Reports

Prehistoric Fauna From Shanidar, Iraq

Abstract. *A comparative analysis of the faunal material from Shanidar Cave and the nearby proto-Neolithic site of Zawi Chemi Shanidar indicates that sheep were domesticated at Zawi Chemi Shanidar at the beginning of the 9th millennium B.C., more than 1000 years earlier than the earliest known evidence of animal husbandry.*

Archeologists have been aware that faunal remains can make an important contribution to the reconstruction of a culture and that animal bones should be collected with the same care as artifacts. All too often this has been honored more in the breach than in the observance—particularly in the Near East. Fortunately, this has not been the case in the excavations at Shanidar Cave and the nearby proto-Neolithic site of Zawi Chemi Shanidar (*1*), and a wealth of faunal material has been recovered. With such a sample it is not enough merely to list and describe the various species present, although such a list may yield valuable information on climatic change. The size of the sample from the two sites is large enough to lend itself to statistical analysis and evaluation of the economic basis of the culture. From the data there is evidence that sheep were domesticated at Zawi Chemi Shanidar. The age of Zawi Chemi Shanidar, as determined by the carbon-14 method, is 10,870 ± 300 years; thus, this is the earliest record of domestication of animals, and advances the known beginnings of animal husbandry by more than 1000 years (*2*).

The lack of adequate comparative material from the Near East makes it impossible to identify several specimens, in particular remains of small mammals, birds, and fish. Furthermore, some of the forms that were of importance economically pose problems in identification that no amount of comparative material can help to solve. The postcranial skeletons of sheep and goats are remarkably similar, and the separation of sheep and goat skeletal material is notoriously difficult unless there is a size difference between the two forms; this is not the case in the Near East. Differences reported in the literature have been based on small samples or on comparison with modern domestic races, and are not reliable (*3*). Surprisingly enough, postcranial fragments of *Bos* and *Cervus elaphus* are equally difficult to identify. In two previous communications on the Shanidar fauna the presence of a small race of *Bos primigenius* was reported (*4*, p. 141; *5*). A more detailed examination of the prehistoric levels revealed the complete absence of *Bos* teeth except in the uppermost levels of layer B1 (proto-Neolithic) in the cave, whereas teeth and antler fragments of *Cervus elaphus* were relatively numerous. It is now evident that the supposed "small *Bos*" material was either *Bos* fragments intrusive from the historic levels or misidentified *Cervus* fragments.

The species that have been identified are as follows: *Ovis orientalis gmelini* (red sheep); *Capra hircus aegagrus* (bezoar, the wild goat of the Near East); *Sus scrofa attila* (wild boar); *Cervus elaphus maral* (red deer); *Dama mesopotamica* spp. (fallow deer); *Capreolus capreolus capreolus* (Roe deer); *Canis lupus pallipes* (wolf); *Canis aureus aureus* (jackal); *Vulpes vulpes flavesens* (tawny fox); *Ursus arctos syriacus* (Syrian brown bear); *Martes foina* spp. (marten); *Castor fiber* spp. (beaver); *Meriones* sp. (gerbil); *Testudo graeca* spp. (land tortoise); *Helix salomonica* (land snail); and *Unio tigridis* (riverine clam).

In addition, there were large numbers of unidentified rodent bones from both sites. The less numerous bird bones appeared to be from modern species (*4*, p. 165). Fish remains were rare.

The fauna, even from the earliest levels in the cave, is modern, although several species, notably *Ovis orientalis* and *Cervus elaphus*, have become extinct in historic times as the result of excessive hunting. It appears that the climate during the periods of the cave's occupancy was the same as today. However, this does not necessarily indicate that there were no climatic fluctuations. There are breaks in the sequence of the cave that indicate periods during which the cave was not inhabited, presumably during glacial maxima (*6*).

Although there is evidence of fishing and fowling, the primary source of food was big game. The bones of *Ovis orientalis, Capra hircus aegagrus* and *Cervus elaphus* comprise more than 90 percent of the faunal remains. *Ovis orientalis* and *Capra hircus aegagrus* are the ancestors of domestic sheep and goats, and the question arises as to whether either or both of these animals had been domesticated by proto-Neolithic times which are represented here by Zawi Chemi Shanidar and the contemporary levels in layer B1 in the cave. The sheep and goat specimens from these levels are morphologically identical to specimens of wild sheep and goats, but domestication before sufficient time had elapsed for osteological change to occur can be demonstrated. An increase in the number of specimens from a potentially domesticable species, coupled with an increase in the number of immature specimens from that species, implies cultural control (that is, domestication) (*7*). These shifts were looked for in the statistical analysis of the fauna.

In analyzing the relative economic importance of the three most frequently occurring species, the problems of identification must be considered. Since the presence of *Bos* has been ruled out for the prehistoric levels, all the red deer specimens can be identified. On the other hand, of the *Ovis/Capra* material, only the metapodials, the first and third phalanges, and the scapula can be identified. To list the number of identifiable fragments from the three species obviously would be misleading, for such a list would be biased on the side of dependence on *Cervus elaphus*. To correct for this I used a method derived

Table 1. Data for *Ovis*, *Capra* and *Cervus* samples from Zawi Chemi Shanidar and Shanidar Cave. Layer B1, proto-Neolithic; layer C, Baradostian; layer D, Mousterian.

Animal	Specimens (*N*)	Sample (%)	Metapodials (*N*)	Immature animals (%)
Zawi Chemi Shanidar; 0.50 to 1.00 in depth				
Ovis	63	81.0	48	54.2
Capra	8	10.1	8	25.0
Cervus	22	8.9		
Zawi Chemi Shanidar; 1.00 to 1.50 in depth				
Ovis	473	65.9	176	44.3
Capra	79	9.6	72	25.0
Cervus	576	24.5		
Zawi Chemi Shanidar; 1.50 to 2.95 in depth				
Ovis	4 (adult)			
Cervus	31			
Shanidar Cave; layer B1				
Ovis	27	42.9	19	57.9
Capra	36	57.1	14	42.9
Shanidar Cave; layer C				
Ovis	17	38.5	12	16.7
Capra	27	59.5	23	21.8
Cervus	4	2.0		
Shanidar Cave; layer D				
Ovis	8	20.4	7	42.9
Capra	29	75.1	9	11.2
Cervus	6	4.4		

from Shotwell's analysis of several Pliocene sites in Oregon (*8*).

The first step was to establish the number of diagnostic elements in the skeleton of each species. For sheep and goats there are 22 elements: 8 third phalanges, 8 first phalanges, 2 metatarsals, 2 metacarpals, and 2 scapulae. For the red deer there are 72: all the elements of the postcranial skeleton except the vertebrae.

Secondly, the number of specimens for each species was determined—that is, the number of identifiable bone fragments from each species in the sample.

Thirdly, the relative frequency, f, of occurrence of each species was calculated as follows:

$$f = \frac{\text{No. of specimens}}{\text{No. of diagnostic elements}}$$

The relative frequencies are ratios and may be expressed in percentiles. The percentage of adult and immature animals (the "immature" are those less than 1 year old) was calculated for the *Ovis* and *Capra* samples (*9*) (such a calculation cannot be made for the *Cervus* material until the rate of fusion of the epiphyses is better known). The results are given in Table 1.

It is evident that the economy at Zawi Chemi Shanidar was quite different from that of the Baradostian and Mousterian levels in Shanidar Cave. Most notable is the increase in *Ovis* and *Cervus* and, in the upper levels, almost complete reliance on *Ovis* (the change is not so evident in the contemporary levels in the cave, but at present the data from these levels cannot be evaluated, since there has been considerable admixture from the historic levels). Shanidar Cave is located on a spur of the Baradost Mountains, 300 m above Zawi Chemi Shanidar on the valley floor, and it could be argued that the change represents a regional difference. Certainly, red deer would have been more common in the scrub oak forest on the valley floor than in the heights close to the cave. The shift to a high percentage of *Ovis* does not represent a regional difference, however. If sheep had been present in the valley they would have been more frequently killed as game than the goats on the heights above the cave. It is doubtful that wild sheep were ever very common in the immediate vicinity of the two sites; this is suggested by their relative scarcity in the Baradostian and Mousterian levels. The valley of the Greater Zab river at Shanidar is flat and narrow, with precipitous cliffs on each side. There is still a considerable remnant of scrub oak forest, despite the fact that it has been trimmed for fuel for centuries. The highest reaches of the mountains flanking the valley are typical of the habitat preferred by goats, and *Capra hircus aegagrus* is still fairly common in the vicinity of Shanidar. On the other hand, sheep prefer broad high pasturelands and the treeless grassy slopes of mountains. The results suggest that the two shifts that indicate cultural control did take place at Zawi Chemi Shanidar: (i) there is evidence of an increased reliance on *Ovis*, particularly in the upper levels of Zawi Chemi Shanidar, and (ii) the percentage of immature *Ovis* increased to approximately 50 percent. Presumably domestic sheep, morphologically identical to their wild ancestors, were introduced from some other region. Domestication of a species prior to the onset of osteological change has long been postulated by archeologists, but the data from Zawi Chemi Shanidar and Shanidar Cave are the first direct evidence of this important stage in the beginnings of animal husbandry.

DEXTER PERKINS, JR.
Harvard, Massachusetts

References and Notes

1. For a description of the two sites, see R. S. Solecki, *Science* **139**, 179 (1963).
2. C. A. Reed reported the presence of domestic goats at Jarmo [*Science* **130**, 1629 (1959)]. The approximate date is 6750 B.C. [R. J. Braidwood and B. Howe, *Studies in Ancient Oriental Civilization, No. 31* (Univ. of Chicago Press, Chicago, 1960), p. 160].
3. There are several references, notably J. W. Amschler, *Archeologia Austriaca* **3**, 26 (1949); V. Gromova, *Komissiia po Izucheniiu Chetvertichnogo Perioda* **10**, 1 (1953); and M. Hildebrand, *Calif. Fish Game* **41**, 327 (1955). I was forced to discard many of the diagnostic characters proposed by these authors. My study was based on a far larger sample than theirs—one that included specimens of both wild and domestic animals.
4. C. A. Reed, in R. J. Braidwood *et al.*, *Studies in Ancient Oriental Civilization, No. 31* (Univ. of Chicago Press, Chicago, 1960).
5. D. Perkins, Jr., *Sumer* **16**, 77 (1960).
6. H. E. Wright, Jr., in R. J. Braidwood *et al.*, *Studies in Ancient Oriental Civilization, No. 31* (Univ. of Chicago Press, Chicago, 1960), p. 90.
7. R. H. Dyson, Jr., *Am. Anthropologist* **55**, 661 (1953).
8. J. A. Shotwell, *Ecology* **36**, 327 (1955); **39**, 271 (1958).
9. The metapodial epiphyses, which fuse at 12 to 15 months, were used to determine the percentage of young animals. The first and third phalanges, which fuse well within the first year, cannot be used, since the separate epiphyses are rarely preserved and the diaphysis alone is unrecognizable. For the epiphysial-union pattern see T. W. Todd and A. W. Todd, *Am. J. Anat.* **63**, 1 (1938), and R. N. Smith, *Vet. Rec.* **68**, 257 (1956).

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Neutron and Proton Dosages in the Upper Atmosphere from Solar Flare Radiation

Abstract. *The radiation dosage from secondary neutrons as well as from primary and secondary protons in the earth's atmosphere during solar particle events is calculated as a function of the solar proton flux, atmospheric depth, and geomagnetic-cutoff rigidity. The dosage in rems from secondary neutrons exceeds the dosage from protons below 30 g/cm² of residual atmosphere. Neutron dosages in rads are less than the dosage from primary protons at all depths above 100 g/cm². The maximum neutron dose to travelers in supersonic aircraft during solar particle events of the magnitude observed during the last solar cycle would be of the order of 1 rem.*

Freier and Webber (*1*) have discussed the hazard to space travelers from solar particle beams exhibiting the two-parameter exponential-rigidity spectrum typical of such radiation. They calculate the dosage from the primary protons as a function of the two parameters and of shielding thickness from 1 to 10 g/cm². Over this range of thicknesses, the dosage from secondary neutrons and protons produced in the