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Massospondylus carinatus Owen 1854 (Dinosauria: Sauropodomorpha) from the Lower Jurassic of South Africa: Proposed conservation of usage by designation of a neotype

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The purpose of this article is to preserve the usage of the binomen *Massospondylus carinatus* by designating a neotype specimen. *Massospondylus* is the most abundant basal sauropodomorph dinosaur from the Early Jurassic strata of southern Africa. This taxon forms the basis for an extensive palaeobiological literature and is the eponym of Massospondylidae and the nominal taxon of a biostratigraphical unit in current usage, the '*Massospondylus* Range Zone'. The syntype series of *M. carinatus* (five disarticulated and broken vertebrae) was destroyed during World War II, but plaster casts and illustrations of the material survive. Nonetheless, these materials cannot act as type material for this taxon under the rules of the ICZN Code. In order to avoid nomenclatural instability, we hereby designate BP/1/4934 (a skull and largely complete postcranial skeleton) as the neotype of *Massospondylus carinatus*.

Keywords: Dinosauria, Sauropodomorpha, Massospondylidae, *Massospondylus*, *Massospondylus carinatus*, neotype, South Africa, upper Elliot Formation, Early Jurassic.

INTRODUCTION

Richard Owen described and named *Massospondylus carinatus* (1854, p. 97) with *carinatus* as the type species of the genus by monotypy. The original description lacked illustrations and was based on part of a collection of 56 disarticulated fossil reptile bones that were donated to the Hunterian Museum of the Royal College of Surgeons, London. These bones were collected from the farm Beauchef Abbey 215 in the Harrismith District of what is now the Free State Province, South Africa (Kitching & Raath 1984). Although the type stratum was not recorded only the upper member of the Elliot Formation is accessible at the type locality (Kitching & Raath 1984). Owen positively ascribed five vertebrae to *M. carinatus* (Owen 1854: catalogue numbers 331–335), although 13 others (336–337, 349–350, 352, 354, 358–364) were referred to this taxon with some reservations. No holotype was designated. Consequently specimens 331–335 form the syntype series of this taxon.

The syntype series was destroyed when the Hunterian Museum was hit during a bombing raid on 10 May 1941, but many of the bones were illustrated by Lydekker (1890), Seeley (1895) and von Huene (1906), and a series of casts of the syntypes still survive and are housed in the Iziko South African Museum, Cape Town, South Africa (SAM PKC 958–62), and the Natural History Museum, London (NHMUK R3027–8).

Owen (1854) proposed two additional binomials, based upon other bones from the same collection: *Pachyspondylus orpeni* (Owen 1854, p. 99) and *Leptospondylus capensis* (Owen 1854, p. 100). As noted by Seeley (1895), these taxa were based on caudal vertebrae that may represent the same taxon, possibly even the same individual, as at least some of the syntype series of *Massospondylus carinatus*. Their initial separation from *Massospondylus carinatus* was based on Owen's mistaken belief that the cervical vertebrae in the syntype series were caudals. Seeley (1895, pp. 103–104), acting as first reviser, affirmed the priority of *Massospondylus carinatus* and relegated *Pachyspondylus orpenii* and *Leptospondylus capensis* to the status of *nomina dubia* that may be junior synonyms of *Massospondylus carinatus*. All subsequent works that mention *P. orpenii* and *L. capensis* continue to treat these two taxa as *nomina dubia* that cannot be distinguished from *Massospondylus carinatus* (von Huene 1906; Broom 1911; Steel 1970; Cooper 1981; Galton 1990; Galton & Upchurch 2004; Sues *et al.* 2004).

Four other species in the genus *Massospondylus* (*M. browni* Seeley 1895; *M. harriesii* Broom 1911; *M. schwarzi* Haughton 1924; and *M. kaalae* Barrett 2009) have been named subsequently; the earlier three are based on fragmentary postcranial specimens from the upper part of the Elliot Formation. With the exception of *M. kaalae*, which is retained as a valid taxon, these taxa are currently regarded as either *nomina dubia* or junior subjective synonyms of *M. carinatus* Owen (e.g. Cooper 1981; Galton & Upchurch 2004). Numerous other taxa (*Hortalotarsus skirtopodus* Seeley 1894; *Aetonyx palustris* Broom 1911; *Aristosaurus erectus* Van Hoepen 1920a; *Dromicosaurus gracilis* Van Hoepen 1920b; *Gryponyx taylori* Haughton 1924; and *Thecodontosaurus dubius* Haughton 1924), also from the upper Elliot Formation or the overlying Clarens Formation, are similarly regarded as junior subjective synonyms of *M. carinatus* or *nomina dubia* that are indistinguishable from *M. carinatus*.

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THE NEED FOR A NEOTYPE

Examination of the surviving plaster casts indicates that the original syntype series is inadequate for diagnosing a genus and species of basal sauropodomorph. All of the diagnostic characteristics currently applied to *Massospondylus carinatus* are features of the skull (Sues *et al.* 2004) and the syntype series preserves no cranial material. A prominent muscle scar on the lateral surface of the midshaft of the fibula has also been proposed as an autapomorphy of this taxon (Galton & Upchurch 2004). However, this character is widespread amongst basal sauropodomorphs and cannot be determined in the syntype series, which includes only vertebrae. Indeed the syntypes are so inadequate that it is not possible to determine with confidence whether or not they belong to the more inclusive taxon Massospondylidae. This problem could be solved by designating *Massospondylus carinatus* a *nomen dubium* and re-instating the next available genus and species name based on diagnostic material. Unfortunately, only *M. kaalae* is based on a specimen that includes adequate skull material and this appears to be distinctive and unlike any of the other skulls referred to *M. carinatus* to date. None of the other named taxa displays any of the characters that are currently used to diagnose *Massospondylus carinatus.* Although it is likely that a relatively complete postcranium will display a unique combination of character states, none of the available names are based on sufficiently complete material. If *Massospondylus* is to be rendered a *nomen dubium* the only course left in strict accord with the code is to erect a new name for the set of specimens universally recognized as *M. carinatus* and to base this new name on one of several relatively complete specimens that include a well-preserved skull (e.g. BP/1/4779, BP/1/4923, BP/1/5241 or SAM-PK-K1314, for skulls see Gow *et al.* 1990; Sues *et al.* 2004; Barrett & Yates 2006).

Massospondylus carinatus has been regarded as the dominant vertebrate taxon of the upper Elliot Formation since its description. Due to its abundance, the biostratigraphical unit at the top of the Karoo succession in southern Africa has been designated the '*Massospondylus* Range Zone' (Kitching & Raath 1984), which is a term in general usage (e.g. Smith & Kitching 1997; Barrett 2004; Bordy *et al.* 2004; Sidor & Hancox 2006). Furthermore, the abundance of high quality material has enabled numerous palaeobiological studies that refer these specimens to the binomen *Massospondylus carinatus.* These include general anatomical studies (Cooper 1981; Gow 1990; Gow *et al.* 1990; Sues *et al.* 2004, Barrett & Yates 2006), detailed cranial anatomy based on CT-scanning (Sereno *et al.* 2007; Holliday & Witmer 2008), bone histology and growth trajectories (Chinsamy 1993), feeding ecology (Raath 1974; Cooper 1981; Crompton & Attridge 1986; Barrett 2000), nesting and possible parental behaviour (Reisz *et al.* 2005), eggshell microstructure (Zelenitzky & Modesto 2002) and embryological anatomy and growth allometry (Reisz *et al.* 2005). Lastly, *Massospondylus* has been a mainstay of numerical cladistic analyses of sauropodomorph dinosaur phylogeny (Upchurch 1995; Sereno 1999; Benton *et al.* 2000; Yates 2003, 2004, 2007; Yates & Kitching 2003; Galton & Upchurch 2004; Smith & Pol 2007; Upchurch *et al.* 2007; Martínez 2009). To rename the taxon would create widespread confusion by referring to a large set of material, widely known as *Massospondylus carinatus,* to a new unfamiliar binomen, with any new taxon name obscuring the relationship between these specimens and this large body of work.

Massospondylus is also the eponym of the family group name Massospondylidae (von Huene 1914, p. 13) which is in current use in dinosaur systematics (Galton 1990; Sereno 1999; Yates 2003, 2007; Smith & Pol 2007; Martínez 2009) and renaming *Massospondylus* would also necessitate destabilizing higher sauropodomorph taxonomy by requiring the replacement of Massospondylidae.

One might argue that if all basal sauropodomorphs from the upper Elliot Formation are referable to a single species, then the inadequacy of the syntypes is not an issue, since we can be confident that they belong to the same taxon that the name is being applied to. However, this is not the case. Although the recent literature treats the genus as monotypic, there are now indications that several basal sauropodomorph taxa are present in the upper Elliot Formation (Yates *et al.* 2007) and more than one species is present within the *Massospondylus* sample from the upper Elliot Formation (Barrett 2009). Without an adequate type specimen it is currently impossible to correctly decide which of these species might represent *M. carinatus* as based on its syntype series.

Sues *et al.* (2004, p. 240) suggested that it was advisable to designate a neotype specimen for *Massospondylus carinatus* but noted that this action would have to wait until a "comprehensive revision of all basal sauropodomorphs from the 'Stormberg Group' of South Africa". However, as we note in the preceding paragraph, the lack of a neotype is actually impeding the progress of this revision. Sues *et al.* (2004) suggested BP/1/4934 as a candidate neotype specimen, but it should be noted that this proposal does not qualify as a formal neotype designation as it does not fulfill all of the requirements of Article 75 of the ICZN Code (ICZN 1999).

The plaster casts of the syntype specimens cannot act as type specimens under the auspices of the ICZN code, which states clearly that type specimens must represent actual specimens, rather than copies or illustrations thereof (Article 72.5: ICZN 1999). As there is good documentary evidence that the syntype series of *Massospondylus carinatus* has been destroyed it is necessary and appropriate to designate a neotype for this taxon, under Article 75 of the Code (ICZN 1999). Such designations can be made without a formal ruling from the ICZN Commissioners (ICZN 1999; S. Nikolaeva, pers. comm. 2009).

SUGGESTED NEOTYPE

Here, we formalize the suggestion of Sues *et al.* (2004) and propose a neotype specimen for *Massospondylus carinatus.* BP/1/4934 is a well-preserved articulated skeleton, including a skull (Fig. 1). It is preserved in the collections of the Bernard Price Institute for Palaeontological Research, which maintains an active research collection, has adequate facilities for preserving type specimens and will make the

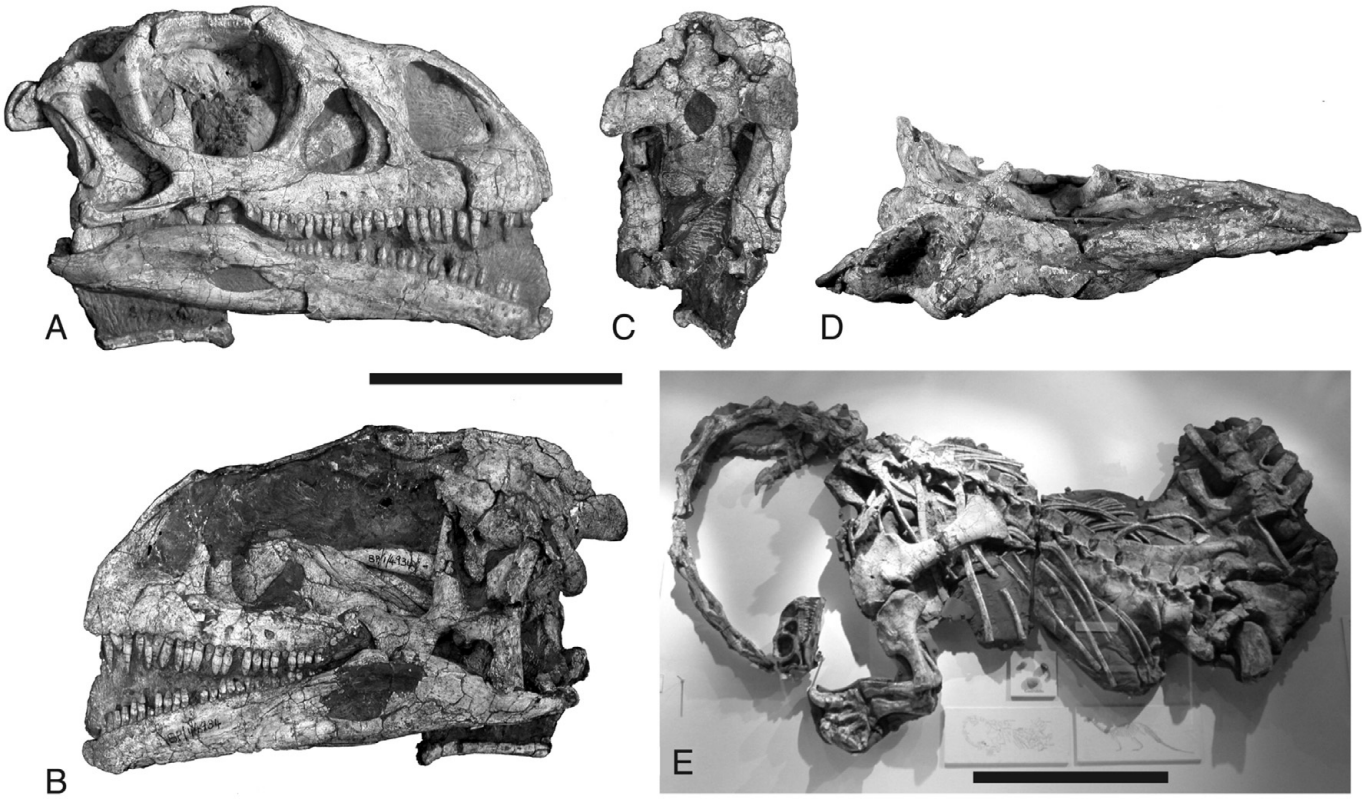

Figure 1. BP/1/4934 the proposed neotype of *Massospondylus carinatus* Owen. **A**, Skull in right lateral view; **B**, skull in left lateral view; **C**, skull in occipital view; **D**, skull in dorsal view; **E**, skull and postcranial skeleton as displayed at the Bernard Price Institute in 2001. Scale bar in A–D = 100 mm; scale bar in E = 500 mm.

proposed neotype accessible for study by other researchers. The skull of this individual has been figured and described in detail (e.g. Gow *et al.* 1990; Sues *et al.* 2004) and a figure of the postcranial skeleton has also been published (MacCrae 1999, p. 203). The specimen is widely acknowledged to be an individual of *Massospondylus carinatus* in the literature and possesses the characteristic features that have been proposed to distinguish this taxon from other basal sauropodomorph dinosaurs (e.g. Gow *et al.* 1990; Sues *et al.* 2004; Barrett 2009; see also references cited therein). Moreover, all features of BP/1/4934 are consistent with those that have been illustrated or described for the original syntype series of *M. carinatus.* No other binomen has ever been applied to this individual. The specimen was collected on the farm Bormansdrift, in the Clocolan District of the Free State Province from the upper part of the Elliot Formation and thus comes from the same stratum as the original syntypes. Fixation of BP/1/4934 as the neotype will solve the above-mentioned problems with no disruption to the existing usage of either the genus name *Massospondylus* or the binomen *Massospondylus carinatus.*

INSTITUTIONAL ABBREVIATIONS

BP	Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg
NHMUK	Natural History Museum, London
SAM	Iziko South African Museum, Cape Town

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