

## LETTER TO THE EDITOR

Comment on “Skeleton of Extinct North American Sea Mink (*Mustela macrodon*)” by Mead *et al.*

Mead *et al.* (2000) provide a good thorough description of new materials of an extinct phenon of mink, which has variously been referred to as *Mustela macrodon* (Prentiss, 1903), *Mustela vison antiquus* (Loomis, 1911), and *Mustela vison macrodon* (Manville, 1966) from the middle Holocene to historic times in the Northeast. As noted by all these authors, including Mead *et al.* (2000), this extinct form is larger than any living forms of mink, including the largest subspecies (*Mustela v. ingens*) which lives in Alaska today. As previous authors have done, Mead *et al.* (2000) raise the question about the taxonomic status of this phenon. They propose two hypotheses. The first hypothesis states (pp. 256–257) that “... large archaeological remains of *Mustela*, often referred to as *M. macrodon*, are merely larger-than-typical individuals in a population of *M. vison*.” Mead *et al.* (2000, p. 257) reject this hypothesis. The second hypothesis, which they prefer, states (p. 257), “A small species (*Mustela vison mink*) lived in interior and coastal regions, and a decidedly larger species (*M. macrodon*) was isolated or restricted to islands off the coast.”

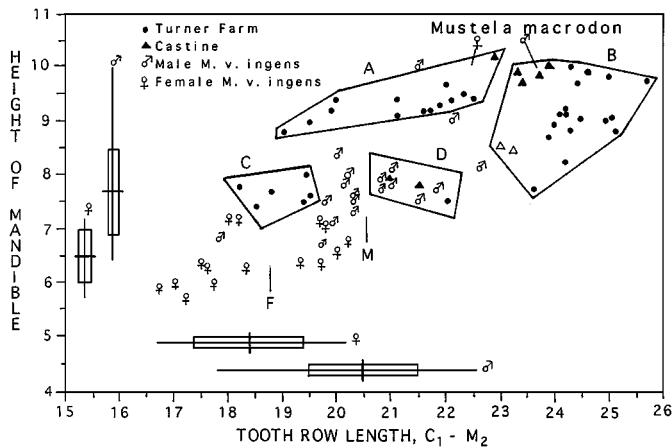
I believe that the data presented by Mead *et al.* (2000) really fit more congruously with Hypothesis I and that Hypothesis I makes better ecological, evolutionary, and taxonomic sense. To this end, I show in my comment that the large and small individuals in the archaeological samples represent males and females of the phenon *macrodon* and that they are not the result of the mixing of mainland and island populations. Therefore, the phenon *macrodon* overlaps in size with *M. v. ingens* but on the average it is a larger mink. The sea mink is not a valid species but should be considered a subspecies. The large size of the sea mink may be due, in part, to a diet of fish and molluscs.

In all the graphs with multiple specimens from the Turner Farm archaeological site (Figs. 7–13 of Mead *et al.*, 2000) at least one, and often several, individuals cluster and overlap with smaller forms of modern subspecies (e.g., *M. v. ingens*, *M. v. nesolestes*, and *M. v. letifera*). Mead *et al.* (2000, p. 256) interpret these smaller specimens as being derived from the mainland and transported to the islands by humans rather than having been indigenous to the island. They (p. 256) state, “Certain *Mustela* remains recovered from the Turner Farm site indicate two types (sizes) of mink; some of these surely represent coastal American mink specimens (e.g., Figs. 7–12).” Conversely, they believe large specimens on the mainland are *M. macrodon* that have been transported there by humans.

Although this explanation is plausible, it is more parsimonious to assume that all of the specimens from a specific site are derived from a single local population (i.e., Hypothesis I). If this assumption is applied to the Turner Farm population, as well as the other archaeological samples, then mean “body” size for this population is larger than modern subspecies but there is considerable overlap between the fossil and modern populations. Intrasite variation in size and a tendency toward bimodality (small and large individuals) could reflect sexual dimorphism that is prevalent in most modern mustelids.

Sexual dimorphism was recognized by Loomis (1911), as well as by Loomis and Young (1912), in their original analyses of the fossil *Mustela vison antiquus* (= *M. macrodon*). Their measurements suggest that males were about 20–25% larger than females in the fossil population. This variance is comparable to sexual dimorphism in modern New England populations. Also, it appears from the graphs of Mead *et al.* (2000, Figs. 7–12) that the size difference between the large and small specimens from the archaeological samples ranges between 20–25%, consistent with fossil populations of *macrodon*. Therefore, the large specimens, labeled by Mead *et al.* (2000) as *M. macrodon*, are probably males and the smaller specimens, assumed by Mead *et al.* (2000) to be from other mainland populations, are more than likely females of the *macrodon* phenon. In other words, the females of the archaeological samples overlap in size with males of the modern subspecies but the males of the archaeological samples are much larger than modern male mink. It appears that Norton (1930, p. 31) recognized this relationship when he stated, “It seems apparent that the small females and young animals of *Mustela macrodon* would not much, if any, exceed large individuals of *Mustela vison mink*.”

Finally, I would suggest that the identification of males and females of *M. macrodon* by Mead *et al.* (2000, p. 259) in their Fig. 13 may be interpreted in another way. I have modified Mead *et al.*'s (2000) Fig. 13 for discussion here (Fig. 1). In the original Fig. 13, Mead *et al.* (2000) identified two clusters of *M. macrodon* and labeled them female and male. I have labeled these clusters “A” and “B” in my Fig. 1. Other archaeological specimens were assumed by Mead *et al.* (2000) to be small *Mustela* from the mainland. These small individuals can also be divided into two clusters. I have labeled them “C” and “D” (Fig. 1).



**FIG. 1.** Modified after Fig. 13 of Mead *et al.* (2000). Clusters A and B contain male specimens of *M. v. macrodon* and clusters C and D incorporate female individuals of this taxon, in contrast to the interpretation of Mead *et al.* (2000). Tick marks show the separation of clusters within modern male (M) and female (F) groups along the tooth row length  $C_1-M_2$  axis (see text for discussion).

For modern *M. v. ingens*, the differentiation of sexes is dependent on both the tooth row length  $C_1-M_2$  and height of the mandible. Females generally have a tooth row length  $C_1-M_2 < 20.5$  mm, whereas males have larger values than this. Female mandibles are usually smaller than 7.5 mm whereas for males mandible heights are greater. The female/male clusters of the fossil specimens (A and B, respectively, in Fig. 1), as defined by Mead *et al.* (2000), are peculiar because the primary factor differentiating the clusters is tooth row length  $C_1-M_2$ . Their female *M. macrodon* have a tooth row length  $C_1-M_2 < 22.75$  mm and the males have larger values. However, both their female (A) and male (B) clusters have broad overlap in height of mandible (ca. 8.75–10 mm) and cannot be differentiated by this character as the modern males (ca. >7.5 mm) and females (ca. <7.5 mm) can (Fig. 1). Clusters C and D show the same relationship as A and B in that C and D have tooth row length  $C_1-M_2$  less than or greater than ca. 20 mm. However, these two clusters (Fig. 1) also broadly overlap between height of mandible (ca. 7.5–8.5 mm) and cannot be differentiated by this character unlike modern males and females (ca. > and <7.5 mm, respectively).

I believe that individuals in both clusters A and B represent male *M. macrodon* and that both clusters C and D contain female individuals of this taxon. Both the modern males and females can be arranged into similar clusters (Fig. 1). For instance, females of *M. v. ingens* can be split between tooth row length  $C_1-M_2$  of ca. 19 mm as indicated by the vertical line labeled “F” in Fig. 1. Both of these clusters have a broad overlap in height of mandible (ca. 6–7.5 mm). Males can be divided into two groups at tooth row length  $C_1-M_2$  of ca. 20.75 mm (see the vertical line labeled “M” in Fig. 1). Again, height of mandible broadly overlaps between 7.5 and 8.5 mm.

This interpretation of the sexual dimorphism of the fossil specimens is more consistent with the modern data than that

of Mead *et al.* (2000). However, this interpretation still supports Mead *et al.*'s (2000) contention that the archaeological material represents a phenon larger than any modern mink. Therefore, the question as to taxonomic status must still be considered. One of the first questions asked by Mead *et al.* (2000, p. 247) is “Are there morphological differences between the living *Mustela vison* and the archaeological sea mink?” Mead *et al.* (2000, p. 251) “could not corroborate Prentiss’s (1903) claim that the nasals ascend more abruptly than do those of the various subspecies of the American mink; nor could [they] verify that there was any difference in the angle of the long axis of  $p^4$  from the parasagittal as he [Prentiss] suggested.” However, they did feel that there were a number of other qualitative characters that could be used to separate *M. macrodon* from *M. vison*. Mead *et al.* (2000, p. 258) suggest that “The  $p^4$  exhibits a relatively longer paracone. The junction of the anterior margin of the zygomatic with the cranium is over the  $p^4$  on *M. macrodon* (versus between the  $p^3$  and  $p^4$  in *M. vison*.)” I believe that both of these characters may simply be an allometric response to the larger size of the skull of the archaeological specimens.

Therefore, it appears that the only real difference between the *M. macrodon* specimens and the modern subspecies of *M. vison* is the tendency toward a larger size for *M. macrodon*. It is interesting to note that differences in size are one of the primary features distinguishing most of the modern subspecies of *M. vison* (Humphrey and Setzer, 1989). Consequently, I believe that it is more reasonable to assign the *macrodon* phenon to *M. vison macrodon* as originally done by Manville (1966). Humphrey and Setzer (1970) found that fossil specimens from the coastal regions of Florida were larger than modern *M. vison* from Florida but they concluded that the fossil forms should only be recognized as an extinct subspecies. These facts would further corroborate assignment of the *macrodon* taxon to a subspecies of *M. vison* rather than to its own species.

This approach is also more consistent with modern evolutionary theory regarding speciation. Mead *et al.* (2000, p. 260) suggest the following scenario for the evolution of *M. macrodon*: “The sea mink progenitor, *Mustela vison*, probably arrived in the Gulf of Maine region from the south, along with the poplar woodland landscape, about 13,000 years ago. A ‘true’ *Mustela macrodon* may not predate 7000–6000 yr B.P.” Mead *et al.* (2000, p. 258) note that even though there are few Pleistocene mink specimens all of them fall within the size range and morphological variability of modern *M. vison*; *M. macrodon* is not recognized in the Pleistocene samples. Genetic studies in birds and mammals suggest that speciation requires at least a million years of genetic differentiation (Klicka and Zink, 1999). Clearly, the appearance of a species in the middle Holocene is not consistent with the vast amount of genetic data for speciation in other vertebrates (Avisé and Walker, 1998; Avisé and Wollenberg, 1997; Avisé *et al.*, 1998; Klicka and Zink, 1999).

Finally, it can be asked why the *macrodon* phenon was so large. Body size in mammals can be a response to a host of biological and environmental factors including, but not limited to,

physiological response to temperature (Bergmann's response), competition with other species, and diet. McNab (1971) has shown that Bergmann's response is not a good explanation for body size in mustelids. Both McNab (1971) and Dayan *et al.* (1989, 1991) have shown that competition can be an important aspect in determining body size, and especially tooth size, in mustelids and other carnivores. Specifically, the more competitors a species has the narrower the variance in body size. For island populations of *macrodon*, large size might result from the lack of potential competitors such as *Martes* and *Vulpes*. However, larger size for mainland populations of *macrodon* is not explained by this argument because these potential competitors were present.

Variations in diet might suggest the best explanation. Brown bears (*Ursus arctos*) show clinal variation in body size throughout their modern range with the largest ones along the Alaskan coast and nearby islands, especially Kodiak Island (Kurtén, 1973). The diet of these large individuals primarily consists of fish, especially salmonids (Pasitschniak-Arts, 1993). McNab (1971) has shown that the higher the protein content of an animal's diet the larger size it will attain. Therefore, it is quite possible that *macrodon* was a fish/mollusc eating mustelid. There is some anecdotal evidence for this hypothesis. An interview with Captain Rodney Sadler of Bar Harbor, Maine, in 1934 was summarized by Manville (1966) who stated that "The bull mink [= *macrodon* phenon] were said to feed almost entirely on fish; the most common remains about their dens were of toad sculpin (probably *Myoxocephalus octodecemspinosus*) and horned pout (probably *Macrozoarces americanus*)." Mansueti (1954) stated, "they [sea mink] had been reported in association with the banded snail, *Capaea (Helix) hortensis*, on the outer islands. Probably mussels and other shell fish contributed to their diet." Furthermore, according to Manville (1966), Manly Hardy (1903) of Brewer, Maine, described the skin of the sea mink as "... usually extremely fat and possessed a very strong, peculiar, fishlike odor."

In conclusion, the remains of the extinct sea mink represent a continuously varying, sexually dimorphic, subspecies, *M. v. macrodon*. Female *M. v. macrodon* overlap in size with modern male *M. v. ingens* but the males of *M. v. macrodon* are larger than any modern *M. vison*. *M. v. macrodon* inhabited the coastal areas and islands of the northeastern United States during the middle Holocene to historic times. The large size of *Mustela v. macrodon* may have been primarily due to its high protein diet of fish and other marine organisms. Ancient DNA analysis of archaeological remains could potentially be used to test the relationship of the *macrodon* phenon to other archaeological and modern populations. Finally, if the diet of *M. v. macrodon* was an important factor in determining its large size, it should be reflected in analysis of carbon, nitrogen, and strontium isotopes of the archaeological remains.

## ACKNOWLEDGMENTS

I thank Donald K. Grayson and Bax R. Barton for their constructive review of a previous draft of this paper, although I assume full responsibility for all interpretations. I thank Judy Peterson for drafting Fig. 1.

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