



BABY HADROSAURID MATERIAL ASSOCIATED WITH AN UNUSUALLY HIGH ABUNDANCE OF *TROODON* TEETH FROM THE HORSESHOE CANYON FORMATION, UPPER CRETACEOUS, ALBERTA, CANADA

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ABSTRACT: A new microvertebrate site (≈ 72 Ma) in the Horseshoe Canyon Formation, south-central Alberta, is a deflation lag in interbedded silty shales. The site represents deposition on a waterlogged coastal plain ≈ 100 km to the west of the Bearpaw Sea. Approximately two-thirds ($n=224$) of the 388 elements recovered from this site belong to indeterminate hadrosaurids. Forty of these are from baby-sized individuals, suggesting that a nesting site of unknown size was located nearby. These fossils are notable for being the first occurrence of baby dinosaurs in the formation and the geologically youngest occurrence of baby dinosaurs in Canada. The next most common taxon (17% of elements) is the small theropod *Troodon*, represented by abundant teeth ($n=65$). *Troodon* teeth are normally rare in Upper Cretaceous sites in southern Alberta. The large number of *Troodon* teeth at the new site suggests a non-random association with the baby hadrosaurid elements, and is potentially indicative of predation. Elements of other dinosaurs are less common at the site, and include 45 teeth or tooth fragments from at least four other theropod taxa, and rare ankylosaurid and ceratopsid elements.

INTRODUCTION

Dinosaur eggs and babies are rare in the fossil record, as is their association with fossils of potential predators. The first dinosaur eggs were found in the Upper Cretaceous of France in 1859, but were not

recognized as such until the early twentieth century (BUFFETAUT & LE LOEUFF, 1994). The first widespread public recognition of dinosaur eggs occurred with the discovery of eggs referred to *Protoceratops andrewsi* GRANGER & GREGORY, 1923 in the Upper Cretaceous of the Gobi Desert by the Central Asiatic

Expeditions from the American Museum of Natural History (ANDREWS, 1932). MARSH (1883) made the first mention of baby dinosaur material, a small (2m) "foetal" skeleton associated with the holotype of *Camarasaurus grandis* MARSH, 1877 from the Upper Jurassic Morrison Formation, Como Bluff, Wyoming. The oldest baby dinosaur bones and dinosaur eggshell co-occur in the Upper Triassic of Argentina (CARPENTER & ALF, 1994). Other reports of eggs and baby dinosaurs have come from North America, South America, Europe and Asia (see review by CARPENTER & ALF, 1994), but are best known from Campanian outcrops of the Djadokhta and Barun Goyot formations in Central Asia (e.g. BROWN & SCHLAIKJER, 1940; SOCHOVA, 1972; COOMBS, 1982; DONG & CURRIE, 1993; NORELL *et al.*, 1994) and the Two Medicine Formation in northwestern Montana (HORNER & MAKELA, 1979; HORNER 1982, 1984a, 1984b) and at Devil's Coulee, southcentral Alberta (CURRIE & HORNER, 1988; HORNER & CURRIE, 1994). Maastrichtian occurrences of eggs and babies are known from the United States, Peru, France, Spain, Romania, India, Mongolia, and China (CARPENTER & ALF, 1994), but remain poorly documented in Canada. Undescribed eggshell fragments have been reported from the St. Mary River (lower Maastrichtian) and Willow Creek (upper Maastrichtian) formations of southern Alberta (CARPENTER & ALF, 1994). The hadrosaurid elements reported here from Alberta represent the first record of baby dinosaurs from the Horseshoe Canyon Formation (lower Maastrichtian) and the geologically youngest occurrence of baby dinosaur fossils in Canada.

Associations of carnivorous and potential (usually adult) prey species of dinosaurs in the fossil record, with the inference of scavenging or active predation of the former on the latter, is well documented in the literature for both articulated skeletons (e.g. JERZYKIEWICZ *et al.*, 1993; MAXWELL & OSTROM, 1995; UNWIN, PERLE & TRUEMAN, 1995) and disarticulated bone bed material (e.g. CURRIE & DODSON, 1984; RYAN, 1992). The best evidence to date for the supposition that theropods may have fed upon dinosaur eggs and babies comes from the presence of elements of small theropods at ornithopod nesting sites in the Upper Cretaceous of western North America. HORNER (1994) reported teeth and bones of small theropods (*Troodon* LEIDY, 1856 and *Sauromitholestes* SUES, 1978, where identifiable), with nests and elements of embryonic to small juvenile ornithopods (the hypsilophodontid *Orodromeus makelai* HORNER & WEISHAMPEL, 1988 and the hadrosaurids *Maiasaura peeblesorum* HORNER & MAKELA, 1979 and *Hypacrosaurus* BROWN, 1913) at nesting sites in the Two Medicine Formation of Montana. Although the theropod material was rare and no direct evidence of predator manipulation

of ornithopod bones or eggs (e.g. tooth marks) was found at any of these sites, these associations of fossils suggest that the theropods may have preyed and/or scavenged on the ornithopods. The baby hadrosaurid elements described here from the geologically younger Horseshoe Canyon Formation are found in association with abundant theropod teeth, primarily those of *Troodon*, which we interpret as indicating that these theropods may also have fed upon hadrosaurid eggs and babies in a nearby nesting area.

GEOGRAPHICAL AND GEOLOGIC SETTING

THE HORSESHOE CANYON FORMATION

The predominantly nonmarine Horseshoe Canyon Formation (early Maastrichtian in age), is the lowest of four formations comprising the Edmonton Group (sensu GIBSON, 1977; Fig. 1). The formation crops out along a north to south trend in southcentral Alberta, where it is best exposed in the Red Deer

Formation	Seam/Horizon	Age
Paskapoo		Palaeocene Tertiary
Scollard	14	
	13	
	Scollard Tuff	
Battle	Kneehills Tuff	Maastrichtian Cretaceous
Whitemud		
Horseshoe Canyon	12	
	11	
	10	
	Drumheller Marine Tongue	
	← L2000	
	9	
	8	
	7	
	6	
	5	
4		
3		
2		
1		
0		
Bearpaw	Dorothy Bentonite	

Fig. 1 - Geological table for southern Alberta showing stratigraphic position of L2000. Numbers indicate coal seams (sensu GIBSON, 1977). Table modified from BRAMAN, JOHNSTON & HAGLUND (1995): Table 9.

River Valley near Drumheller. IRISH (1970) named the formation for an eastwardly-thickening clastic wedge of mostly flat-lying, interbedded silty sandstones, siltstones and claystones, with locally abundant carbonaceous shales, 13 coal seams, diagenetic ironstones and altered volcanic ashes. Deposition occurred largely in fluvial, overbank and coal swamp environments along the broad coastal plain that bordered the western margin of the Bearpaw Sea (BRAMAN, JOHNSTON & HAGLUND, 1995). The Drumheller Marine Tongue (sensu GIBSON, 1977) documents a short-lived transgression of the Bearpaw Sea westwards over the coastal plain. A diverse vertebrate assemblage is known from the formation, with dinosaurs being represented by at least 20 published genera (WEISHAMPEL, 1990) and over one hundred collected skeletons (BRAMAN, JOHNSTON & HAGLUND, 1995).

L2000 SEDIMENTOLOGY

RTMP locality 2000 (L2000) is located in the middle part of the Horseshoe Canyon Formation, in Horse Thief Canyon along the Red Deer River Valley (Fig. 2). L2000 is capped by the lowest coal of seam number 9 (sensu GIBSON, 1977), which lies approximately 33.5 m below the Drumheller Marine Tongue. Utilizing figures 17 and 19 of LERBEKMO & COULTER (1985), we estimate the age of coal seam number 9 based on magnetostratigraphic correlation to be about 72.25 Ma. When sediments comprising L2000 were deposited, the western margin of the Bearpaw Sea lay about 100 km to the east.

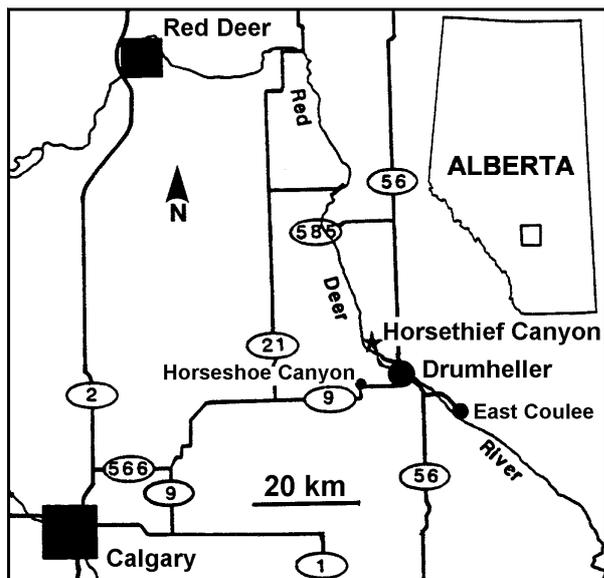


Fig 2 - Map of southern Alberta showing geographic location of Horse Thief Canyon.

Microvertebrate fossils at L2000 are derived from a 3.5 m thick, olive-coloured, silty shale that contains one prominent ironstone layer, abundant small siderite nodules and rare sideritized rhizoliths. This deposit thins markedly to the east and has been erosionally removed to the west, producing an exposed area approximately 50 x 10 m. This shale overlies a channel sand having steeply-dipping lateral accretion surfaces, which become shallower near the top of the sand and are taken to represent the initiation of channel abandonment. The top of this channel sand is bentonitic and locally rooted, suggesting a hiatus prior to deposition of the overlying shale. In short, L2000 occurs in a series of meandering channel deposits and is interpreted as having been deposited in an overbank setting during a flood event. EBERTH (1990) has advocated that at least some microvertebrate assemblages represent accumulations of reworked, but locally derived material. This raises the possibility that some of the vertebrate fossils at L2000 may have been reworked from deposits that had accumulated earlier over a number of years in the vicinity.

Fossils at L2000 consist of isolated small bones and teeth and fragments of larger bones. These fossils do not occur in a discrete fossiliferous horizon, but rather are scattered across the entire surface of the deposit and are interpreted to represent a modern deflation lag formed by winnowing away of fine-grained sediments. Few other microvertebrate sites are documented in the Horseshoe Canyon Formation. In terms of the number of fossils and taxa represented, microsites in this formation are less productive than those in nearby exposures of the middle Campanian, nonmarine Judith River Group (BRINKMAN, 1990; BASZIO, 1997a, 1997b).

MATERIALS AND METHODS

As no discrete fossiliferous level could be identified at L2000, the site was intensely surface collected over a two month period by staff of the RTMP and participants in the RTMP Day Digs program. This yielded 300 of the 388 catalogued specimens. The original discoverer of this locality and two similar sites in the formation claimed that small (1-2 m²) patches of mauve-coloured sediments were associated with abundant *Troodon* teeth. To test this observation, about 400 kg of matrix were collected from two such areas at L2000 and screen washed using a 0.66 mm (diagonal) screen mesh. This process yielded a further 85 identifiable specimens, largely fragments of hadrosaurid teeth, but only a few *Troodon* teeth. Hence, the mauve discolorations do not indicate the presence of rich concentrations of *Troodon* teeth, and instead appear to be the result of unrelated localized diagenetic changes in the exposed sediments. Specimens from these two screen

washed areas were combined and added to the surface collected material. Rare weathered fragments of large indeterminate dinosaur bone were noted on the surface and indeterminate bones fragments were recovered from the screen washed material, but few of these specimens were included in our study.

Our identifications of hadrosaurid elements are based on firsthand comparisons with specimens of *Hypacrosaurus stebingeri* HORNER & CURRIE, 1994 in collections of the RTMP (see HORNER & CURRIE, 1994). A confusing and poorly-defined nomenclature exists for dinosaur growth stages. Of particular relevance to our study are the following five ontogenetic stages used by HORNER & CURRIE (1994) for hadrosaurids: embryonic, hatchling, nestling, juvenile and adult. These authors also used the terms "nepionic" for post-embryonic stages and "baby" as a general term for embryos, hatchlings and nestlings. Others (see papers in CARPENTER, HIRSCH & HORNER, 1994) also use "baby" in this sense, and we follow this convention here, largely because we have not been able to reliably differentiate between embryonic-, hatchling- and nestling-sized hadrosaurid elements in the collection from L2000. We identified baby teeth and bones by their small size. Baby bones are further characterized by their porous periosteal texture. We identify larger hadrosaurid elements, including bones having a nonporous texture, as pertaining to "adults." Although some hadrosaurid elements from L2000 and elsewhere in the Horseshoe Canyon Formation (undescribed RTMP specimens) are evidently from moderate-sized individuals, we hesitate to identify these as belonging to "juveniles" because (1) maximum body size is difficult to estimate reliably from bone fragments and (2) hadrosaurids from the formation range in maximum size from about 9 m (*Hypacrosaurus*) to 12 m (*Edmontosaurus* LAMBE, 1920). Our identifications of isolated theropod teeth follow CURRIE, RIGBY & SLOAN (1990), FIORILLO & CURRIE (1994) and BASZIO (1997b) and are based on comparisons with specimens in the RTMP collections.

DESCRIPTION OF SPECIMENS

Dinosaur elements comprise nearly 88% (n=340) of the 388 fossils collected from L2000 (TABLE I), with bones and teeth of hadrosaurids (n=224) and theropod teeth (n=110) constituting the bulk of the collection. These are briefly described and discussed below. The remainder of the collection from L2000 includes elements from neopterygian fish, turtles (Baenidae, Chelydridae and Trionychidae), champsosaurids, pterosaurs, ankylosaurids, ceratopsids, birds and mammals, all of which are characteristic components of Upper Cretaceous non-

marine vertebrate assemblages in western North America (e.g. ESTES, 1964; SAHNI, 1972; BRINKMAN, 1990).

HADROSAURIDAE INDET. ELEMENTS

Most of the 224 identifiable hadrosaurid elements from L2000 are adult-sized teeth. The remaining 40 elements are baby-sized teeth and bones, which we briefly describe below. These are virtually identical in size and structure to embryonic- to nestling-sized elements of *Hypacrosaurus stebingeri* (HORNER & CURRIE, 1994), but cannot reliably be referred to this species.

Only one cranial bone is available, a basioccipital (RTMP 97.36.27; Fig. 3A), from which much of the periosteal bone has been weathered away from the ventral surface and the sutural margins. RTMP 97.36.27 resembles baby basioccipitals of *Hypacrosaurus stebingeri* figured by HORNER & CURRIE, 1994: figs. 21.7G, 21.10) in being hexagonal in dorsal outline, broadest across the floor of the foramen magnum and having the dorsal surface shallowly concave.

The best preserved and largest of the ten baby teeth is RTMP 97.36.45 (Fig. 3B), which has a crown height and width of 6.45 mm and 1.75 mm, respectively. The smallest tooth (RTMP 97.36.54) is worn and measures 4.00 mm high and 1.75 mm wide. Three teeth (RTMP 97.36.54, 97.36.42 and 97.36.44) have worn occlusal surfaces and four teeth (RTMP 97.36.35, 97.36.41, 97.36.43 and 97.36.45) have incipient marginal denticles; in *Hypacrosaurus stebingeri* nestlings, tooth denticles are absent or tiny (HORNER & CURRIE, 1994). The position occupied by any of the teeth in life (i.e. maxilla or dentary; left or right side) is uncertain.

Three-quarters of the identifiable baby-sized specimens are from the postcranium. Vertebral specimens include a cervical (RTMP 97.36.28), five dorsals (RTMP 96.44.1, 97.36.29, 97.36.30, 97.29.3 and 97.36.70), four caudals (RTMP 96.29.7, 96.44.15, 97.36.31 [Fig. 3C] and 97.36.68), and a fragmentary centrum end plate (RTMP 97.36.32). These exhibit the following three features that are characteristic for baby hadrosaurid vertebrae (see Fig. 3C): (1) notochordal pit present; (2) neural canal relatively broad; and (3) sutural surfaces on centrum for neural arch and transverse processes smooth (WEISHAMPEL & HORNER, 1990; HORNER & CURRIE, 1994). Two dorsal rib fragments (RTMP 96.36.14 and 97.36.61), two fragmentary sacral ribs (RTMP 97.36.49 and 97.36.60), a possible fragment of an ilium (RTMP 96.44.14), the shaft of a left femur (RTMP 96.44.16), the distal end of a left tibia (RTMP 96.44.17), a possible crushed distal femoral shaft (RTMP 96.44.18), a possible proximal tibial shaft

BABY HADROSAURID MATERIAL ASSOCIATED WITH ABUNDANT TROODON TEETH

TABLE I
Microvertebrate specimens (n=388) from L2000, Alberta, Canada; Horseshoe Canyon Formation.

TAXA	TEETH	OTHER ELEMENTS
<i>Troodon</i> LEIDY, 1856 (n=65)		
premaxillary	10	
maxillary	40	
dentary	15	
cf. <i>Sauornitholestes</i> SUES, 1978	8	
<i>Richardoestesia</i> CURRIE, RIGBY & SLOAN, 1990	11	
<i>Paronychodon</i> COPE, 1876	1	
Tyrannosauridae		
Indet. fragments	25	
Hadrosauridae (n=224)		
Baby	10	30
Adult	184	
Ceratopsidae	2	
Ankylosauridae	3	1
Neopterygian fish		4
Chelonia		
Chelydridae		21(a)
Trionychidae		3
Baenidae		1
Chelonia indet.		1
Champsosauridae		1
Pterosauria		3
Indet. reptilian claw		1
Indet. amphibian or reptilian limb bones		7
Aves		1
Mammalia		
<i>Pedionomys</i> MARSH, 1889	1	
indet.		4

(a) - Each counted separately, although some fragments appear to be associated.

(RTMP 96.44.19) and a pedal phalanx from digit IV (RTMP 97.36.33; Fig.3D) have also been identified, but all are unremarkable.

Eight indeterminate bone fragments complete the collection of baby-sized hadrosaurid specimens from L2000.

THEROPODA TEETH

The most common teeth (n=65; TABLE I) from L2000 are easily identified as belonging to *Troodon* based on their relatively large, strongly-hooked denticles and overall shape. These cannot be distinguished from teeth identified by CURRIE (1987: fig. 8.3A-M) as *T. formosus* LEIDY, 1856 from the younger Judith River Group of Alberta and Montana. Because of the difference in age between the Judith River Group (middle Campanian) and the Horseshoe Canyon Formation (lower Maastrichtian), we conservatively identify the teeth from L2000 as *Troo-*

don sp. CURRIE (1987) and CURRIE, RIGBY & SLOAN (1990) used aspects of tooth shape, structure (particularly of the denticles) and size to differentiate between premaxillary, maxillary and dentary teeth of *Troodon*. Teeth from the upper and lower jaws are represented at L2000. Figured here are a posterior maxillary tooth (Fig. 3E-F), a maxillary tooth (Fig. 3G-I), a posterior premaxillary or anterior maxillary tooth (Fig. 3J-L) and a dentary tooth (Fig. 3M-N).

Based on their tiny denticles 11 teeth, including the two shown in Figure 4A-E, can be identified as belonging to *Richardoestesia* CURRIE, RIGBY & SLOAN, 1990, an enigmatic genus known from a single pair of dentaries and many isolated teeth. The long, curved axis of the teeth from the Horseshoe Canyon Formation is similar to that seen in teeth of *R. gilmorei* CURRIE, RIGBY & SLOAN, 1990 from middle Campanian beds (CURRIE, RIGBY & SLOAN, 1990: fig. 8.4G-U). By contrast, teeth of *Richardoestesia* from the lower Campanian Milk River For-

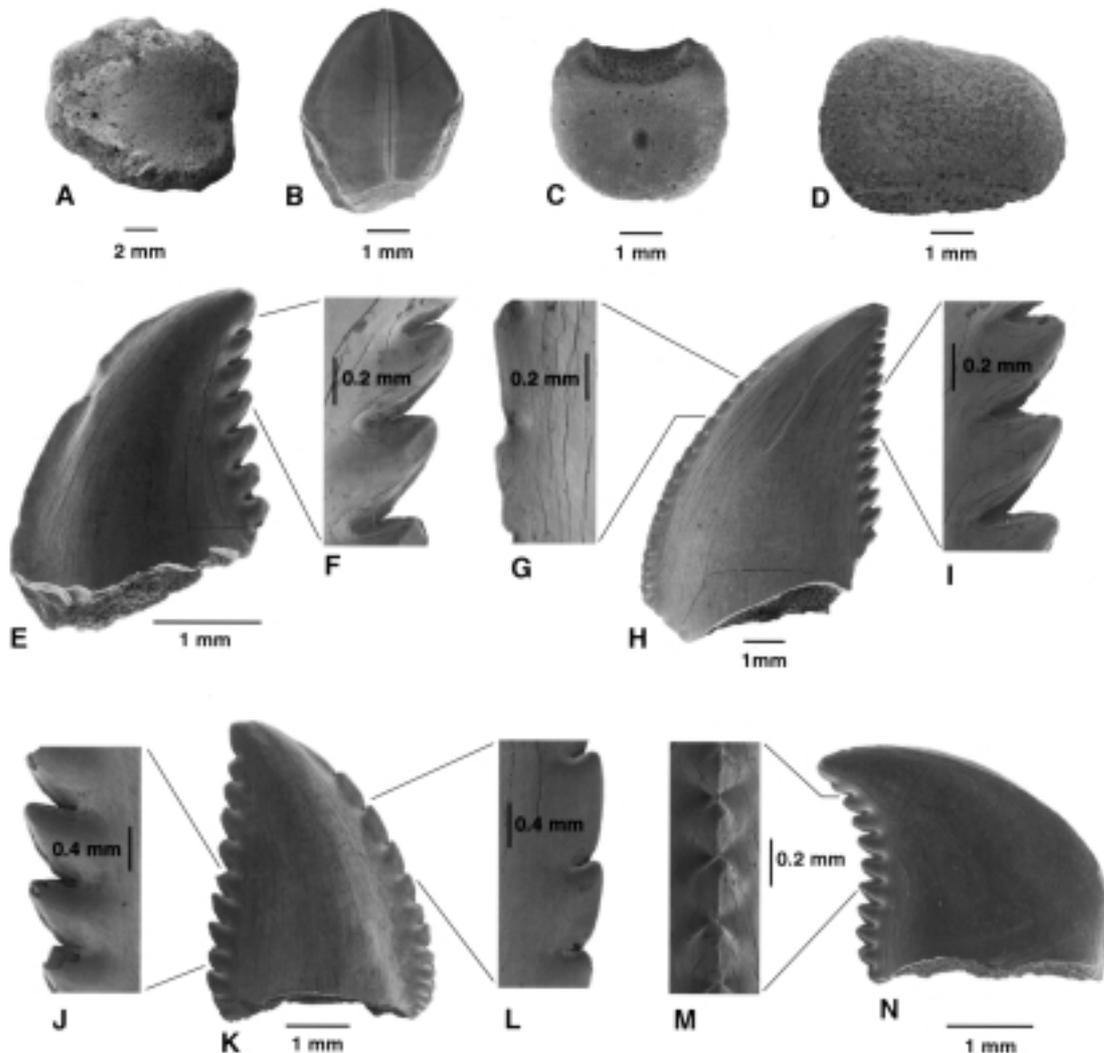


Fig. 3 - Baby hadrosaurid elements and teeth of *Troodon* LEIDY, 1856 from L2000, Alberta, Canada; Horseshoe Canyon Formation. **A** - Hadrosaurid basioccipital, RTMP 97.36.27 (dorsal, anterior to left). **B** - Hadrosaurid tooth, RTMP 97.36.45 (lingual). **C** - Hadrosaurid caudal vertebra, RTMP 97.36.31 (oblique anterodorsal). **D** - Hadrosaurid phalanx, RTMP 97.36.33 (distal). **E-F** - *Troodon* posterior dentary tooth, RTMP 97.39.3 (labial): **E** - Entire specimen; **F** - Detail of posterior denticles. **G-I** - *Troodon* posterior maxillary tooth, RTMP 96.29.29 (labial): **G** - Detail of anterior denticles; **H** - Entire specimen; **I** - Detail of posterior denticles. **J-L** - *Troodon* posterior premaxillary or anterior maxillary tooth, RTMP 97.39.7 (labial): **J** - Detail of posterior denticles; **K** - Entire specimen; **L** - Detail of anterior denticles. **M-N** - *Troodon* dentary tooth, RTMP 97.39.5: **M** - Detail of anterior denticles (anterior); **N** - Entire specimen (?lingual).

mation, the upper Maastrichtian Frenchman, Hell Creek and Lance formations and the upper Maastrichtian part of the Scollard Formation typically have a straighter axis and resemble in labial or lingual outline an elongate isosceles triangle (CURRIE, RIGBY & SLOAN, 1990; BASZIO, 1997b: pl. 5).

Velociraptorine teeth (Fig. 4F-H) are easily recognized by being strongly compressed labiolingually, the elongate and distally hooked shape of the posterior denticles and the marked disparity in

size between the anterior and posterior denticles (CURRIE, RIGBY & SLOAN, 1990). Velociraptorine teeth from L2000 cannot be distinguished from teeth described by CURRIE, RIGBY & SLOAN (1990: fig. 8.2, 8.3N) for the middle Campanian species *Saurornitholestes langstoni* SUES, 1978. The identification of isolated velociraptorine teeth from the Horseshoe Canyon Formation is complicated by the recent discovery in the formation of the skull of a new velociraptorine genus (to be described elsewhere by P.J. CURRIE and D.J. VARRICCHIO) having teeth that do

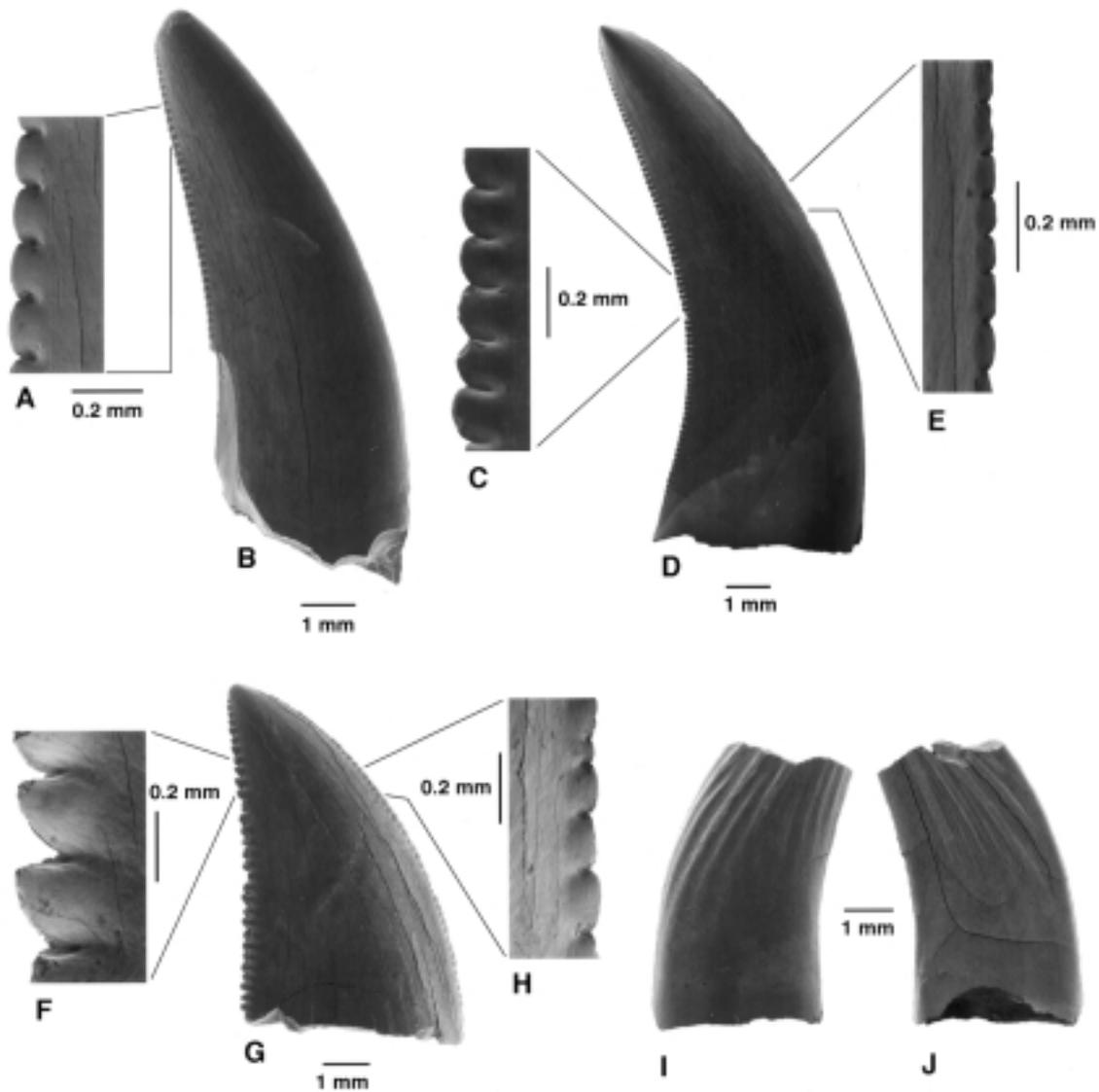


Fig. 4 - Miscellaneous theropod teeth from L2000, Alberta, Canada; Horseshoe Canyon Formation. **A-B** - *Richardoestesia* CURRIE, RIGBY & SLOAN, 1990, RTMP 96.29.2 (?labial): **A** - Detail of posterior denticles; **B** - Entire specimen. **C-E** - *Richardoestesia*, RTMP 97.39.2 (?lingual): **C** - Detail of posterior denticles; **D** - Entire specimen; **E** - Detail of anterior denticles; **F-H** - cf. *Sauornitholestes* SUES, 1978, RTMP 97.39.4 (?labial): **F** - Detail of posterior denticles; **G** - Entire specimen; **H** - Detail of anterior denticles. **I-J** - *Paronychodon* COPE, 1876, RTMP 97.39.6, tooth missing distal one-half: **I** - Labial; **J** - lingual.

not differ appreciably from those of *Sauornitholestes*. For this reason, we conservatively identify the velociraptorine teeth from L2000 as cf. *Sauornitholestes* sp.

One distally incomplete tooth (RTMP 97.39.6; Fig. 4I-J) of *Paronychodon* COPE, 1876 was recovered from L2000. This specimen is the first unequivocal record of this problematic tooth genus (see CURRIE, RIGBY & SLOAN, 1990) from the Horseshoe Canyon Formation (however, see BASZIO, 1997b).

Both sides of the tooth have longitudinal ridges, with at least eight on the flat lingual surface (Fig. 4J) and ten on the convex labial side. Although the two surfaces are separated by sharply defined, ridge-like inflections, there are no distinct anterior or posterior carinae. Among teeth that have been assigned to *Paronychodon*, denticles may be present or absent (CURRIE, RIGBY & SLOAN, 1990: fig. 8.5A-D; BASZIO, 1997b: pl. 6). RTMP 97.39.6 belongs to the latter category.

TABLE II

Number of theropod and hadrosaurid specimens from microvertebrate localities in Oldman, Dinosaur Park and Horseshoe Canyon formations, Alberta, Canada.

TAXA	OLDMAN + DINOSAUR PARK FORMATIONS (a)	HORSESHOE CANYON FORMATION (b)	HORSESHOE CANYON FORMATION SITE L2000 (c)
<i>Dromaeosaurus</i>	20	8	0
<i>Paronychodon</i>	(d)	0	1
<i>Richardoestesia</i>	(d)	7	11
<i>Sauornitholestes</i>	296	27	8 (e)
<i>Troodon</i>	23	12	65
Tyrannosauridae	45	8	25
Hadrosauridae	3621	231	224

a - BRINKMAN (1990); number of sites = 25; number of Dinosauria specimens = 4039. b - BASZIO (1997a: fig. 4); number of sites = 4; number of Dinosauria specimens = 302. c - This paper; number of sites = 1; number of Dinosauria specimens = 388. d - Taxa not recognized at time of study. e - cf. *Sauornitholestes* SUES, 1978 for the Horseshoe Canyon Formation.

Fragments of tyrannosaurid teeth have also been collected from L2000, but these are uninformative beyond demonstrating the presence of these large theropods in the area.

MAMMALIA

Mammal fossils recovered from L2000 include four indeterminate bones and an incomplete tooth (RTMP 97.36.67), the latter identified by R.C. Fox (pers. comm., 1997) as a lower left molar from an indeterminate species of *Pediomys* MARSH, 1889, a marsupial genus previously unreported from the Horseshoe Canyon Formation. Mammals are poorly known from this formation, with the only other documented taxa being the marsupial *Didelphodon coyi* FOX & NAYLOR, 1986 (FOX & NAYLOR, 1986) and an undescribed, indeterminate multituberculate (BRAMAN, JOHNSTON & HAGLUND, 1995). As RTMP 97.36.67 is not diagnostic to the specific level and *Pediomys* is widespread in the Campanian and Maastrichtian of the Western Interior (e.g. LILLEGRAVEN & MCKENNA, 1986; MONTELLANO, 1992), this tooth is biostratigraphically uninformative.

DISCUSSION

Hadrosaurids are well known from the Horseshoe Canyon Formation by isolated elements, skulls and skeletons, and three species are currently recognized (WEISHAMPEL & HORNER, 1990): the hadrosaurines *Edmontosaurus regalis* LAMBE, 1917 and *Saurolophus osborni* BROWN, 1912 and the

lambeosaurine *Hypacrosaurus altispinus* BROWN, 1913. The hadrosaurid elements from L2000 all lack generically diagnostic characteristics and thus cannot be identified more precisely than Hadrosauridae indet.

Despite being taxonomically indeterminate, the collection of hadrosaurid elements from L2000 is nonetheless notable for including abundant baby-sized elements (18% of 224 hadrosaurid elements). Although hadrosaurid elements are common in most Campanian and Maastrichtian microvertebrate sites in the Western Interior, where they often outnumber all other dinosaur elements combined (e.g. SAHNI, 1972; BRINKMAN, 1990; BASZIO, 1997a), baby-sized hadrosaurid elements are typically rare (D.B. BRINKMAN, pers. commun., 1997). Given that baby-sized hadrosaurid teeth and bones are not particularly robust, they would not likely have survived being transported far from their source. The majority of the hadrosaurid elements from L2000 show only minor abrasion, further suggesting that they were derived from a nearby source, specifically a nesting site. The absence of eggshell from this locality (and in the rest of the Horseshoe Canyon Formation) is best explained by the high percentage of siderite in the formation, which would have rendered the soil too acidic for preservation of eggshell.

Palaeoenvironmental settings have been interpreted for several hadrosaurid nesting sites in the Western Interior. HORNER (1987) reported that nest sites at Egg Mountain and Egg Island in the Campanian Two Medicine Formation, Montana, are con-

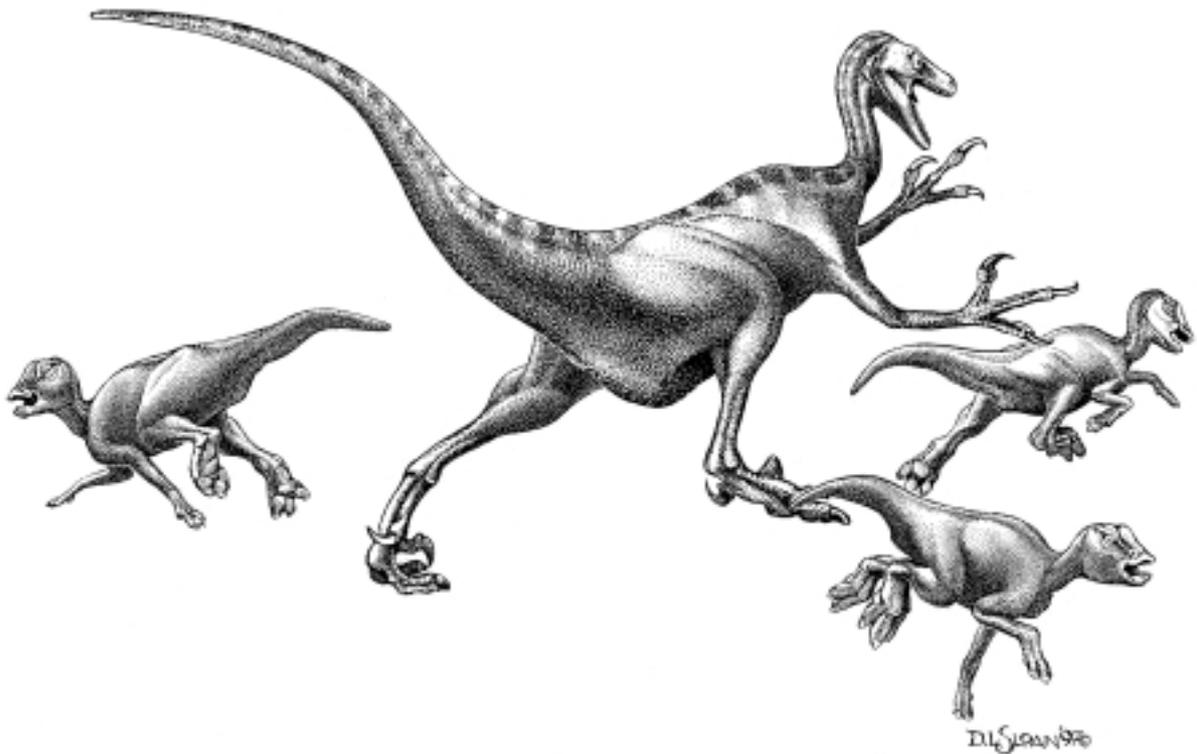


Fig. 5 - Reconstruction of a troodontid preying on baby hadrosaurids.

fined to flood plain deposits traversed by anastomosing rivers. The contemporaneous Devil's Coulee nesting site in southernmost Alberta has sediments deposited within and between ephemeral, non-meandering rivers that seasonally flooded, depositing sheets of fine sand and mud on the flood plain (D.A. Eberth, pers. comm., 1997). We similarly interpret L2000 as having formed on an overbank setting adjacent to active channels. Sites in Montana and Alberta thus suggest that hadrosaurids living along the western margin of the Western Interior Seaway broadly preferred flood plain-style environments for their nesting areas.

Isolated theropod teeth are common at L2000, where they comprise about 33% of the identifiable dinosaur elements. Unlike many Campanian sites in the Western Interior where velociraptorine teeth are the most commonly recovered theropod elements (CURRIE, RIGBY & SLOAN, 1990; FIORILLO & CURRIE, 1994), only eight velociraptorine teeth were collected from L2000 and these were significantly outnumbered by teeth of most other theropods. Sixty-five, or one-half, of the theropod teeth from L2000 are from *Troodon*. Although teeth of this genus are characteristic components in lower Campanian to upper Maastrichtian microsites in the Western Interior (e.g. SAHNI, 1972; BRINKMAN, 1990; BASZIO, 1997a, b), they are never abundant nor are they the

most common element at these sites (TABLE II). For example, in 25 microvertebrate sites sampled from the Oldman and Dinosaur Park formations in Dinosaur Provincial Park (BRINKMAN, 1990), *Troodon* teeth typically constituted less than 1% of the dinosaurian elements, with the greatest number from any site being only four teeth. BASZIO (1997a: fig. 7) reported similarly low values for *Troodon* teeth from sites in these formations, as well as from the lower Campanian Milk River Formation, the upper Maastrichtian Frenchman and Lance formations and sites other than L2000 in the Horseshoe Canyon Formation. It is thus evident that L2000 contains an anomalously high number of *Troodon* teeth.

The preponderance at L2000 of *Troodon* teeth and baby hadrosaurid elements, to the near exclusion of elements of other dinosaur taxa, suggests a non-random association. All *Troodon* teeth from L2000 are either broken below the crown or lack the root, suggesting that these were shed in life. Most teeth have relatively unworn denticles, indicating that these were not old teeth. Instead, these teeth were functional and were likely lost while feeding. Three fragments of indeterminate, adult-sized dinosaur bone from L2000 are scarred by theropod tooth marks, but these marks cannot be associated with teeth from any theropod taxon. The abundant baby-sized hadrosaurid elements at L2000 suggests that

babies, and by inference eggs, were located nearby, and we speculate that these were utilized as food by the troodontids. By virtue of their small size, relatively defenceless nature and high densities, we believe that baby hadrosaurids and eggs would have made ideal prey items for troodontids (Fig. 5), as HORNER (1984a) and OSMÓLSKA & BARSBOLD (1990) have suggested.

Hadrosaurid nesting sites in the Two Medicine Formation show that these animals nested colonially and used the same nesting sites for multiple breeding seasons (HORNER & MAKELA, 1979; HORNER, 1982; HORNER, 1987). Consequently, the hadrosaurid nesting site located near present day L2000 may have served as a seasonal food source for troodontids living in the area.

In conclusion, the association at L2000 of anomalously high numbers of baby hadrosaurid elements and *Troodon* teeth suggests the following: (1) a hadrosaurid nesting site of unknown dimensions and temporal duration was located nearby and (2) troodontids may have been feeding, if not preferentially then at least opportunistically, on hadrosaurid eggs and babies at this nesting site.

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ABBREVIATIONS

RTMP - Royal Tyrrell Museum of Palaeontology, Drumheller.

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