovsk province (Fig. 1). The highest sable population densities (1.1 – 1.4 per 1000 ha) were observed along the Lozva River, with a maximum density (2.63 per 1000 ha) in the eastern portion of the southern taiga zone (WS2 GEC). The average population density of sable within the occupied area was 0.99 per 1000 ha. For comparison, the average density of pine marten within this occupied area is 1.02 per 1000 ha (Fig. 2).

The highest pine marten population densities (2.1 – 2.45 per 1000 ha) were observed in these 5 districts of the Sverdlovsk province: the Artinskii, Krasno-Turinskii, and Kirovgradskii municipal districts (MDs) of Ural Mountain zone U (Monakhov 2011); the Slobodo-Turinskii MD on the East of southern taiga WS2 GEC; and the Pyshminskii MD in forest-steppe WS3 GEC (Fig. 2). However, the maximum pine marten density of about 6 per 1000 ha was observed in the Kamyshlov MD of forest-steppe WS3 GEC in the SE of Sverdlovsk province. This indicates that pine marten have successfully adapted to a very fragmented forest landscape. Average pine marten densities (1 to 2 per 1000 ha) can be found in the mountainous middle-taiga U2, southern taiga WS2, and the To-Urals area PU GEC (Fig. 2).

Pine marten population densities in districts of cohabitation with sable are usually low. Only in Karpinskii MD, where the pine marten population is about 800 animals, does the density attain almost 1.5 per 1000 ha. The zone of marten and sable overlap mainly occupies 7 municipalities in the northeastern portion of Sverdlovsk province. This is Severo-Uralsky U1, plain middle-taiga WS1, and northeast of South taiga WS2 GEC (Fig. 1). In these 3 GECs, the number of sable in the spring of 2013 was 5,500 animals.

In the main sable dwelling area (plain middle-taiga WS1 GEC), the number of sables decreased by 30% compared to average figures from 2005 – 2011 (Table 1). In the other 2 GECs, sable resources have increased: in Severouralsk MD by 1.7 times; and in the southern taiga (Taborinsky MD) by 1.4 times (Table 1). This possibly can be explained by new registration of sables outside of the specific range in 2013 (Monakhov, 2013, in press).

We have estimated the ratio of martens and sables in the area of cohabitation in the Sverdlovsk province in 2013. Table 2 shows that the marten is prevalent in western districts of the Sverdlovsk province, while the sable is prevalent in eastern districts of the Sverdlovsk province.

Hunting use of sable in the Sverdlovsk province is at a low level. We estimate that seasonal production is no more than 1,000 animals. A possible hunting quota for sable could be increased to 3,000.

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Table 1. The number of sable in the Sverdlovsk province in the spring of 2013.

	Sable numbers		
Game-Economy County (GEC)	**2005 – 2011**	**2013**	**Change (%)**
U1	34	49	173
WS1	5181	3620	70
WS2	1281	1788	140
Total	6496	5457	84

Table 2. The ratio of the number of pine marten and sable in the area of joint habitation in the Sverdlovsk province in 2013.

			Ratio
Municipal District	**Pine marten**	**Sable**	**Pine martens / Sables**
Garinskii	63	1436	0.04
Serovskii	565	159	3.55
Ivdelskii	151	1822	0.08
Pelym	15	203	0.07
Karpinsk	793	43	18.21
Severo-Uralskii	164	6	27.33
Tabory	231	1788	0.13
Total	1982	5457	0.36

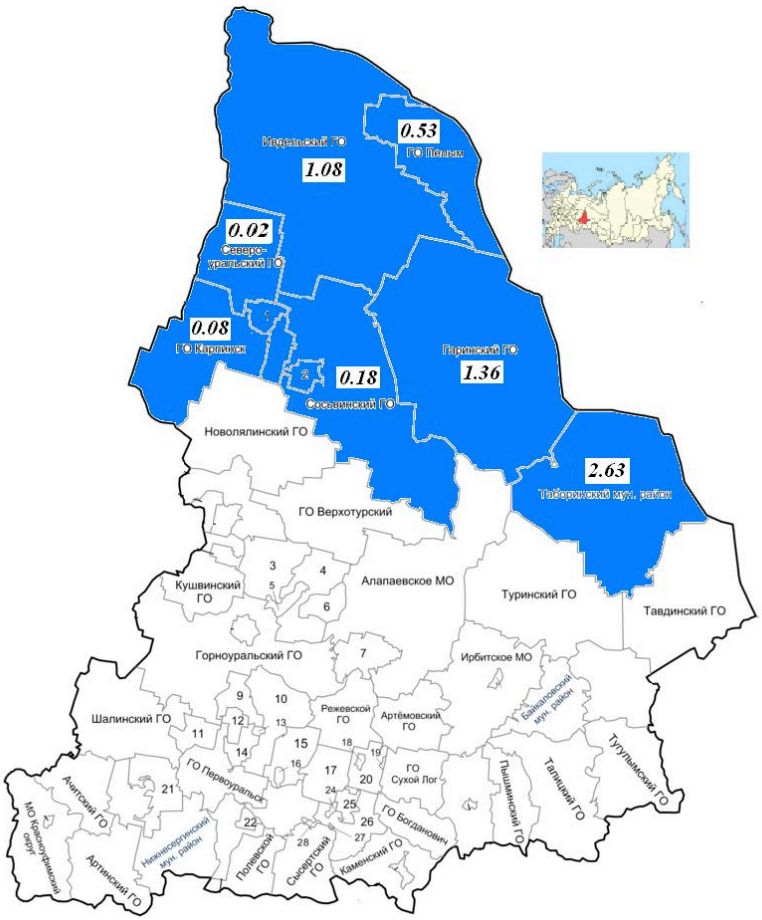

Figure 1. Area of distribution and population density of sable in the Sverdlovsk province.

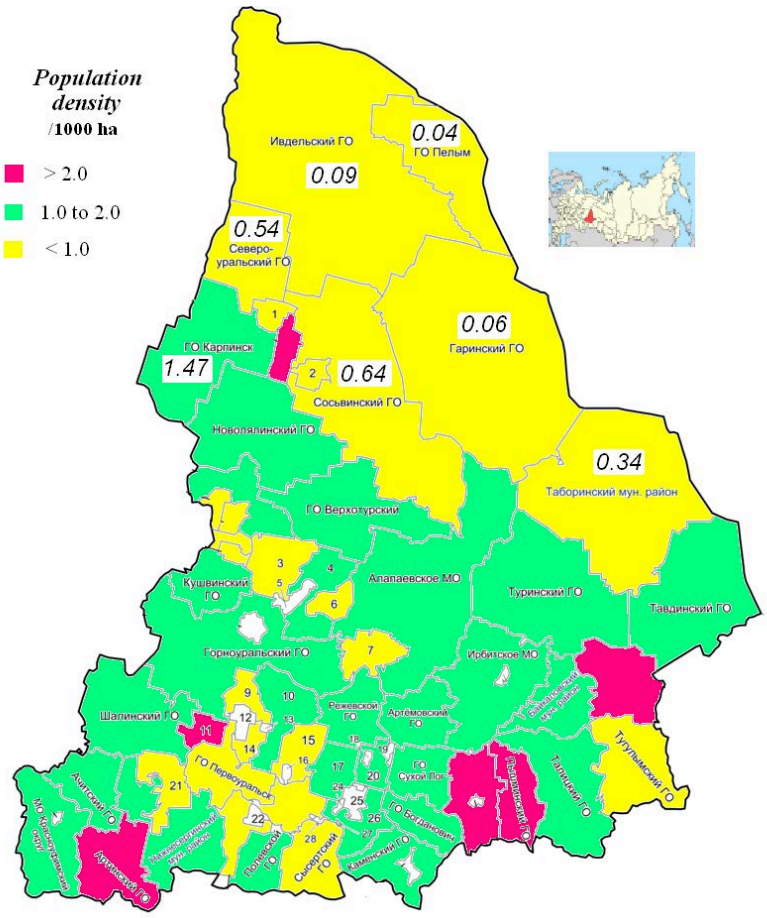

Figure 2. The population density of pine marten in the Sverdlovsk province in 2013.

Hybrids between sable and pine marten: a study by the method of geometric morphometrics

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The identification of hybrids between morphologically closely related species is frequently associated with methodical difficulties. Sables (*Martes zibellina*) and European pine martens (*M. martes*) are not only morphologically similar, but also genetically similar (Rozhnov *et al*. 2010). However, crossings between kiduses (F_1 sable x Eurasian pine marten hybrids), including absorptive crossing of male sables with female kiduses, have not yielded offspring thus far (Portnova 1941, Grakov 1970, 1971; Bakeyev and Sinitsyn 1994). The kidus males are considered reproductively sterile (Grakov 1981) because offspring have been obtained only from kidus females and male pine martens. This fact suggests the possibility of introgressive hybridization.

We attempted to estimate craniological differentiation of sable and pine marten hybrids using a formalized method based on geometric morphometrics (Bookstein 1991, Pavlinov *et al*. 1984, Rohlf, 1998). Comparisons have been based on the analysis of one cranial construction, namely the bulla ossea region. The bulla ossea region has been used by some authors as a diagnostic character for *Martes* species (Novikov 1956, Stroganov 1962, Heptner *et al*. 1967).

We studied skull collections of sables, martens, and kiduses from the Zoological Museum of the Moscow State University (collections from the Pechoro-Ilychsky State Reserve, the transgression zone), pine martens from the Zoological Museum of the Institute of Plant and Animal Evolution of the Ural Branch of the Russian Academy of Sciences (Talitsa and Sukhoi Log municipalities of Sverdlovsk province in the Middle Urals), and sables from the personal collection of A.V. Krutikov (the upper Taz River basin) (Table 1). The animals were identified as hybrids by collectors (or suppliers) of the material and accepted according to the museum descriptions and collection labels. Only adult individuals (older than 1 year) were included in the analysis. The age was determined according to methods described by Smirnov (1960) and Timofeev and Nadeev (1955).

Photographs of the cranium ventral side taken with a digital camera (with a resolution of 4320 × 2432 pixels, Fig. 1) were processed with the use of TPS, MorphoJ 1.01c, and IMP software (Zelditch *et al*. 2004). Statistical calculations were processed with MS Excel 2003, Past 2.07, and Statistica 6.0 software. The cluster analysis was conducted on a matrix of generalized Mahalanobis distances (D^2). Twenty-seven landmarks were used to characterize the shape of bullae osseae and their relative position on the cranium (Fig. 1).

We observed statistically significant differences ($p < 0.0001$) between sexes for all kiduses, as well as for pine martens and sables. For this reason, the analysis of the shape of auditory bulla was carried out with separate samples for each sex. When gender differences have been accounted for, geographic patterns for *Martes* species and kiduses also exhibited statistically significant differences ($p < 0.0056$).

We created canonical discriminant analysis diagrams for kidus samples compared with pine marten and sable samples (Fig. 2). The first canonical variable, which accounts for 52.1 – 63.6% of intergroup variance, includes interspecific differences. Male and female kiduses occupy an intermediate position between sables and pine martens of the Pechoro-Ilychsky National Reserve. This is consistent with data for first-generation hybrids, which inherit characters of both parental forms, and because of this they have "mixed" sable and marten morphological traits. With respect to the shape and location of auditory bulla, kiduses are most different from the Upper Taz River sables.

In evaluating the classification based on the shape and position of auditory bulla, the percentage of correct identification (kidus, pine marten, and sable) in all samples is on average 73.15%. Sables from the Upper Taz River have the highest percentage of correct classification (84.3%). The lowest percentage of correct classification (62.5%) was

observed for Pechora kiduses, and three-quarters of incorrectly certain representative Pechora sable and marten (the "parents" hybrids).

Figure 3 presents the classification of *Martes* samples based on a cluster analysis using the unweighted pair-wise group average (UPGMA) applied to a matrix of generalized Mahalanobis distances (D^2). The tree diagram shows that the investigated samples are clearly divided into 2 clusters: sable and marten. In this case, males and females from each geographical location fall in 1 cluster, indicating the priority of the geographical differences in the studied traits. Kidus females and males stand out in a separate cluster, which tends to marten.

The analysis of samples of male and female sable and pine marten revealed statistically significant differences between the forms of auditory bulla. Sables tend to exhibit a more elongated and rounded form of auditory bulla, resulting in a visually larger 2-dimensional image of their area. Martens have a narrower and angular form of auditory bulla, resulting in a visually smaller 2-dimensional image of their area.

It can be assumed that the shape of auditory bulla and their relative positions in the studied *Martes* species can be correlated with features of their way of life. Martens are more adapted to life in trees than sable, and actively use this additional ecological niche. In this connection during evolution the features primarily associated with the development of the vestibular apparatus were fixed. The sable demonstrates the terrestrial way of life, as characterized by a more-developed hearing compared to the pine marten. It can be assumed that these differences in ecology are reflected in the morphology, and as a result, in the shape of interposition, and construction of bullae osseae.

We found that the sable, marten, and kidus show statistically significant interspecific, gender, and geographical differences. Kiduses occupy an intermediate position between the parental forms and comply with the classical ideas on the status of interspecific F1 hybrids. They are characterized by a combination of morphological characters of sable and pine marten.

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Table 1. The craniological collections studied.

Geographic Location	Sample Name	Species	No. Males	No. Females
Pechoro-Ilychskii State Reserve	Pechora	*Martes martes*	30	25
		Martes zibellina	26	20
		M. martes x M. zibellina (kidus)	20	12
Talitsa and Sukhoi Log municipalities of Sverdlovsk Province	Middle Urals	*Martes martes*	16	17
Upper Taz River	Taz	*Martes zibellina*	30	21
Total (M-F)			122	95
Total (animals)			217	

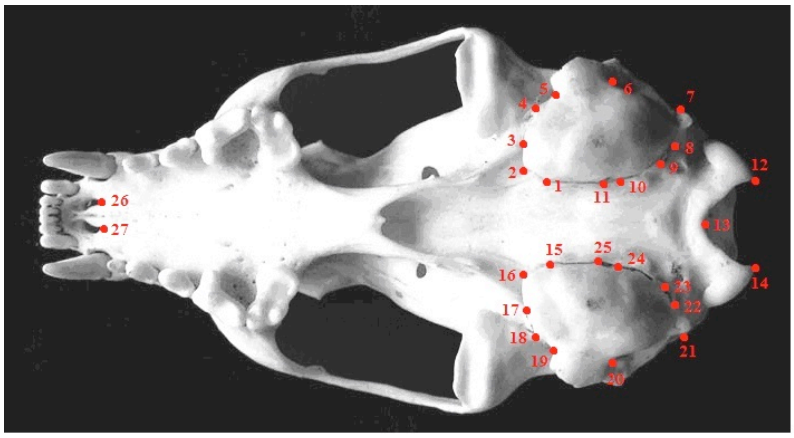
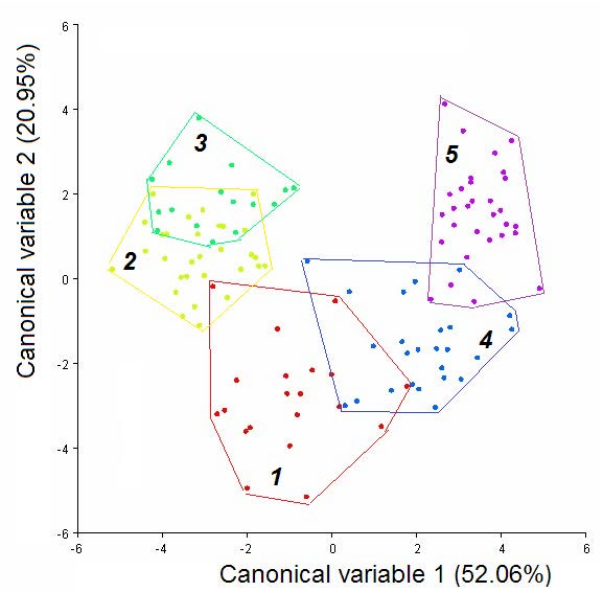


Figure 1. Positions of landmarks on the cranium of *Martes*.

A



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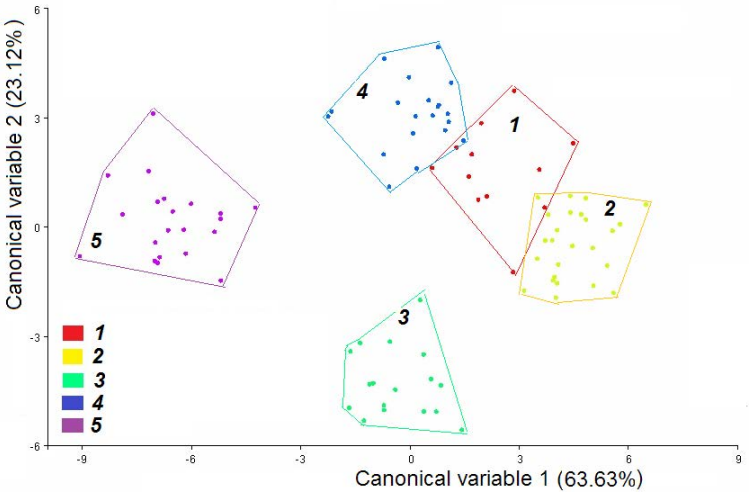

Figure 2. Locations of male (A) and female (B) kiduses (1), sables (4, 5), and pine martens (2, 3) in the space of the 2 first canonical variables: (2, 4) Pechora; (5) Taz; (3) Middle Urals.

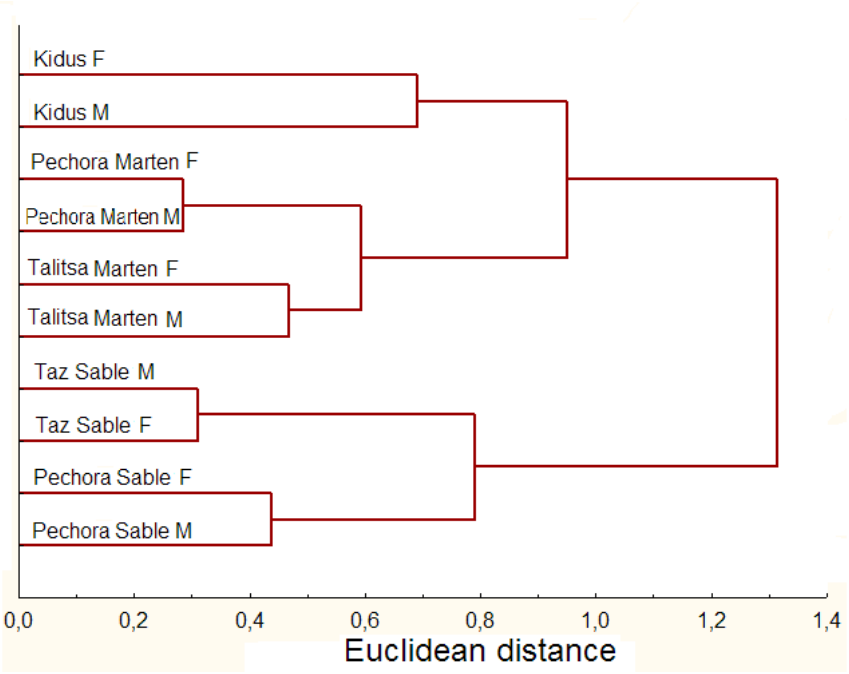

Figure 3. Tree diagram depicting a cluster analysis of sable, pine marten, and kidus samples based on the UPGMA method applied to generalized Mahalanobis distances (D^2) (F, females; M, males).

Anomalies and traumas in sable, *Martes zibellina* (Carnivora, Mustelidae) of Yakutia

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Abstract
A number of anomalies and post-traumatic disorders have been detected while examining 4,738 sable carcasses. Distinct malformations in the skull structure were found in 0.5% of sables, commonly in the maxillofacial area (58.3%). Maldevelopment of the internals has been detected in 0.2% of the specimens, more often being manifested in the number and size of kidneys (85.7%). The most commonly widespread cranial traumas of sable are considered in the article. Frequency of occurrence of craniological anomalies in sable in the territory of Yakutia is much less than in the Magadan Region. Possible reasons for these distinctions are discussed.

Key words: sable, Yakutia, anomalies, traumas

Introduction
Deformity phenomena frequently arouse the interest of researchers. It is believed that some deviations in animal body constitution resulting from evolution facilitated new species origin (Kaliev 2011, Shimkevich 2012). Anomalies in skull structure, body, and

extremities, including maldevelopment of the internals, in wild animals have been poorly described because of insufficient evidence. This article considers anomalies and traumas occurring in sables of Yakutia.

Material and Methods

4,738 sable carcasses from the main sable areas of Yakutia hunted from 2002 to 2010 were examined. Carcasses and skulls of sables were examined according to common methods (Kuznetsov 1975, Novikov 1975). All detected anomalies and lifetime traumas of the animals were recorded and grouped later. There is little information available relating to maldevelopment of species from genus *Martes*, mainly on morphological deviations of the skull (Pavlinin 1963, Samusev 1972, Pavlinov 1980, Dubinin 2001).

Results and Discussion

In our study anomalies in skulls occurred more frequently than in extremities and in organs. Three sables (0.06%) with prognathism were recorded. Their eye teeth were in front of the stomach teeth (Fig. 1). Two individuals had micrognathia (Fig. 1a), and 1 had microgenia (Fig. 1b). Besides these, 1 sable had asymmetrical morphology of the rostral part of its maxilla (Fig. 1c).

Zygomatic arch deviations were very significant in 5 sables (0.1 ± 0.04%) (Fig. 2). Such an anomaly also was found in Tobolsk sables, in approximately 0.81% of cases (Pavlinin 1963).

In 2 sables abnormal outgrowths on the upper dorsal skull area were found (0.04%) (Fig. 3). They also were recorded earlier in Tobolsk sables (Pavlinin 1963).

Two males at the age of 1 year and 2 years (0.04%) had deformations of the occipital condyle (Fig. 4a and 4b, respectively). Congenital anomaly of craniovertebral area development with asymmetry of occipital condyles occurs in 0.4 – 2.2% of humans (Khabirov 2001). One young female also refers to this group with the defective ventral area of the occipital condyle (Fig. 4c).

Deviations in the tooth system consisted of the number of maxilla cutting teeth and their maldevelopment (Fig. 5). The percent of sables with partial edentia (with 5 upper cutting teeth) was 0.15 ± 0.05% (n = 7). Usually the reasons for edentia are defects of dental germ development in the fetal life period, and inflammatory processes in postnatal development. It is known that absence of 1 or several teeth leads to atrophy of maxillary bone tissue and malalignment of healthy teeth nearby. Secondary partial edentia of the upper cutting teeth was observed in 11 sables (0.23 ± 0.07%). Individuals with 7 and 8 upper cutting teeth were recorded 1 time each (0.02%). One sable had a double upper left fang. Improper development of the cutting teeth, caused by a spur in the rostral part of intermaxilla, was observed in the young female. Supernumerary teeth may be an attribute, vanished during evolution.

Among 24 sables with deviant craniological characteristics, females accounted for 41.7%, males 58.3%, adults 41.7%, and young 58.3%.

Interior deviations of 3,458 examined individuals consisted essentially in size or absence of 1 kidney. Two sables (0.06%) had only a right kidney and a hypertrophied adrenal gland instead of the left kidney. One kidney was 1.8 – 2.8 times smaller than another in 3 animals (Table 1). One young male had a weight of 2 kidneys (500 mg each) that was 6.9 times smaller than the average weight of this organ (3451.4 ± 97.3 mg; *n* = 48) in males of the same age. Among 6 sables with kidney anomalies, 4 (66.7%) were caught within the limits of 1 region – the western spurs of the Verkhoyansk Mountain Range.

An adult male with 2 spleens was recorded. They resembled parts of 1 bifid organ. Externally these 2 spleens were in the normal condition. Cases of doubled spleens in humans are well known; the absence of this lymphoid organ occurs less frequently.

In the winter of 2009 – 2010, 1 male with 3 anomalous extremities (hind limbs and 1 fore limb) was recorded. This male had a shortened and thickened metacarpus, foot, and phalanges (Fig. 7).

Traumatic anomalies were found mostly in skulls. Predominantly, fractures of zygomatic arches (1.8 ± 0.2%; *n* = 86; Fig. 8) were observed, because this is the most fragile element of the skull. Zygomatic arch traumas of common martens (*Martes martes*) were recorded in 3.2% of males and 2.8% of females (Pavlinov 1980).

Skull traumas in the form of holes of different size, remaining perhaps after old bites, were infrequent (Fig. 9). Mainly, they were in the lateral surface of the cerebral area, less often in some other areas. The share of animals with such traumas was 0.8 ± 0.1% (*n* = 38).

Skulls with mamelons and malunions were occasional (Fig. 10a, b). As a rule, formation of numerous small mamelons relates to deviations in the sagittal crest. Large bony outgrowths were found predominantly in adult animals.

Only the most apparent anomalies in sables have been discussed here. The proportion of sables with craniological anomalies in Yakutia is much lower than in the Magadan region. According to E.A. Dubinin (2001), the average number of individuals with dentition anomalies varied from 2.45% to 31.9% in the Magadan region, and from 0.02% to 0.23% in Yakutia. He assumed that the high percent of anomalies in Magadan sables might be associated with environmental pollution by the mining industry and with their hybrid origin from Kamchatka (*Mustela zibellina kamtschadalica*) and Bureja (*M. z. princes*) subspecies. In Yakutia, anthropogenic influence on the environment has a local character so far and is hardly associated with anomalies in sables. As for subspecies crossbreeding, Kamchatka and Bureja sables intermixed only in the Kolyma basin, and Yenisei (*M. z. yenissensis*) and Vitim (*M. z. vitimensis*) subspecies interbred in the Vilyui basin (Zakharov and Safronov 2012). Vast Yakutia territories are inhabited by descendants of Vitim invasive sables, formed “in cleanness.” The anomaly frequency in the animals discussed above is likely within natural developmental variation.

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Table 1. Deviations in kidney weight in Yakutian sables.

Animal Record			**Kidney weight (mg)**	
Number	**Region, Season**	**Sex**	**Left**	**Right**
1210	Aldan region, 2005/2006	Female	4700	2490
2566	Kobyay region (Predverkhoyanie), 2007/2008	Male	500	500
3182	Kobyay region (Predverkhoyanie), 2008/2009	Female	2260	1260
4210	Kobyay region (Predverkhoyanie), 2009/2010	Male	2640	950
3202	Kobyay region (Predverkhoyanie), 2008/2009	Male	4920	-
4257	Olenek region, 2009/2010	Female	5500	-

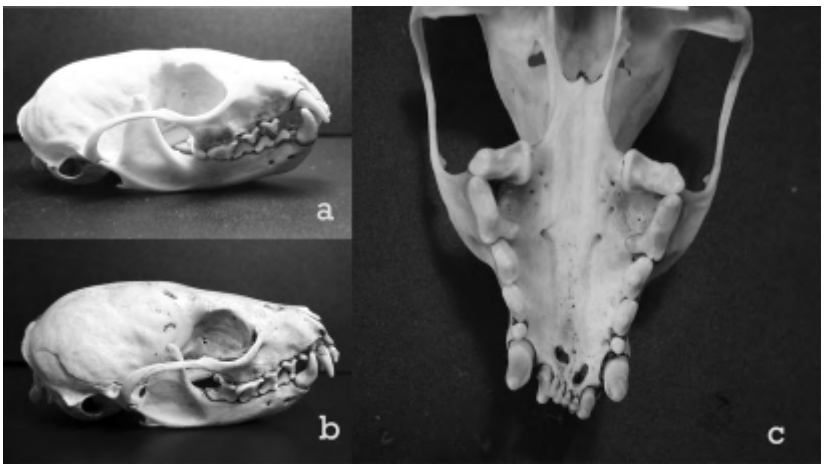

Figure 1. Anomalies in morphology of maxillo-mandibular apparatus in the sable.

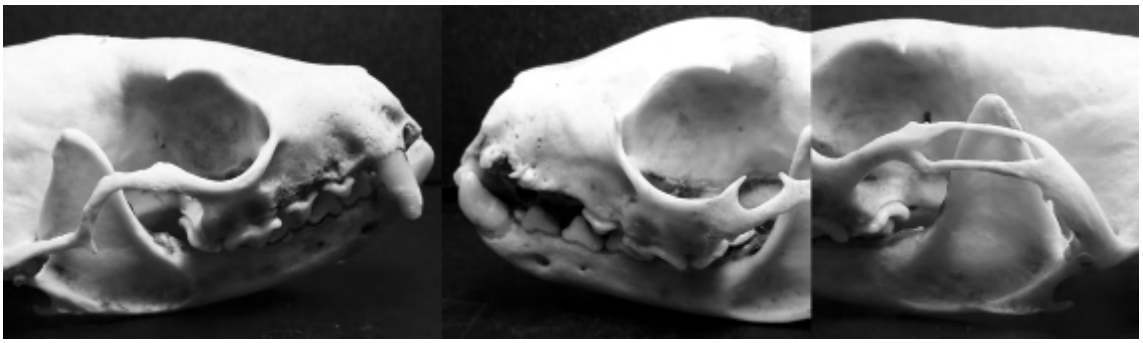
Figure 2. Abnormal sable zygomatic arches.

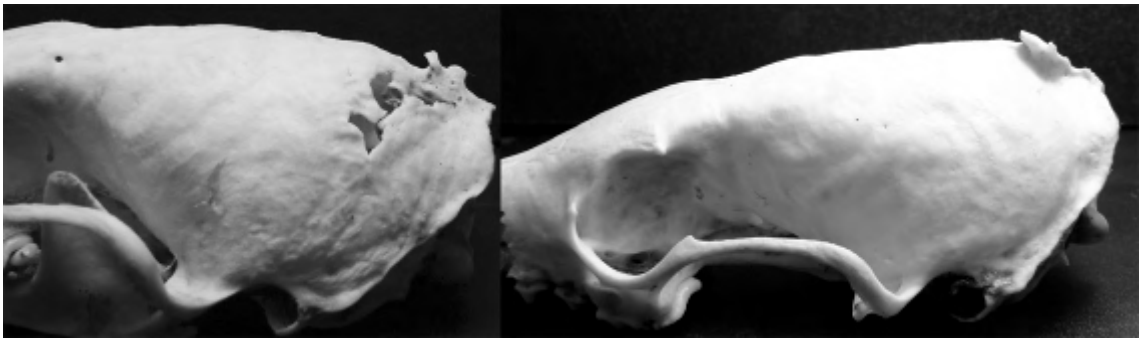
Figure 3. Mamelon on skull crest.

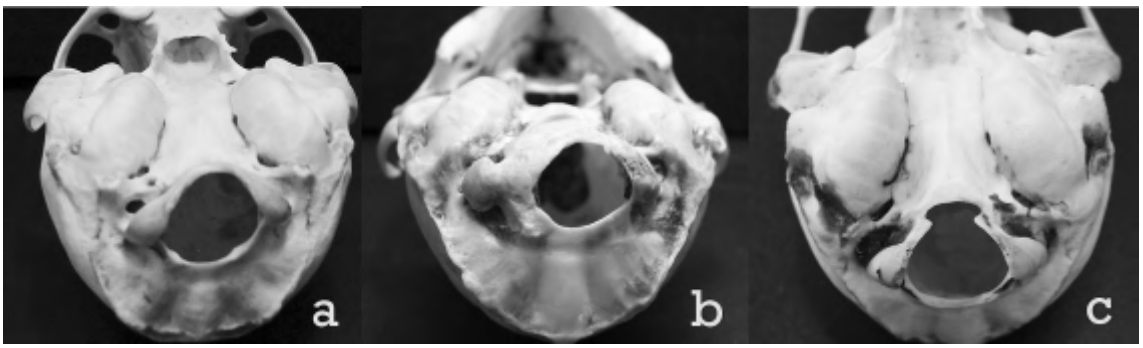

Figure 4. Deviant structure of occipital condyle bones.


Figure 5. Deviations of dentition development.

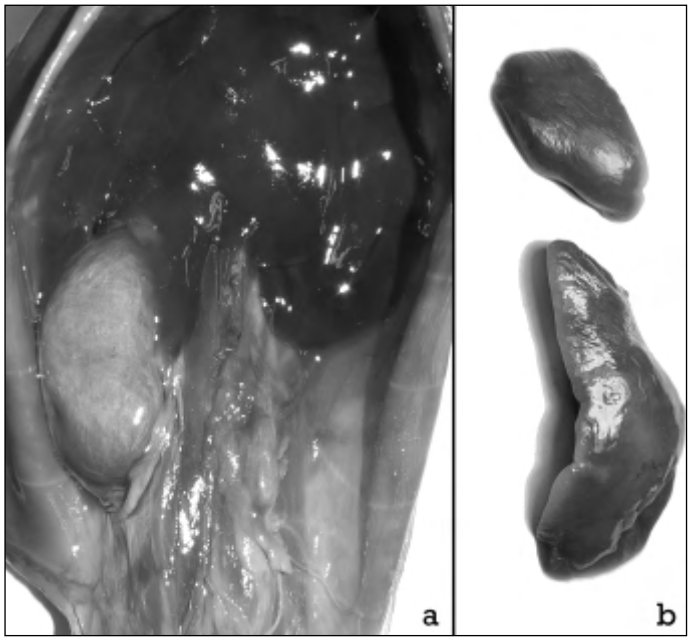

Figure 6. (a) sable with one kidney; (b) bifid spleen of the sable.

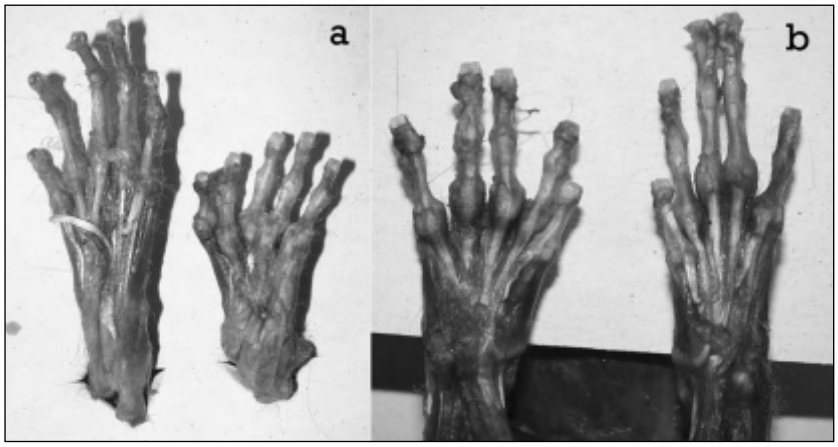

Figure 7. Acropathology of sables: a – right hind foot; b - fore foot.

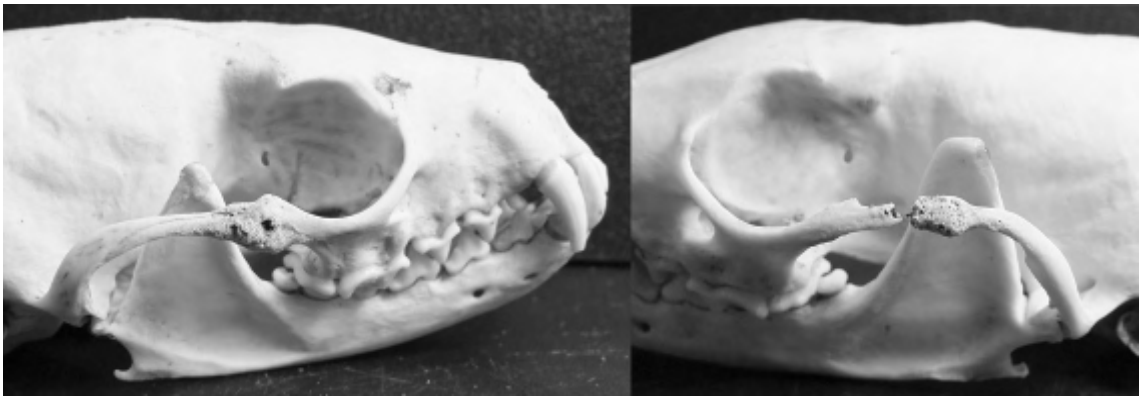

Figure 8. Callus in the site of zygomatic arch fracture.

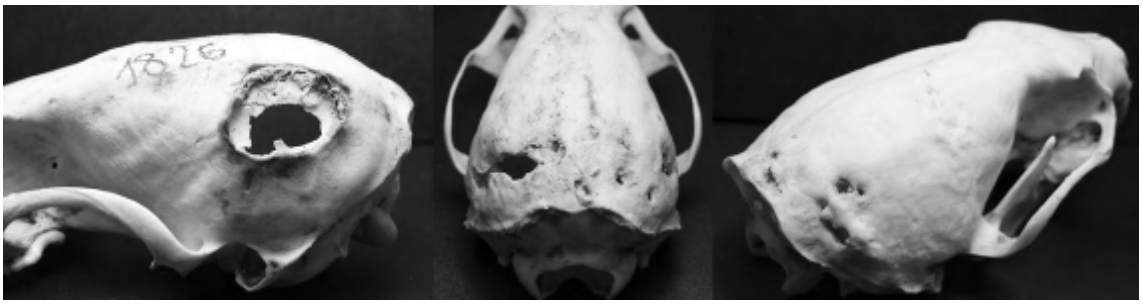

Figure 9. Traumas in cerebral area of skull.

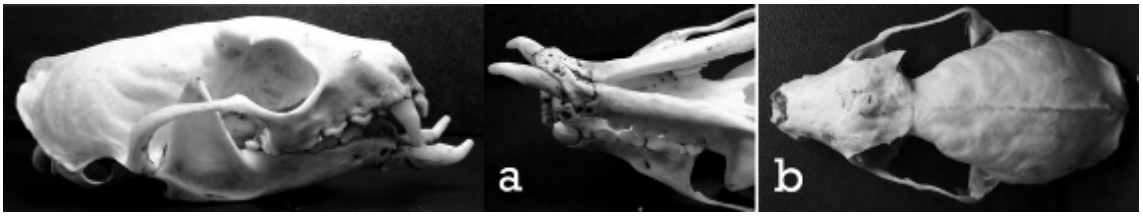

Figure 10. United fracture of mandible (a) and bony mamelon of postorbital apophysis (b).

ASIA

New data on sable craniology of China

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Ma and Wu (1981) described a new subspecies of sable for China, *Martes zibellina linkouensis*. This description was carried out on a small sample. These authors compared the main cranial measurements of their samples with samples from the neighboring regions of Siberia to China with the assistance of data available in the literature. Now we are able to verify the findings of Ma and Wu (1981) by comparing their observations with new materials.

To begin, we would like to describe the basic craniometrical characteristics that were obtained by Ma and Wu (1981). They examined 16 skulls (including 5 males) collected in Heilongjiang Province. *M. z. linkouensis* subspecies were collected in Linkou county of Heilongjiang province (about 46N 130E). Holotype and paratype specimens were deposited in Forestry Research Institute of Heilongjiang Province taxidermy room. For comparison, major cranial measurements from Ma and Wu (1981) are provided in Table. 1.

We studied 18 skulls (11 males, 7 females), most of which were collected in 2012 from the Yichun area in the Xiaoxing'anling Mountains of the Heilongjiang province (about 47°N, 128 E). Of these, 5 were collected (by B. Li) in the Tuqiang area in the Daxing'anling Mountains of the Inner Mongolia Autonomous Region (about 49N, 123E). This collection is stored in the College of Wildlife Resources, North-East Forest University, Harbin, China.

It should be noted that in China the sable is a protected species (Zhu *et al*. 2011) and, accordingly, there are considerable difficulties in collecting biological material, including skulls. In this study, we sampled sable skulls that were incidentally captured in poaching cases.

V. Monakhov used standard techniques to measure craniometrical features, which allows direct comparisons across samples. Each skull was measured using an electronic caliper with an accuracy of 0.1 mm. Table 2 lists the 17 characters that were measured: (1) basal length, (2) condylobasal length (CBL), (3) profile length, (4) braincase length, (5) facial length, (6) teeth row length, (7) molar row length, (8), length of the auditory bulla, (9) braincase width, (10) greatest width of the skull (GW), (11) width of the occipital condyles, (12) choanal width, (13) facial width between the zygomatic foramina, (14) width of the upper incisors row, (15) width of auditory bulla, (16) height in the area of auditory bullae (greatest height, GH), and (17) height in the area of the interorbital narrowing. Zygomatic wight (ZW) was taken in addition.

Comparing the average values of the samples showed that sables from the more recent sample are larger (Tables 1 and 2). The average differences are about +4.6% for males and 4.5% for females (Table 1). It is possible that the sample that Ma and Wu (1981) measured consisted mainly of young animals.

In addition, we classified the above collections according to the presence on skulls of the phenetic trait FFCI described by Monakhov (2006, 2010), with localization as shown in Fig. 1. If we compare our data (Table 3) with the mean values obtained by Monakhov (2010), we notice that the female percentage is close to the values of the East Siberian and Far Eastern Russian sable populations from the Sikhote Alin Mountains (83.5 %), Barguzin Mountains (71.3%), Gorin River (72.7%), Vitim River (71.4%), and Hamar-Daban Mountains (73.7%). The values for males are similar to the averages for sable populations at Abakan River (25.6 %), Angara River (27.7), and Kamchatka Peninsula (27.9%); and also to some Ural populations of Lozva River (27.7%), Ugan River (23.0), and Kazim River (26.5 %).

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Table 1. Some of cranial measurements of sable (5 males and 11 females) provided Ma and Wu (1981) (mm).

Character		Average (mm)	Lim (Range)	Differences with our data (%)
CBL	Males	78.8	77.4 – 81.3	+2.9
	Females	72.5	69.6 – 75.2	+3.6
Profile length	Males	79.1	77.4 – 81.3	+5.1
	Females	73.0	69.6 – 75.3	+4.4
Zygomatic wight	Males	44.5	42.8 – 48.8	0
	Females	40.2	38.2 – 43.3	+1.7
Length of auditory bulla	Males	17.3	17.0 – 17.8	10.4
	Females	17.1	15.8 – 18.2	+8.2

Table. 2. Mean values (mm) and other statistical features of sables (11 males and 7 females) from China.

Character		Average (mm)	Lim (Range)	± SE
1. Basal length	Males	73.98	72.0 – 76.6	0.39
	Females	68.14	65.2 – 70.2	0.66
2. Condylobasal length (CBL)	Males	81.10	79.1 – 83.3	0.43
	Females	75.06	79.1 – 83.3	0.72
3. Profile length	Males	83.17	80.1 – 86.1	0.58
	Females	76.19	72.9 – 79.8	0.74
4. Braincase length	Males	53.42	51.7 – 55.0	0.35
	Females	49.16	46.7 – 50.9	0.53
5. Facial length	Males	34.87	33.5 – 37.1	0.33
	Females	32.11	30.3 – 33.6	0.44
6. Teeth row length	Males	30.96	30.0 – 32.2	0.24
	Females	28.60	27.6 – 30.2	0.34
7. Molar row length	Males	24.05	22.8 – 25.4	0.23
	Females	22.27	21.6 – 23.0	0.22
8. Length of the auditory bulla	Males	19.05	18.0 – 20.4	0.22
	Females	18.46	16.7 – 19.9	0.34
9. Braincase width	Males	34.91	33.6 – 35.8	0.21
	Females	33.57	32.4 – 34.6	0.33
10. Greatest width of the skull (GW)	Males	36.01	34.7 – 36.7	0.19
	Females	34.83	33.6 – 36.5	0.33
11. Width of the occipital condyles	Males	19.22	18.3 – 19.8	0.13
	Females	17.93	17.2 – 18.7	0.20
12. Choanal width	Males	8.33	7.7 – 8.8	0.10
	Females	8.16	7.8 – 8.9	0.13
13. Facial width between the zygomatic foramina	Males	19.43	18.8 – 20.4	0.14
	Females	18.11	17.4 – 18.8	0.17
14. Width of the upper incisors row	Males	7.73	7.3 – 8.5	0.11
	Females	7.37	6.9 – 7.8	0.11
15. Width of the auditory bulla	Males	10.79	10.6 – 11.4	0.07
	Females	10.64	10.2 – 11.3	0.15
16. Height in the area of the auditory bullae (greatest height, GH)	Males	31.37	30.3 – 33.0	0.21
	Females	29.57	29.0 – 30.1	0.14
17. Height in the area of the interorbital narrowing	Males	22.86	21.8 – 23.8	0.19
	Females	21.30	20.4 – 22.5	0.23
ZW Zygomatic wight	Males	44.47	39.5 – 47.9	0.69
	Females	40.91	39.5 – 43.9	0.52

Table 3. Expression of the phonetic trait FFCI in sables (11 males and 8 females) from China.

Morph	Males	Females	Total
L0-R0	8	1	9
L0-R1	1	2	3
L1-R0	-	-	-
L1-R1	2	4	6
% (without L0-R0)	27.3	85.7	50.0

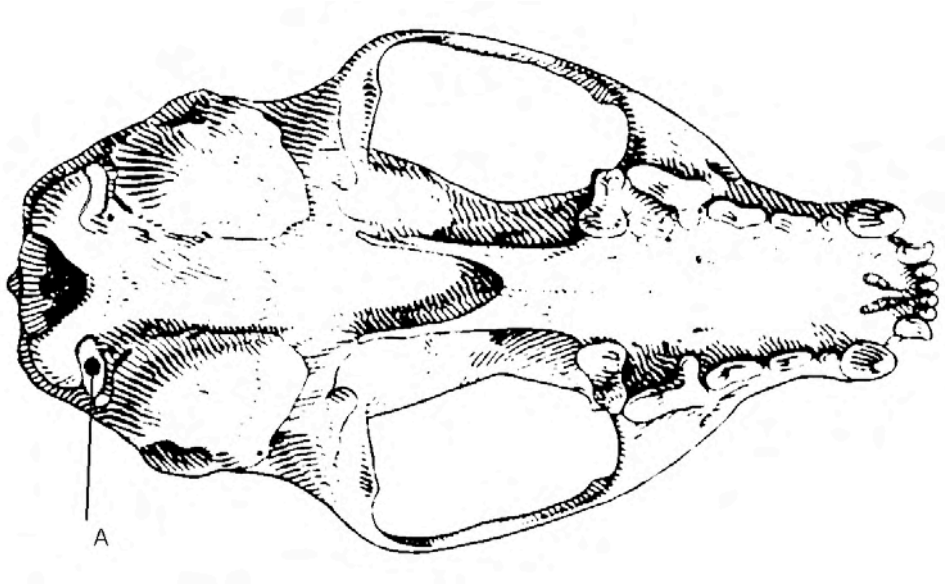

Figure 1. Localization of the phenetic trait FFCI on the skull of a sable (A). The morph L1-R0 is shown.

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