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SIZE REDUCTION IN BIGHORN SHEEP (*OVIS CANADENSIS*) AT THE CLOSE OF THE PLEISTOCENE

In 1961, Stokes and Condie concluded that bighorn sheep from the middle and late Pleistocene of the Great Basin were more similar to *Ovis ammon* of Asia than to the American *Ovis canadensis* or *Ovis dalli*, and probably represented "direct migration of ammon-like ancestors to North America in middle Pleistocene times." These sheep, characterized particularly by their large size, were referred tentatively to a fossil species, *Ovis catclawensis* Hibbard and Wright. It also was suggested that the primitive ammon-like "forms evolved into *Ovis dalli* in northwestern North America and into *Ovis canadensis* in western and southwestern North America."

Additional material led to re-evaluation (Stock and Stokes, 1969). Pertinent points include the revised conclusion that the Pleistocene Great Basin specimens assigned to *O. catclawensis* are more closely related to *O. canadensis* than *O. ammon*, that these specimens probably date from between 68,000 and 33,000 BP, and that *O. catclawensis* represents one of "many temporal and spatial local populations with varying characteristics." Characteristics of the Great Basin specimens include great size, great orbital width, and a wide rostrum.

New specimens of bighorn sheep in the Museum of Arid Land Biology (MALB) come from the Pleistocene of New Mexico and shed further light on the late evolutionary history of this animal. The specimens consist of the posterior portion of a skull with complete horn cores (MALB 22-252), a fragmentary right dentary with p4 and ml-3 (MALB 22-250), and the lateral two-thirds of a left M3 (MALB 22-980). Likely one individual, a male of 10 or more years, is represented. The specimens were recovered within a few feet of each other from the lowest deposits (Charlies Parlor) of the Entrance Fissure system, Dry Cave, Eddy County, New Mexico (see Harris, 1970). A C^{14} date on bone from the same level is $15,030 \pm 210$ BP (I-6201). The measurements of these specimens (Table 1) compare favorably with those of the large *O. catclawensis* specimens reported by Stokes and Condie (1961). Indeed, many skull measurements are the largest reported for North America. The lower tooth measurements are quite similar to those of the holotype of *O. catclawensis* (Hibbard and Wright, 1956), but the extreme wear makes tooth measurement difficult and comparisons dangerous.

Although orbital and rostral widths are not obtainable, these specimens do show that large size continued nearly to the end of the Pleistocene. Other specimens suggest the same. Schultz and Howard (1935) assigned late Pleistocene bighorn specimens from Burnet Cave, about 20 miles west of Dry Cave, to *Ovis auduboni* (= *O. canadensis auduboni*) on the basis of large size (length of lower dentition, 104 millimeters; this compares to 101 millimeters for the holotype of *O. catclawensis*) and a horn core fragment suggesting great massiveness. Another large Pleistocene specimen of *Ovis* is known from northwestern New Mexico (Stovall, 1946). Churcher (1968) obtained a large *Ovis* metacarpal from near Cochrane, Alberta, dated at $10,760 \pm 160$ and $11,370 \pm 170$ BP. However, a specimen from the Parsnip River, British Columbia, is well within the size range of modern *O. c. canadensis*; it has a C^{14} date of 9280 ± 200 BP (Rutter *et al.*, 1972.). Stock and Stokes (1961) place a specimen from near Winnemucca, Nevada, as *O. canadensis* rather than *O. catclawensis*, with an age of some 6500 years.

TABLE 1.—Pertinent measurements of the Dry Cave specimens (in millimeters).

Character	Measurement	MALB specimen no.
Maximum diameter at base of horn cores	139	22—252
Length of horn cores	385	22—252
Circumference of horn cores at base	428	22—252
Greatest distance between core tips (outside distance)	503	22—252
Minimum distance between horn core bases	19	22—252
Minimum angle between horn cores	101°	22—252
Maximum diameter of occipital condyles	76	22—252
Minimum mastoid width	122	22—252
Minimum basioccipital width	35	22—252
Transverse width p4	9.8	22—250
Transverse width m1	10.5	22—250
Transverse width m2	12.2	22—250
Anteroposterior length p4	11.9	22—250
Anteroposterior length m1	14.1	22—250
Anteroposterior length m2	20.1	22—250
Length of M3 at top of roots	27	22—980

Thus fossil specimens from southern Canada and interior United States dating from before about 10,000 radiocarbon years ago average considerably larger than those from after that date.

Geist (1971) suggests that upon entering new territory with a superabundance of forage, selection acts to increase the size of bighorn males; that as the new territory becomes saturated and living quality falls, smaller males are selected for. He then hypothesizes that relatively small, presumably primitive *Ovis canadensis nelsoni*-like animals existed in a refugium in California and Nevada during the last glacial, radiating "from there during postglacial dispersal." Entering newly opened territory, the *nelsoni*-like forms increased in size to that seen in other present, more advanced subspecies.

In view of the fossil record, it seems to us more reasonable that much of the specific character of *O. canadensis* was set by mid-Wisconsin time, that populations with relatively large sized males (likely a result of the selective pressures discussed by Geist) were widespread in western United States and northern Mexico throughout the latter half of the Wisconsin, and that as a result of environmental deterioration, there was a general selection for smaller size at the close of the Pleistocene. The present subspecies, then, would be a reflection of this selection, other selective adjustments more regional in nature, and an increase in geographic isolation as suitable habitat decreased in Holocene time.

In our opinion, *O. c. nelsoni* most likely retains relatively primitive characters because of isolation in California during much of the Wisconsin, contributing perhaps to adjacent populations during the post-Pleistocene. Such a model avoids 1) the necessity of post mid-Wisconsin extinction of all bighorns outside a California-Nevada refugium during a time of probable enhancement of sheep habitat and 2) the necessity of the Dry Cave bighorn progenitors migrating from the refugium and greatly increasing in size during the few thousand years following the last glacial peak.

Ovis catclawensis, characterized by large size by Hibbard and Wright (1956), seems to have led directly, and by a transition period of perhaps less than 2000 years, to thoroughly modern *O. canadensis*. If the large, pre-Holocene sheep are to be recognized nomenclaturally, it clearly should be as a temporal subspecies (*Ovis canadensis catclawensis*) rather than as a separate species.

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