

*H. antarcticum* the sheath is well developed. Be that as it may, the small shell of *H. antarcticum* illustrated by Bage (1938, pl. 7, fig. 1) is similar externally to the small shell of *H. corolliforme* illustrated by Hoek (1883, pl. 6, fig. 27), and the large scutum (40 by 35 by 22 mm.) in our collection is similar to the small scutum (about 18 by 13 by 9 mm.) illustrated by Hoek (1883, pl. 13, fig. 3). There is considerable difficulty in separating the several species of *Hexelasma*, but as this problem is not within the purview of this note, the Sars Bank and Scotia Ridge specimens are referred to *Hexelasma antarcticum* Borradaile with which they appear to be identical. One of the distinguishing characters of the compartments in our collection is the shallow sulcus and gentle ridge which is parallel with, and adjacent to, the summit margin of the alae.

*Hexelasma antarcticum* Borradaile is now known to range from early Pleistocene to Recent. The species was first found as a subfossil on glacial ice as much as 200 feet above sea level, and to account for this unusual occurrence, two theories have been advanced. One of the theories was proposed by Debenham (1919) who concluded that the barnacle (together with other organisms and bottom debris) was trapped in the ice by freezing when the ice shelf touched the sea floor and then migrated slowly to the top of the ice sheet by the melting of the upper surface while new ice formed at the bottom. The other theory, elaborated upon by Speden (1962), accounts for the occurrence of *H. antarcticum* on ice by the plucking and up-ploughing of the ice sheet as it moved across upraised fossiliferous sediment and by the subsequent melting into the ice by heat absorption of the sediment with its enclosed organisms.

A fossil species close to *H. antarcticum* Bor-

radaile is the New Zealand Miocene *H. aucklandicum* (Hector, 1887) which may have been the progenitor of the Antarctic form.

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## A NEW CHIPMUNK, *TAMIAS ARISTUS*, FROM THE PLEISTOCENE OF GEORGIA

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### INTRODUCTION

In the fall of 1963 Mr. Warren Moore and family discovered fossil bones and molluscs in a limestone quarry at Ladds, Bartow County, northwestern Georgia. They reported the find to faculty members of Shorter College, Rome, Georgia, and subsequent collecting, continuing at present, has been conducted under the

auspices of Shorter College in collaboration with the Smithsonian Institution. Although many people have participated in the project, among the most active have been the public school teachers, including Mr. and Mrs. Moore, enrolled in the 1963-1964 National Science Foundation In-Service Institute at Shorter College, and students (Leon Avery, John Henry,

and Lamar Thornbrough), faculty (Lewis Lipps), and friends (Robert Bagby, Charles Cressler, and Jennings B. Gordon, Jr.) of the geology department of the college. Access to the quarry, under lease to Bartow County, has been made possible through the interest and cooperation of Mr. Griffin Smith, County Commissioner. I wish to thank Drs. John E. Guilday, David H. Johnson, and Karl F. Koopman for critically reading the manuscript, and Drs. Johnson of the U. S. National Museum (USNM), Malcolm C. McKenna of the American Museum of Natural History (AMNH), Dale A. Russell of the National Museum of Canada (NMC), and Horace G. Richards of the Academy of Natural Sciences of Philadelphia (ANSP) for access to collections under their care. Dr. Guilday has also made available unpublished results of current work at the Carnegie Museum. Text-figure 1 is the work of Mr. Lawrence B. Isham. This paper is published by permission of the Secretary of the Smithsonian Institution.

The fossils occur in small fissures exposed in a remnant pinnacle of limestone representing the southerly end of Quarry Mountain (also known as Ladds Mountain), now isolated from the major part of the mountain by extensive quarrying. The fossiliferous matrix is a red cave earth in part little indurated and yielding readily to standard washing techniques and in part firmly cemented as a "cave breccia." The disturbed (by dynamiting) and open nature of the deposit, together with the presence of certain apparently ecologically incompatible species, suggest the possibility of a heterochronic assemblage rather than a unit fauna. Collecting thus far has yielded some 40 species of vertebrates, including the Pleistocene indicators, *Dasypus bellus*, *Tapirus* cf. *veroensis*, *Equus* sp., and *Mylohyus nasutus*. Studies in progress of these and other components of the deposit will be published elsewhere. The purpose of the present communication is to describe a new large chipmunk of the genus *Tamias* occurring in the Ladds assemblage.

SYSTEMATIC DESCRIPTION  
Order RODENTIA  
Family SCIURIDAE  
Genus TAMIAS

The chipmunks, comprising the subtribe Tamiina of the tribe Marmotini (Moore, 1959) or a separate tribe Tamiini (Black, 1963), include three generic group taxa, *Tamias* Illiger 1811, *Eutamias* Trouessart 1880, and *Neotamias* Howell 1929. Ellerman (1940) and Bryant (1945) have regarded the three as subgenera of the genus *Tamias*, whereas Howell (1929), White (1953) and others, followed here, have

recognized the apparently closer relationship between *Eutamias* and *Neotamias* by arranging them as subgenera within the genus *Eutamias*, distinguished from the genus *Tamias*. Of much greater significance for the present study than the hierarchical status of these taxa are the analyses of supraspecific cranial characters in chipmunks and other sciurines provided especially by Howell (1929, p. 12, 26), Bryant (1945, p. 370-372), White (1953), and Moore (1959, p. 180-181).

The genus *Tamias* includes a single living species, *T. striatus* (Linnaeus), the Eastern Chipmunk, currently subdivided into 10 subspecies, all in eastern North America (see Hall and Kelson, 1959, p. 293-296, map 196). *Tamias* is now known from the following Pleistocene and early Recent localities:

Conard Fissure, Newton County, Arkansas (Brown, 1908). Abundant material (AMNH 11796 and 11797) described as *T. nasutus* Brown, but seemingly inseparable from *T. striatus*. See tables 1 and 2.

Cherokee Cave, St. Louis, Missouri (Simpson, 1949). *T. striatus*, represented by a complete left mandibular ramus, a right ramus lacking cheekteeth, and a left premaxilla with incisor (all AMNH 45744). Old but probably Recent according to Simpson (p. 11).

Ladds, Bartow County, Georgia (reported herein). Both *T. striatus* and the new species, described below.

Robinson Cave, Overton County, Tennessee (Guilday, written communication). *T. striatus*.

Whitesburg, one mile north of, Hamblen County, Tennessee (Hay, 1920). Represented only by a partial right lower incisor (USNM 8961), not positively identifiable.

Wythe County, Virginia (Cope, 1869). Exact locality uncertain, possibly Early's Pits (Guilday, 1962a). *T. laevidens* Cope, described on basis of single fragmentary immature mandibular ramus (AMNH 8081), reduced to synonymy of *T. striatus* by Guilday.

Natural Chimneys, Augusta County, Virginia (Guilday, 1962b). *T. striatus*, represented by two size classes.

Strait Canyon, fissure deposit, 17 miles south of Franklin, Pendleton County, West Virginia, on road between Franklin and Monterey, Highland County, Virginia. A fragment of a left mandibular ramus with M<sub>1</sub> and M<sub>2</sub> (USNM 23397) collected by C. L. Gazin in 1949 and identified by him as *Tamias* sp. cf. *T. striatus*.

Cumberland Cave, Allegany County, Maryland (Gidley and Gazin, 1938). *T. sp. cf. T. striatus*, represented by a fragmentary lower jaw (USNM 12367). Additional specimens may be expected through work in progress by Guilday and associates.

New Paris No. 4, Bedford County, Pennsylvania (Guilday, Martin, and McCrady, 1964). *T. striatus*, represented by abundant material.

Bootlegger Sink, York County, Pennsylvania (Guilday, Hamilton, and McCrady, in press). *T. striatus*.

Hartman's Cave, Monroe County, Pennsylvania (Leidy, 1880, 1889). *T. striatus*, represented by several specimens (ANSP 22, 525, 623). See table 2.

Near Hamilton, Ontario, Canada (Wetmore, 1958). *T. striatus*, represented by an essentially com-

plete skull (USNM 21920) and miscellaneous bones, all modern in appearance. Derived from sediments in a small cave, dated as late Pleistocene.

Ottawa vicinity, Ontario, Canada. Listed as *Tamias striatus* by Hay (1923, p. 287) with the implication that the species had been reported by Ami (1897, 1901), which seems not to be the case. Coleman (1901, p. 131) includes "chipmunk" among animals recovered from nodules in the Leda clay. Johnston (1917, p. 25) mentions the "bones of a chipmunk" among fossils found in concretions "along the south shore of the Ottawa between Besserers wharf and the mouth of Greens creek a few miles down the river from the city of Ottawa."

Moose Creek, Stormont County, Ontario, Canada. *T. striatus*, represented by two mandibular rami (NMC 6824) and a skull, jaws, and partial skeleton (NMC 6825), collected by H. M. Ami in 1890 from marine gravels and sands (Saxicava sands). Perhaps these, the only fossil *Tamias* to be found at present in the National Museum of Canada (Russell, written communication), are the specimens referred to by Hay and others above. See table 2.

With the exception of the new form from Georgia, all of the above records appear to represent *Tamias striatus*, or in the case of meager materials are at least indistinguishable from *T. striatus*.

TAMIAS ARISTUS n. sp.  
Text-fig. 1A-C

*Etymology*.—From the Greek, *aristos*, best, noblest.

*Type*.—USNM 23320, well preserved skull, lacking nasals, zygomatic arches, tips of incisors, and cheek teeth of right side. Collected and prepared summer, 1964, by Mr. and Mrs. Warren Moore and family.

*Referred material*.—USNM 23321, left mandibular ramus with incisor (lacking extreme tip), and all cheek teeth, but missing posterior portion of ramus; USNM 23322, four isolated teeth, a right  $M^2(?)$  and  $M^3$ , and two left lower molars, representing  $M_1$  or  $M_2$ , or both.

*Occurrence*.—Fissure fillings at Ladds (34° 09'N., 84° 50'W.), Quarry Mountain, 2.3 miles west southwest of Cartersville, Bartow County, Georgia. Probably late Pleistocene. Known only from the type locality.

*Diagnosis*.—Similar to *Tamias striatus*, but much larger than its largest modern representatives; almost all cranial and dental dimensions 10–30% greater (table 1).

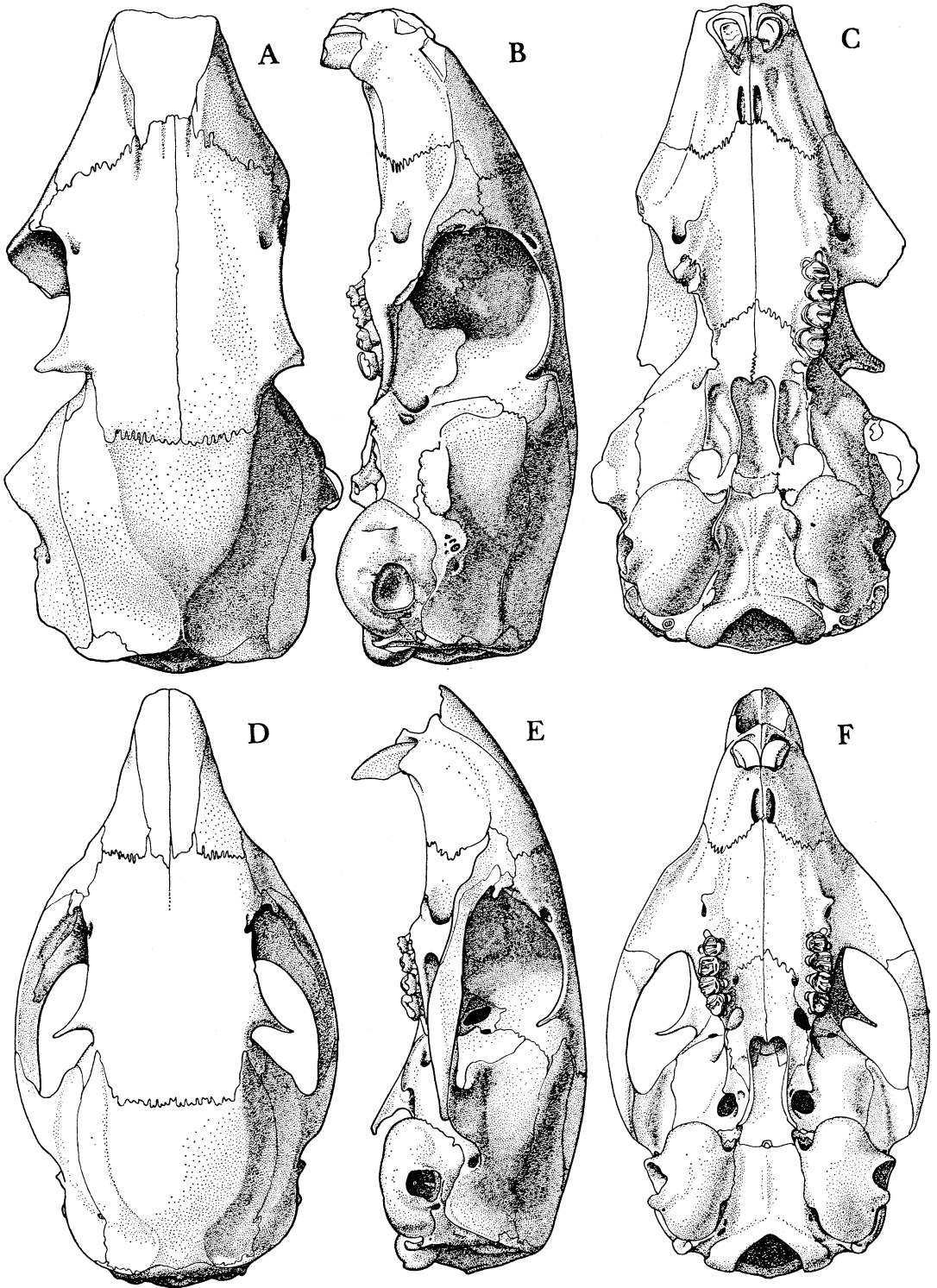
*Measurements*.—Measurements of *T. aristus* are presented in table 1, along with those for specimens from Ladds assigned to *T. striatus*, the type of *T. nasutus*, and selected large individuals of modern *T. striatus*. The estimated greatest length of skull for *T. aristus* is extrapolated on the basis of a mean ratio of .91 between condylobasal and greatest length in the sample of modern *T. striatus pipilans*.

Some statistics of various samples of *T. striatus* are presented in table 2. The sample of *T. s. pipilans*, the largest modern subspecies, includes all specimens in the National Museum from within the range of the subspecies that are sufficiently mature to have  $M^3$  in use. The data available from Lowery (1943) suggest that a sample drawn from Louisiana would average slightly larger than the geographically heterogeneous sample available. Only specimens with all cheek teeth fully erupted were measured. Except as otherwise noted, all measurements of paired structures utilized in tables 1 and 2 were taken from the left side. The alveolar lengths of  $P_4-M_3$  in the Conard Fissure, New Paris No. 4, and Hartman's Cave samples suggest populations perhaps slightly larger than the largest modern ones. This impression is reinforced by alveolar length,  $P^4-M^3$ , in 4 maxillae from New Paris No. 4, of 6.5, 6.6, 6.7, and 6.9 mm (Guilday, written communication). It should be noted that alveolar length of tooth rows in samples of fossils is biased upward somewhat as a result of breakage of alveolar borders.

*Description*.—(Cranial terminology after Moore, 1959, p. 162–166). Resembles *Tamias striatus* much more closely than it does any other sciurid, differing from the modern form primarily in larger size and in minor features probably correlated with larger size (text-fig. 1). Skull large, elongate, and narrow; dorsal profile gently convex throughout; rostrum broad at

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TEXT-FIG. 1.—Skulls of chipmunks, genus *Tamias*,  $\times 2$ . A–C, *Tamias aristus*, type USNM 23320, Pleistocene, Ladds assemblage, Bartow County, Georgia; A, dorsal view; B, lateral view; C, ventral view. D–F, *Tamias striatus pipilans*, USNM 284859, Recent, one mile north of Cornor, West Feliciana Parish, Louisiana; D, dorsal view; E, lateral view; F, ventral view.



base, tapering gradually anterad from zygomatic plate; zygomatic plate forms angle of about 45 degrees with occlusal plane of maxillary tooth row; sharp, anteroventrally directed edge of anterior portion of zygoma not as strongly developed as in *T. striatus*; infraorbital foramen large, subcircular, opening directly through zygomatic plate as a fenestra, not a canal; masseteric tubercle ventrad and mesad of infraorbital foramen; least distance from suborbit to infraorbital foramen 1.27 times length of incisive foramen; suborbit extends anteriorly to level of posterior margin of P<sup>4</sup>; P<sup>3</sup> absent as in *Tamias* (rarely present in *Tamias*, White, 1953, p. 553 and Guilday, et al., 1964, p. 153; rarely

absent in *Eutamias*, Jones, 1960, p. 268); anterior root of P<sup>4</sup> directed toward masseteric tubercle; upper tooth rows convergent posteriorly; palate extended well beyond M<sup>3</sup>; orbital length 1.08 times interorbital breadth; interorbital region narrow; supraorbital notch closed, situated well anterior to level of suborbit; postorbital process broad and short as compared to that in *T. striatus*; frontoparietal suture not ankylosed; temporal foramen in squamosoparietal suture absent; short sagittal ridge developed posteriorly by convergence of temporal ridges near posterior margin of parietals, a feature rare in *T. striatus* but present in some large individuals (as USNM 207223 and

TABLE 1—MEASUREMENTS (MM.) OF SOME PLEISTOCENE AND RECENT CHIPMUNKS, GENUS *TAMIAS*  
Measurements followed by an asterisk (\*) are from the right side

	<i>T. arisatus</i> , USNM 23320, type. (A)	<i>T. arisatus</i> USNM 23321. (A)	A — B	<i>T. striatus pipilans</i> , USNM 284859. ♂ (B)	<i>T. striatus pipilans</i> , USNM 207224. ♀	<i>T. masulus</i> , AMNH 11797, type.	<i>T. striatus</i> , Ladds USNM 23319			
							a	b	c	d
Greatest length of skull	(52.7)		118	44.7	43.9					
Condylobasal length	48.0		119	40.2	39.9					
Palatal length	27.6		124	22.3	22.6	21.3				
Diastemal length	15.2		128	11.9	12.3	11.4				
Length of incisive foramen	3.31		124	2.68	2.57	3.0				
Interorbital breadth	15.6		126	12.4	12.0	12.9				
Postorbital constriction	14.0		120	11.7	11.5	12.8				
Breadth of braincase on squamosals	20.5		116	17.6	17.1					
Height of foramen magnum	5.1		88	5.8	4.9					
Width of foramen magnum	6.7		105	6.4	5.9					
Crown length P <sup>4</sup> -M <sup>3</sup>	7.25		113	6.42	6.08	6.0*				
Alveolar length P <sup>4</sup> -M <sup>3</sup>	7.25		109	6.64	6.54	6.6*				
Upper incisor										
anteroposterior diameter	2.63		123	2.14	2.19	2.2*				
transverse diameter	1.50		130	1.15	1.29	1.1*				
P <sup>4</sup> length	1.61		110	1.47	1.37	1.4	1.43			
width	2.00		121	1.65	1.66	1.7	1.69			
M <sup>1</sup> length	1.72		102	1.68	1.47		1.59			
width	2.21		111	2.00	1.94		1.94			
M <sup>2</sup> length	1.84		112	1.65	1.65		1.65			
width	2.39		121	1.97	2.00		1.99			
M <sup>3</sup> length	2.22		120	1.85	1.84	2.0				
width	2.34		126	1.85	1.91	1.9				
Crown length P <sub>4</sub> -M <sub>3</sub>		8.04	123	6.52	6.23		5.98			
Alveolar length P <sub>4</sub> -M <sub>3</sub>		8.10	124	6.54	6.68		6.50			
Lower incisor										
anteroposterior diameter		2.57	124	2.07	2.03					
transverse diameter		1.45	125	1.16	1.30					
P <sub>4</sub> length		1.68	124	1.35	1.38		1.33			1.38
width		1.80	128	1.41	1.40		1.33			1.32
M <sub>1</sub> length		2.12	127	1.67	1.49		1.49	1.60		
width		2.29	132	1.73	1.70		1.74	1.73		
M <sub>2</sub> length		2.42	122	1.98	1.81		1.82	1.90		
width		2.53	129	1.96	1.83		1.81	1.78		
M <sub>3</sub> length		2.91	127	2.29	2.25		2.17			
width		2.34	130	1.80	1.74		1.65			

TABLE 2—STATISTICS AND MEASUREMENTS (MM.) OF SOME PLEISTOCENE AND RECENT SAMPLES OF CHIPMUNKS, GENUS *TAMIAS*  
New Paris data after Guilday, et al., 1964, p. 153

	N	OR	$\bar{X}$	x	V
<i>T. striatus pipilans</i> , Recent					
Condylobasal length	19	36.1–40.2	38.52	1.29	3.36
Palatal length	19	19.9–22.7	21.56	.85	3.94
Diastemal length	19	10.6–12.5	11.53	.56	4.90
Interorbital breadth	19	11.2–12.6	11.85	.43	3.65
Postorbital constriction	19	10.9–12.9	11.83	.53	4.49
Breadth of braincase on squamosals	19	15.8–17.8	16.98	.49	2.90
Crown length P <sup>4</sup> -M <sup>3</sup>	19	5.7–6.8	6.19	.31	4.99
Crown length P <sub>4</sub> -M <sub>3</sub>	19	5.8–6.9	6.34	.28	4.38
Alveolar length P <sub>4</sub> -M <sub>3</sub>	19	6.3–7.4	6.76	.30	4.40
<i>T. nasutus</i> , fossil					
Conard Fissure					
Alveolar length P <sub>4</sub> -M <sub>3</sub> (right)	11	6.5–7.1	6.77	.19	2.80
<i>T. striatus</i> , fossil					
Cherokee Cave					
Alveolar length P <sub>4</sub> -M <sub>3</sub> (one right)	2	6.4–6.7			
New Paris No. 4 (11,300 B.P.)					
Alveolar length P <sub>4</sub> -M <sub>3</sub> (left and right)	30	6.3–7.1	6.74	.2	6.67
New Paris No. 2 (1,875 B.P.)					
Alveolar length P <sub>4</sub> -M <sub>3</sub> (left and right)	114	5.8–6.8	6.28	.18	2.86
Hartman's Cave					
Alveolar length P <sub>4</sub> -M <sub>3</sub> (6 right)	9	6.2–7.7	6.90	.42	6.11
Moose Creek					
Alveolar length P <sub>4</sub> -M <sub>3</sub> (one right)	2	6.2–6.3			

207226, *T. s. pipilans*; cf. Moore, 1959, p. 181); temporal ridges continuously divergent forward from confluence, not slightly convergent adjacent to transverse frontoparietal suture as in *T. striatus*; supraoccipitals extend farther onto dorsal surface of skull than in *T. striatus*; lambdoidal crest strongly developed; foramen magnum relatively low and small as compared to that of *T. striatus*.

#### DISCUSSION

*Tamias aristus* assuredly is very closely related to *T. striatus*, although the exact nature of the relationship is uncertain at present. *T. striatus* is represented in the Ladds assemblage by material inseparable from modern *T. s. striatus* from Georgia. If the populations represented by the two size classes were in fact sympatric at Ladds, which is a possibility, there can be little doubt that *T. aristus* was a distinct species, now extinct, reproductively isolated from *T. striatus*.

Unfortunately, lack of stratigraphic control at Ladds prevents determination of temporal relationships between the two size groups. If the two populations were not sympatric, then *T. aristus* possibly, but not necessarily, can be interpreted as a large, extinct temporal subspecies

of *T. striatus*. The meager morphological differentiation between the two, at least largely size-related, is compatible with conspecificity. However, the type of *T. aristus* exceeds the largest modern *T. striatus* in cranial dimensions by about the same amount as the latter exceeds the smallest modern *T. striatus*, and the modern extremes are of course connected by a continuous series of intermediates. The inclusion of *T. aristus* in *T. striatus* would essentially double the cranial size range as observed in modern populations, without significant intermediary series in the upper half of the variation. Further, it is improbable that the type of *T. aristus* represents the upper size limit of the population from which it was drawn; USNM 23321 appears to represent an individual larger than the type (table 1).

This radical gap in observed size ranges well might disappear if more Pleistocene samples were available. The late Pleistocene sample from New Paris No. 4 represents a population notably larger than the Recent population from the same area and, along with the samples from the Conard fissure and Hartman's Cave, perhaps slightly larger than the largest living populations (table 2). If other late Pleistocene populations of *Tamias* prove to be similarly scaled

upward in size, as experience with other mammalian groups leads one to expect, then *T. aristus* could represent merely a large (southern) extreme in the geographic variation of late Pleistocene *Tamias*.

Many additional samples, adequately dated and studied, comparable to those from New Paris, will be needed before an interpretation such as the above can be more than conjectural. Meanwhile, on the basis of present inadequate chronological and populational evidence, even if *T. aristus* is assumed to lie within the lineage of *T. striatus*, it may be distinguished as a successional species antecedent to modern *T. striatus*. This interpretation is supported by analogy to degree of differentiation among contemporary species of *Eutamias* (cf. Johnson, 1943, for example; *Tamias* is monotypic). Simpson's (1961, p. 163-176) discussion of species and subspecies in paleontology has been especially helpful in approaching the present problem.

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