Regressions of Skull and Molar Measurements for Estimating Body Size of Microtus breweri and Microtus pennsylvanicus from Southeastern Massachusetts

ABSTRACT: Regression formulae estimating weight and head-body length of *Microtus breweri* and *M. pennsylvanicus* from southeastern Massachusetts were constructed using skull and molar measurements of *M. breweri* and *M. pennsylvanicus* of known weight and length. Predictions based on equations using combinations of skull and molar measurements give the best results; however, equations using a combination of molars or single molars are also highly significant and may be used to predict body size of these species when intact skulls are not available. These formulae can be applied to measurements of skulls or molars found in raptor pellets or carnivore scats.

INTRODUCTION

Rodents of the genus *Microtus* (field mice and voles) often constitute a major prey item of avian and mammalian predators. Material retrieved from raptor pellets and carnivore scats can be used to assess the impact of predation on vole populations (Pearson, 1964, 1966, 1971; Boonstra, 1977). In studies of this type, it is desirable to determine the characteristics (size, age and sex) of individual voles consumed by predators. Skeletal and dental material can serve as the basis of these studies. Boonstra (1977) used multiple linear regression and discriminant analysis of innominate bones from *M. townsendii* of known weight and sex to determine weights and sexes of consumed mice. Lidicker and MacLean (1969) used cranial measurements to construct regression formulae for estimating age in *M. californicus*.

In the present study, we constructed multiple linear regression equations to estimate body weight and head-body length of *Microtus pennsylvanicus* from mainland Massachusetts and *M. breweri* from Muskeget Island, Massachusetts, using skull and molar measurements of voles from those areas. These equations were designed to estimate the size of voles consumed by predators.

MATERIALS AND METHODS

Fifty-nine *Microtus pennsylvanicus* and 52 *M. breweri* were captured in southeastern Massachusetts from 1972-1976 (Tamarin, 1977). Animals were weighed and measured just prior to autopsy. The skulls were cleaned and measured using 42 molar measurements (Guthrie, 1965) and the following skull measurements: zygomatic breadth (ZB), diastema length (DL), least interorbital breadth (LIB), nasal breadth (NB), palatine foramen length (PFL), palatine foramen greatest width (PFWG), palatine foramen least width (PFWL) and rostral length (RL). Other common skull measurements are likely to be affected by predator digestion. Measurements are expressed in millimeters.

Separate regression equations were formulated for the *Microtus pennsylvanicus* and *M. breweri* populations using the STEPWISE feature of SPSS NEW REGRESSION. Variables entered the analysis in order of partial F significance, each variable adding significantly at $p<0.05$ to a model already containing the preceding variables (Hull and Nie, 1981). Variables were removed from the analysis if the partial F significance dropped to $p<0.10$.

We ran multiple linear regression analyses on the entire set of measurements, the set of molar measurements alone, and on measurements of single molars.

RESULTS AND DISCUSSION

Head-body length (HBL) of *Microtus breweri* ranged from 145-194 mm and weight (WT) ranged from 29-79 g. The weight of adult *M. breweri* was >45 g. *Microtus breweri* weighing 32-45 g were subadults and those <32 g were considered juveniles (Tamarin, 1977).

All regressions on *Microtus breweri* body weight and head-body length were highly significant. The following equations gave the best correlation predicting body weight ($R = 0.94$, $p<0.00005$) and head-body length ($R = 0.87$, $p<0.00005$):

$$WT = -147.27 + 10.79(ZB) + 13.14(M11) + 12.64(PFL) - 6.23(m3L)$$
$$HBL = -44.02 + 7.43(ZB) + 8.35(PFL) + 10.09(m12)$$

Head-body length of *Microtus pennsylvanicus* ranged from 126-195 mm. Weight ranged from 16-69 g. Adult *M. pennsylvanicus* weighed >33 g, subadults 22-33g, and juveniles <22 g (Tamarin, 1977).

Many of the variables in the equations for *Microtus pennsylvanicus* differed from those found for *M. breweri*, but the regression lines had the same degree of significance and similar correlation coefficients. All regressions on *M. pennsylvanicus* body weight and head-body length were highly significant. The following equations gave the best correlation predicting body weight ($R = 0.85$, $p < 0.00005$ and head-body length ($R = 0.89$, $p < 0.00005$):

$$WT = -130.44 + 9.47(ZB) - 17.19(m21) + 15.39(m2P) + 10.27(NB)$$
$$HBL = -31.36 + 8.68(ZB) + 14.03(PFL) - 15.72(M35)$$

Skulls found in raptor pellets and carnivore scats often are too digested for accurate measurements, but the molars may be available. In this case, the following equations can be used ($p < 0.00005$):

Microtus breweri:

$$WT = -159.12 + 12.92(M23) + 18.87(m13) + 8.08(M3L)$$
$$HBL = -36.09 + 9.90(M1A) + 24.30(m12) + 9.54(m3P) - 28.54(m22) + 7.97(M3P) + 13.14(M22)$$

Microtus pennsylvanicus:

$$WT = -119.16 + 30.55(m2P) + 7.55(M3A)$$
$$HBL = -20.55 + 16.16(M2L) + 19.95(m3P) - 10.93(m3L) + 9.19(M3A)$$

Equations predicting weight and head-body length of the two species are also available for each molar ($p. < 0.0002$).

Of 51 skull and molar variables, we have formulated equations that need four or fewer variables to predict weight or head-body length of *Microtus breweri* and *M. pennsylvanicus* in southeastern Massachusetts. If any of these variables are not available, other equations may be used that do not require skull measurements.

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