

Diet Breadth, Adaptive Change, and the White Mountains Faunas

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Drawing on faunal data from high elevation sites in the White Mountains of eastern California (USA), Grayson (*Journal of Archaeological Science* 18, 483–506, 1991) tested implications of the Bettinger & Baumhoff (*American Antiquity* 47, 485–503, 1982) model of late prehistoric human adaptive change in the Great Basin. Madsen (*Journal of Archaeological Science* 20, 321–329, 1993) challenges the validity of these tests, and raises a number of arguments concerning the testing of diet breadth models in archaeological settings. We argue that the tests presented by Grayson are valid and that many of the critiques posed by Madsen apply only to the Bettinger & Baumhoff model. We also explore the issues Madsen raised concerning archaeological tests of foraging models.

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Introduction

Grayson (1991) attempted to test certain implications of the Bettinger & Baumhoff (1982) model of late prehistoric human adaptive change in the Great Basin. We welcome the critical comments offered by Madsen (1993) as regards this attempt. We also welcome the opportunity to address the more general issues he raised regarding the testing of implications drawn from diet breadth models. We emphasize, however, that Grayson (1991) was presented neither as a test of diet breadth models in general nor of predictions from a particular diet breadth model, but instead of what were perceived to be straightforward implications of the arguments presented by Bettinger and Baumhoff (the “BB model”). Here, we respond to Madsen’s criticisms of Grayson (1991), and, adopting his diet breadth interpretation of the BB model, briefly explore some of the issues he raised.

Testing The Bettinger and Baumhoff Model: The White Mountains Case

The BB model states that prior to about 1000 BP, Great Basin peoples were highly mobile foragers whose diet focused on high-ranked resources, particularly artiodactyls. With a decidedly narrow diet breadth, these people—“travellers” in the BB model—excluded

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such low-ranked resources as seeds from their diet. At about 1000 years ago, these people were replaced by Numic-speaking “processors” who swept across the Great Basin from its south-western corner. The “processors” were characterized by a broad diet breadth, with low-ranked items playing an important role. Though “processors” would take higher ranked items on encounter, and thus would compete with “travellers” for them, the “travellers” would not compete with “processors” for low-ranked foods. The BB model maintains that, as a result of these fixed differences in diet breadth and of the asymmetry in competition for resources, the “travellers” were competitively excluded by the “processors”. To Bettinger (1991: 674), it follows that “pre-Numic peoples were powerless to stay the invasive spread of the more costly, but less spatially demanding, Numic adaptation”. At the most general level, this model would seem to predict clear differences in resource use between these two sets of populations.

The White Mountains faunal tests

Grayson (1991) compared the mammalian faunas represented in pre-village (“traveller”) and village (“processor”) high elevation (*c.* 3100 m) settings in the White Mountains of eastern California. He viewed differential taxonomic richness as a potentially telling test of the BB model because that model “specifies that ‘travellers’ focused on a relatively small variety of high quality resources, while subsequent ‘processors’ focused on a wider variety of lower quality resources” (Grayson, 1991: 489). Grayson found no significant differences in taxonomic richness between the two sets of faunas, and concluded that this apparent prediction of the BB model was not met. Because the BB model also stipulated that “processors” used a wider variety of resources than “travellers”, and that the latter focused more tightly on specific taxa—artiodactyls—Grayson also argued that village faunas should be more diverse than previllage ones. No significant differences in diversity were found between these two sets of faunas, and Grayson again concluded that the apparent predictions of the BB model were not met.

Grayson did, however, find dramatically significant differences in the NISP-based abundances of artiodactyls and small mammals (primarily mountain sheep, *Ovis canadensis*, and yellow-bellied marmots, *Marmota flaviventris*). Given that the BB model requires the pre-village occupations to have been characterized by a heavier emphasis on artiodactyls, and that village occupations exploited low-ranked taxa more extensively, Grayson concluded that this result provided strong support for the BB model (but see also Grayson, 1993).

Were the Tests Valid? Madsen’s Critique

Madsen saw six fundamental problems with the tests presented by Grayson, and concluded that these tests were of little use in testing either the BB model or diet breadth models in general. We address each of these issues in turn.

Problem 1: tests with mammals alone

Madsen argues that the White Mountains mammalian faunas alone cannot be used to test the BB model because within that model “the two systems are predicted to differ principally by the addition of seed and plant processing”.

This assertion is false. Although the BB model is vague, Bettinger is not vague as regards the differential role of small mammals in pre-village and village diets. In his own words, the BB model predicts that in contrast to pre-village peoples, the villagers “intentionally targeted . . . a variety of lower-quality alpine resources including numerous small rodents” (Bettinger, 1991: 661). It is abundantly clear that if seeds alone can form an appropriate test of the BB model, then so can mammals alone.

At its very foundation, the BB model predicts that diet breadths expanded *generally* across the pre-village–village transition. As a result, the model can be tested using any class of resources as long as substantial differences exist in the relative ranks of particular resources contained within the target class. We would not object to an argument that maintained that full sets of resources would provide an ideal test of the model, but we do object to the incorrect implication that while seeds form an appropriate test, other aspects of the diet do not.

We also note that the BB model explicitly states that artiodactyls are the highest ranked food items, while small seeds are the lowest ranked. It follows that small mammals fall somewhere between. Since diet breadth models predict that resources will be added to the diet sequentially in order of rank, and the BB model clearly implies differences in rank among mammals, the differences in diet breadth called for by the BB model should be clearly signalled within mammals alone.

Problem 2: focusing on larger and smaller mammals

As a criticism of Grayson (1991), Madsen (1993) suggests that return rates for marmots and mountain sheep might be comparable. Once again, however, the relative ranks of artiodactyls and small mammals utilized by Grayson (1991) were taken directly from the continuum of ranks indicated in the BB model, and later stated explicitly by Bettinger (1991). Hence, this criticism is properly addressed not to Grayson, but to the BB model itself.

We also note that Madsen's assertion regarding the relative ranks of these mammals does not follow from available data. In several experimental and ethnographic settings (e.g. Hawkes *et al.*, 1982, 1991; Hill *et al.*, 1987; Simms, 1987), large mammals have been shown to have substantially higher post-encounter return rates than small ones. As Simms (1987: 77) has noted in the Great Basin context, "rank is generally correlated with the *package size* of the resources. In every case, the larger the animal the higher the rank". Indeed, prey body size is routinely regarded as a proxy measure of prey rank by animal ecologists (e.g. Schoener, 1971; Davies, 1977; Krebs *et al.*, 1977; Barnard & Brown, 1981; Stephens & Krebs, 1986; see also Bayham, 1979). In this context, we note that, by weight, mountain sheep are roughly 17 times larger than yellow-bellied marmots (Aldous *et al.*, 1958; Lee & Funderburg, 1982).

Problem 3: taxonomic richness as a general measure of diet breadth

Madsen suggests that taxonomic richness is an invalid measure of diet breadth in archaeological faunas because diet breadth varies from individual to individual and "from minute to minute". As a result, archaeological richness values fail to track fine-scale variability in diet breadth, but instead represent an average. Accordingly, he argues, only minor differences in richness are to be expected.

Fine-scale variability in human diet breadth is well established. Unfortunately, such variability cannot, in most circumstances, be extracted from the archaeological record. As a result, archaeological tests of foraging models cannot address many of the complexities revealed by ethnographic analyses of diet breadth (see, for instance, Hawkes *et al.*, 1991; Hill *et al.*, 1987). Concomitantly, when significant changes in diet breadth are indicated archaeologically, they are likely to be adaptively meaningful.

We agree with Madsen that taxonomic richness may be insensitive to changes in diet breadth. We agree not because archaeological faunas might be taken to represent "average" diet breadth, but instead because taxonomic richness *per se* potentially measures the *maximum* diet breadth of a population over a given time. Populations with significant differences in average diet breadth may not be signalled in measures of taxonomic richness if the diet breadth of the populations being compared exhibited identical

amplitudes over the period of faunal accumulation. That is, in the archaeological setting, richness may measure the amplitude of diet breadth, not average diet breadth.*

We emphasize, however, that Grayson (1991) did not use taxonomic richness as a measure of diet breadth. Indeed, the term "diet breadth" is not to be found in Grayson (1991). Instead, he used *richness* as a *measure of the difference in the numbers of taxa* exploited through time, in precisely the way specified by the BB model. That model depends on the fact that "Pre-Numic" peoples were incapable of expanding their diet to include low-ranked items, while Numic peoples incorporated both low- and high-ranked items in their diet. Because the flexibility inherent in diet breadth models is expunged in the BB model, measures that may be inappropriate as tests of true diet breadth models are not necessarily inappropriate as tests of the BB model. Madsen's comments regarding richness simply do not apply to the situation at hand.

Problem 4: taxonomic richness as a measure of diet breadth in the White Mountains setting
Madsen finds the use of taxonomic richness as a guide to diet breadth "even more troubling" in the White Mountains context, because mammals other than marmots and mountain sheep may have been taken "inadvertently".

We argue that the means by which small mammals were taken by village and pre-village peoples are largely unknown, unknowable and irrelevant to the WM faunal test of the BB model. The model predicts that pre-village peoples focused on artiodactyls, while village peoples included a wide variety of smaller mammals in their diet. Taxonomic richness provides a straight-forward measure of the requirements of the BB model as regards resource use. That both groups took the same array of species and that pre-village faunas do not differ significantly from village faunas in terms of the numbers of species that they contain simply does not support that model.

Problem 5: diversity as a measure of diet breadth

Madsen suggests that variation in abundances across taxa in archaeological assemblages measures the diversity of prey species, and does not inform on diet breadth. To make this argument, Madsen conceptually divorces diet breadth from prey rank estimates and assumes that all taxa included in an analysis of diversity have identical ranks. In that approach, each species is invariably included in the diet and attacked upon encounter. Clearly, however, insofar as differences exist in the relative ranks of prey species, such an assumption is unjustified.

We agree with Madsen that the actual diet breadth of a given prehistoric population must have expanded and contracted with time. Since diet breadths continually expand and contract, with only the highest ranked species always included in the diet, the relative abundances of lower ranked prey in a faunal assemblage must reflect the *frequencies* with which they entered the diet.

It follows that the abundances of high-ranked and low-ranked taxa are asymmetrical in meaning. The proportion of the highest ranked species should reflect the encounter rate or the population size of the prey, since they are always included in the diet and thus always taken when encountered. Other taxa can conceivably move into and out of the diet, depending on the abundance of higher ranked taxa. The relative abundances of high- and low-ranked taxa are thus a direct index of diet breadth. In this view, taxonomic diversity becomes an important measure of diet breadth in archaeological settings, as long as the prey ranks of the component taxa are taken into account.

*Changes made in Madsen's paper after this manuscript was accepted bring our positions on this point closer.

Problem 6: decrease in the relative abundance of mountain sheep

As a specific example of the issue raised in problem 5, Madsen challenges the validity of using the relative abundances of mountain sheep and rodents as a measure of diet breadth. He argues that if mountain sheep, marmots and ground squirrels were all within the diet breadth of both pre-village and village peoples, each would be taken upon encounter, and changes in their relative abundances will say nothing about differences in diet breadth between these two groups.

Madsen is absolutely correct here, *as long as* each of these taxa were always included in the diet breadth of both populations. However, insofar as Madsen is correct in his argument that diet breadth changes continually, there is no reason to assume that marmots and squirrels were included within the diet breadth of both pre-village and village peoples every minute of every day. Indeed, the dramatic differences in size between mountain sheep and, say, ground squirrels suggests they were not. Accordingly, in archaeological settings, the relative abundances of lower ranked taxa reflect both the natural abundance of higher ranked prey and the relative frequency with which low-ranked prey entered the diet.

This, however, is clearly not the logic at work in the BB model. That model requires that smaller mammals were rarely, if ever, utilized by pre-village peoples, but were "intentionally targeted" by village peoples. As a result, the relative abundance of these mammals becomes a clear test of the BB model.

The BB model would also appear to predict that artiodactyl relative abundance must decline across the pre-village-village transition. Indeed, when this decline was first discussed formally (Grayson, 1990), Bettinger was quite pleased, and rightly so. Insofar as Madsen's arguments on this score are correct, they pertain once again to the BB model and not to the tests of that model derived by Grayson.

Conclusions

It has become clear that the BB model is so vague that it will support numerous alternative interpretations. Madsen interprets that model as if it were a diet breadth approach, while at the same time correctly noting that it violates major tenets of foraging theory. Noteworthy among these violations is the stipulation that the diet breadth of the "travellers" was essentially fixed. Within optimal foraging theory, of course, diet breadths are inherently flexible. As a result, very different logic is needed to test true diet breadth approaches than is needed to test the BB model. The profound differences between the BB model and classic diet approaches appear to lie at the heart of many of the critical comments offered by Madsen (1993).

Grayson (1991) was explicitly designed as a test of certain implications of the BB model. By interpreting that model in strict diet breadth terms, and by neglecting the fact that the BB model violates primary tenets of diet breadth approaches, Madsen concludes that Grayson (1991) was an inappropriate test of the BB model. We argue that each of the tests in Grayson (1991) is valid. Indeed, even though Grayson (1991) was designed only as a test of the BB model, we also argue that measures of diversity that incorporate the relative abundances of high- and low-ranked taxa can be fully appropriate for testing diet breadth models in archaeological settings.

Madsen suggests that relatively uncomplicated tests of the BB model can be conducted, and that the data needed for those tests are already available. We assert that Grayson (1991) has already performed one such test, but would be pleased to see additional tests performed.

Finally, we would also like to clarify a possible misunderstanding. Grayson (1991) did not simply argue that tests of evolutionary and ecological models can be done "only with great difficulty, if at all". Instead, he argued that differences that are selectively significant

in the evolutionary sense may be writ very small in the archaeological record, just as they are often writ small in modern biological populations. It was that fact that led Grayson (1991) to suggest that substantial research efforts might be needed to detect them. Madsen's rendition of that statement might be taken to imply that Grayson opposes the application of models drawn from evolutionary and ecological theory to archaeological settings. This is most certainly not the case.

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