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PRELIMINARY REPORT ON NEW VERTEBRATES FROM THE UPPER GANNETT GROUP (APTIAN) AND WAYAN FORMATION (ALBIAN) OF EAST IDAHO

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ABSTRACT

Early Cretaceous vertebrates from the upper Gannett Group and Wayan Formation of eastern Idaho include a variety of taxa, some previously unreported. The Gannett Group has yielded *Hybodus*, cf. *Lepidotes*, cf. *Naomichelys*, cf. *Glyptops*, and as yet unidentified crocodilian teeth and fragmentary archosaur, probably dinosaur, remains. New vertebrate material from the Wayan Formation includes a theropod tooth fragment tentatively assigned to the Dromaeosauridae; skeletal remains, similar to *Othnielia*, that are tentatively assigned to the basal Euornithopoda; and indeterminate, probable ornithopod remains. Basal euornithopods are previously unreported from the Wayan. Fragmentary remains from a large crocodilian, unidentified turtles, and *Lepidotes* like fish add to the vertebrate fauna.

INTRODUCTION

Early Cretaceous strata of the upper Gannett Group (Aptian) and Wayan Formation (Albian) of eastern Idaho have previously produced a modest amount of vertebrate remains. These fossils are among the oldest terrestrial vertebrate fossils from Idaho and include the only dinosaur remains known from Idaho. A preliminary description is given of findings from research partially supported by Idaho State University undergraduate research grants R-2002-26 and FY04-R19. This research is part of a larger collaborative effort on the Wayan.

Dorr (1985) first reported turtle carapace and reptile bone fragments from the upper Gannett. Krumenacker (2002) briefly reported various fragmentary fish remains from the Gannett including cf. *Lepidotes* and pycnodonts, also reported were hybodontid sharks, crocodilians, and the turtles cf. *Glyptops* and cf. *Naomichelys*. Dorr also reported from the Wayan an isolated *Tenontosaurus* tooth, a nodosaur tooth, indeterminate ornithischian material, and abundant dinosaur eggshell. Weishampel et al. (2002) reported caudal and pelvic sections of probable neoceratopsians , an indeterminate ankylosaur tooth, and indeterminate theropod and ornithischian material. Chapman et al. (2004) reported fish, an iguanodont and abundant dromaeosaurs from the Wayan.

Materials described in this report were collected under a voluntary agreement for paleontological inventory on National Forest System lands and under IMNH permit number IDSUP 34. Measurements were made with metric calipers. Where figures are included of discussed specimens, measurements given are for these figured specimens.

Abbreviations--IMNH, Idaho Museum of Natural History, Idaho State University, Pocatello, Idaho; ISU, Idaho State University; BYU, Brigham Young University, Provo, Utah; UgRC, Undergraduate Research Committee, Idaho State University.

Measurements—AP, length from anterior portion to posterior portion; BW, labio-lingual basal width**;** CH, centrum height at tallest portion of anterior/posterior end; CL, centrum length from anterior to posterior ends; CW- centrum width at widest point of anterior/posterior end; SH, Scale height; SL- scale length.

IMNH Cataloguing System--The vertebrate paleontology collections at IMNH are catalogued using a two number system. The first number precedes or is above a dash and is the IMNH locality number, the second number follows or is below the dash and is the specimen number (e.g. IMNH 1127/44919 is specimen number 44919, and comes from IMNH locality 1127). A single referenced number (e.g. IMNH 1130) refers to a locality only.

GEOGRAPHY AND GEOLOGY

The Gannett Group and Wayan Formation occur in the thrust belt of eastern Idaho. A diagram of the regional stratigraphy is provided (Figure 1). Fossil localities are scattered throughout the study area (Figure 2). No radiometric dates have been obtained from the Cretaceous sediments of east Idaho, dates are

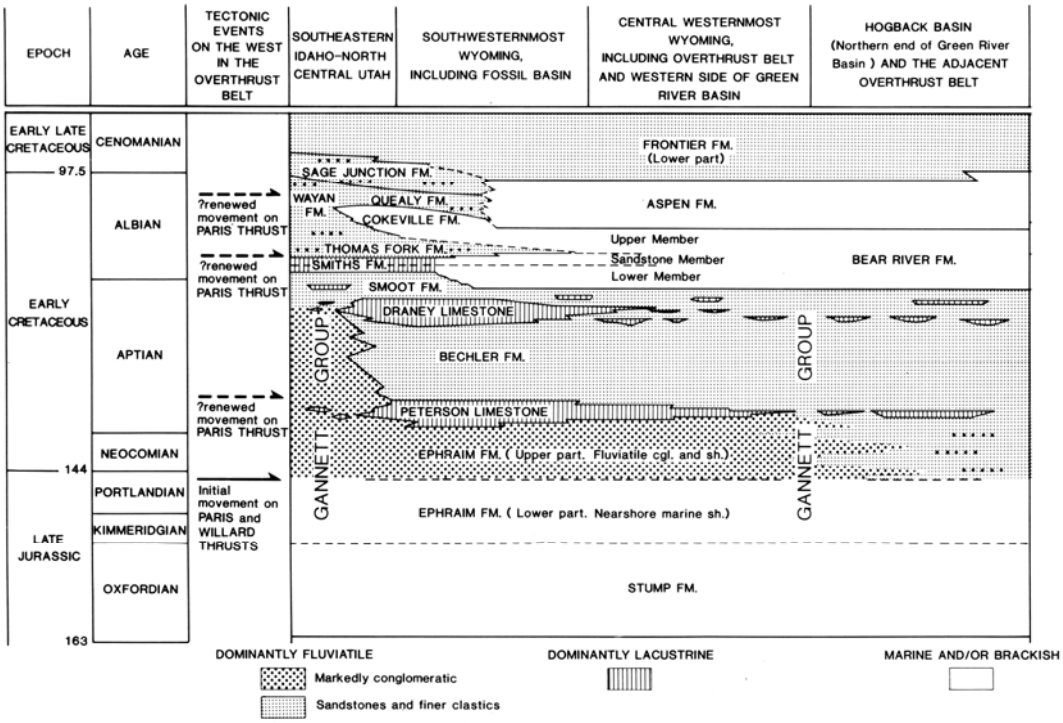

FIGURE 1. Regional stratigraphy of east Idaho and westernmost Wyoming. Modified from Dorr (1985)

established on the basis of invertebrates and palynomorphs.

The Gannett Group has been dated as Kimmeridgian to Aptian on the basis of stratigraphic position relative to other formations and invertebrate fossils (Eyer, 1969), and consists of over 1,005 meters (3,300 feet) of conglomerate, sandstones, mudstones, and lacustrine limestones (Eyer, 1969). Deposition occurred predominantly in fluvial, flood plain, and lacustrine environments (Eyer, 1969; Brown and Wilkinson, 1981). Fossil vertebrate localities in the Gannett in Idaho are known from the upper Gannett (Draney Limestone and ?Smoot Formation).

The Wayan Formation is dated as middle Albian in age on the basis of stratigraphic position and palynomorphs (Schmitt and Moran, 1982), and consists of over 585.6 meters (1,921 feet) of interbedded pebble conglomerate, coarse to fine grained sandstones, siltstones, mudstones, and shales, with minor limestones and tuffs (Schmitt and Moran, 1982). Strata of the Wayan are conspicuously color variegated (Dorr, 1985). Deposition occurred in a semi-arid, upland, meandering stream fluvial system possibly similar to the modern Indogangetic Plain (Schmitt and Moran, 1982; Dorr, 1985). The study area is heavily folded, faulted, contains many slumps, and has abundant vegetative cover. These factors combine to make stratigraphic correlation of the fossil localities currently unfeasible.

GANNETT GROUP

Fossil vertebrates from the Gannett Group are generally very fragmentary (Dorr, 1985) and mainly consist of lower vertebrates (Krumenacker, 2002). These remains come from three separate localities which are here treated separately.

Pine Bar Locality (IMNH 1127)--The Pine Bar locality is the most productive vertebrate locality in the Gannett Group. The lithology consists of sandstones, limestones, and carbonaceous shales, tentatively assigned to the Draney Limestone. Deposition appears to have occurred in a nearshore, freshwater lake environment (Brown and Wilkinson, 1981; Krumenacker, 2002). Fossils occur primarily within the limestones and shales and consist of isolated and rarely associated elements. Identified osteichthyans from this locality include cf. *Lepidotes* and unidentified pycnodontids, commonly occurring as teeth, scales, and isolated bones. Chondrichthians are represented by isolated teeth from *Hybodus* (Figure 3A). Reptilian remains include a partial hypoplastron from a pluerosternid turtle (IMNH 1127/43956), cf. *Glyptops* (Figure 3B), crocodilian teeth, and a very fragmentary

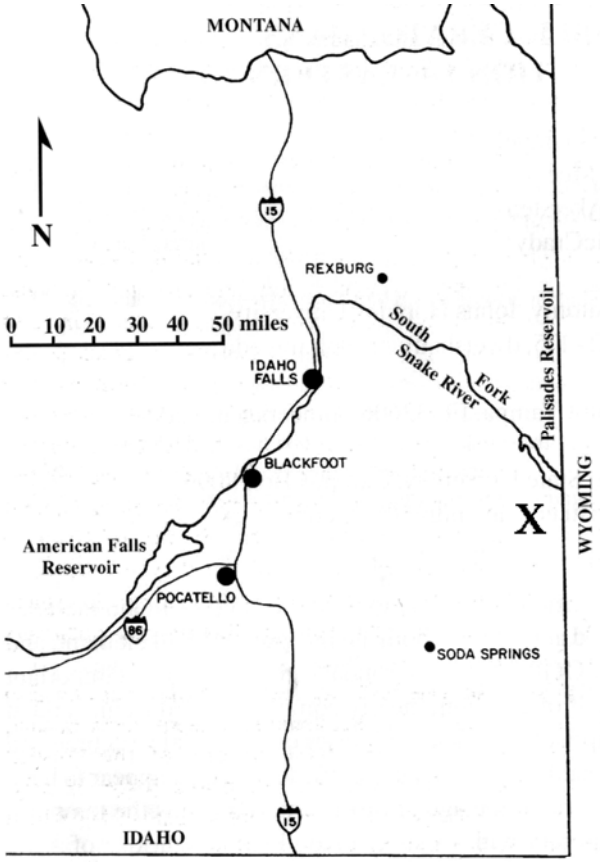

FIGURE 2. X = general location of study area. Modified from Weishampel et al. (2002).

archosaur, probably dinosaur, vertebral centrum (IMNH 1127/44919). A possible poorly preserved dinosaur trackway within a limestone unit may be present and is currently under investigation. Non-vertebrates such as the freshwater gastropod *Liaplacodes*, unionid bivalves, and petrified wood (some possibly in growth position) indicate a nearshore, freshwater depositional setting. Ostracods are particularly abundant and are often associated with the fish and shark remains. Fossils at this locality are commonly disarticulated and range from moderately abraded to unabraded, suggesting lower energy levels predominated in the depositional environment. The presence of *Hybodus* suggests a fluvial connection to the Western Interior Seaway.

Cretaceous Park Locality (IMNH 1130)--Cretaceous Park consists of blocky lacustrine limestones and interbedded shales referred to the Draney Limestone. The most abundant vertebrate material at this locality consists of broken carapace and plastron fragments of the turtles cf. *Glyptops* and cf. *Naomichelys* (Figure 3C). Indeterminate reptile bone fragments, crocodilian teeth (Figure 3D) of the 'Goniopholis' type (Ostrom, 1970), rare reptilian scutes, a lizard jaw, and one small fish vertebra have been recovered. Invertebrates consist of abundant fragmented ostracods and rare freshwater gastropods. Fossils at this locality are commonly fragmented and suggest higher energy levels in a lacustrine setting.

Dorr Locality (IMNH 2209)--This locality is the same referred to by Dorr (1985) in his figure 3a where he discovered reptilian limb bone fragments and turtle carapace fragments. Krumenacker (2002) reported more reptilian remains from this locality and tentatively assigned it to the Smoot Formation. It is possible, however, that this locality represents a large slump block of the Wayan Formation. The Dorr locality consists of red, variegated mudstones, sandstones and siltstones. Recent work has produced additional reptilian bone fragments, turtle shell fragments, and one freshwater gastropod. The depositional environment appears to have been an alluvial floodplain similar to that of the Wayan Formation.

WAYAN FORMATION

Wayan vertebrates commonly occur as fragments, isolated small elements, and rarely associated or semi-articulated caudal skeletons. Significant multi-individual or multi-species bonebeds are currently unknown, though one locality (IMNH 128) has produced a few important fossils from different dinosaurs (Weishampel et al., 2002). Caudal skeletons are sometimes associated with ossified tendons partially encasing the bones, perhaps accounting for the preservation of the caudal portions. Small animals are more dominant in the Wayan sample discussed here, with larger animals being more typically represented only by teeth (e.g. ankylosaurs) and rare fragmentary vertebrae. One medium size iguanodont has been reported from the Wayan (Chapman et al., 2004).

Fossil vertebrates from the Wayan Formation discovered under ISU UgRC grant FY04-R19 are from many separate localities. These new specimens from the Wayan are herein treated taxonomically. Following is a brief description of some of the better new material with a brief discussion of less well understood material.

NEW WAYAN VERTEBRATES

Order SEMIONOTIFORMES Arambourg and Bertin, 1958
Family SEMIONOTIDAE sensu Olsen and McCune, 1991
Genus cf. *LEPIDOTES*?

Material--IMNH 2230/44941, an isolated ganoid scale.

Description--This isolated scale (Figure 4) is heavily weathered, smooth, unornamented, diamond

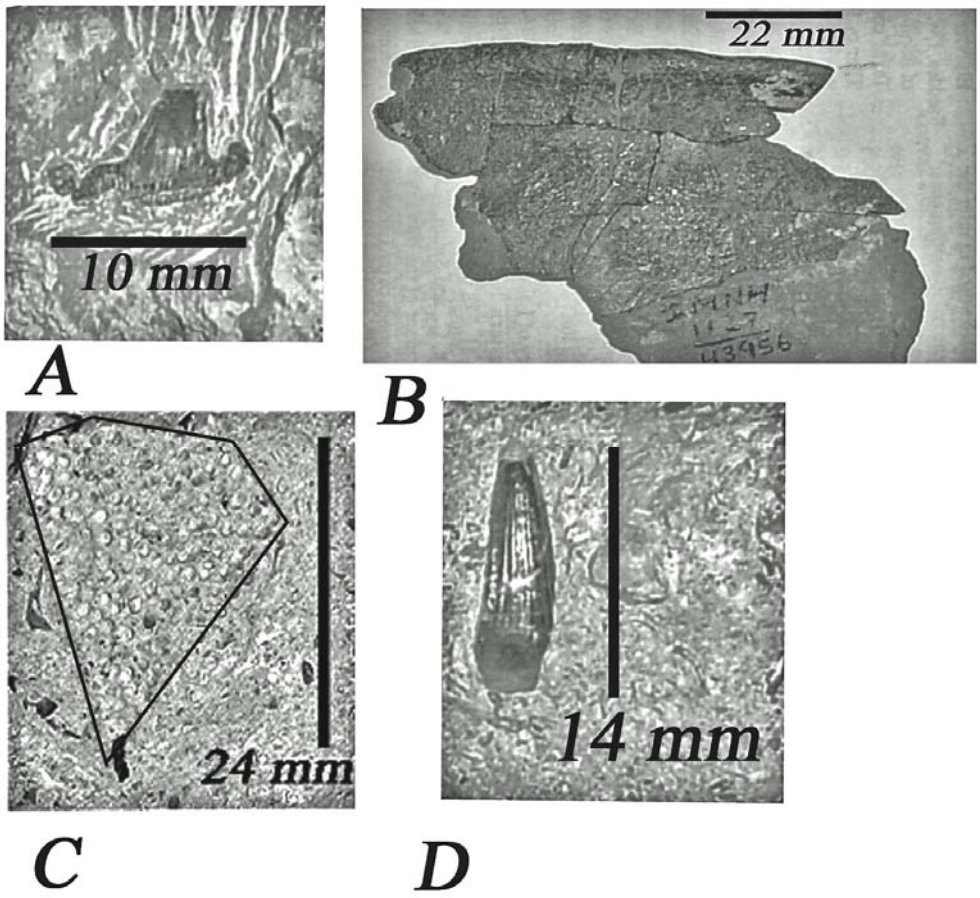

FIGURE 3. Typical Gannett fossils. IMNH 1127/44943, *Hybodus* tooth (A); IMNH 1127/ 43956, partial cf. *Glyptops* hypoplastron (B); IMNH 1130/ 44944, outlined mold of cf. *Naomichelys* shell fragment (C); IMNH 1130/ 44945, crocodilian tooth (D).

shaped, and wider than long. SL= 23 mm. SH= 18 mm.

Discussion--Fish material from the Wayan is extremely rare and only known from fluvial conglomeratic lag deposits. Button like teeth similar to *Lepidotes* occur rarely in the Wayan, but this is the first known fish scale. This scale closely resembles ganoid scales from the Gannett attributed to cf. *Lepidotes* (Krumenacker, 2002) but is of a larger size than those in the Gannett. This specimen also compares well with descriptions and figures of *Lepidotes* scales (e.g. Brito and Gallo, 2003), but is of a larger size.

Order ORNITHISCHIA Seeley, 1888
Suborder ORNITHOPODA Marsh, 1881
Family cf. EUORNITHOPODA Sereno, 1986

Material--IMNH 2227/44934, an isolated cervical centrum; IMNH 2226/44933, dorsal vertebra centrum and associated rib head.

Description—The isolated cervical centrum is heavily weathered but does offer some detail. The ends are damaged but the centrum appears amphiplatyan and is strongly pinched ventrally with a prominent medial keel. The articular ends are somewhat heart shaped. CL= 25 mm, CW= 19.5mm, CH=18mm.

The dorsal vertebral centrum (Figure 5) is well preserved for the Wayan. It is amphiplatyan, laterally concave, and somewhat rectangular in lateral view. Distinct roughened ridges extend laterally along the anterior and posterior edges of the centrum. The articular ends of the centra are circular. The ventral surface of the centrum is pinched to form a thin ventral keel. CL= 22.5mm, CW= 16mm, CH= 17mm.

The rib is double headed, with the capitulum and tuberculum close together, but is not complete enough to determine rib curvature.

Discussion--This material compares well with basal euornithopod material. In particular, the cervical vertebra compares well with those figured by Hulke (1882) and Scheetz (1999), and those discussed by

Norman et al. (2004), notably with regards to the centrum size, shape of the articular ends, and the prominent ventral keel. The dorsal vertebra compares well with descriptions and figures of dorsal vertebrae from basal euornithopods such as *Zephyrosaurus* (pers. obs.), and *Orodromeus* (Scheetz, 1999; Norman et al., 2004). The rugose striations on the articular ends of the dorsal vertebra centrum are features typical on vertebrae of basal euornithopods (Horner, 2001) and some basal iguanodontians (e.g. *Planicoxa*, DiCroce and Carpenter, 2001). The rib head compares well in size and form with *Orodromeus* (Scheetz, 1999) and *Zephyrosaurus* ribs.

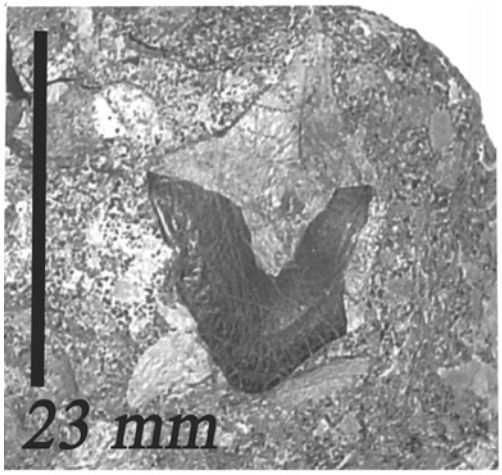

FIGURE 4. IMNH 2230/44941. Cf. *Lepidotes* ? scale.

Also, direct specimen comparison of the Wayan dorsal vertebra with cast BYU *Othnielia* material indicate these fossils may come from a basal euornithopod.

Basal euornithopods are present in many Early Cretaceous faunas across the world (e.g. Hulke, 1882; Long, 1998; Kirkland et al., 1999; Horner, 2001) and their apparent presence in the Early Cretaceous of Idaho adds to their known distribution. These animals appear to be among the more common elements of the Wayan fauna. Continued work in the Wayan, more specimen collection, and preparation of undescribed material will likely result in a much better understanding of these animals.

Order ORNITHISCHIA Seeley, 1888
Suborder ORNITHOPODA Marsh, 1881

Material--IMNH 2178/44920, a partial skeleton consisting of caudal vertebrae, unidentified limb fragments, and associated ossified epaxial tendons with a more distal caudal portion entirely ensheathed in tendons.

Description--An articulated series of proximal caudals (Figure 6) are strongly spool shaped in ventral view and laterally concave. These centra are rectangular in lateral view and weakly amphicoelous. The most distal vertebra in the articulated series has a hexagonal, almost heart shaped articular end. No ossified tendons are directly associated. CL= 26mm, CW= 25mm.

A distal caudal vertebrae (Figure 7) is weakly amphicoelous, laterally concave ventrally, elongate, and rectangular in lateral view. The articular ends are hexagonal and heart shaped. The sides of the centrum are laterally compressed. Ossified epaxial tendons are present on this distal caudal (Figure 7). CL= 32mm, CW= 12mm, CH= 14mm. Caudal portions of this skeleton with articulated vertebrae ensheathed in tendons await further preparation.

Discussion--Caudal vertebrae from IMNH 2178/44920 appear ornithopodan in morphology, with features such as elongated centra, hexagonal, heart shaped ends and abundant associated ossified epaxial tendons. These features are present in both basal euornithopods (Norman et al., 2004) and basal iguanodontians (Ostrom, 1970; Forster, 1990). It is possible that this animal is similar or identical to those referred to the basal euornithopoda in this paper, or this may be a small iguanadontian similar to *Tenontosaurus*.

Order SAURISCHIA Seeley, 1888
Suborder THEROPODA Marsh, 1881
Family DROMAEOSAURIDAE Matthew and Brown, 1922
DROMAEOSAURIDAE indet.

Material--IMNH 2233/44940, a fragmentary tooth.

Description--This tooth fragment is in a small calcareous nodule and heavily weathered on one side. The tooth is typically theropodan in morphology and consists of a 12mm long section of basal crown. The tooth measures 8 mm labio-lingually, is laterally compressed, and is tear drop shaped in the natural cross section of the base. Denticles are present, though poorly preserved, on the posterior portion of the carina and project perpendicular to the long axis of the tooth. Roughly 28 denticles are present per 5 millimeters on the posterior portion. The mesial portion of the tooth is not as well preserved and denticles are not discernible. AP= 14mm, BW= 8mm.

Discussion--Admittedly not the best material for a referral, this tooth fragment is tentatively assigned to the Dromaeosauridae due to the denticle count. The denticle count of this tooth fragment compares well with an indeterminate dromaeosaurid maxillary or dentary tooth from the Murtoi Formation of Russia (Averianov

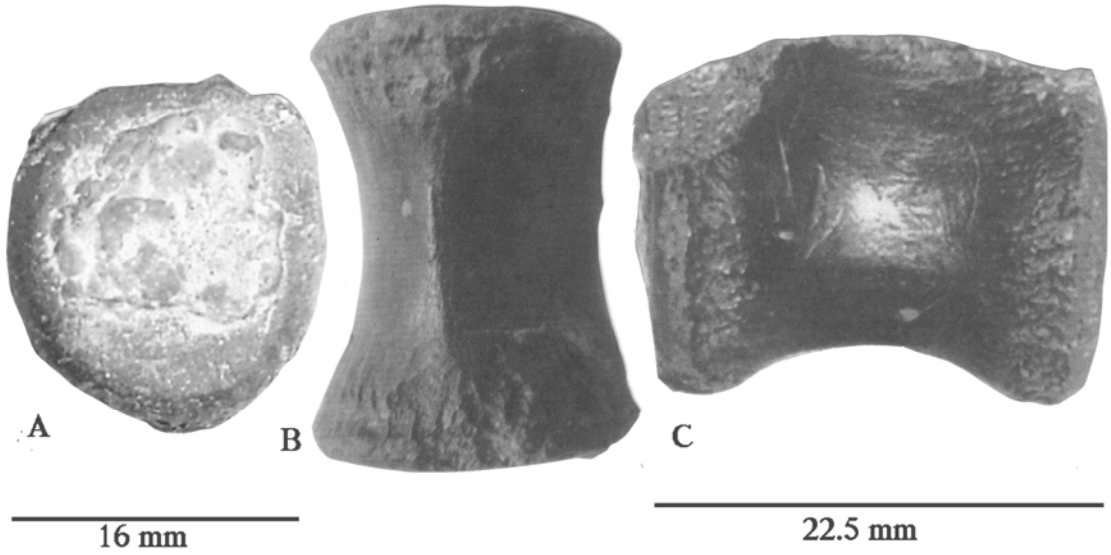

FIGURE 5. IMNH 2226/44933. Cf. euornithopod dorsal vertebra in articular (A), ventral (B), and lateral (C) view.

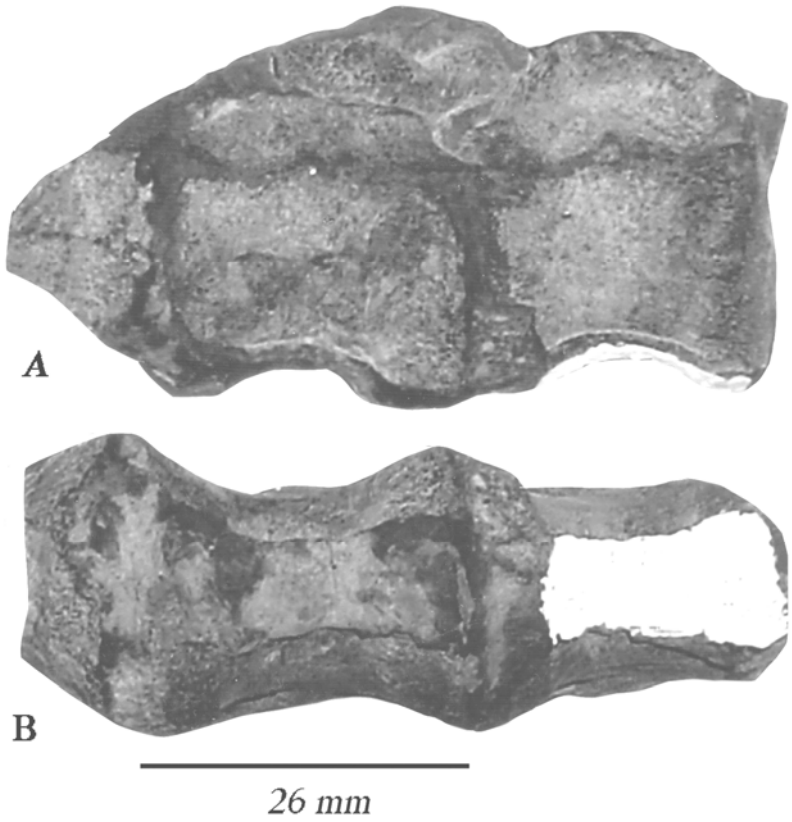

FIGURE 6. IMNH 2178/44920. Articulated ornithopod proximal caudal vertebrae in lateral (A) and ventral (B) views.

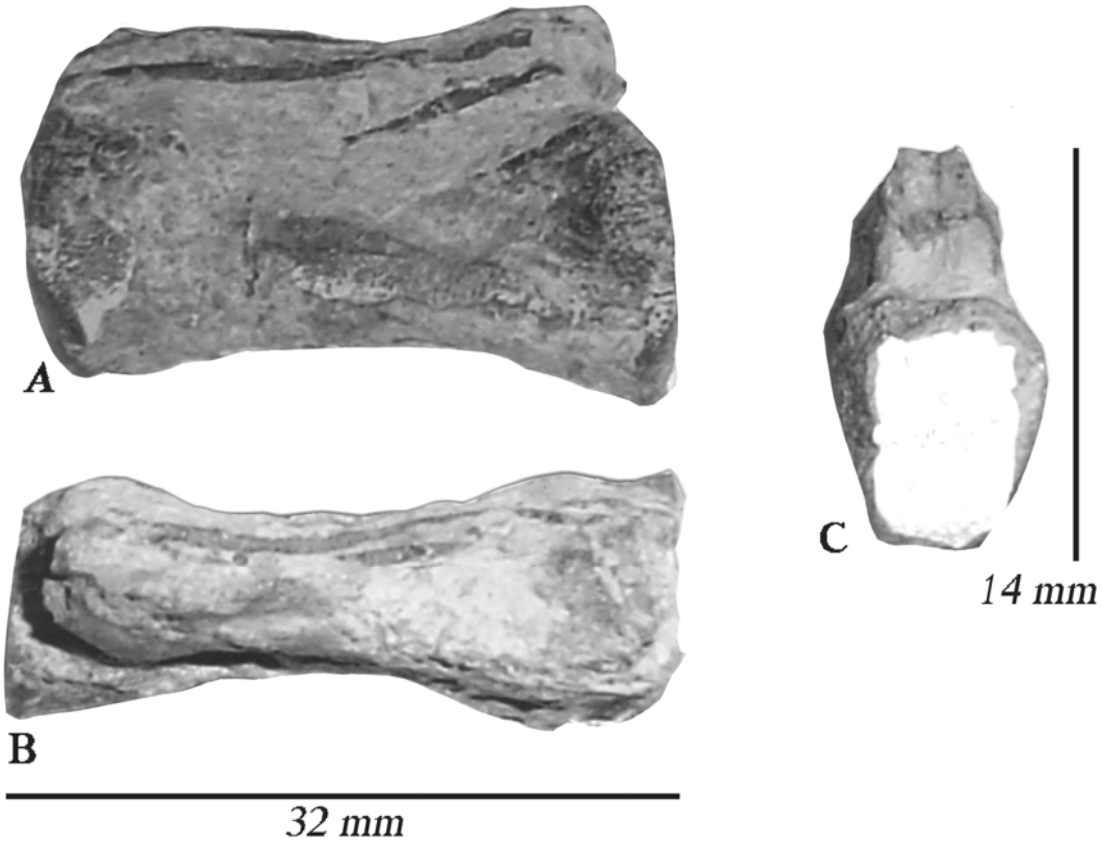

FIGURE 7. Distal caudal vertebra from IMNH 2178/44920, in dorsal (A), lateral (B) and articular (C) views, note the ossified tendons.

et al., 2003) which has a similar denticle count of 30 serrations per 5 millimeters on the posterior carina. Ostrom (1969) reported that the Late Cretaceous dromaeosaurid *Velociraptor* has a denticle count of 25-26 denticles per 5 millimeters on the posterior carina. It is unlikely that this tooth belonged to larger theropods such as the Early Cretaceous form, *Acrocanthosaurus*, due to the much larger denticles of this and related forms (Currie and Carpenter, 2000). The discovery of this probable dromaeosaurid tooth is not entirely surprising, dromaeosaurs are reported worldwide throughout the Early Cretaceous (e.g. Ostrom, 1969; Lipka, 1998; Hwang et al., 2002). It is interesting to note that the size of the tooth is significantly larger than that of *Deinonychus antirrhopus* teeth (Ostrom, 1969), indicating that the Wayan dromaeosaurid may have been a larger animal. A possible dromaeosaurid caudal section discovered under ISU UgRC grant FY04-R19 is also currently under study. As work on the Wayan continues, more information on this enigmatic theropod may be forthcoming.

Other New Vertebrate Material--Other new vertebrate material recently discovered from the Wayan Formation is not adequately prepared or complete enough for detailed description but is worth brief discussion. The first known large crocodilian skeletal material (IMNH 2231/44938) from the Wayan consists of a loose tooth crown (Figure 8A) and associated jaw fragments with fragmentary teeth in place (Figure 8B). A vacant tooth alveolus from an unfigured jaw fragment belonging to this specimen measures 20 millimeters in diameter. Roots of the teeth in recovered specimens are cylindrical in cross section (Figure 8B). The loose tooth is similar to those reported from the Gannett but substantially larger than those commonly found at most Gannett localities. The tooth appears to be of the 'Goniopholis' type (Ostrom, 1970), consisting of a tapered cone with prominent ridges on the side. As work continues at this locality and on this material more information will be forthcoming. This discovery demonstrates that a large crocodilian inhabited the Wayan paleoenvironment. Previously reported Wayan crocodilian material consists of isolated small teeth (Dorr, 1985).

Turtle fossils consist of 2 associated unpatterned shell fragments from a small individual, IMNH 2228/ 44942 (Figure 9). These fossils appear entirely different from specimens of cf. *Naomichelys* and cf. *Glyptops* fossils reported from the Gannett.

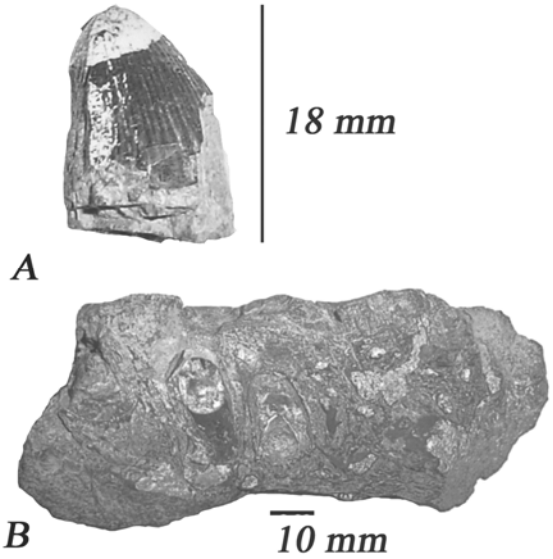

FIGURE 8. IMNH 2231/44938. Crocodilian tooth (A) and jaw fragment (B) associated with crocodilian skeletal remains.

DISCUSSION

Although the record is sparse and material is rare, vertebrates from the Gannett and Wayan compare moderately well with other Early Cretaceous faunas from western North America. Fossils from the lacustrine localities in the Gannett include *Hybodus*, cf. *Lepidotes*, and pycnodonts; Fish from the Wayan are represented by teeth and a scale similar to *Lepidotes*. These animals are also components of other Early Cretaceous faunas such as those in the Cedar Mountain Formation (e.g. Fiorillo, 1999). The Gannett turtles cf. *Glyptops* and cf. *Naomichelys* also occur in the Early Cretaceous faunas of Montana and Wyoming (Ostrom, 1970). Gannett vertebrates demonstrate a wider distribution of some of the common Aptian age vertebrate elements previously described from the western interior of North America. Gannett vertebrate fossils provide a valuable glimpse of the lacustrine settings of the Early Cretaceous of Idaho and add to their poorly known fauna.

Vertebrates from the Wayan include faunal elements reported from other Early Cretaceous localities worldwide. Ankylosaurs (Dorr, 1985; Weishampel et al., 2002), neoceratopsians (Weishampel at al., 2002), iguanodonts (Dorr, 1985; Chapman et al, 2004), euornithopods (this paper), and dromaeosaurs (Chapman et al., 2004) are faunal elements also reported from the Cloverly Formation (Ostrom, 1969; Ostrom, 1970), Arundel Clay (Lipka, 1998) and Cedar Mountain Formation (Kirkland et al., 1999). For reference, tables of reported vertebrate faunas from the Gannett (Table 1) and Wayan (Table 2) are included. Newly recovered and previously unreported remains from probable basal euornithopods, a large crocodilian, and more probable dromaeosaur remains add important new information to the vertebrate paleontology of the Wayan Formation and provides an increased distribution for these animals, adding to the growing faunal understanding of the Wayan.

Continuing field work, preparation of recovered specimens, and collaborative research by those involved in working in the Cretaceous of Idaho should continue to add significantly to the vertebrate paleontology of Idaho and understanding of Early Cretaceous fauna.

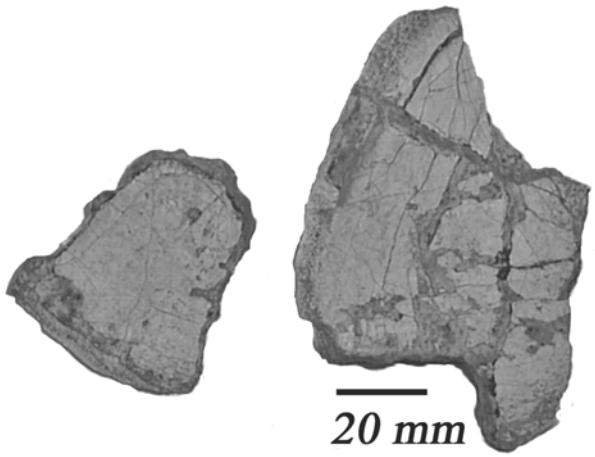

FIGURE 9. IMNH 2228/44942. Associated Wayan turtle shell fragments.

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Thanks forever to my wife, Chantel, who tolerates the bone hunter. Appreciation is expressed to all those who have provided encouragement during the difficulties associated with this research.

Table 1. *Vertebrates reported from the Gannett Group. New taxa from this report indicated by *.*

Class Chondrichthyes
- Order Hybodontiformes (Krumenacker, 2002)
  - Family Hybodontidae
    - *Hybodus* sp. *

Class Osteichthyes
- Order Semionotiformes
  - Family Semionotidae
    - cf. *Lepidotes* sp. (Krumenacker, 2002)
- Order Pycnodontiformes
  - Family Pycnodontidae indet. (Krumenacker, 2002)

Class Reptilia
- Order Chelonia (Dorr, 1985)
  - Family Pluerosternidae
    - cf. *Glyptops* sp. (Krumenacker, 2002)
  - Family incertae sedis
    - cf. *Naomichelys* sp. (Krumenacker, 2002)
- Order Crocodylia indet. (Krumenacker, 2002)
- Subclass Dinosauria indet. (Dorr, 1985; Krumenacker, 2002)

Table 2. *Vertebrates reported from the Wayan Formation. New taxa from this report indicated by *.*

Class Osteichthyes (Chapman et al., 2004)
- Order Semionotiformes
  - Family Semionotidae
    - cf. *Lepidotes*? *

Class Reptilia
- Order Chelonia indet. (Dorr, 1985)
- Order Crocodylia indet. (Dorr, 1985)
- Subclass Dinosauria
- Order Saurischia
  - Suborder Theropoda indet. (Weishampel et al., 2002)
    - Family cf. Dromaeosauridae indet. (Chapman et al., 2004)
- Order Ornithischia indet. (Weishampel et al., 2002)
  - Family cf. Neoceratopsia indet. (Weishampel et al., 2002)
  - Family Iguanodontia indet. (Chapman et al., 2004)
    - *Tenontosaurus* sp. (Dorr, 1985)
  - Family cf. Euornithopoda indet. *
  - Family Ankylosauridae indet. (Dorr, 1985; Weishampel et al., 2002)

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