Supplementary Information

A gigantic nothosaur (Reptilia: Sauropterygia) from the Middle Triassic of SW China and its implication for the Triassic biotic recovery

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Supplementary Note

Character Description. Characters are a combination of the phylogenetically informative characters for resolving the phylogenetic interrelationships of *Nothosaurus*[55] and *Lariosaurus*[27] with some minor revisions, as well as 20 new morphological characters that have not been used previously. If a character is originally from ref. 55 or ref. 27, it is noted as either R01 or R03 in the text.

1. Ratio, condylobasal skull length divided by longitudinal diameter of upper temporal fossa (modified from R01, Character 16):
    0. more than 3.8
    1. 3.0-3.4
    2. less than 2.9

2. Ratio of longitudinal diameter, upper temporal fossa to orbit (modified from R03, Character 13):
    0. less than 1.2
    1. 1.4-1.8
    2. 1.9-2.2
    3. 2.4-3.0
    4. more than 3.2

3. Ratio, the distance from the snout to the anterior margin of the internal naris divided by the distance from the snout to the anterior margin of the external naris

(modified from R01, Character 6):

0. smaller than 1.2

1. larger than 1.3

4. Ratio, distance from posterior margin of external naris to anterior margin of orbit divided by the width of the postorbital arch (modified from R01, Character 13):

0. more than 1.7

1. less than 1.5

5. Snout (R03, Character 3):

0. unconstricted

1. constricted

6. Rostrum (modified from R01, Character 1):

0. short and rounded

1. long, slender and parallel-edged

7. Premaxilla(e) in adult:

0. paired

1. partly or fully fused

8. Maxilla, depression at lateral margin of external naris and a foramen at its bottom for the exit of a lateral branch of the superior alveolar nerve (R01, Character 5):

0. absent

1. present

9. Nasals in adult:

0. paired

1. fused

10. Nasal(s) (R03, Character 8):

0. meeting each other

1. seperated from one another by nasal processes of the premaxillae extending back to the frontal bone(s)

11. Nasal, anterolateral process lining the entire medial margin of external naris (R01, Character 4):

0. absent

1. present

12. Nasal, length behind level of posterior margin of external naris more than twice of the maximal width (R01, Character 7):

0. absent

1. present

13. Nasals (modified from R03, Character 6):

0. large

1. small

14. Nasal-prefrontal contact:

0. present

1. absent

15. Pineal foramen (modified from R01, Character 23):

0. close to the middle of the parietal skull table

1. displaced posteriorly

16. Pineal foramen located within a deep trough:

0. absent

1. present

17. Parietal extending beyond the anterior margin of upper temporal fossa (modified from R01, Character 20):

0. present

1. absent

18. Parietal skull table (R01, Character 22):

0. broad

1. weakly constricted

2. strongly constricted

19. Parietal skull table, constriction in the posteriormost part:

0. absent

1. present

20. Dorsal exposure of prefrontal (R01, Character 8):

0. large

1. reduced

21. Jugal (modified from R01, Character 14):

0. present

1. absent

22. Jugal (modified from R01, Character 14):

0. entering orbit

1. excluded from posterior margin of orbit

23. Jugal-squamosal contact:

0. absent

1. present

24. Postfrontal, shape (modified from R03, Character 26):

0. elongated

1. triradiate

25. Postfrontal, distinct constriction behind the orbit:

0. absent

1. present

26. Postfrontal (R01, Character 10):

0. entering upper temporal fossa

1. excluded from upper temporal fossa

27. Postorbital, forming the entire anterior margin of the upper temporal fossa (R01, Character 12):

0. absent

1. present

28. Upper temporal fenestra, constriction of anterior corner (modified from R01, Character 18):

0. absent

1. present

29. Quadratojugal (R03, Character 29):

0. present

1. absent

30. Pterygoid-ectopterygoid transverse flanges (Rieppel, 2003, character 44):

    0. well developed

    1. strongly reduced

31. Occipital crest (R01, Character 24):

    0. absent

    1. present

32. Supraoccipital, sagittal crest:

    0. absent

    1. reduced

    2. well developed

    3. knob-like

33. Mandibular articulations (R03, Character 33):

    0. approximately level with occipital condyle

    1. displaced to a level distinctly behind occipital condyle

34. Mandible, constriction:

    0. absent

    1. present

35. Mandibular symphysis (modified from R03, Character 51):

    0. short

    1. long

36. Mandibular symphysis, anterior fusion in adult:

    0. absent

    1. present

37. Splenial (R03, Character 52):

    0. entering mandibular symphysis

    1. excluded from mandibular symphysis

38. Splenial, posterior extension:

    0. long

    1. short

39. Retroarticular process:

    0. short

    1. long

40. Retroarticular process dorsal surface, foramen for the innervation of chorda tympani nerve:

0. absent

1. present

41. Retroarticular process, trough on lateral surface for the insertion of the depressor mandibulae muscle/superficial pterygoideus muscle:

0. absent

1. weak

2. strong

42. Retroarticular process, trough on medial surface for the insertion of posterior fibers of pterygoideus internus muscle:

0. absent

1. present

43. Dentary fangs:

0. absent

1. present but less than 5

2. 5

44. Premaxillary teeth:

0. more than 5

1. 5

45. Premaxillary fangs (modified from R01, Character 2):

    0. absent

    1. present but less than 5

    2. 5 or more

46. Number of small maxillary teeth anterior to the maxillary fang(s):

    0. 3 or less

    1. 4

    2. 5 or more

47. Posterior extension of the maxillary tooth row (modified from R03, Character 57):

    0. no more than sixty percent of the skull length (snout tip to posterior margin of quadrate)

    1. more than sixty-five percent of the skull length

48. Neural spines on dorsal vertebrae (modified from R01, Character 25):

    0. low

    1. tall

49. Elongation of neural spines in proximal tail region (R03, Character 125):

    0. absent

    1. present

50. Zygapophyseal pachyostosis (R03, Character 69):

    0. absent

    1. present

51. Pachyostosis of dorsal ribs (R03, Character 72):

    0. absent

    1. present

52. The number of sacral ribs (modified from R03, Character 73):

    0. three

    1. four

    2. five

53. Medial gastral rib elements, lateral process (R03, Character 119):

    0. all single

    1. may two-pronged

54. Clavicles, medially (R03, Character 77):

    0. broad

    1. narrow

55. Clavicles (R03, Character 79):

    0. do not meet in front of the interclavicle

1. meet in an interdigitating anteromedial suture

56. Clavicles, anterolaterally expanded corners (R03, Character 80):

0. absent

1. present

57. Interclavicle (R03, Character 82):

0. rhomboidal

1. T-shaped

2. triangular

58. Humerus, proximal width compared with the mid-shaft (R03, Character 123):

0. greater

1. less

59. Humerus, preaxial margin of shaft in dorso-ventral view:

0. with straight angle

1. smoothly curved

60. Humerus, insertional crest for latissimus dorsi muscle (R03, character 94):

0. reduced

1. prominent

61. Humerus, ectepicondylar groove (R03, Character 96):

    0. open and notched anteriorly

    1. open without anterior notch

62. Humerus, entepicondylar foramen (R03, Character 97):

    0. present

    1. absent

63. Radius, compared with ulna (R03, Character 98):

    0. shorter

    1. longer

    2. approximately of the same length

64. Ulna, mid-diaphysis (R03, Character 120):

    0. slender

    1. broadened

65. Ulna, distinctly broadened proximal head (R03, Character 121):

    0. absent

    1. present

66. Ulna, anterior margin:

    0. smoothly concave

1. with a tuberosity

67. Carpal ossifications, number (R03, Character 124):

0. more than three

1. three or less

68. Hyperphalangy in manus (R03, Character 122):

0. absent

1. present

69. Ilium, iliac blade (R03, Character 99):

0. present

1. absent (i.e., reduced to simple dorsal stub)

70. Pubis, ventral (medial) margin (R03, Character 100):

0. convex

1. concave

71. Pubis, obturator foramen in adult (R03, Character 101):

0. closed

1. open

72. Femur, internal trochanter (R03, Character 105):

0. well developed

1. reduced

73. Femur, intertrochanteric fossa (R03, Character 106):

0. rudimentary or absent

1. distinct but reduced

74. Total number of tarsal ossifications (R03, Character 115):

0. four or more

1. three

2. two

Character Coding. If a character state is unknown for a taxon, it is coded as ?. If a character is not applicable for a taxon, it is coded as -. Both states, however, will be treated as unknown by PAUP in the phylogenetical analysis.

Pachypleurosauria

0 0 0 0 0 0 ? 0 0 0 0 1 0 ? 0 0 0 0 0

0 0 0 0 0 0 0 0 0 0 1 0 ? 1 0 0 0 0 0

0 0 0 0 0 0 ? 0 0 0 0 1 0 0 0 0 1 1 1

0 0 0 0 0 1 0 0 0 1 0 ? 0 0 1 0 0

Simosaurus

2 2 1 0 0 0 0 0 0 1 0 0 1 ? 1 0 1 1 0

0 0 0 0 1 1 0 0 0 0 1 0 0 1 0 0 0 1 0

0 1 2 1 0 1 0 - 1 0 0 0 0 0 1 0 1 1 1

0 0 0 1 1 2 0 1 0 1 0 0 1 0 1 0 0

Germanosaurus

2 2 1 1 1 0 1 0 0 1 0 1 1 1 1 0 0 1 1

1 0 1 1 1 1 0 0 0 ? ? 0 ? ? ? ? ? ? ?

? ? ? ? ? 1 ? ? ? 0 ? ? ? ? ? ? ? ? ?

? ? ? ? ? ? 0 ? ? ? ? ? ? ? ? ? ?

N. winkelhorsti

1 1 ? 1 1 0 1 1 1 0 0 1 0 1 0 0 0 0 0

1 0 1 1 1 0 1 1 1 1 1 1 2 0 ? ? ? ? ?

? ? ? ? ? 1 1 0 0 ? ? ? ? ? ? ? ? ? ?

? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

N. yangjuanensis

2 3 0 1 1 0 0 1 0 0 0 0 0 0 1 0 1 2 1

1 0 1 0 1 1 1 1 0 ? 1 1 2 0 ? ? ? ? ?

1 0 2 1 ? 1 1 2 0 0 1 0 0 1 1 0 0 1 0

1 0 1 0 0 2 1 1 1 0 1 0 1 0 0 0 1

N. marchicus

2 3 0 1 1 0 0 1 0 0 1 0 0 1 1 0 ? 2 ?

1 0 1 1 ? 1 ? ? ? 1 1 1 1 0 1 0 1 ? ?

1 ? ? ? ? 1 2 2 0 0 ? 1 0 0 1 ? ? ? ?

1 0 1 0 0 2 0 ? 0 1 ? ? 1 0 1 ? 1

N. mirabilis

2 4 0 1 1 1 0 1 0 0 1 1 0 1 1 0 1 2 ?

1 0 ? ? 0 0 1 1 1 1 1 1 1 0 1 1 1 1 1

1 ? ? ? 2 1 2 ? 1 1 ? 1 ? ? ? 0 1 1 1

0 0 1 0 0 ? 0 ? ? ? ? ? 1 ? ? ? ?

N. juvenilis

1 1 ? 0 1 1 0 1 0 0 1 1 0 0 1 0 0 1 0

1 0 1 0 1 0 0 0 0 1 ? 1 1 0 ? ? ? ? ?

? ? ? ? ? 1 ? 0 1 0 ? ? ? ? ? ? ? ? ?

? ? ? ? ? ? 0 1 ? ? ? 0 1 1 ? ? ?

N. giganteus

2 4 0 1 1 0 0 1 0 0 1 1 0 1 1 0 1 1 0

1 0 1 ? ? 0 ? 1 1 1 0 1 1 0 1 ? 1 1 ?

1 0 2 1 2 1 1 1 0 0 0 1 0 2 1 1 0 1 0

0 0 1 1 0 2 1 1 ? 0 0 0 1 0 ? ? 1

N. zhangi

? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

? ? ? ? ? ? ? ? ? ? ? ? ? ? 1 0 1 1 0

0 ? ? 1 ? ? ? ? ? 0 ? ? 0 ? ? ? ? ? ?

? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

N. tchernovi

2 3 0 1 1 1 0 0 0 0 1 1 0 0 1 0 1 2 1

1 1 - - 0 0 ? 1 1 1 1 1 ? 0 1 1 ? ? ?

? ? 2 ? 2 1 2 1 1 1 1 1 ? ? ? ? ? ? ?

0 0 1 1 0 ? ? ? ? ? ? ? ? ? ? ? ?

N. haasi

0 2 0 0 1 1 0 0 0 1 0 1 1 1 1 0 1 2 1

1 1 - - 1 0 0 0 0 1 1 1 2 0 ? ? ? ? ?

? ? ? ? ? 1 2 0 1 1 ? ? ? ? ? ? ? ? ?

1 1 1 1 0 ? ? ? ? ? ? ? ? ? 0 1 ?

N. youngi

2 2 0 0 1 0 0 1 0 0 0 1 0 0 1 1 0 2 0

1 0 1 0 1 0 1 1 1 1 0 1 1 0 0 0 0 0 1

1 1 1 1 1 1 2 0 0 0 0 1 1 ? 1 0 0 0 2

0 ? 0 ? ? 2 1 ? 1 0 ? 1 0 0 0 0 1

N. jagisteus

2 3 0 1 1 1 0 1 0 0 1 1 0 1 1 0 1 2 1

1 0 1 0 1 0 1 1 0 1 0 1 1 0 1 1 1 1 1

1 ? 2 1 1 1 2 1 1 0 ? ? 0 ? 1 0 1 1 1

0 0 1 1 0 0 0 0 0 1 ? ? 1 1 ? ? ?

N. edingerae

2 3 0 0 ? 0 0 0 ? ? 1 0 0 ? 1 1 1 2 1

1 ? ? ? 1 0 0 1 1 ? 1 1 ? ? ? ? ? ? ?

? ? ? ? ? 1 ? 0 ? 0 ? ? ? ? ? ? ? ? ?

? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

L. hongguoensis

1 2 0 0 1 0 0 0 ? 0 1 ? ? 1 1 1 0 1 0

1 0 1 0 1 0 1 1 0 0 0 1 1 0 1 0 0 0 1

1 1 0 0 ? 0 2 0 0 ? ? ? ? ? 1 ? ? 0 ?

0 1 1 ? 0 2 1 0 0 0 1 ? 0 1 1 0 2

L. buzzii

0 0 0 0 1 0 1 1 1 0 0 1 0 1 0 0 0 1 0

1 ? ? ? 1 0 0 0 0 1 1 1 2 0 1 0 0 1 ?

1 1 ? ? 1 1 ? ? 0 0 0 1 0 ? 0 1 0 0 ?

0 0 0 1 1 1 1 ? 0 ? ? 1 0 1 1 0 ?

L. calcagnii

0 0 0 1 0 0 0 ? 0 0 0 ? 0 0 1 0 1 2 1

0 0 ? 0 0 0 0 0 0 1 1 1 ? 0 0 1 0 1 ?

1 ? ? ? 2 ? ? ? ? 0 1 1 0 2 0 1 0 1 0

1 1 0 1 0 2 1 0 0 0 1 1 1 1 1 0 1

L. curionii

1 1 0 0 0 0 0 ? 0 1 1 1 0 ? 1 0 ? 2 1

1 ? ? ? 0 0 1 1 1 1 1 1 0 0 0 0 ? 1 ?

1 ? 2 ? 2 0 ? 0 0 0 0 1 1 ? ? 0 1 1 0

1 1 0 1 0 0 1 1 1 ? ? ? ? ? ? ? ?

L. balsami

1 1 0 0 1 0 0 ? 0 1 0 ? 0 ? 1 0 0 2 1

? 0 0 1 0 0 ? ? 0 ? 1 1 2 0 0 0 0 1 ?

1 ? 2 ? ? ? ? ? ? 0 0 1 ? 1 0 0 1 1 0

1 1 0 1 ? ? 1 1 0 0 1 1 0 1 1 0 ?

L. valceresii

1 2 ? 1 1 0 0 ? 0 0 0 0 0 0 1 0 1 2 1

0 ? ? 0 0 0 0 0 0 1 1 1 0 0 ? ? ? 1 ?

1 ? 1 ? ? 0 2 ? ? 0 0 1 0 1 0 ? ? ? ?

1 0 0 0 0 2 1 1 1 0 1 1 0 ? 1 0 2

L. xingyiensis

2 2 0 0 1 0 0 1 0 0 1 0 0 0 1 0 0 2 1

0 ? 1 0 1 0 1 1 1 ? 0 1 2 0 1 1 0 1 0

1 1 1 1 2 1 ? 0 0 0 1 1 1 2 0 1 0 0 0

1 0 0 0 0 2 1 1 1 0 1 1 ? ? 0 1 ?