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An Upper Jurassic ichthyosaur (Ichthyosauria: Ophthalmosauridae) from the Bowser Basin, British
Columbia

Robin L. Sissons^{1,2}, Michael W. Caldwell, Carol A. Evenchick, Donald B. Brinkman, and Matthew J.
Vavrek

R.L. Sissons. Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9,
Canada, robin.sissons@gmail.com

M.W. Caldwell. Department of Earth and Atmospheric Sciences and Department of Biological
Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada, mw.caldwell@ualberta.ca

C.A. Evenchick. Geological Survey of Canada, 1500-605 Robson Street, Vancouver, BC V6B 5J3,
Canada, carol.evenchick@nrcan.gc.ca

D.B. Brinkman. Royal Tyrrell Museum of Palaeontology, Box 7500, Drumheller, AB T0J 0Y0,
Canada, don.brinkman@gov.ab.ca

M.J. Vavrek. Royal Ontario Museum, Department of Natural History, 100 Queen's Park, Toronto, ON
M5S 2C6, Canada, matthew@matthewvavrek.com

¹Corresponding author (email: robin.sissons@gmail.com)

²Current Address: Philip J. Currie Dinosaur Museum, 9301-112 Ave, Wembley, AB T0H 3S0, Canada

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Abstract:

Although the Jurassic was a period of high diversity in ichthyosaurs, only a small number of specimens have been recorded from Canada to date. We describe here a new occurrence of an ophthalmosaurid ichthyosaur from a shallow marine depositional environment within the Bowser Basin of northern British Columbia. Based on vertebral diameters and the size of the humerus, the ichthyosaur was relatively large compared to other contemporaneous forms, yet possessed teeth that were small for its body size. As well, the height to length ratio of the preserved vertebrae suggest it may have had a more elongate, less regionalized body shape. Although indeterminate at a generic level, the presence of Late Jurassic ichthyosaurs in nearshore waters of northwestern North America further demonstrates their cosmopolitan distribution.

Keywords: Bowser Basin, Jurassic, northern Canada, Ophthalmosauridae, Stikinia

Introduction

Ichthyosaurs were a diverse and cosmopolitan group of highly aquatic marine reptiles that first appeared in the Early Triassic and survived until the Late Cretaceous (Sander 2000; McGowan and Motani 2003). The Jurassic Period represents possibly the zenith of their evolution, with large numbers of specimens and species recovered from this time (McGowan and Motani 2003; Druckenmiller and Maxwell 2014). Despite their relative diversity and abundance during this time period, Jurassic ichthyosaurs are almost unknown from Canada. To date, there have been three described occurrences: a partial skeleton of *Arthropterygius chrisorum* from the Ringnes Formation (Oxfordian to Kimmeridgian) of Melville Island, Northwest Territories (Russell 1993; Maxwell 2010); partial skeletons of two specimens of *Ichthyosaurus* sp. from the Sandilands Formation (Sinemurian) in the Queen Charlotte Islands, British Columbia (Dennison et al. 1990); and an isolated paddle of *Ichthyosaurus* sp. from the Fernie Formation (Nordegg Member, Sinemurian; Poulton et al. 1994) in Jasper National Park, Alberta (McGowan 1978). Additional ichthyosaur material from the Fernie Formation was reported by Nicholls (1976) from southwestern Alberta, but none of the material was figured.

Although Triassic ichthyosaurs have been extensively reported from northern British Columbia (e.g. McGowan 1991, 1994, 1995; Brinkman et al. 1992; Nicholls and Brinkman 1993; Nicholls et al. 1999; Nicholls and Manabe 2001, 2004), Jurassic ichthyosaurs were previously unknown from this region. We report here on new remains of an Upper Jurassic ichthyosaur from rocks in the Bowser Basin, northern British Columbia, Canada. These remains are the first described Upper Jurassic ichthyosaur material from non-Arctic Canada.

Institutional Abbreviations

BGS, British Geological Survey, Keyworth, Nottingham, U.K.; SMNS, Staatliches Museum für Naturkunde Stuttgart, Germany; TMP, Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta, Canada; UW, University of Wyoming, Laramie, USA.

Geological setting

The site described here, west of the Klappan River and south of Maitland Creek, was found in 2004 by CAE during regional mapping of the Bowser Basin, conducted by the Geological Survey of Canada (GSC) and the British Columbia Ministry of Energy and Petroleum Resources (Fig. 1). Material was collected from talus blocks on 15 August 2005, when CAE, DBB, and field crew returned to do more extensive examination and collecting.

The Bowser Basin, and the sedimentary Bowser Lake Group found within it, was formed on the ‘suspect’ terrane Stikinia by the closure of the Cache Creek Ocean that existed between Stikinia and the margin of North America (Evenchick and Thorkelson 2005). The exact palaeogeographic position of Stikinia relative to the North American craton during the Jurassic is uncertain. Most reconstructions interpret it to have been between 700 and 900 km farther south than its present position in the late Early Cretaceous (e.g. Gabrielse et al. 2006), but its position in the Jurassic is more difficult to constrain. The Bowser Lake Group was deposited during the late Middle Jurassic to mid-Cretaceous, on what was then the west coast of North America, and consists of marine and non-marine shales, siltstones, sandstones, and conglomerates (Evenchick and Thorkelson 2005). The Bowser Lake Group is composed of progressively shallowing units in a regressive setting of basin infill sourced from the east

(Evenchick and Thorkelson 2005).

The site is in the Skelhorne assemblage of the Bowser Lake Group, 100 m from the location of a collection of ammonites (Evenchick et al. 2001). The co-occurrence of the ammonites *Rasenia* and *Zenostephanus* suggest a late Early Kimmeridgian age for this locality (Rogov and Poulton 2014, p. 14-15). The Skelhorne is a thinly interbedded assemblage of siltstone and sandstone with varied amounts of coal (up to 5%) and/or conglomerate (5-40%), ranging from early Oxfordian to early Kimmeridgian in age (Evenchick and Thorkelson 2005). The presence of coarsening upward cycles, coal, common marine and plant fossils, and in some places, a position overlying shelf or slope deposits, were the primary reasons Evenchick and Thorkelson (2005) interpreted the Skelhorne assemblage as having been deposited in a shallow marine deltaic environment, ranging from prodelta slope to upper delta plain.

Systematic paleontology

Superorder Ichthyopterygia Owen, 1840

Order Ichthyosauria De Blainville, 1835

Family Ophthalmosauridae Baur, 1887

Ophthalmosauridae indet.

REFERRED MATERIAL: TMP 2009.010.0001, incomplete remains, including lower jaw fragments with portions of the left dentary, splenial, surangular and angular present (Fig. 2), teeth, articulated posterior

trunk vertebrae, rib fragments, head of left humerus, isolated phalanx (Fig. 3), and associated unidentified fragments. Additional elements were observed in the field (Fig. 4) but were not collected due to time and weight constraints.

LOCALITY: Sandstone beds, Skelhorne assemblage, early Oxfordian to early Kimmeridgian (Upper Jurassic), Bowser Basin, northwestern British Columbia, Canada (UTM 9V 463984 6354922 NAD83). The fossil material was once likely largely articulated in situ, and was subsequently disturbed by glaciation in the area, moving elements of the specimen in a downslope direction.

DESCRIPTION: The specimen is incomplete, fragmentary, and still largely encased in matrix, though originally likely preserved as an articulated skeleton. Individual bones were collected in fragmented blocks, broken and disturbed into multiple pieces in part by glacial activity. Some pieces could be re-associated once in collections.

Cranium—The cranium is represented by portions of the lower jaws. Two portions are preserved, a more anterior and highly fragmented segment of the left dentary, measuring approximately 232 mm in length, and a segment that includes the posterior end of the left dentary and the anterior end of the postdentary bones, measuring 350 mm in length (Fig. 2). The tip of the snout was preserved in a large nodule that could not be collected, although photographs of the remains were taken. The preserved portion of the dentary tapers from a width of 65 mm to 38 mm. The more posterior section includes the posterior end of the dentary, and the anterior ends of the splenial, surangular, and angular. These are slightly disarticulated but are in approximate position. The splenial shows the forked anterior end seen in other ophthalmosaurs (Sander 2000). The anterior end of the preserved portion of the surangular is

overlapped by the dentary. The angular is represented by impression, with a small amount of adhering bone. The dentary is well preserved and tapers strongly to its posterior end, although its posterior-most tip is missing. An uncollected cross section of the anterior end of the tip of the snout shows that both dentaries were originally preserved approximately in articulation. [Fig. 4; Sollas 1916, text-fig. 2 (11)]. Other elements may be present as well in the uncollected cross-section, but cannot be confirmed from photographs alone.

Teeth—There are no teeth preserved in the alveolar groove but several isolated teeth are present adjacent to the jaws (Fig. 2F-G). This tooth loss was likely post-mortem and is a condition that is seen in a number of other described ophthalmosaurs (Kirtan 1983; McGowan and Motani 2003). The teeth are conical and slightly recurved and are without distinct carinae. The teeth are relatively small, pointed and rather stout, and do not show any signs of wear. The tooth crowns range in size from 14 mm to 16 mm in length. Striations are spaced at approximately 1 mm intervals at the base and converge towards the tip. The roots are bulbous, flaring out from the base of the enamel.

Vertebrae—Three articulated vertebrae and one associated vertebra were found in a single block (Fig. 2A). Two of the vertebrae could be accurately measured. They are 116 mm and 129 mm in greatest diameter, and both are 60 mm in antero-posterior length. The third vertebra is broken across its width and has the characteristic antero-posterior constriction of the doubly concave profile, with the narrowest portion in the centre of the vertebra being less than 2 mm antero-posteriorly. The vertebrae in articulation are not well exposed, making further measurements difficult. Cross-sections through processes, which are likely rib heads or neural arches, can be seen in the matrix immediately adjacent to the vertebrae. The circumference is rounded, forming a sharp, nearly perpendicular angle with the non-articulating surface. Due to the worn nature of the vertebrae, there are no obvious apophyses or rib articulations visible, making exact placement within the column difficult.

Ribs—Many partial rib sections are preserved, one of which was extracted from the surrounding matrix. The fragment is 112 mm long, with a median furrow on both the anterior and posterior surfaces, giving an hourglass cross-section. The dorsoventral height of the ‘hourglass’ is 27 mm, the anteroposterior length at the widest portion is 16 mm, and the anteroposterior length at the constriction is 13 mm.

Appendicular skeleton—A fragment of bone associated with one of the rib fragments is tentatively identified as a portion of a coracoid, preserving the strongly concave profile of either the anterior, or posterior coracoid notch. The proximal half of the left humerus is large, though the surface is incomplete (Fig. 2B-C). The complete side preserves a low ridge, the dorsal crest. The width of the humerus at the proximal end is 160 mm. The broken distal end is the narrowest portion and is oval in shape. The total proximal-distal length of the humerus is 122 mm. A partially eroded phalanx was also collected and is dorsoventrally thickened and rounded in shape (Fig. 2D-E). Numerous tubercles are present near the mid-line of the articulating surface of the phalanx, projecting perpendicularly from that surface.

Discussion

Taxonomic Relationships

During the Late Jurassic, ichthyosaurs had been reduced to virtually a single group, the Ophthalmosauridae [although see Fischer et al. (2013) for a recent discovery of a non-ophtalmosaurid ichthyosaur from the Early Cretaceous]. Based on its stratigraphic position alone, it is highly likely that

the Bowser Basin ichthyosaur was an ophthalmosaur, and indeed the specimen possesses a number of features indicative of, although not exclusive to, ophthalmosaurs.

The humeral head compares well with that of previously described ophthalmosaurs, with a large dorsal crest. The large size of the humerus implies a strong, well-developed forefin, typical of ophthalmosaurids (McGowan and Motani 2003). The isolated phalanx is rounded in outline and possesses a roughened margin indicating a large, unpreserved cartilage portion to the element, consistent with the morphology of the rounded, widely spaced phalanges in the fore and hind limbs of all ophthalmosaurs (McGowan and Motani 2003). The relatively thick nature of the element dorsoventrally is consistent with Ophthalmosauridae and their closest sister taxon *Chacaicosaurus* (Fisher et al. 2011).

The proportions of the humerus vary in Late Jurassic ichthyosaurs, especially the development of the shaft. The shaft constriction in TMP 2009.010.0001 is much more pronounced than *Arthropterygius chrisorum*, *Paraophthalmosaurus saveljeviensis*, *O. icenicus*, and *Aegirosaurus leptospondylus*, and resembles instead the more constricted shaft morphology seen in *Caypullisaurus bonapartei*, *Brachypterygius pseudoscythius*, *O. natans*, *Sveltonectes insolitus*, *Cryptopterygius kristiansenae*, and the two species of *Ophthalmosaurus* from Russia (Gilmore 1905; Arkhangel'sky 1997; Fernández 1997; McGowan 1997; Efimov 1998, 1999; Bardet and Fernández 2000; Maxwell 2010; Fischer et al. 2011; Druckenmiller et al. 2012).

The skull of specimen TMP 2009.01.0001 conforms well with other ophthalmosaurs with the presence of an anteriorly forked splenial, but is notable for the relatively small size of the teeth. The teeth are close to the size range of those found in *Ophthalmosaurus* cf. *O. icenicus* (Buchy 2010) and *Sveltonectes insolitus* (Fischer et al. 2011). This is in contrast to the large teeth of *Brachypterygius*

(McGowan 1976) or *Platypterygius* (Fischer et al. 2011). As well, the small size of the teeth, combined with the lack of wear facets suggest the Bowser Basin ichthyosaur may have been a “Pierce I guild” feeder, eating softer bodied prey such as small fish or cephalopods (Massare 1987).

The limited suite of diagnostic characters that can be observed in TMP 2009.010.0001 make it difficult to suggest a close similarity to any particular subgroup of ophthalmosaurids. The humeral morphology appears similar to several taxa that are not themselves closely related, and other characters, such as the forked splenial, small tooth size and large body size, are either variable across the group or are plesiomorphic.

Body Shape and Size

Although the exact position of the vertebrae within the vertebral column is not certain, their large width (129 mm) makes them some of the largest recorded centra for an ophthalmosaur. The largest centra for *O. icenicus* measure approximately 110 mm in their greatest dimension, while those of *O. natans* are about 115 mm (Massare et al 2006). *A. chrisorum* and *Undorosaurus gorodischensis* have slightly larger vertebrae, with maximum recorded sizes of 131 mm and 130 mm respectively (Maxwell 2010). The taxon “*Ichthyosaurus trigonus*” from the Kimmeridge Clay has even larger vertebrae at a maximum centrum size of 133 mm (Phillips 1871), although the species is considered a nomina dubia as it was based on composite and inadequate specimens (Bardet and Fernandez 2000), making any taxonomic comparisons difficult. The large size of the centra in the Bowser Basin ichthyosaur suggests that the vertebrae may have originated within the posterior dorsal or anterior caudal region, where the vertebrae in other, better known ichthyosaurs, are at their largest. The ratio of centrum height to length in TMP 2009.010.0001 is approximately 1.93 and 2.15 in the two

measurable vertebrae, ratios which indicate a relatively long shape. If these vertebrae are from within the posterior dorsal or anterior caudal region, this suggests that TMP 2009.010.0001 had a body shape that was more elongate and less regionalized, similar to *O. natans*, in contrast to the short, highly regionalized body shape of *O. icenicus* (Massare et al. 2006).

The size of the humerus and vertebrae in TMP 2009.010.0001 suggest that the animal was relatively large in comparison with other ophthalmosaurs. The proximal humeral width in *A. chrisorum* is 171 to 172 mm (Russell 1993), just slightly larger than the humerus of the Bowser Basin ichthyosaur at 160 mm. For comparison, the width of the humerus in *O. icenicus*, specimen BMNH R3702, is approximately 115 mm (McGowan and Motani 2003), and the humeral width for *C. kristiansenae* was also 115 mm (Druckenmiller et al. 2012). Proximal humeral head width to total length ratios of ichthyosaurs in general range from approximately 1:36 in *Leptonectes*, which has a relatively large humerus (e.g. BGS 51236, see McGowan and Motani 2003) to 1:90 in *Temnodontosaurus*, which has a comparatively small humerus (e.g. SMNS 15950, see McGowan and Motani 2003). Based on these two ratios, TMP 2009.010.0001 could have been between 6 and 14 m in length. However, the more closely related and well preserved *C. kristiansenae* has a proximal humeral width to total body length ratio of approximately 1:45 (Druckenmiller et al. 2012), so a more likely estimate of the Bowser Basin ichthyosaur is 7 to 8 m. According to Motani (2005), there is no record of ichthyosaurs larger than 10 m long in Late Jurassic or Cretaceous deposits, and Druckenmiller et al. (2012) state that the 5.5 m long *C. kristiansenae* was relatively large for the Late Jurassic. If our estimates are correct, the Bowser Basin ichthyosaur could be one of the largest known ichthyosaurs from the Late Jurassic.

Conclusions

Although the exact taxonomic position of TMP 2009.010.0001 is uncertain, it nonetheless represents an important data point for Upper Jurassic ophthalmosaurs. It represents one of only a small number of known Jurassic ichthyosaurs, and more generally, Jurassic tetrapods, from Canada. The Bowser Basin ichthyosaur was relatively large compared to other, contemporary taxa, yet possessed relatively small teeth for its size. Despite its large size, it was found within a restricted, shallow marine setting that had a strong terrestrial influence. The fact that articulated elements and large portions of the skull were observed suggests that this specimen was relatively well preserved before glacial disturbance, and that further research in remote northern regions of Canada and other Arctic countries has the potential to provide new occurrences and potentially new species from novel times and locations.

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Figure Captions

Fig. 1. Specimen locality and stratigraphic context of TMP 2009.010.0001. (A) map of Canada with British Columbia in dark grey on the west coast; (B) map of specimen locality, with the Bowser Basin in grey; (C) stratigraphic relationships in the northwest Bowser Basin. Star indicates approximate geographic and stratigraphic position of TMP2009.010.0001. Map and stratigraphic column modified from Evenchick et al., 2010. [Formatted for page width]

Fig. 2. Portion of the left mandible of TMP 2009.010.0001. (A) medial view; (B) dorsal view; (C) lateral view. Anterior is to the right in A and B, and to the left in C. a, angular; d, dentary; sa, surangular; spl, splenial; t, tooth. [Formatted for page width]

Fig 3. Preserved elements from the Bowser Basin ichthyosaur (TMP 2009.010.0001). (A) block with four vertebrae; (B) proximal half of left humerus; (C) line drawing of proximal half of left humerus; (D) planar view of phalanx; (E) marginal view of phalanx; (F) small tooth; (G) large tooth. dc, dorsal crest. 100 mm scale bar for images A-C, 20 mm scale bar for images D-G. [Formatted for page width]

Fig. 4. Uncollected cross section through the anterior portion of the lower jaw of TMP 2009.010.0001. (A) image of jaw in situ, at the field locality; (B) outline of jaw cross section through the left and right dentaries. ag, alveolar groove.[Formatted for column width]

Fig. 5. Reconstructed size of Bowser Basin ichthyosaur with elements in white, and *Ophthalmosaurus icenicus* for comparison. Scale bar in metres. [Formatted for column width]

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