

## APPENDIX S1. List of characters

The characters listed below are mainly from Forey (1998), with the exception of character 109 from Dutel et al. (2012). The few changes introduced to previous description of characters are explained in each character. In certain cases a new character state was added to include the condition present in the new fossil.

### Skull Roof Characters

1. Intracranial joint margin: straight [0]; strongly interdigitate [1]; undulated [2].  
Character state 3 was added to include *Atacamaia solitaria* new gen. et sp.
2. Snout bones lying free from one another [0]; snout bones consolidated [1].
3. Single median rostral [0]; several median rostrals (internasals) [1].
4. Paired premaxillae [0], fragmented premaxillae [1].
5. Premaxilla: with dorsal lamina [0], without dorsal lamina [1].
6. Anterior opening of the rostral organ: contained within premaxilla [0]; within separated rostral ossicle [1].
7. One pair of parietal bones [0]; two pairs [1]; more than two pairs [2]. *Chinlea* is coded herein with '2' following Elliott (1987).
8. Anterior and posterior pairs of parietal bones of similar size [0]; dissimilar size [1].  
*Atacamaia solitaria* new gen. et sp. is coded as non-applicable = N.
9. Number of supraorbitals/tectals: fewer than eight [0]; more than 10 [1].
10. Preorbital: absent [0]; present [1].
11. Parietal descending process: absent [0]; present [1].
12. Intertemporal: absent [0]; present [1].
13. Postparietal descending process: absent [0]; present [1].

14. Supratemporal descending process: absent [0]; present [1].
15. Extrascapulars: sutured with postparietals [0]; free [1].
16. Extrascapulars: behind level of neurocranium 90; forming part of the skull roof [1].
17. Number of extrascapulars: three [0]; five [1]; seven or more [2]. Character state 2 is modified here from Forey (1998) who presented it as “more than seven extrascapulars”.
18. Posterior margin of the skull roof: straight [0] embayed [1].
19. Supraorbital sensory canal: running through centre of ossification (0); following sutural course [1].
20. Medial branch of otic canal: absent [0]; present [1].
21. Otic canal joining supratemporal canal: within lateral extrascapular [0]; in supratemporal [1].
22. Anterior branches of supratemporal commissure: absent [0]; present [1].
23. Supraorbital sensory canals opening through bones: as single large pores [0]; bifurcating pores [1]; many tiny pores [2]; a large, continuous groove crossed by pillars [3]. We follow here Dutel et al. (2012) in the new presentation and coding of this character.
24. Anterior pit-line: absent [0]; present [1].
25. Middle and posterior pit-lines: within posterior half of postparietals [0]; within anterior third [1].
26. Pit-lines; marking postparietals [0]; not marking postparietals [1].
27. Parietals and postparietals ornamented with: enamel-capped ridges/tubercles [0]; bones unornamented [1]; bones marked by coarse rugosities [2].
28. Parietals and postparietals: without raised areas [0]; with raised areas [1].

## **Cheek Bones**

29. Cheek bones; sutured to one another [0]; separated from one another [1].

*Guizhoucoelacanthus* was coded '0' following Geng et al. (2009).

30. Spiracular (postspiracular): absent [0]; present [1].

31. Preoperculum: absent [0]; present [1].

32. Suboperculum: absent [0]; present [1].

33. Quadratojugal: absent [0]; present [1].

34. Squamosal: limited to the mid-level of cheek [0]; extending behind the postorbital to reach the skull roof [1].

35. Lachrymojugal: not expanded anteriorly [0]; expanded anteriorly [1].

36. Lachrymojugal ending: without anterior angle [0]; angled anteriorly [1].

37. Squamosal: large [0]; reduced to a narrow tube surrounding the jugal sensory canal only [1].

38. Preoperculum: large [0]; reduced to a narrow tube surrounding the preopercular canal only [1].

39. Preoperculum: undifferentiated [0]; developed as a posterior tube-like canal-bearing portion and an anterior blade-like portion [1].

40. Postorbital: simple, without anterodorsal excavation [0]; anterodorsal excavation in the postorbital [1].

41. Postorbital: without anterior process [0]; with anterior process [1].

42. Postorbital: large [0]; reduced to a narrow tube surrounding the sensory canal only [1]; moderately large, but narrow.

43. Postorbital: entirely behind the level of the intracranial joint [0]; spanning the intracranial joint [1].

- 44. Infraorbital canal within the postorbital: with simple pores opening directly from the main canal [0]; anterior and posterior branches with the postorbital [1]; with no branches and/or pores [2].
- 45. Infraorbital sensory canal: running through centre of postorbital [0]; running at the anterior margin of the postorbital [1].
- 46. Jugal sensory canal: simple [0]; with prominent branches [1].
- 47. Jugal canal: running through centre of bone [0]; running along the ventral margin of the squamosal [1].
- 48. Pit-lines: marking cheek bones [0]; failing to mark cheek bones [1].
- 49. Ornaments upon cheek bones: absent [0]; tubercular [1]; represented as a coarse superficial rugosity [2].
- 50. Infraorbital, jugal and preopercular sensory canals: opening through many tiny pores [0]; opening through a few large pores [1]; a large, continuous groove crossed by pillars [2]. We follow the new presentation and coding of this character after Dutel et al. (2012).
- 51. Lachrymojugal sutured to: preorbital and lateral rostral [0]; lying in a sutural contact with the tectal-supraorbital series [1].
- 52. Sclerotic ossicles: absent [0]; present [1].

### **Lower Jaw**

- 53. Retroarticular and articular: co-ossified [0]; separated [1].
- 54. Dentary teeth: fused to the dentary [0]; separated from dentary [1].
- 55. Number of coronoids, coded as integers. Only 2 characters states (3 and 4) were coded for this character by Forey (1998).
- 56. Coronoid opposite to the posterior end of dentary: not modified [0]; modified [1].

- 57. Dentary: simple [0]; hook-shaped [1].
- 58. Oral pit-line: confined to angular [0]; reaching forward to the dentary and/or the splenial [1].
- 59. Oral pit-line located at centre of ossification of angular (0), removed from centre of ossification (1).
- 60. Subopercular branch of the mandibular sensory canal: absent [0]; present [1].
- 61. Dentary sensory pore: absent [0]; present [1].
- 62. Ornaments in lower jaw: ridged [0]; granular ornaments in lower jaw [1].
- 63. Dentary: with ornament [0]; without ornament [1].
- 64. Splenial: with ornament [0]; without ornament [1].
- 65. Dentary: without prominent lateral swelling [0]; with swelling [1].
- 66. Principal coronoid: lying free [0]; sutured to angular (1).
- 67. Coronoid fangs: absent [0]; present [1].
- 68. Prearticular and/or coronoid teeth: pointed and smooth [0]; rounded and marked with fine striations radiating from the crown [1].

#### **Neurocranium, Parasphenoid, and Vomer**

- 69. Orbitosphenoid and basisphenoid regions: co-ossified [0]; separate [1].
- 70. Basisphenoid extending forward to enclose the optic foramen [0]; optic foramen lying within separate interorbital ossification or cartilage [1].
- 71. Processus connectens: meeting parasphenoid [0]; failing to meet parasphenoid [1].
- 72. Basispterygoid process: absent [0]; present [1].
- 73. Antotic process: not covered by parietal descending process [0]; covered [1].
- 74. Temporal excavation: lined with bone [0]; not lined [1].
- 75. Otico-occipital: solid [0]; separated to prootic/opisthotic [1].

- 76. Supraoccipital: absent [0]; present [1].
- 77. Vestibular fontanelle: absent [0]; present [1].
- 78. Buccohypophysial canal: closed [0]; opening through parasphenoid [1].
- 79. Parasphenoid: without ascending laminae anteriorly [0]; with ascending laminae [1].
- 80. Suprapteygoid process: absent [0]; present [1].
- 81. Vomers: not meeting in the midline [0]; meeting medially [1].
- 82. Prootic: without complex suture with the basioccipital [0]; with a complex suture [1].
- 83. Superficial ophthalmic branch of anterodorsal lateral line nerve: not piercing antotic process [0]; piercing antotic process [1].
- 84. Process on braincase for articulation of infrabranhial 1: absent [0]; present [1].
- 85. Separate lateral ethmoids: absent [0]; present [1].
- 86. Separate basioccipital: absent [0]; present [1].
- 87. Dorsum sellae: small [0]; large and constricting entrance to cranial cavity anterior to the intracranial joint [1].

### **Postcranial Skeleton and Scales**

- 88. Extracleithrum: absent [0]; present [1].
- 89. Anocleithrum: simple [0]; forked [1].
- 90. Posterior neural and haemal spines: abutting one another [0]; not abutting [1].
- 91. Occipital neural arches: not expanded [0]; expanded [1].
- 92. Ossified ribs: absent [0]; present [1].
- 93. Diphyccercal tail: absent [0]; present [1].
- 94. Fin rays more numerous than radials [0]; equal in number [1].
- 95. Fin rays: branched [0]; unbranched [1].
- 96. Fin rays in D1: >10 = [0]; 8 or 9 = [1]; <8 = [2].

97. Caudal lobes: symmetrical [0]; asymmetrical [1].
98. D1: without denticles [0]; with denticles [1].
99. Paired fin rays: not expanded [0]; expanded [1].
100. Pelvics: abdominal [0]; thoracic [1].
101. Basal plate of D1: with smooth ventral margin [0]; emarginated and accommodating the tips of adjacent neural spines [1].
102. D2 basal support: simple [0]; forked anteriorly [1].
103. Median fin rays: not expanded [0]; expanded [1].
104. Scale ornament: not differentiated [0]; differentiated [1].
105. Lateral line openings in scales: single [0]; multiple [1].
106. Scales ornament of: ridges or tubercles [0]; rugose [1].
107. Swim bladder: not ossified [0]; ossified [1].
108. Pelvic bones of each side remain separate [0]; pelvic bones of either side fused in midline [1].
109. Ventral swelling of the palatoquadrate: absent [0]; present [1]. (From Dutel et al., 2012).