

Bothersome burrowers: tracking gopher (*Thomomys bottae*) time-averaging in a late-Holocene site in California

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INTRODUCTION

Understanding the biases affecting archaeological sites is necessary in order to extract the true ecological signals from these deposits. In terrestrial sites, the mixing of soil by mammalian bioturbators can substantially increase time-averaging, obscuring or even erasing stratification. In particular, pocket gophers (within the family Geomyidae) are known to burrow in archaeological sites and thereby complicate the contextualization of artifacts (Bocek, 1986; Erlandson, 1984; Pierce, 1992; Shaffer, 1992; Wood and Johnson, 1978). In fact, they have been shown to preferentially burrow in the loose, rich sediments characteristic of archaeological sites over compact, un-altered soils (Pierce, 1992). Bocek (1986) confirmed that gophers at the Jasper Ridge Site (CA-SMA-204) rapidly move any archaeological material smaller than the size of their heads from the artifact's place of deposition. After excavating a 1 by 2 meter unit and backfilling with sterile soil, she returned seven years later to find that 41% of the original quantity of cultural material had returned to the site via vertical mixing (Bocek, 1992). Such intense bioturbation can obliterate informative stratification and also displaces artifacts from their original contexts.

The problem is doubled, however, for the study of faunal remains found in archaeological deposits: not only is it unclear if bones have been transported vertically by gophers, but the gophers themselves have the potential to die in their burrows, adding young skeletal remains to older archaeological deposits (Shaffer, 1992). Skeletal material younger than the most recent archaeological layer should not be included in reconstructions of the small mammal community from the archaeological context. Therefore, it is important for zooarchaeologists to understand whether gopher bones from archaeological sites are representative of past gopher abundances or are instead intrusive to the deposit.

In order to assess whether or not gopher remains are younger than or contemporary to the formation of the archaeological site, Shaffer (1992) recommends a combination of ethnographic information about the hunting practices of small mammals by local native peoples and analysis of the completeness of skeletons. However, no studies have empirically tested this using dating techniques.

Here we establish the degree of bias introduced by gopher remains in archaeofaunal reconstructions by radiocarbon dating skeletal remains of gophers and non-fossorial small mammals from a late-Holocene archaeological site in Woodside, California. We test whether the dated gopher (*Thomomys bottae*) remains are younger than those from the included non-fossorial small mammals from the same sediment layers in order to assess where the gophers were introduced after the site's deposition as a consequence of burrowing.

We hypothesized that a significant number of gopher (*Thomomys bottae*) remains were introduced after the site's deposition as a consequence of their burrowing. If this was the case, we expected the distribution of ages of *T. bottae* bones to be younger overall, and span a wider range, than the distribution of ages from other small mammals from the same site and sediment layers.

METHODS

Study Site - Jasper Ridge Site (CA-SMA-204):

The Jasper Ridge Site is located within the boundaries of Jasper Ridge Biological Preserve, Woodside, CA, 1.4 km downstream of where San Francisquito Creek and Bear Creek meet (Bocek, 1987). The site is a large human midden deposit excavated in the early 1980's (Bocek, 1987). In the initial excavation of the site, Bocek (1987) selected 24 1x2 meter units which were excavated in 10-cm levels.

Small mammal record:

Thomomys bottae is the most abundant small mammal at the Jasper Ridge Site and is represented by cranial material at every excavation level. *Microtus californicus* and *Neotoma fuscipes* represent sympatric, non-burrowing small mammals that will be dated as a comparison to the highly-fossorial *T. bottae*. Although voles are weakly fossorial, they only dig shallowly and therefore do not significantly impact site stratification. *N. fuscipes* is not fossorial, constructing above-ground stick houses for shelter. Presumably, these non-fossorial small mammals entered the archaeological record as it was being deposited. Additionally, one leporid (likely *Sylvilagus* spp.) incisor was taken as the final non-fossorial small mammal, as there were not enough of the previous two species at the appropriate levels.

Analysis:

We targeted incisors because they retain a significant amount of collagen necessary for dating. One incisor per specimen was taken directly from previously-identified mandibles and premaxillae to ensure the correct species identification. We sent 10 gopher (5 from near the top of the deposit and 5 from near the bottom of the deposit) and 9 non-fossorial small mammal (4 from near the top of the deposit and 5 from near the bottom) incisors to Lawrence Livermore National Laboratory for radiocarbon dating. We also selected one specimen per taxa to be tested for $\delta^{13}\text{C}$.

RESULTS

One sample, a *Microtus californicus* incisor from near the top of the deposit (level 1), failed to produce sufficient carbon to make a measurement and is therefore not included in the analysis. The radiocarbon dates ranged from 1850 ybp (+/- 30) to 145 ybp (+/- 20) (Table 1). The gopher radiocarbon dates and age model are significantly younger, especially at deeper depths (Figure 1, 2). The top 30 cm has overlapping confidence intervals on age models and multiple dates between gophers and non-gophers, but at the bottom of the deposit neither are overlapping (Figure 2).

Sample name	Level	¹⁴ C age	¹⁴ C error	Species
T2019.2.154.1	2	375	25	<i>Microtus californicus</i>
T2019.2.144.1	2	145	20	<i>Thomomys bottae</i>
T2019.2.90.1	2	240	25	<i>Thomomys bottae</i>
T2019.2.128.1	3	955	25	<i>Microtus californicus</i>
T2019.2.359.1	3	1850	30	<i>Thomomys bottae</i>

T2019.2.485.1	3	285	30	<i>Thomomys bottae</i>
T2019.2.96.1	3	880	30	<i>Thomomys bottae</i>
T2019.2.162.1	4	370	20	<i>Microtus californicus</i>
T2019.2.57.1	4	300	25	<i>Microtus californicus</i>
T2019.2.18.1	8	1330	20	Leporidae
T2019.2.205.1	9	810	25	<i>Microtus californicus</i>
T2019.2.205.2	9	815	25	<i>Microtus californicus</i>
T2019.2.212.1	9	795	20	<i>Neotoma fuscipes</i>
T2019.2.142.1	9	330	20	<i>Thomomys bottae</i>
T2019.2.469.1	9	365	25	<i>Thomomys bottae</i>
T2019.2.160.1	10	790	25	<i>Neotoma fuscipes</i>
T2019.2.201.1	10	320	25	<i>Thomomys bottae</i>

Table 1: Radiocarbon dates of gopher and non-fossorial small mammal incisors from the Jasper Ridge Site. Dates produced by Bruce Buchholz at Lawrence Livermore National Laboratory.

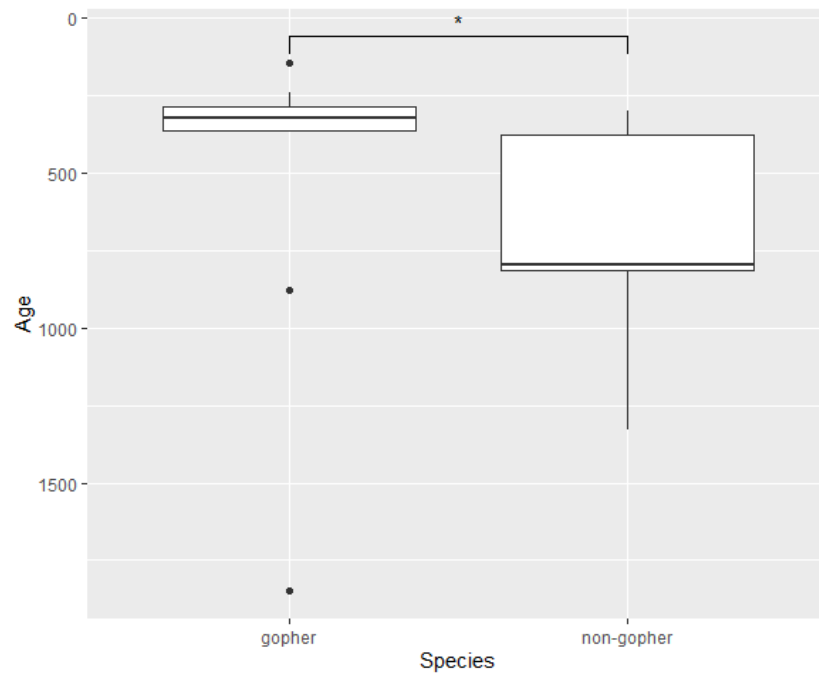


Figure 1: Boxplots of gopher (n=10) and non-gopher (n=8) radiocarbon dates. Significance at the 0.1 level (p=0.077).

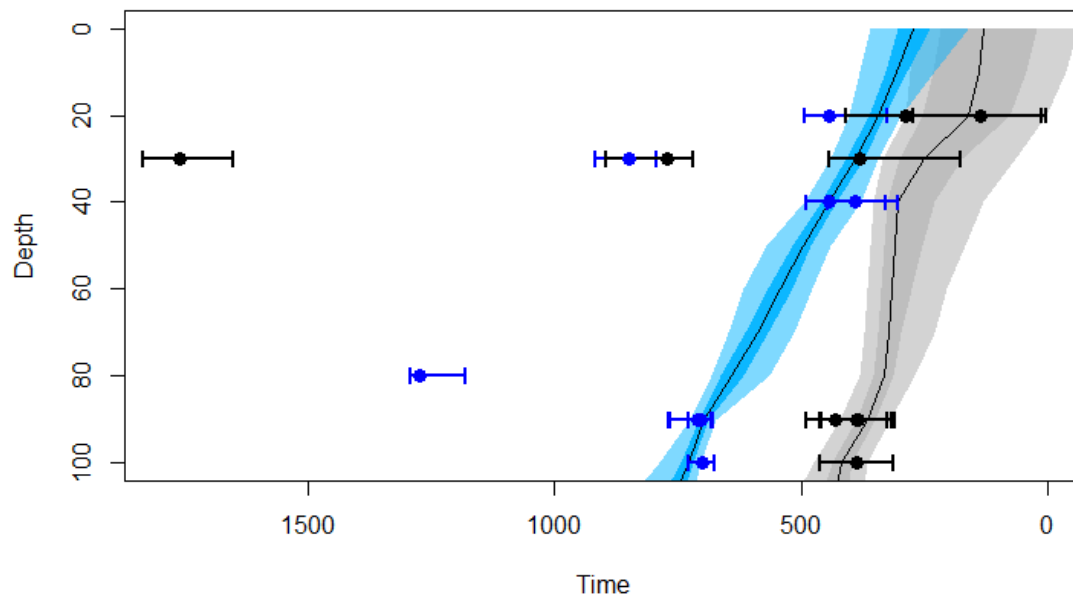


Figure 2: Age models of the Jasper Ridge Site produced from gopher (black) and non-fossorial small mammals (blue) radiocarbon dates. Age model 50% confidence intervals shown in grey (gophers) and blue (non-gophers), and 95% confidence intervals shown in light grey and light blue. Radiocarbon dates plotted as points with 95% confidence intervals (black = gopher, blue = non-gopher).

DISCUSSION

Dates of gopher incisors overall had both a wider range and were younger than those of non-fossorial small mammals at the Jasper Ridge Site. At the same depths-below-surface, gopher remains were also younger than other non-fossorial small mammal remains, but especially at deeper depths. Therefore, gopher remains cannot be binned with other small mammal bones from the same levels for zooarchaeological analysis and also should not be relied upon for creating age models for sites. The observed pattern may be explained by gophers dying in their burrows, as most pocket gopher burrows are found 15 to 30 cm below the surface (Bocek, 1986). Gophers would have lived and died at deeper depths than contemporaneous non-fossorial mammals, so it tracks that a vole and a gopher with the same radiocarbon date could easily appear 30 cm apart from each other in the deposit. This might also explain the higher degree of mixing in the top 30 cm of the soil, since this modern surface has presumably been stable for a longer time than when the site was actively occupied.

While the age models (especially for non-fossorial mammals) show increasing age with depth, there are some gopher and non-gopher dates at shallow depths that are much older than predicted by the models (Figure 2). This may be as a result of sequential bioturbation over time, as gophers and other organisms tend to displace smaller objects upward (Robertson and Johnson, 2001; Bocek, 1986). It may also be explained by the site topography at the time of initial excavation. The sediments were removed in arbitrary 10 cm levels, regardless of starting

elevation, and have been binned across excavation units in this analysis. Without the original excavation records, this possibility cannot be tested.

CONCLUSION

Despite substantial vertical mixing, the well-constrained age model based on non-fossorial small mammals suggests that they retain some temporal signal and can therefore be reliably used in faunal analyses. However, gopher remains should be excluded from community-level analyses unless dating shows them to be contemporaneous.

These results shed light on a common taphonomic process that impacts archaeological sites and prompts reevaluation of faunal community reconstructions from fossil deposits impacted by gophers and other fossorial mammals.

ACKNOWLEDGEMENTS

We would like to thank the Muwekma-Ohlone council and the Stanford Archaeology center, especially Christina Hodge and Veronica Jacobs-Edmondson, for access to the Jasper Ridge Site materials. Thanks to Laura Jones for valuable input. Thanks also to Bruce A. Buchholz at the Lawrence Livermore National Laboratory Center for Accelerator Mass Spectrometry for providing the radiocarbon dates. We further thank Diane Gifford-Gonzalez and Allison Stegner for their helpful feedback. Finally, we acknowledge the National Science Foundation and the Paleontological Society for funding this work.

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