

## Dispersal and Diversity in the Earliest North American Sauropodomorph Dinosaurs

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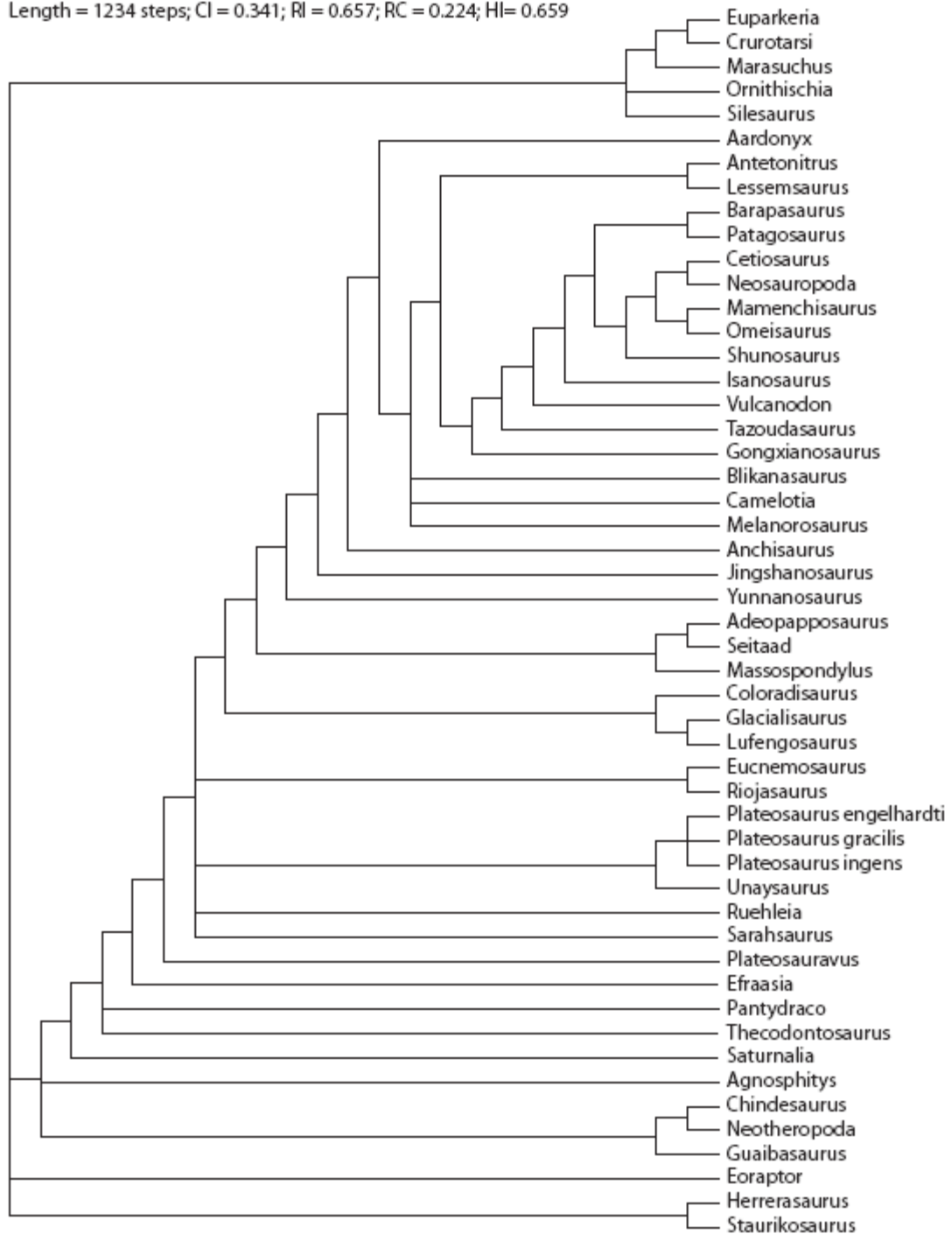
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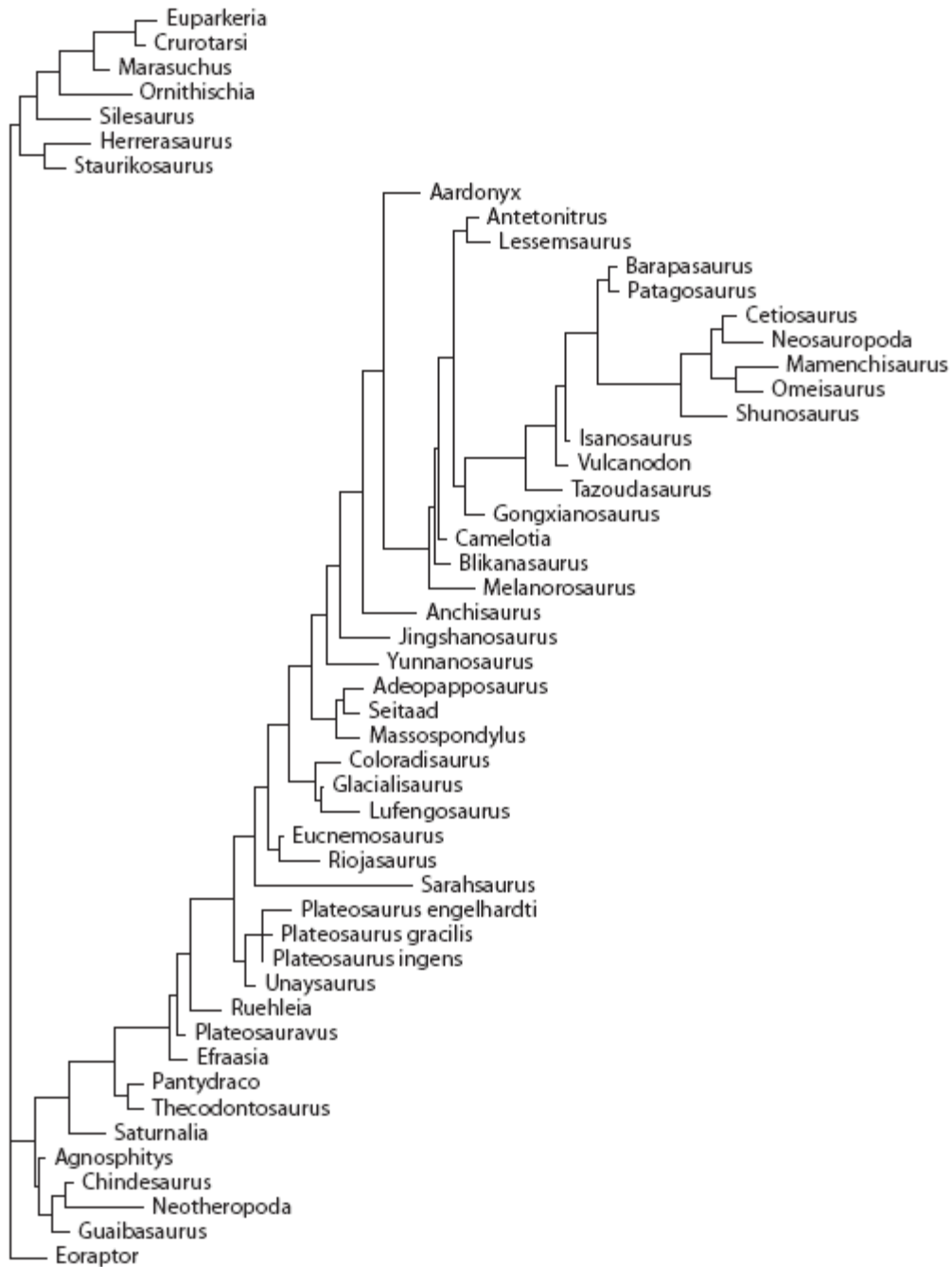
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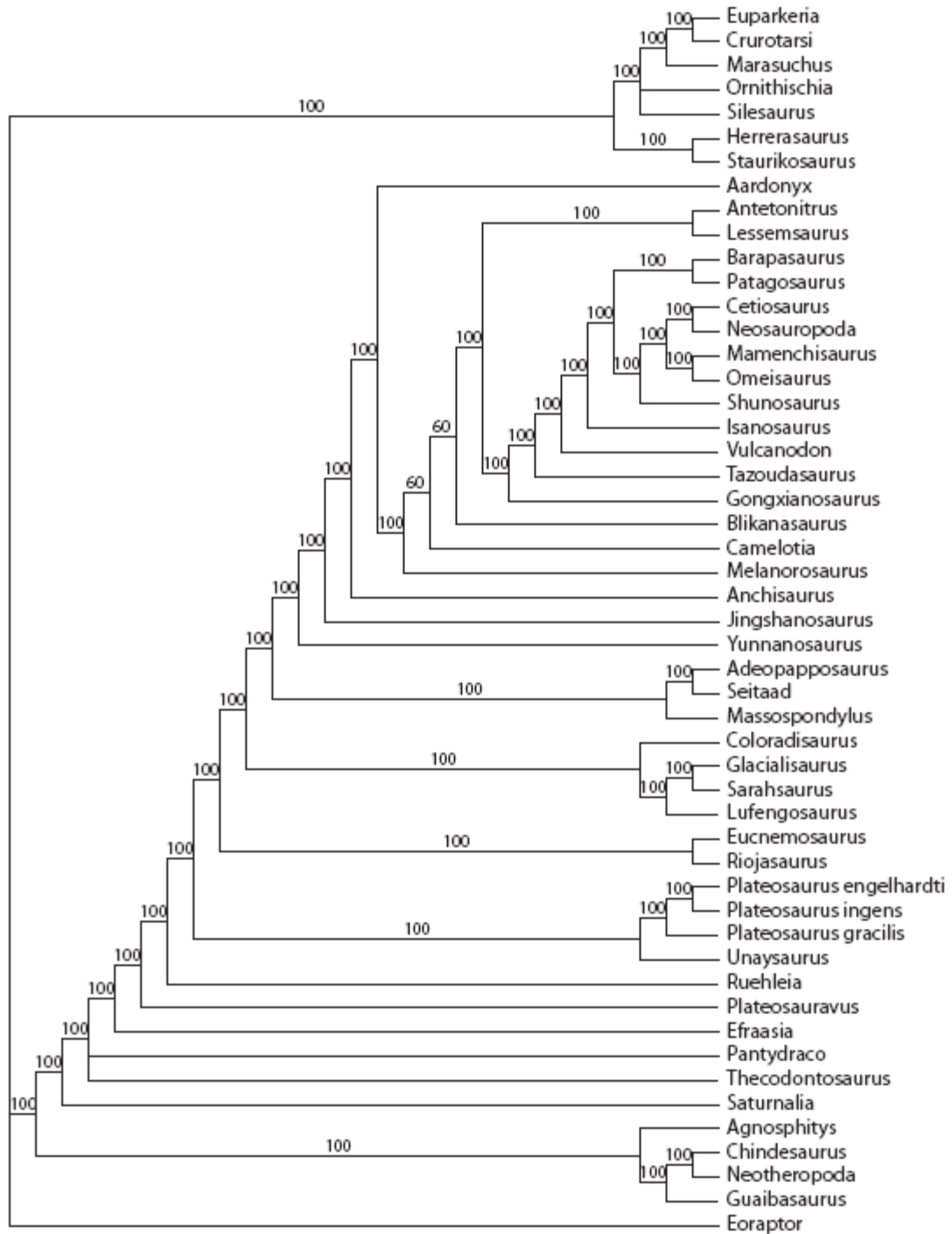
1) Yates (2007) matrix; Strict consensus of 130 equally parsimonious trees  
Length = 1234 steps; CI = 0.341; RI = 0.657; RC = 0.224; HI = 0.659



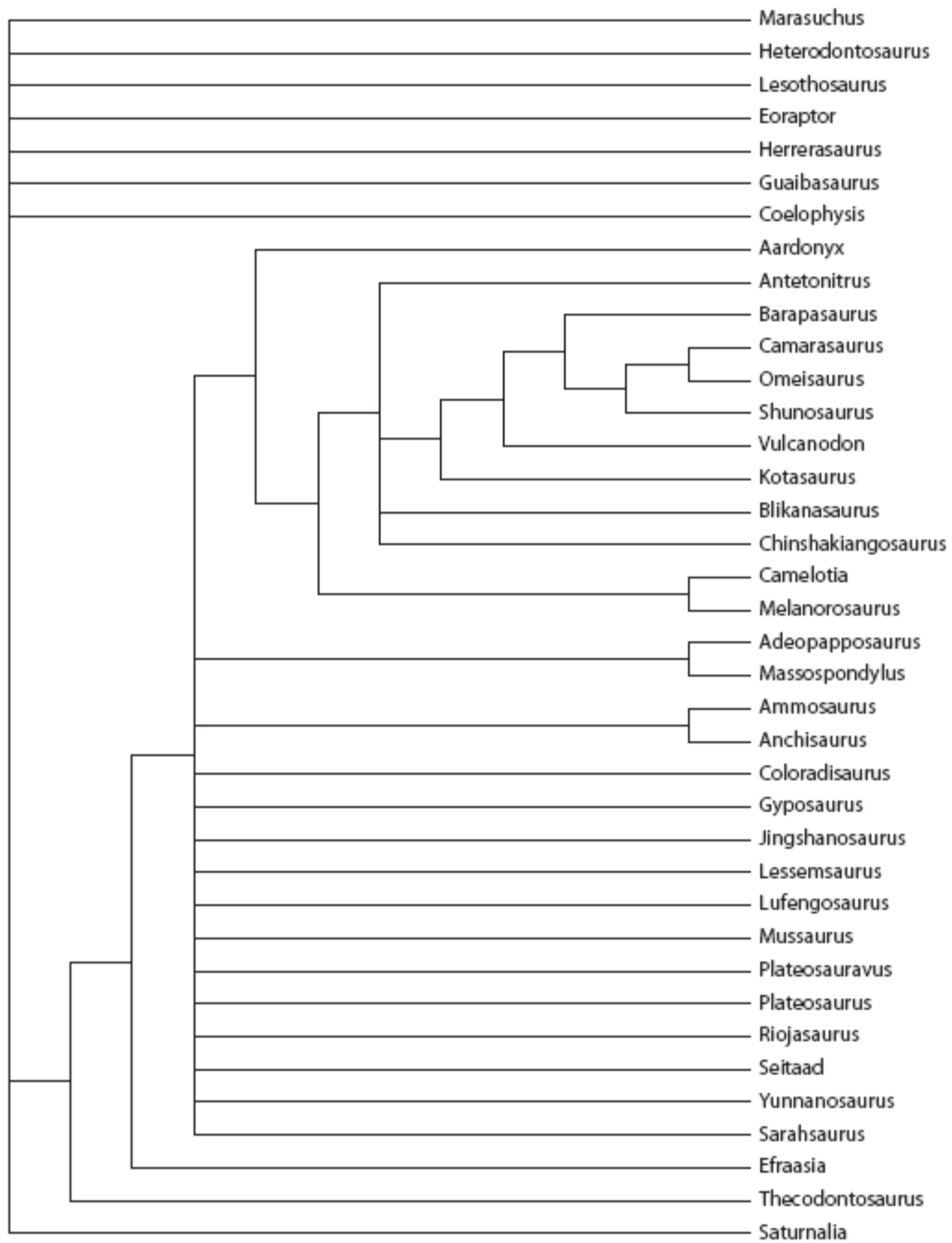
2) Yates (2007) matrix; Adams consensus of 130 equally parsimonious trees  
Length = 1234 steps; CI = 0.341; RI = 0.657; RC = 0.224; HI = 0.659



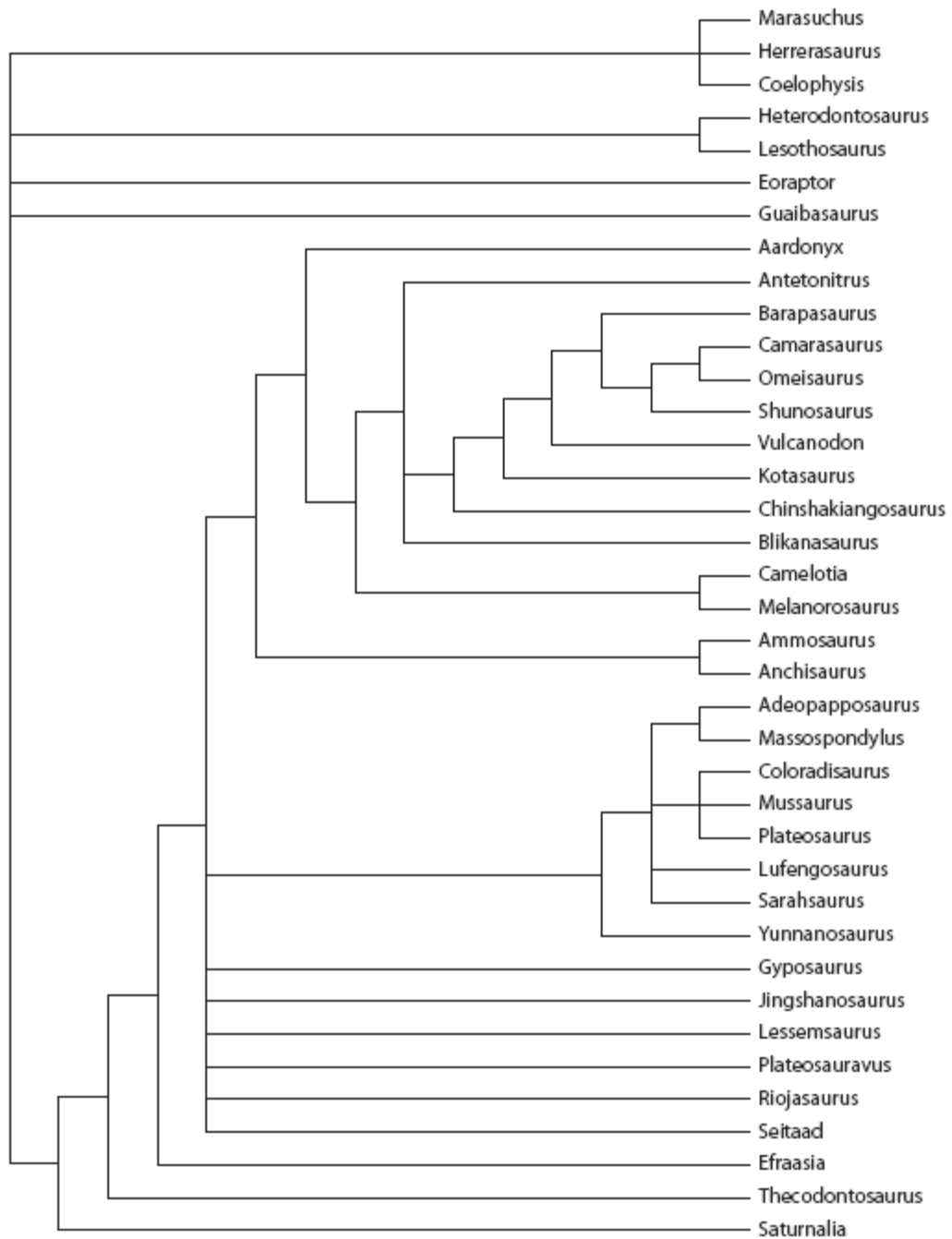
3) Yates (2007) matrix; 50% Majority-rule consensus tree (total evidence).



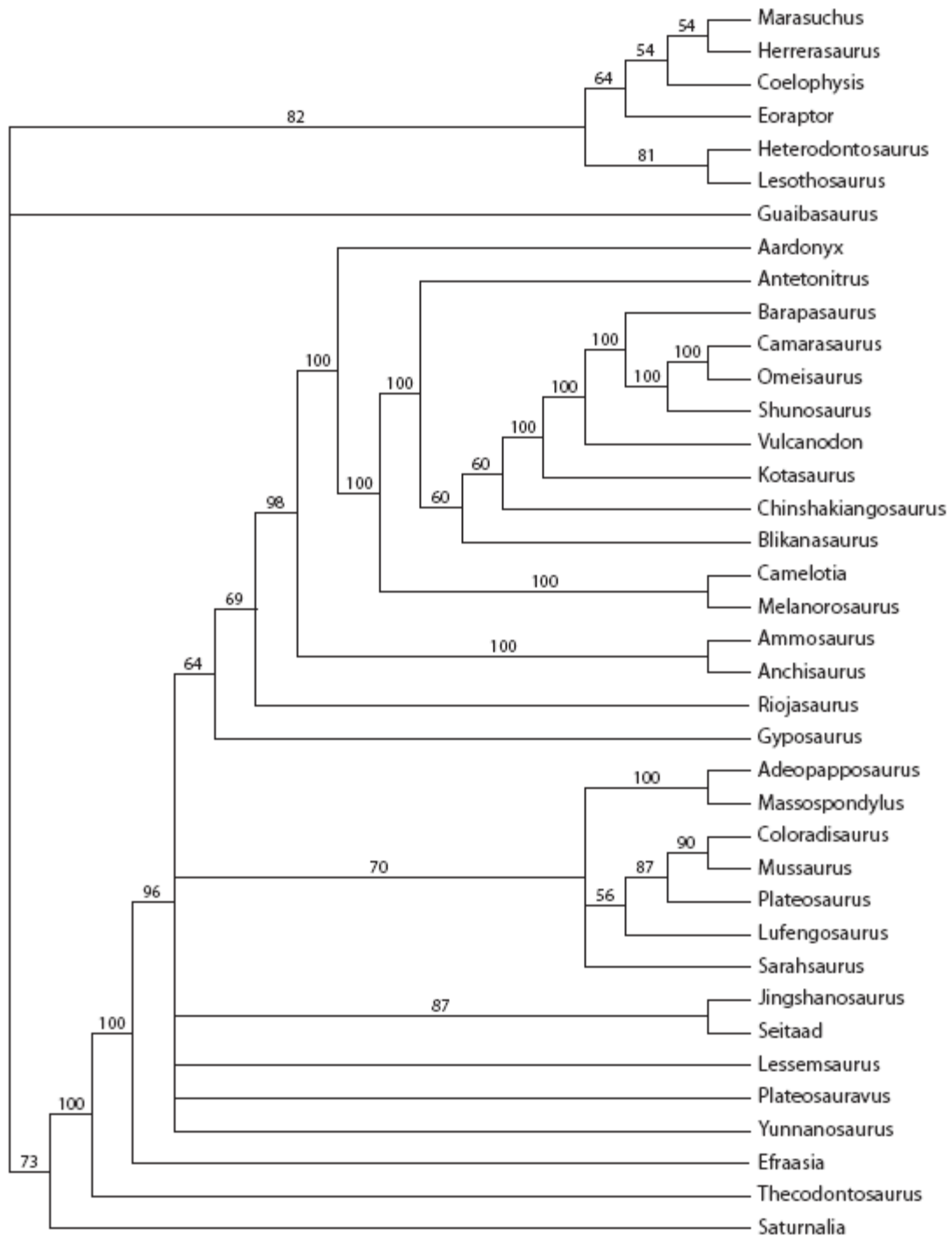
4) Upchurch et al. (2007) matrix; Strict consensus tree based on 3585 equally parsimonious trees;  
Length = 820 steps; CI = 0.365; RI = 0.638; RC = 0.233; HI = 0.635



5) Upchurch et al. (2007) matrix; Adams consensus tree based on 3585 equally parsimonious trees; Length = 820 steps; CI = 0.365; RI = 0.638; RC = 0.233; HI = 0.635 Adams consensus tree



6) Upchurch et al. (2007) matrix; Majority-rule consensus tree (total evidence).



7) Yates (2007) matrix, only taxa 50% or more complete (plus Seitaad)

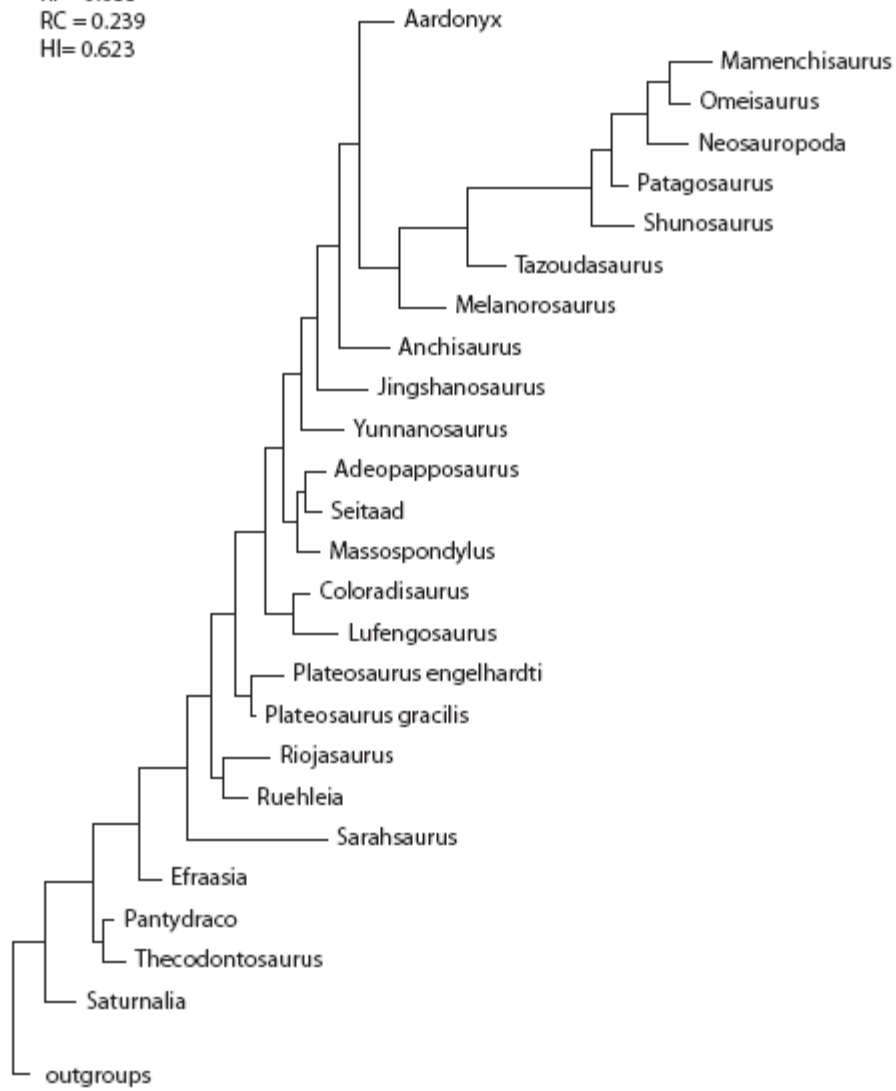
Length = 1110 steps

CI = 0.377

RI = 0.635

RC = 0.239

HI = 0.623





8) Upchurch et al. (2007) matrix; Single most parsimonious tree based on taxa 50% or more complete (plus Seitaad); Length = 695 steps; CI = 0.429; RI = 0.620; RC = 0.266; HI= 0.571

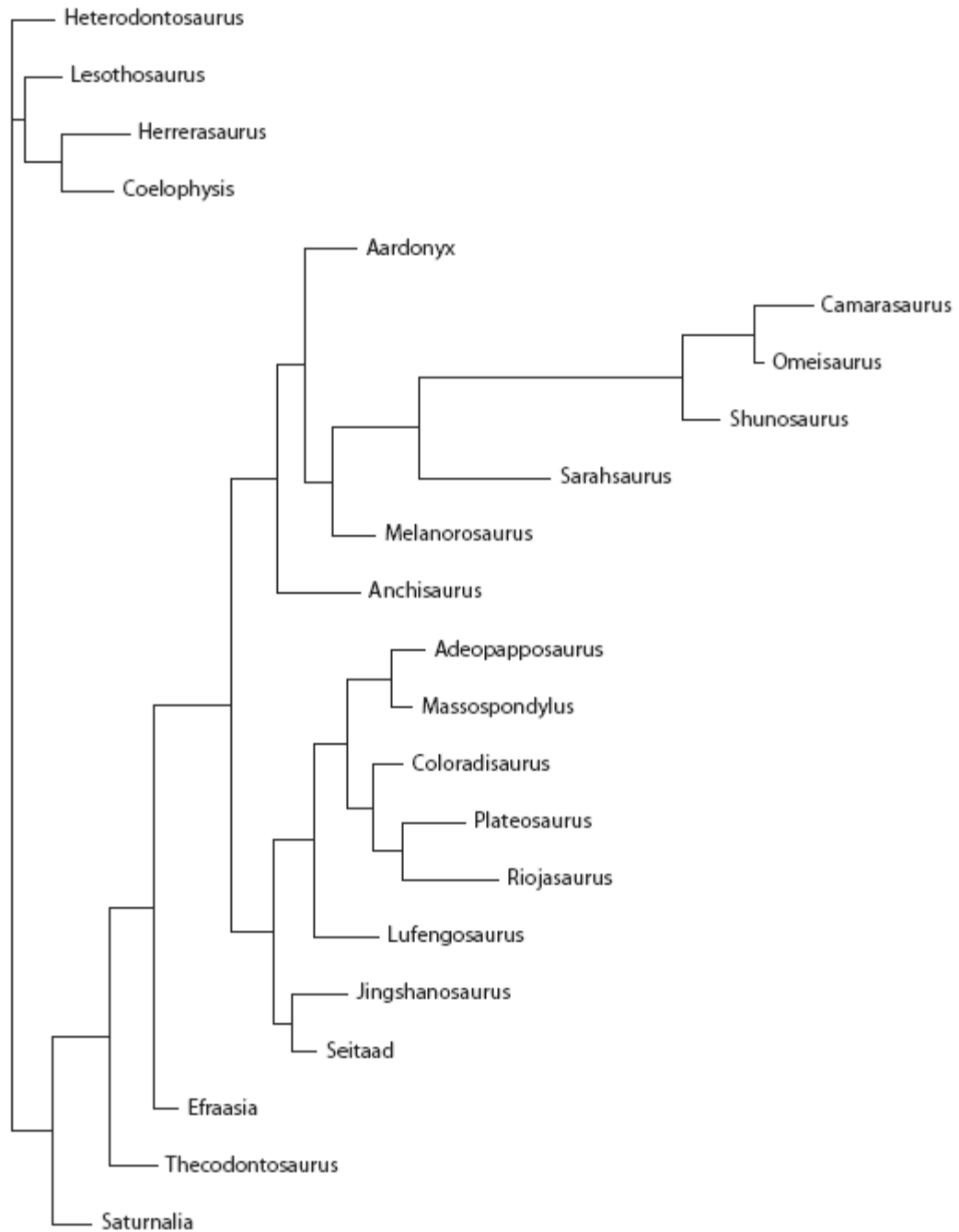


Table 1 Yates Matrix: Reduced Cladistic Consensus Trees

```
*****
* REDCON 3.0 REDUCED CONSENSUS PROGRAMS *
* STRICT - Computes Strict basic RCC/RPC *
* profiles *
* *
* *
* Department of Zoology *
* The Natural History Museum *
* marw@nhm.ac.uk *
*****
```

Strict Reduced Cladistic Consensus Profile 17/8/2010  
10 trees input from Yates1a.tre

Partition table of 46 n-taxon statements

111111111122222222223333333333444444444455  
12345678901234567890123456789012345678901

```
-----
1 .....*.....*.....
2 .....*.....*.....
3 .....*.....*.....
4 .....*.....*.....
5 .....*.....**.....
6 .....*.....***.....
7 .....**.....****.....
8 .....**.....*****.....
9 .....**.....*****.....
10 .....**.....*****.....
11 .....**.....*****.....
12 .....**.....*****.....
13 .....*****.....
14 .....*****.....
15 .....*****.....
16 .....*****.....
17 .....*****.....
18 .....*.....*.....
19 .....*.....*.....
20 .....*****.....**.....
21 .....*.....*.....
22 .....*.....*.....
```

```

23 ...**.*.....*...**.*.....*.....**.*...
24 .....*.....*.....
25 .....***.....
26 .....***.....*.....
27 ...**.*.....*...**.*.....*.....**.*.....**.*.....
28 .....*.....*.....
29 .....*.....*.....*.....
30 .....*.....**.....*.....
31 ...**.*.....*...**.*.....**.*.....*.....**.*.....**.*.....**.*.....
32 ...**.*.....*...**.*.....**.*.....*.....**.*.....**.*.....**.*.....
33 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
34 .....*.....*.....
35 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
36 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
37 .....*.....*.....
38 .....*.....*.....*.....
39 .....*.....*.....*.....*.....
40 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
41 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
42 .....*.....*.....
43 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
44 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
45 ...**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....**.*.....
46 .....**.*.....*.....*.....*.....*.....*.....*.....*.....

```

Groupings of n-taxon statements into 2 basic RCC trees

(1) STRICT COMPONENT CONSENSUS - ALL LEAVES

Including 45 Statements: 1-45

(2) - Excluding leaf 11

Including 46 Statements: 1-46

#NEXUS

begin trees;

Translate

- 1 Euparkeria,
- 2 Crurotarsi,
- 3 Marasuchus,
- 4 Aardonyx,
- 5 Adeopapposaurus,

- 6 Agnosphitys,
- 7 Anchisaurus,
- 8 Antetonitrus,
- 9 Barapasaurus,
- 10 Blikanasaurus,
- 11 Camelotia,
- 12 Cetiosaurus,
- 13 Chindesaurus,
- 14 Coloradisaurus,
- 15 Efraasia,
- 16 Eoraptor,
- 17 Eucnemosaurus,
- 18 Gongxianosaurus,
- 19 Glacialisaurus,
- 20 Guaibasaurus,
- 21 Herrerasaurus,
- 22 Isanosaurus,
- 23 Jingshanosaurus,
- 24 Lessemsaurus,
- 25 Lufengosaurus,
- 26 Mamenchisaurus,
- 27 Massospondylus,
- 28 Melanorosaurus,
- 29 Neosauropoda,
- 30 Neotheropoda,
- 31 Omeisaurus,
- 32 Ornithischia,
- 33 Pantydraco,
- 34 Patagosaurus,
- 35 Plateosaurus\_engelhardti,
- 36 Plateosaurus\_gracilis,
- 37 Plateosaurus\_ingens,
- 38 Plateosauravus,
- 39 Riojasaurus,
- 40 Ruehleia,
- 41 Saturnalia,
- 42 Seitaad,
- 43 Shunosaurus,
- 44 Silesaurus,
- 45 Staurikosaurus,
- 46 Tazoudasaurus,
- 47 Thecodontosaurus,
- 48 Unaysaurus,
- 49 Vulcanodon,
- 50 Yunnanosaurus,
- 51 Sarahsaurus

utree SRCC1 =

```
((((((((((((((((((((((((((((((((12,29),(26,31)),43),(9,34)),22),49),46),18),(8,24)),10,11,28),4),7),23),50),(5,42),27),),((19,25),14),),((35,37),36),48),),(((17,39),51),40),),38),15),(33,47)),41),(((13,30),20),6),),16),(21,45)),32,44),3),1,2);
```

utree SRCC2 =

```
((((((((((((((((((((((((((((((((12,29),(26,31)),43),(9,34)),22),49),46),18),(8,24)),10),28),4),7),23),50),(5,42),27),),((19,25),14),),((35,37),36),48),),(((17,39),51),40),),38),15),(33,47)),41),(((13,30),20),6),),16),(21,45)),32,44),3),1,2);
```

end;

Table 2 Upchurch et al. Matrix: Reduced Cladistic Consensus Trees

```

*****
* REDCON 3.0 REDUCED CONSENSUS PROGRAMS *
* STRICT - Computes Strict basic RCC/RPC *
* profiles *
* *
* *
* Department of Zoology *
* The Natural History Museum *
* marw@nhm.ac.uk *
*****

```

Strict Reduced Cladistic Consensus Profile 17/8/2010  
1000 trees input from Upchurch.tr

Partition table of 26 n-taxon statements

```

1111111111222222222333333333
12345678901234567890123456789012345678

```

---

1	.....*	.....*	.....
2	.....*	.....*	.....*
3	.....*	.....*	.....*
4	.....*	.....*	.....*
5	.....*	.....*	.....*
6	.....*	.....*	.....*
7	.....*	.....*	.....*
8	.....*	.....*	.....*
9	.....*	.....*	.....*
10	.....*	.....*	.....*
11	.....*	.....*	.....*
12	.....*	.....*	.....*
13	.....*	.....*	.....*
14	.....*	.....*	.....*
15	.....*	.....*	.....*
16	.....*	.....*	.....*
17	.....*	.....*	.....*
18	.....*	.....*	.....*
19	.....*	.....*	.....*
20	.....*	.....*	.....*
21	.....*	.....*	.....*
22	.....*	.....*	.....*

23 .....\*.....\*..?..?\*\*\*.\*.?\*..?..\*\*  
24 .....?.....\*..?..\*?..\*..\*..?.....?  
25 .....\*.....?..?..?\*.?..?..?.....\*  
26 .\*\*..?..????????????????????????????????  
-----

Groupings of n-taxon statements into 13 basic RCC trees

(1) STRICT COMPONENT CONSENSUS - ALL LEAVES

Including 14 Statements: 1-14

(2) - Excluding leaf 33

Including 15 Statements: 1-15

(3) - Excluding leaf 29

Including 15 Statements: 1-14 16

(4) - Excluding leaf 14

Including 15 Statements: 1-14 17

(5) - Excluding leaf 30

Including 15 Statements: 1-14 18

(6) - Excluding leaf 6

Including 15 Statements: 1-14 19

(7) - Excluding 2 leaves: 4 6

Including 16 Statements: 1-14 19-20

(8) - Excluding 2 leaves: 6-7

Including 16 Statements: 1-14 19 21

(9) - Excluding 3 leaves: 20 29 33

Including 17 Statements: 1-16 22

(10) - Excluding 4 leaves: 20 23 29 33

Including 18 Statements: 1-16 22-23

(11) - Excluding 5 leaves: 9 20 25 33 38

Including 15 Statements: 1-10 12-15 24

(12) - Excluding 6 leaves: 18 20 24 27 30 33

Including 15 Statements: 1-14 25

(13) - Excluding 32 leaves: 6 8-38

Including 1 Statement: 26

#NEXUS

begin trees;

Translate

- 1 Marasuchus,
  - 2 Heterodontosaurus,
  - 3 Lesothosaurus,
  - 4 Eoraptor,
  - 5 Herrerasaurus,
  - 6 Guaibasaurus,
  - 7 Coelophysis,
  - 8 Aardonyx,
  - 9 Adeopapposaurus,
  - 10 Ammosaurus,
  - 11 Anchisaurus,
  - 12 Antetonitrus,
  - 13 Barapasaurus,
  - 14 Blikanasaurus,
  - 15 Camarasaurus,
  - 16 Camelotia,
  - 17 Chinshakiangosaurus,
  - 18 Coloradisaurus,
  - 19 Efraasia,
  - 20 Gyposaurus,
  - 21 Jingshanosaurus,
  - 22 Kotasaurus,
  - 23 Lessemsaurus,
  - 24 Lufengosaurus,
  - 25 Massospondylus,
  - 26 Melanorosaurus,
  - 27 Mussaurus,
  - 28 Omeisaurus,
  - 29 Plateosauravus,
  - 30 Plateosaurus,
  - 31 Riojasaurus,
  - 32 Saturnalia,
  - 33 Seitaad,
  - 34 Shunosaurus,
  - 35 Thecodontosaurus,
  - 36 Vulcanodon,
  - 37 Yunnanosaurus,
  - 38 Sarahsaurus
- ;



```
utree SRCC1 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11),(9,25),18,20,21,23,24,27,2
9,30,31,33,37,38),19),35),1,2,3,4,5,6,7,32);
utree SRCC2 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11),(9,25),(18,27,30),20,21,23,
24,29,31,37,38),19),35),1,2,3,4,5,6,7,32);
utree SRCC3 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11)),(9,25),18,20,21,23,24,27,
30,31,33,37,38),19),35),1,2,3,4,5,6,7,32);
utree SRCC4 =
(((((((((((15,28),34),13),36),22),17),12),(16,26)),8),(10,11),(9,25),18,20,21,23,24,27,29,
30,31,33,37,38),19),35),1,2,3,4,5,6,7,32);
utree SRCC5 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11),(9,25),(18,27),20,21,23,24,
29,31,33,37,38),19),35),1,2,3,4,5,6,7,32);
utree SRCC6 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11),(9,25),18,20,21,23,24,27,2
9,30,31,33,37,38),19),35),32),1,2,3,4,5,7);
utree SRCC7 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11),(9,25),18,20,21,23,24,27,
29,30,31,33,37,38),19),35),32),2,3),1,5,7);
utree SRCC8 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11),(9,25),18,20,21,23,24,27,
29,30,31,33,37,38),19),35),32),2,3,4),1,5);
utree SRCC9 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11)),(9,25),(18,27,30),24,38),
21,23,31,37),19),35),1,2,3,4,5,6,7,32);
utree SRCC10 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11)),((9,25),(18,27,30),24,38)
,37),21,31),19),35),1,2,3,4,5,6,7,32);
utree SRCC11 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11)),(18,27,30),24),21,23,29,3
1,37),19),35),1,2,3,4,5,6,7,32);
utree SRCC12 =
(((((((((((15,28),34),13),36),22),12,14,17),(16,26)),8),(10,11)),(9,25),38),21,23,29,31,37)
,19),35),1,2,3,4,5,6,7,32);
utree SRCC13 = ((2,3),1,4,5,7);

end;
```

TABLE 3  
 COMPLETENESS OF TAXA SCORED IN YATES (2007) MATRIX  
 (361 CHARACTERS TOTAL)

<u>taxon</u>	<u>missing data</u>	<u>characters scored</u>	<u>completeness</u>
<u>Outgroups</u>			
Euparkeria	72	289	80%
Chindesaurus	296	65	18%
Crurotarsi	27	334	93%
Eoraptor	149	212	59%
Guaibasaurus	243	118	33%
Herrerasaurus	17	344	95%
Marasuchus	162	199	55%
Neotheropoda	7	354	98%
Silesaurus	113	248	69%
Staurikosaurus	212	149	41%
<u>Ingroup</u>			
Aardonyx	162	199	55%
Adeopapposaurus	28	333	92%
Agnosphitys	302	59	16%
Anchisaurus	86	275	76%
Antetonitrus	221	140	39%
Barapasaurus	261	100	28%
Blikanasaurus	306	55	15%
Camelotia	301	60	17%
Cetiosaurus	228	133	37%
Coloradisaurus	90	271	75%
Efraasia	65	296	82%
Eucnemosaurus	298	63	17%
Gongxianosaurus	276	85	24%
Glacialisaurus	333	28	07%
Isanosaurus	327	34	09%
Jingshanosaurus	73	288	80%
Lessemsaurus	222	139	38%
Lufengosaurus	28	333	92%
Mamenchisaurus	53	308	85%
Massospondylus	8	353	98%
Melanorosaurus	40	321	89%
Neosauropoda	16	345	96%
Omeisaurus	54	307	85%
Ornithischia	21	340	94%
Pantydraco	175	186	52%
Patagosaurus	212	149	41%
Plateosaurus engelhardti	0	361	100%
Plateosaurus gracilis	145	216	60%
Plateosaurus ingens	346	15	05%

Plateosauravus	237	124	34%
Riojasaurus	42	313	87%
Ruehleia	206	155	57%
Sarhsaurus	27	334	92%
Saturnalia	138	223	62%
Seitaad	251	100	29%
Shunosaurus	56	305	84%
Tazoudasaurus	179	182	50%
Thecodontosaurus	117	244	68%
Unaysaurus	214	147	41%
Vulcanodon	249	112	31%
Yunnanosaurus	79	286	79%

TABLE 4  
 COMPLETENESS OF TAXA SCORED IN UPCHURCH MATRIX  
 (292 CHARACTERS TOTAL)

taxon	missing data	characters scored	completeness
<u>Outgroups</u>			
Coelophysis	25	267	91%
Eoraptor	152	140	48%
Guaibasaurus	200	92	31%
Herrerasaurus	19	272	94%
Heterodontosaurus	83	209	72%
Lesothosaurus	65	227	78%
Marasuchus	173	119	41%
<u>Ingroup</u>			
Aardonyx	130	162	55%
Adeopapposaurus	2	290	99%
Ammosaurus	223	69	24%
Anchisaurus	72	220	75%
Antetonitrus	188	104	36%
Barapasaurus	191	101	35%
Blikanasaurus	256	36	12%
Camarasaurus	21	271	93%
Camelotia	258	34	12%
Chinshakiangosaurus	271	21	07%
Coloradisaurus	106	186	64%
Efraasia	80	212	73%
Gyposaurus	188	104	36%
Jingshanosaurus	69	223	76%
Kotasaurus	188	104	36%
Lessemsaurus	280	12	04%
Lufengosaurus	42	250	86%
Massospondylus	10	282	97%
Melanorosaurus	138	154	53%
Mussaurus	219	73	25%
Omeisaurus	41	251	86%
Plateosaurus	3	289	99%
Plateosauravus	223	69	24%
Riojasaurus	37	255	87%
Sarahsaurus	28	264	90%
Saturnalia	138	154	53%
Seitaad	212	80	27%
Shunosaurus	25	267	91%
Thecodontosaurus	54	238	82%
Vulcanodon	183	109	37%
Yunnanosaurus	149	143	49%

Table 5

*Sarahsaurus* diagnostic apomorphies, based on the Upchurch et al. (2007) matrix; based on the 50% or more complete taxon tree (ESM Figure 3); character numbers refer to characters described in ESM Table 1

*Sarahsaurus* branch length = 61 characters

Character #	state change (from x to y)
12	0-1
23	0-1
45	0-1
50	0-1
58	1-0
68	1-0
77	1-0
81	0-1
87	0-1
108	2-1
123	0-1
130	0-1
132	1-0
135	0-1
136	0-1
138	0-1
144	0-1
146	0-1
158	1-0
159	0-1
160	0-1
161	0-1
167	0-1
174	0-1
183	0-1
188	0-1
198	0-1
200	1-0
204	1-0
206	1-0
208	0-1
214	0-1
215	0-1
241	0-1
244	0-2
245	0-1
247	1-0

254	0-1
262	0-1
264	0-1
269	0-1
273	0-1
280	0-2
281	0-1
284	1-0
287	1-0
288	0-1
290	0-1
296	0-1
305	0-1
307	1-0
316	1-0
318	0-1
322	0-1
324	0-1
326	0-1
331	0-1
332	0-1
341	1-0
344	0-1
348	0-1

Table 6

*Sarahsaurus* diagnostic apomorphies, based on the Upchurch et al. (2007) matrix; based on the 50% or more complete taxon tree (ESM Figure 6); character numbers refer to characters described in ESM Table 3

*Sarahsaurus* branch length = 35 characters

Character #	state change (from x to y)
3	1-0
22	0-1
33	0-1
39	0-1
58	0-1
61	0-2
62	2-0
63	2-1
64	1-0
68	0-1
98	1-0
99	1-0
125	0-1
126	0-1
127	1-0
128	0-1
137	0-1
141	0-1
145	1-0
161	1-0
167	0-1
169	1-0
178	1-0
184	1-0
191	1-0
201	1-0
203	0-1
215	0-1
219	0-1
222	0-2
225	1-0
263	1-0
269	1-0
281	1-0
286	1-0

Table 7

Yates (2007) character list (characters 1-353), plus additional characters from Smith and Pol 2007 (characters 354-361), used to score *Sarhsaurus* in an analysis, with minor alterations as noted.

1) Skull to femur ratio: greater than (0), or less than (1), 0.6.

*Sarhsaurus* (1)

2) Lateral plates appressed to the labial side of the premaxillary, maxillary, and dentary teeth: absent (0), or present (1).

*Sarhsaurus* (0)

3) Relative height of the rostrum at the posterior margin of the naris: more than (0), or less than (1), 0.6 of the height of the skull at the middle of the orbit.

*Sarhsaurus* (?)

4) Foramen on lateral surface of premaxillary body: absent (0), or present (1).

*Sarhsaurus* (1)

5) Distal end of the dorsal premaxillary process: tapered (0), or transversely expanded (1).

*Sarhsaurus* (0)

6) Profile of premaxilla: convex (0), or with an inflection at the base of the dorsal process (1).

*Sarhsaurus* (0)

7) Size and position of the posterolateral process of premaxilla: large and lateral to anterior process of the maxilla (0), or small and medial to anterior process of maxilla (1).

*Sarhsaurus* (0)

8) Relationship between posterolateral process of the premaxilla and the anteroventral process of the nasal: broad sutured contact (0), point contact (1), or separated by maxilla (2).

*Sarhsaurus* (?)

9) Posteromedial process of premaxilla: absent (0) or present (1).

*Sarhsaurus* (1)

Note: polarity of this character is probably backward as scored by Yates, but for the sake of consistency we do not alter it here.

10) Shape of the anteromedial process of the maxilla: narrow, elongated and projecting anterior to lateral premaxilla-maxilla suture (0), or short, broad and level with lateral premaxilla-maxilla suture (1).

*Sarhsaurus* (0)



11) Development of external narial fossa: absent or weak (0) or well developed with sharp posterior and anteroventral rims (1).

Sarhsaurus (?)

12) Development of narial fossa on the anterior ramus of the maxilla: weak and oriented laterally to dorsolaterally (0), or well developed and forming a horizontal shelf (1).

Sarhsaurus (1)

13) Size and position of subnarial foramen: absent (0), small (no larger than adjacent maxillary neurovascular foramina) and positioned outside of narial fossa (1), or large and on the rim of, or inside, the narial fossa (2).

Sarhsaurus (1)

14) Shape of subnarial foramen: rounded (0), or slot-shaped (1).

Sarhsaurus (0)

15) Maxillary contribution to the margin of the narial fossa: absent (0), or present (1).

Sarhsaurus (1)

16) Diameter of external naris: less than (0), or greater than (1) 0.5 of the orbital diameter.

Sarhsaurus (0)

17) Shape of external naris (in adults): rounded (0), or subtriangular with an acute posteroventral corner (1).

Sarhsaurus (?)

18) Level of the anterior margin of the external naris: anterior to (0), or posterior to (1) the midlength of the premaxillary body.

Sarhsaurus (1)

19) Level of the posterior margin of external naris: anterior to, or level with the premaxilla-maxilla suture (0), posterior to the first maxillary alveolus (1), or posterior to the midlength of the maxillary tooth row and the anterior margin of the antorbital fenestra (2).

Sarhsaurus (1)

20) Dorsal profile of the snout: straight to gently convex (0) or with a depression behind the naris (1).

Sarhsaurus (?)

21) Elongate median nasal depression: absent (0), or present (1).

Sarhsaurus (1)

22) Width of anteroventral process of nasal at its base: less than (0), or greater than (1) width of anterodorsal process at its base.

*Sarhsaurus* (?)

23) Nasal relationship with dorsal margin of antorbital fossa: not contributing to the margin of the antorbital fossa (0), lateral margin overhangs the antorbital fossa and forms its dorsal margin (1), overhang extensive, obscuring the dorsal lacrimal-maxillary contact in lateral view (2).

*Sarhsaurus* (1)

24) Pointed caudolateral process of the nasal overlapping the lacrimal: absent (0), or present (1).

*Sarhsaurus* (?)

25) Anterior profile of maxilla: slopes continuously towards the rostral tip (0), or with strong inflection at the base of the ascending ramus, creating a rostral ramus with parallel dorsal and ventral margins (1).

*Sarhsaurus* (0)

26) Length of rostral ramus of the maxilla: less than (0), or greater than (1), its dorsoventral depth.

*Sarhsaurus* (1)

27) Shape of main body of maxilla: tapering posteriorly (0) or dorsal and ventral margins parallel for most of their length (1).

*Sarhsaurus* (1)

28) Shape of the ascending ramus of the maxilla in lateral view: tapering dorsally (0) or with an anteroposterior expansion at the dorsal end (1).

*Sarhsaurus* (0)

29) Rostrocaudal length of the antorbital fossa: greater (0), or less (1), than that of the orbit.

Note: We interpret “antorbital fossa” to mean “antorbital fenestra” in this instance.

*Sarhsaurus* (1)

30) Posteroventral extent of medial wall of antorbital fossa: reaching (0), or terminating anterior to (1), the anterior tip of the jugal.

*Sarhsaurus* (1)

31) Development of the antorbital fossa on the ascending ramus of the maxilla: deeply impressed and delimited by a sharp, scarp-like rim (0), or weakly impressed and delimited by a rounded rim or a change in slope (1).

*Sarhsaurus* (0)

32) Shape of the antorbital fossa: crescentic with a strongly concave posterior margin that is roughly parallel to the rostral margin of the antorbital fossa (0), subtriangular with a straight to gently concave posterior margin (1), or antorbital fossa absent (2).

Sarahsaurus (1)

33) Size of the neurovascular foramen at the caudal end of the lateral maxillary row: not larger than the others (0), or distinctly larger than the others in the row (1).

Sarahsaurus (0)

34) Direction of the neurovascular foramen at the caudal end of the lateral maxillary row opens: caudally (0), or rostrally, ventrally, and laterally (1).

Sarahsaurus (0)

Note: comparable to Upchurch character 17, but with reversed polarity

35) Arrangement of lateral maxillary neurovascular foramina: linear (0), or irregular (1).

Sarahsaurus (0).

36) Longitudinal ridge on the posterior lateral surface of the maxilla: absent (0), or present (1).

Sarahsaurus (0)

37) Dorsal exposure of the lacrimal: present (0), or absent (1).

Sarahsaurus (0)

38) Shape of lacrimal: dorsoventrally short and block-shaped (0), or dorsoventrally elongate and shaped like an inverted L (1).

Sarahsaurus (1)

39) Orientation of the lacrimal orbital margin: strongly sloping anterodorsally (0), or erect and close to vertical (1).

Sarahsaurus (0)

40) Length of anterior ramus of the lacrimal: greater than (0), or less than (1) half the length of the ventral ramus, or absent altogether (2).

Sarahsaurus (0)

41) Web of bone spanning junction between anterior and ventral rami of lacrimal: absent and antorbital fossa laterally exposed (0) or present and obscuring posterodorsal corner of antorbital fossa (1).

Sarahsaurus (0)

42) Extension of the antorbital fossa onto the ventral end of the lacrimal: present (0) or absent (1)

Sarahsaurus (0)

43) Length of the caudal process of the prefrontal: short (0), or elongated (1), so that the total prefrontal length is equal to the rostrocaudal diameter of the orbit.

Sarhsaurus (1)

44) Ventral process of prefrontal extending down the posteromedial side of the lacrimal: present (0), or absent (1).

Sarhsaurus (0)

45) Maximum transverse width of the prefrontal: less than (0), or more than (1) 0.25 of the skull width at that level.

Sarhsaurus (1)

46) Shape of orbit: subcircular (0) or ventrally constricted making the orbit subtriangular (1).

Sarhsaurus (0)

47) Slender anterior process of the frontal intruding between the prefrontal and nasal: absent (0), or present (1).

Sarhsaurus (0)

48) Jugal-lacrimal relationship: lacrimal overlapping lateral surface of jugal or abutting it dorsally (0), or jugal overlapping lacrimal laterally (1).

Sarhsaurus (1)

49) Shape of the suborbital region of the jugal: an anteroposterior elongate bar (0) or an anteroposteriorly shortened plate.

Sarhsaurus (0)

50) Jugal contribution to the antorbital fenestra: present (0), or absent (1).

Sarhsaurus (1)

51) Dorsal process of the anterior jugal: present (0) or absent (1).

Sarhsaurus (1)

52) Ratio of the minimum depth of the jugal below the orbit to the distance between the rostral end of the jugal and the rostroventral corner of the infratemporal fenestra: less than (0), or greater than (1) 0.2.

Sarhsaurus (1)

53) Transverse width of the ventral ramus of the postorbital: less than (0), or greater than (1) its rostrocaudal width at midshaft.

Sarhsaurus (0)

54) Shape of the dorsal margin of postorbital in lateral view: straight to gently curved (0) or with a distinct embayment between the anterior and posterior dorsal processes (1).

Sarhsaurus (0)

55) Height of the postorbital rim of the orbit: flush with the posterior lateral process of the postorbital (0) or raised so that it projects laterally to the posterior dorsal process.  
Sarahsaurus (0)

56) Postfrontal bone: present (0) or absent (1).  
Sarahsaurus (1)

57) Position of the rostral margin of the infratemporal fenestra: behind the orbit (0), or extends under the rear half of the orbit (1), or extends as far forward as the midlength of the orbit (2).  
Sarahsaurus (1)

58) Frontal contribution to the supratemporal fenestra: present (0), or absent (1).  
Sarahsaurus (0)

59) Orientation of the long axis of the supratemporal fenestra: longitudinal (0) or transverse (1).  
Sarahsaurus (0)

60) Medial margin of supratemporal fossa: simple smooth curve (0), or with a projection at the frontal/postorbital-parietal suture producing a scalloped margin (1).  
Sarahsaurus (0)

61) Length of the quadratojugal ramus of the squamosal relative to the width at its base: less than (0), or greater than (1) four times its width.  
Sarahsaurus (1)

62) Proportion of infratemporal fenestra bordered by squamosal: more than (0) or less than (1), 0.5 of the depth of the infratemporal fenestra.  
Sarahsaurus (0)

Note: polarity of this character is probably backward as scored by Yates, but for the sake of consistency we do not alter it here.

63) Squamosal-quadratojugal contact: present (0) or absent (1).  
Sarahsaurus (?)

64) Angle of divergence between jugal and squamosal rami of quadratojugal: close to 90 degrees (0), or close to parallel.  
Sarahsaurus (0)

65) Length of jugal ramus of quadratojugal: no longer than (0), or longer than (1), the squamosal ramus.  
Sarahsaurus (?)

66) Shape of the rostral end of the jugal ramus of the quadratojugal: tapered (0) or dorsoventrally expanded (1).

Sarhsaurus (?)

67) Relationship of quadratojugal to jugal: jugal overlaps the lateral surface of the quadratojugal (0), or quadratojugal overlaps the lateral surface of the jugal (1), or quadratojugal sutures along the ventrolateral margin of the jugal (2).

Sarhsaurus (?)

68) Position of the quadrate foramen: on the quadrate-quadratojugal suture (0), deeply incised into, and partly encircled by, the quadrate (1), or on the quadrate-squamosal suture, just below the quadrate head (2).

Sarhsaurus (0)

69) Shape of posterolateral margin of quadrate: sloping anterolaterally from posteromedial ridge (0), everted posteriorly creating a posteriorly facing fossa (1), posterior fossa deeply excavated, invading quadrate body (2).

Sarhsaurus (0)

70) Exposure of the lateral surface of the quadrate head: absent, covered by lateral sheet of the squamosal (0) or present (1).

Sarhsaurus (1)

71) Proportion of the length of the quadrate that is occupied by the pterygoid wing: at least 70 percent (0) or greater than 70 percent (1).

Sarhsaurus (0)

Note: polarity reversed from Upchurch #55.

72) Depth of occipital wing of the parietal: less than (0), or more than (1) 1.5 times the depth of the foramen magnum.

Sarhsaurus (0)

73) Position of foramen for mid-cerebral vein on occiput: between supraoccipital and parietal (0) or on the supraoccipital (1).

Sarhsaurus (0)

74) Postparietal fenestra between supraoccipital and parietals: absent (0) or present (1).

Sarhsaurus (1)

75) Shape of the supraoccipital: diamond-shaped, at least as high as wide (0), or semi-lunate and wider than high (1).

Sarhsaurus (1)

76) Orientation of supraoccipital plate: erect to gently sloping (0), or strongly sloping forward so that the dorsal tip lies level with the basiptyergoid process (1).

Sarhsaurus (1)

- 77) Orientation of the paroccipital process in occipital view: slightly dorsolaterally directed to horizontal (0), or ventrolaterally directed (1).  
Sarahsaurus (0)
- 78) Orientation of the paroccipital process in dorsal view: posterolateral forming a V-shaped occiput (0) or lateral forming a flat occiput (1).  
Sarahsaurus (0)
- 79) Size of the post-temporal fenestra: large fenestra (0) or a small hole that is much less than half the depth of the paroccipital process (1).  
Sarahsaurus (1)
- 80) Exit of the mid-cerebral vein: through trigeminal foramen (0) or through a separate foramen anterodorsal to the trigeminal foramen.  
Sarahsaurus (?)
- 81) Shape of the floor of the braincase in lateral view: relatively straight with the basal tubera, basiptyergoid process and parasphenoid rostrum roughly aligned (0), bent with the basiptyergoid process and the parasphenoid rostrum below the level of the basioccipital condyle and the basal tubera (1), or bent with the basal tubera lowered below the level of the basioccipital and the parasphenoid rostrum raised above it (2).  
Sarahsaurus (1)
- 82) Shape of the basal tubera: knob-like, with basisphenoidal component rostral to basioccipital component (0), or forming a transverse ridge with the basisphenoidal component lateral to the basioccipital component (1).  
Sarahsaurus (1)
- 83) Length of the basiptyergoid process (from the top of the parasphenoid to the tip of the process): less than (0), or greater than (1), the height of the braincase (from the top of the parasphenoid to the top of the supraoccipital).  
Sarahsaurus (0)
- 84) Ridge formed along the junction of the parabasisphenoid and the basioccipital, between the basal tubera: present with a smooth rostral face (0), present with a median fossa on the rostral face (1), or absent with the basal tubera being separated by a deep caudally opening U-shaped fossa (2).  
Sarahsaurus (1)
- 85) Deep septum spanning the interbasiptyergoidal space: absent (0) or present (1).  
Sarahsaurus (1)
- 86) Dorsoventral depth of the parasphenoid rostrum: much less than (0), or about equal to (1) transverse width.  
Sarahsaurus (1)

87) Shape of jugal process of ectopterygoid: gently curved (0) or strongly recurved and hook-like (1)

Sarhsaurus (1)

88) Pneumatic fossa on the ventral surface of the ectopterygoid: present (0); or absent (1).

Sarhsaurus (1)

89) Relationship of the ectopterygoid to the pterygoid: ectopterygoid overlapping the ventral (0), or dorsal (1) surface of the pterygoid.

Sarhsaurus (1)

90) Position of the maxillary articular surface of the palatine: along the lateral margin of the bone (0), or at the end of a narrow anterolateral process due to absence of the posterolateral process (1).

Sarhsaurus (?)

91) Centrally located tubercle on the ventral surface of the palatine: absent (0) or present (1).

Sarhsaurus (?)

92) Medial process of pterygoid forming a hook around the basipterygoid process: absent (0), flat and blunt-ended (1), or bent upward and pointed (2).

Sarhsaurus (1)

93) Length of the vomer: less than (0) or more than (1), 0.25 of the total skull length.

Sarhsaurus (?)

94) Position of jaw joint: no lower than the level of the dorsal margin of the dentary (0), or depressed well below this level (1).

Sarhsaurus (1)

95) Shape of upper jaws in ventral view: narrow with an acute rostral apex (0), or broad and U-shaped (1).

Sarhsaurus (0)

96) Length of the external mandibular fenestra: more than (0), or less than (1), 0.1 of the length of the mandible.

Sarhsaurus (?)

97) Caudal end of dentary tooth row medially inset with a thick lateral ridge on the dentary forming a buccal emargination: absent (0), or present (1).

Sarhsaurus (1)

98) Height : length ratio of the dentary: less than (0), or greater than (1), 0.2.



Sarhsaurus (0)

99) Orientation of the symphyseal end of the dentary: in line with the long axis of the dentary (0), or strongly curved ventrally (1).

Sarhsaurus (0)

100) Position of the first dentary tooth: adjacent to symphysis (0) or inset one tooth's width from the symphysis (1).

Sarhsaurus (1)

101) Dorsoventral expansion at the symphyseal end of the dentary: absent (0) or present (1).

Sarhsaurus (0)

102) Splenial foramen: absent (0), present and enclosed (1), or present and open anteriorly (2).

Sarhsaurus (?)

103) Splenial-angular joint: flattened sutured contact (0), synovial joint surface between tongue-like process of angular fitting into a groove of the splenial (1).

Sarhsaurus (?)

104) A stout, triangular, medial process of articular, behind the glenoid: present (0), or absent (1).

Sarhsaurus (?)

105) Length of retroarticular process: less than (0) or greater than (1), the depth of the mandible below the glenoid.

Sarhsaurus (?)

106) Strong medial embayment behind glenoid of the articular in dorsal view: absent (0), or present (1).

Sarhsaurus (?)

107) Number of premaxillary teeth: four (0), or more than four (1).

Sarhsaurus (0)

108) Number of dentary teeth in adults: less than 18 (0), or 18 or more (1).

Sarhsaurus (1)

109) Arrangement of teeth within the jaws: linearly placed, crowns not overlapping (0) or imbricated with the distal side of the tooth overlapping mesial side of succeeding tooth (1).

Sarhsaurus (1)

110) Orientation of maxillary tooth crowns: erect (0) or procumbent (1).

Sarhsaurus (0)

111) Orientation of dentary tooth crowns: erect (0) or procumbent (1).

Sarhsaurus (0)

112) Teeth with basally constricted crowns: absent (0) or present (1).

Sarhsaurus (1)

113) Tooth-tooth occlusal wear facets: absent (0), or present (1).

Sarhsaurus (0)

114) Mesial and distal serrations of the teeth: fine and set at right angles to the margin of the tooth (0), or coarse and angled upwards at an angle of 45 degrees to the margin of the tooth (1).

Sarhsaurus (1)

115) Distribution of serrations on the maxillary and dentary teeth: present on both the mesial and distal carinae (0), absent on the posterior carinae (1), or absent on both carinae (2).

Sarhsaurus (0)

116) Long axis of the tooth crowns distally recurved: present (0), or absent (1).

Sarhsaurus (1)

117) Texture of the enamel surface: entirely smooth (0), finely wrinkled in some patches (1), or extensively and coarsely wrinkled (2).

Sarhsaurus (0)

118) Lingual concavities of the teeth: absent (0) or present (1).

Sarhsaurus (0)

119) Longitudinal labial grooves on the teeth: absent (0) or present (1).

Sarhsaurus (0)

120) Distribution of the serrations along the mesial and distal carinae of the tooth: extend along most of the length of the tooth crown (0), or are restricted to the upper half of the crown (1).

Sarhsaurus (0)

121) Number of cervical vertebrae: eight or fewer (0), 9-10 (1), 12-13 (2), or more than 13 (3).

Sarhsaurus (1)

122) Shallow, dorsally facing fossa on the atlantal neurapophysis bordered by a dorsally everted lateral margin: absent (0) or present (1).

Sarhsaurus (?)

123) Width of axial intercentrum: less than (0), or greater than (1), width of axial centrum.

Sarhsaurus (1)

124) Position of axial prezygapophyses: on the anterolateral surface of the neural arch (0) or mounted on anterolaterally projecting pedicels (1).

Sarhsaurus (0)

125) Posterior margin of the axial postzygapophyses: overhang the axial centrum (0) or are flush with the caudal face of the axial centrum (1).

Sarhsaurus (1)

126) Length of axial centrum: less than (0), or at least (1) three times the height of the centrum.

Sarhsaurus (1)

Upchurch # 104

127) Length of the anterior cervical centra (cervicals 3-5): no more than (0), or greater than (1), the length of the axial centrum.

Sarhsaurus (1)

128) Length of middle to posterior cervical centra (cervicals 6-8): no more than (0), or greater than (1), the length of the axial centrum.

Sarhsaurus (1)

129) Dorsal excavation of the cervical parapophyses: absent (0), or present (1).

Sarhsaurus (0)

Upchurch # 107

130) Lateral compression of the anterior cervical vertebrae: centra are no higher than they are wide (0), or are approximately 1.25 times higher than wide (1).

Sarhsaurus (1)

131) Relative elongation of the anterior cervical centra (cervicals 3-5): lengths of the centra are less than 2.5 times the height of their anterior faces (0), lengths are 2.5-4 times the height of their anterior faces (1), or the length of at least cervical 4 or 5 exceeds 4 times the anterior centrum height (2).

Sarhsaurus (1)

132) Ventral keels on cranial cervical centra: present (0) or absent (1).

Sarhsaurus (0)

Upchurch # 109

133) Height of the mid cervical neural arches: no more than (0), or greater than (1), height of the posterior centrum face.

Sarhsaurus (0)  
Upchurch # 111

134) Cervical epiphyses on the dorsal surface of the postzygapophyses: absent (0), or present on at least some cervical vertebrae (1).  
Sarhsaurus (1)

135) Caudal ends of cranial, postaxial epiphyses: with a free pointed tip (0), or joined to the postzygapophysis along their entire lengths (1).  
Sarhsaurus (1).  
Upchurch # 115

136) Shape of epiphyses: tall ridges (0) or flattened, horizontal plates (1).  
Sarhsaurus (1)

137) Epiphyses overhanging the rear margin of the postzygapophyses: absent (0), or present (1) on at least some postaxial cervical vertebrae.  
Sarhsaurus (0)  
Note: polarity is reversed in Upchurch # 114

138) Anterior spur-like projections on mid-cervical neural spines: absent (0) or present (1).  
Sarhsaurus (1)

139) Shape of mid-cervical neural spines: less than (0), or at least (1), twice as long as high.  
Sarhsaurus (1)

140) Shape of cervical rib shafts: short and posteroventrally directed (0) or longer than the length of the centra and extending parallel to cervical column (1).  
Sarhsaurus (1)

141) Position of the base of the cervical rib shaft: level with, or higher than the ventral margin of the cervical centrum (0), or located below the ventral margin due to ventrally extended parapophysis (1).  
Sarhsaurus (0)

142) Postzygodiapophyseal lamina in cervical neural arches 4-8: present (0) or absent (1).  
Sarhsaurus (1)

143) Laminae of the cervical neural arches 4-8: well developed tall laminae (0) or weakly developed low ridges (1).  
Sarhsaurus (1)

144) Shape of anterior centrum face in cervical centra: concave (0) or flat (1), or convex (2).

Sarhsaurus (1)

145) Ventral surface of the centra in the cervicodorsal transition: transversely rounded (0) or with longitudinal keels (1).

Sarhsaurus (1)

146) Number of vertebrae between cervicodorsal transition and primordial sacral vertebrae: 15-16 (0) or no more than 14 (1).

Sarhsaurus (1)

147) Lateral surfaces of the dorsal centra: with at most vague, shallow depressions (0), with deep fossae that approach the midline (1), or with invasive, sharp-rimmed pleurocoels (2).

Sarhsaurus (0)

148) Oblique ridge dividing pleural fossa of cervical vertebrae: absent (0) or present (1).

Sarhsaurus (0)

149) Laterally expanded tables at the midlengths of the dorsal surface of the neural spines: absent in all vertebrae (0), present on the pectoral vertebrae (1), or present on the pectoral and cervical vertebrae (2).

Sarhsaurus (1)

150) Dorsal centra: entirely amphicoelous to amphiplatyan (0), or first two dorsals are opisthocoelous (1), or cranial half of dorsal column is opisthocoelous (2).

Sarhsaurus (0)

151) Shape of the posterior dorsal centra: relatively elongated for their size (0), strongly axially compressed for their size (1).

Sarhsaurus (0)

152) Laminae bounding triangular infradiapophyseal fossae (chonae) on dorsal neural arches: absent (0), or present (1).

Sarhsaurus (1)

153) Location of parapophysis in first two dorsals: at the anterior end of the centrum (0), or located at the mid-length of the centrum, within the middle chonos (1).

Sarhsaurus (0)

154) Parapophyses of the dorsal column completely shift from the centrum to the neural arch: anterior (0), or posterior (1) to the thirteenth presacral vertebra.

Sarhsaurus (1)

- 155) Orientation of the transverse processes of the dorsal vertebrae: most horizontally directed (0), or all upwardly directed (1).  
Sarahsaurus (0)
- 156) Contribution of the paradiapophyseal lamina to the margin of the anterior chonos in mid-dorsal vertebrae: present (0), or prevented by high placement of parapophysis (1).  
Sarahsaurus (0)
- 157) Hyposphenes in the dorsal vertebrae: absent (0), present but less than the height of the neural canal (1), or present and equal to the height of the neural canal (2).  
Sarahsaurus (1)
- 158) Prezygodiapophyseal lamina and associated anterior triangular fossa (chonos): present on all dorsals (0), or absent in mid-dorsals (1).  
Sarahsaurus (0)  
See Upchurch #124
- 159) Anterior centroparapophyseal lamina in dorsal vertebrae: absent (0), or present (1).  
Sarahsaurus (1)
- 160) Prezygoparapophyseal lamina in dorsal vertebrae: absent (0), or present (1).  
Sarahsaurus (1)
- 161) Accessory lamina dividing posterior chonos from postzygapophysis: absent (0), or present (1).  
Sarahsaurus (1)
- 162) Lateral pneumatic fenestra in middle chonos of middle and posterior dorsal vertebrae opening into neural cavity: absent (0), present (1).  
Sarahsaurus (0)
- 163) Separation of lateral surfaces of anterior dorsal neural arches under transverse processes: widely spaced (0), or only separated by a thin midline septum (1).  
Sarahsaurus (0)
- 164) Height of dorsal neural arches, from neurocentral suture to level of zygapophyseal fascets: much less than (0), or subequal to or greater than (1) height of centrum.  
Sarahsaurus (0)  
Upchurch #119
- 165) Form of anterior surface of neural arch: simple centroprezygopophyseal ridge (0) or broad anteriorly facing surface bounded laterally by centroprezygopophyseal lamina (1).  
Sarahsaurus (0)
- 166) Shape of posterior dorsal neural canal: subcircular (0), or slit-shaped (1).  
Sarahsaurus (0)

167) Height of middle dorsal neural spines: less than the length of the base (0), higher than the length of the base but less than 1.5 times the length of the base (1), or greater than 1.5 times the length of the base (2).

Sarhsaurus (1)

168) Shape of anterior dorsal neural spines: lateral margins parallel in anterior view (0), or transversely expanding towards dorsal end (1)

Sarhsaurus (0)

169) Cross-sectional shape of dorsal neural spines: transversely compressed (0), broad and triangular (1), or square-shaped in posterior view (2).

Sarhsaurus (0)

170) Spinodiapophyseal lamina on dorsal vertebrae: absent (0), present and separated from spinodiapophyseal lamina (1), or present and joining spinodiapophyseal lamina to create a composite posterolateral spinal lamina (2).

Sarhsaurus (0)

Upchurch #132

171) Well-developed, sheet-like suprapostzygapophyseal lamina: absent (0), present on at least the caudal dorsal vertebrae (1).

Sarhsaurus (0)

172) Shape of suprapostzygapophyseal lamina in middle and posterior dorsal vertebrae: singular (0) or bifurcated (1).

Sarhsaurus (0)

173) Shape of the posterior margin of middle dorsal neural spines in lateral view: approximately straight (0) or concave with a projecting posterodorsal corner (1).

Sarhsaurus (1)

174) Transversely expanded plate-like summits of posterior dorsal neural spines: absent (0), or present (1).

Sarhsaurus (1)

175) Last presacral rib: free (0), or fused to vertebra (1).

Sarhsaurus (1)

176) Sacral rib much narrower than the transverse process of the first primordial sacral vertebra (and dorsosacral if present) in dorsal view: absent (0), or present (1).

Sarhsaurus (1)

177) Number of dorsosacral vertebrae: none (0), one (1), or two (2).

Sarhsaurus (1).

178) Caudosacral vertebrae: absent (0), or present (1).

Sarhsaurus (0)

179) Shape of the iliac articular facets on the first primordial sacral rib: singular (0) or divided into dorsal and ventral facets separated by non-articulating gap (1).

Sarhsaurus (0)

180) Depth of the iliac articulate surface of the primordial sacra: less than (0), or greater than (1), 0.75 of the depth of the ilium.

Sarhsaurus (0)

181) Sacral ribs contributing to the rim of the acetabulum: absent (0) or present (1).

Sarhsaurus (0).

182) Posterior and anterior expansion of the transverse processes of the first and second primordial sacral vertebrae, respectively, partly roofing the intercostal space: absent (0) or present (1).

Sarhsaurus (1)

183) Length of the first caudal centrum: greater than (0), or less than (1), its height.

Sarhsaurus (1)

184) Length of base of the proximal caudal neural spines: less than (0), or greater than (1), half the length of the neural arch.

Sarhsaurus (0)

185) Position of postzygapophyses in proximal caudal vertebrae: protruding with an interpostzygapophyseal notch visible in dorsal view (0) or placed on either side of the base of the neural spine without any interpostzygapophyseal notch (1).

Sarhsaurus (0)

186) A hyposphene ridge on caudal vertebrae: absent (0), or present (1).

Sarhsaurus (0)

187) Depth of the bases of the proximal caudal transverse processes: shallow, restricted to the neural arches (0), deep, extending from the centrum to the neural arch (1).

Sarhsaurus (0)

188) Position of last caudal vertebra with a protruding transverse process: distal (0), or proximal (1), to caudal 16.

Sarhsaurus (1)

189) Orientation of posterior margin of proximal caudal neural spines: sloping posterodorsally (0), or vertical (1).

Sarhsaurus (0)



190) Longitudinal ventral sulcus on proximal and middle caudal vertebra: present (0), or absent (1)

Sarhsaurus (0)

Note polarity is reversed from Upchurch #146

191) Length of midcaudal centra: greater than (0), or less than (1) twice the height of their anterior faces.

Sarhsaurus (1)

192) Cross-sectional shape of the distal caudal centra: oval with rounded lateral and ventral sides (0) or square-shaped with flattened lateral and ventral sides (1).

Sarhsaurus (0)

193) Length of distal caudal prezygapophyses: short, not overlapping with the preceding centrum by more than a quarter (0), or long and overlapping the preceding centrum by more than a quarter (1).

Sarhsaurus (0)

194) Shape of the terminal caudal vertebrae; unfused, size decreasing toward tip (0), or expanded and fused to form a club-shaped tail (1).

Sarhsaurus (0)

195) Length of the longest chevrons: is less than (0), or greater than (1) twice the length of the preceding centrum.

Sarhsaurus (0)

196) Anteroventral process on distal chevrons: absent (0), or present (1).

Sarhsaurus (0)

197) Mid-caudal chevrons with a ventral slit: absent (0), or present (1).

Sarhsaurus (0)

198) Longitudinal ridge on the dorsal surface of the sternal plate: absent (0), or present (1).

Sarhsaurus (1)

Note: we take “dorsal” to be superficial or external surface

199) Craniocaudal length of the acromion process of the scapula: less than (0), or greater than (1), 1.5 times the minimum width of the scapular blade.

Sarhsaurus (0)

Upchurch #155

200) Minimum width of scapula: less than (0), or greater than (1), 20 percent of its length.

Sarhsaurus (0)

Upchurch #156

201) Caudal margin of the acromion process of the scapula: rises from the blade at angle that is less than (0), or greater than (1), 65 degrees from the long axis of the scapula, at its steepest point.

Sarhsaurus (0)

Upchurch #158

202) Width of dorsal expansion of the scapula: less than (0), or equal to (1), the width of the ventral end of the scapula.

Sarhsaurus (0)

203) Flat caudoventrally facing surface on the coracoids between glenoid and coracoids tubercle: absent (0), or present (1).

Sarhsaurus (1)

Upchurch #159

204) Coracoid tubercle: present (0), or absent (1).

Sarhsaurus (0)

Upchurch # 160

205) Length of humerus: less than 55 per cent (0), 55-65 percent (1), 65-70 per cent (2), or more than 70 per cent of the femur.

Sarhsaurus (1)

Upchurch #168-170

206) Shape of the deltopectoral crest: subtriangular (0) or subrectangular (1).

Sarhsaurus (0)

207) Length of the deltopectoral crest of the humerus: less than 30 per cent (0), 30-50 percent (1), or greater than 50 percent (2), of the length of the humerus.

Sarhsaurus (2)

Upchurch #164

208) Shape of the anterolateral margin of the deltopectoral crest of the humerus: straight (0), or strongly sinuous (1).

Sarhsaurus (1)

Upchurch #167

209) Rugose pit centrally located on the lateral surface of the deltopectoral crest: absent (0), or present (1).

Sarhsaurus (0 )

210) Well-defined fossa on the distal flexor surface of the humerus: present (0), or absent (1).

Sarhsaurus (0)

Upchurch #171

211) Transverse width of the distal humerus: is less than (0), or greater than (1), 33 per cent of the length of the humerus.

Sarahsaurus (1)

Upchurch #172

212) Shape of the entepicondyle of the distal humerus: rounded process (0), or with a flat distomedially facing surface bounded by a sharp proximal margin (1).

Sarahsaurus (1)

213) Length of radius: greater than (0), or less than (1), 80 percent of the humerus.

Sarahsaurus (1)

Upchurch # 176

Note: polarity is reversed by Yates

214) Deep radial fossa, bounded by an anteriolateral process, on proximal ulna: absent (0), or present (1).

Sarahsaurus (1)

Upchurch #173

215) Olecranon process on proximal ulna: present (0), or absent (1).

Sarahsaurus (1)

Upchurch # 184

216) Maximum linear dimensions of the ulnare and radiale: exceed that of at least one of the first distal carpals (0) or are less than any of the distal carpals (1).

Sarahsaurus (1)

Upchurch #179

217) Transverse width of the first distal carpal: less than (0), or greater than (1), 120 per cent of the transverse width of the second distal carpal.

Sarahsaurus (1)

218) Sulcus across the medial end of the first distal carpal: absent (0), or present (1).

Sarahsaurus (0)

219) Lateral end of first distal carpal: abuts (0), or overlaps (1) second distal carpal.

Sarahsaurus (1)

Upchurch #181

220) Second distal carpal: does (0), or does not (1), completely cover the proximal end of the second metacarpal.

Sarahsaurus (1)

Upchurch #183

221) Ossification of the fifth distal carpal: present (0), or absent (1).

Sarahsaurus (1)

222) Length of the manus: less than 38 per cent (0), 38-45 per cent (1), or greater than 45 per cent (2), of the humerus + radius.

Sarahsaurus (1)

Upchurch #184 (modified with extra state)

223) Shape of metacarpus: flattened to gently curved and spreading (0), or a colonnade of subparallel metacarpals tightly curved into a U-shape (1).

Sarahsaurus (0)

224) Proximal width of first metacarpal: less than (0), or greater than (1), the proximal width of the second metacarpal.

Sarahsaurus (1)

Upchurch #186

225) Minimum transverse shaft width of first metacarpal: less than (0), or greater than (1), twice the minimum transverse shaft width of second metacarpal.

Sarahsaurus (1)

226) Proximal end of first metacarpal: flush with other metacarpals (0), or inset into carpus (1).

Sarahsaurus (0)

Upchurch #182

227) Shape of the first metacarpal: proximal width less than 65 per cent (0), 65-80 per cent (1), 80-100 percent (2), or greater than 100 per cent (3), of its length.

Sarahsaurus (0)

Upchurch # 188, 189

228) Strong asymmetry in the lateral and medial distal condyles of the first metacarpal: absent (0), or present (1).

Sarahsaurus (1)

Upchurch #190

229) Deep extensor pits on the second and third metacarpals: absent (0), or present (1).

Sarahsaurus (1)

Upchurch #191

230) Shape of the distal ends of second and third metacarpals: subrectangular in distal view (0) or trapezoidal with flexor rims of distal collateral ligament pits flaring beyond extensor rims (1).

Sarahsaurus (1)

Note: these states probably reflect ontogenetic status of the specimens, young (0) to mature (1); a similar condition exists in *Dilophosaurus*

231) Shape of the fifth metacarpal: longer than wide at the proximal end with a flat proximal surface (0), or close to as wide as it is long with a strongly convex proximal articulation surface (1).

Sarhsaurus (1)

Upchurch # 192

232) Length of the fifth metacarpal: less than (0), or greater than (1), 75 per cent of the length of the third metacarpal.

Sarhsaurus ( ) check

233) Length of manual digit one: less than (0), or greater than (1) the length of manual digit two.

Sarhsaurus (0)

234) Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end: absent (0), or present but much less than 60 degrees (1), or 60 degrees (2).

Sarhsaurus (1).

235) Length of first phalanx of manual digit one: less than (0), or greater than (1), the length of the first metacarpal.

Sarhsaurus (1)

236) Shape of the proximal articular surface of the first phalanx of manual digit one: rounded (0) or with a medial embayment on the medial side (1).

Sarhsaurus (1)

237) Shape of the first phalanx of manual digit one: elongate and subcylindrical (0), or strongly proximodistally compressed and wedge-shaped (1).

Sarhsaurus (0)

238) Length of the penultimate phalanx of manual digit two: less than (0), or greater than (1), the length of the second metacarpal.

Sarhsaurus (0)

239) Length of the penultimate phalanx of manual digit three: less than (0), or greater than (1), the length of the third metacarpal.

Sarhsaurus (0)

240) Shape of non-terminal phalanges of manual digits two and three: longer than wide (0), or as long as wide (1).

Sarhsaurus (0)

241) Shape of the unguals of manual digits two and three straight (0), or strongly curved with tips projecting well below flexor margins of proximal articular surface (1).

Sarhsaurus (1).

242) Length of the ungual of manual digit two: greater than the length of the ungual of manual digit one (0), or 75-100 per cent of the ungual of manual digit one (1), less than 75 per cent of the ungual of manual digit one (2), or the ungual of manual digit two is absent.

Sarhsaurus (2)

243) Phalangeal formula of manual digits two and three: three and four, respectively (0), or with at least one phalanx missing from each digit (1).

Sarhsaurus (0)

244) Phalangeal formula of manual digits four and five: greater than (0), or less than (1), 2-0, respectively; or 2-2 (2)

Sarhsaurus (2)

Note: state two is added here; matrix run unordered (TR)

245) Strongly convex dorsal margin of the ilium: absent (0), or present (1).

Sarhsaurus (1)

Upchurch #212

246) Cranial extent of preacetabular process of ilium: does not (0), or does (1), project further forward than cranial end of pubic peduncle.

Sarhsaurus (0)

247) Shape of the postacetabular process: blunt and rectangular (0), or with a pointed, projecting cranioventral corner and a rounded dorsum (1)

Sarhsaurus (0)

248) Depth of the preacetabular process of the ilium: much less than (0), or subequal to (1), the depth of the ilium above the acetabulum.

Sarhsaurus (0)

249) Length of the preacetabular process of the ilium: less than (0), or greater than (1), twice its depth.

Sarhsaurus (0)

250) Buttress between preacetabular process and the supra-acetabular crest of the ilium present (0) or abasent (1).

Sarhsaurus (0)

251) Medial wall of acetabulum: fully closed acetabulum with a triangular ventral process between the pubic and ischial peduncles (0, partially open acetabulum with a straight ventral margin between the pubic and ischial peduncles (1), partially open acetabulum with a concave ventral margin between the peduncles, (2) or fully open acetabulum with medial margin closely approximating lateral rim of acetabulum (3).

Sarhsaurus (3)

252) Length of the pubic peduncle of the ilium: less than (0), or greater than (1), twice the craniocaudal width of its distal end.

Sarahsaurus (1)

Upchurch #213

253) Caudally projecting 'heel' at the distal end of the ischial peduncle: absent (0), or present (1).

Sarahsaurus (1)

Upchurch #215)

254) Length of the ischial peduncle of the ilium: similar to pubic peduncle (0), much shorter than pubic peduncle (1), or virtually absent so that the cord connecting the distal end of the pubic peduncle with the ischial articular surface contacts the postacetabular process (2).

Sarahsaurus (1)

Modified after Upchurch #214

255) Length of the postacetabular process of the ilium: between 40 and 100 percent of the distance between the pubic and ischial peduncles (0), less than 40 per cent of this distance (1), or more than 100 percent of this distance (2).

Sarahsaurus (0)

Upchurch # 216

256) Well developed brevis fossa with sharp margins on the ventral surface of the postacetabular process of the ilium: absent (0), or present (1).

Sarahsaurus (1)

257) Anterior end of ventrolateral ridge bounding brevis fossa: not connected to (0), or joining (1) supra-acetabular crest.

Sarahsaurus (0)

258) Shape of caudal margin of the postacetabular process of the ilium: rounded to bluntly pointed (0), square ended (1), or with a pointed ventral corner and a rounded caudodorsal margin (2).

Sarahsaurus (2)

Upchurch # 218

259) Width of conjoined pubes: less than (0), or greater than (1), 75 per cent of their length.

Sarahsaurus (1)

Modified from Upchurch # 226

260) Pubic tubercle on the lateral surface of the proximal pubis: present (0), or absent (1).

Sarahsaurus (0)

Upchurch #225

261) Proximal anterior profile of pubis: anterior margin of pubic apron smoothly confluent with anterior margin of iliac pedicel (0), or iliac pedicel set anterior to the pubic apron creating a prominent inflection in the proximal anterior profile of the pubis (1).

Sarahsaurus (0)

262) Minimum transverse width of the pubic apron: much more than (0), or less than (1), 40 percent of the width across the iliac peduncles of the ilium.

Sarahsaurus (1)

Upchurch #227

263) Position of obturator foramen of the pubis: at least partially occluded by the iliac pedicel (0), or completely visible (1), in anterior view.

Sarahsaurus (1)

264) Lateral margin of the pubic apron in anterior view: straight (0), or concave (1).

Sarahsaurus (1)

Upchurch #220

265) Orientation of distal third of the blades of the pubic apron: confluent with the proximal part of the pubic apron (0), or twisted posterolaterally relative to proximal section so that the anterior surface turns to face laterally (1).

Sarahsaurus (0)

Upchurch #224

266) Orientation of entire blades of pubic apron: transverse (0), or twisted posteromedially (1).

Sarahsaurus (0)

267) Craniocaudal expansion of the distal pubis: absent (0), less than 15 per cent (1), or greater than 15 per cent (2), of the length of the pubis.

Sarahsaurus (1)

268) Notch separating posteroventral end of the ischial obturator plate from the ischial shaft: present (0), or absent (1)

Sarahsaurus (1)

Note: presence of a notch may be artifact of breakage of thin ischial plate.

Upchurch #229

269) Elongate interischial fenestra: absent (0), or present (1).

Sarahsaurus (1)

Upchurch # 230

Note: Yates reverses polarity of this character

270) Longitudinal dorsolateral sulcus on proximal ischium: absent (0) or present (1).

Sarahsaurus (1)



271) Shape of ischium: broad and plate-like, not distinct from obturator region (0), or with a discrete rod-like distal shaft (1).

Sarhsaurus (1)

272) Length of ischium: less than (0) or greater than (1) that of the pubis.

Sarhsaurus (0)

Upchurch # 221

273) Ischial component of acetabular rim: larger than (0), or equal to (1), the pubic component.

Sarhsaurus (1)

Upchurch #219

Note: Upchurch et al. probably mean pubic acetabular margin is twice (not half) the length of the ischial margin, based on how they scored *Massospondylus* with state (1).

274) Shape of the transverse section of the ischial shaft: ovoid to subrectangular (0), or triangular (1).

Sarhsaurus (1)

275) Orientation of the long axes of the transverse section of the distal ischia: meet at an angle (0), or are coplanar (1).

Sarhsaurus (0)

276) Depth of the transverse section of the ischial shaft: much less than (0) or at least as great as (1), the transverse width of the section.

Sarhsaurus (1)

277) Distal ischial expansion: absent (0), or present (1).

Sarhsaurus (1)

Upchurch #232

278) Transverse width of the conjoined distal ischial expansion: greater than (0), or less than (1) their sagittal depth.

Sarhsaurus (1)

279) Length of hindlimb: greater than (0), or less than (1), the length of the trunk.

Sarhsaurus (0)

Upchurch #136

280) Longitudinal axis of the femur in lateral view: strongly bent with an offset between the proximal and distal axes greater than 15 degrees (0), weakly bent with an offset of less than 10 degrees (1), or straight (2).

Sarhsaurus (2)

281) Shape of cross-section of the mid-shaft of the femur: subcircular (0), or strongly elliptical with the long axis oriented mediolaterally (1).

Sarhsaurus (1)

Upchurch #248

282) Angle between the long axis of the femoral head and the transverse axis of the distal femur: about 30 degrees (0), or close to 0 degrees (1).

Sarhsaurus (1)

Upchurch #249

283) Shape of femoral head: roughly rectangular in profile with a sharp medial distal corner (0) or roughly hemispherical with no sharp medial distal corner (1).

Sarhsaurus (0)

Upchurch #245

284) Posterior proximal tubercle on femur: well-developed (0) or indistinct to absent (1).

Sarhsaurus (0)

285) Shape of lesser trochanter: small rounded tubercle (0), proximally oriented, elongate ridge (1), or absent (2).

Sarhsaurus (1)

Upchurch # 237

286) Position of proximal tip of lesser trochanter: level with (0), or distal to (1), the femoral head.

Sarhsaurus (1)

Note: polarity is backward on this character

287) Projection of the lesser trochanter: just a scar upon the femoral surface (0) or a raised process (1).

Sarhsaurus (0)

Note: polarity is backward on this character

288) Transverse ridge extending laterally from the lesser trochanter: absent (0), or present (1).

Note: this is the trochanteric shelf, and polarity is backward

289) Height of lesser trochanter in cross section: less than (0), or at least as high as (1), basal width.

Sarhsaurus (0)

Note: polarity is backwards.

290) Position of lesser trochanter: near the center of the anterior face (0), or close to the lateral margin (1), of the femoral shaft in anterior view.

Sarhsaurus (1)

291) Visibility of the lesser trochanter in posterior view: not visible (0) or visible (1).  
Sarahsaurus (0)  
Upchurch #236

292) Height of fourth trochanter: tall crest (0), or low rugose ridge (1).  
Sarahsaurus (1)  
Upchurch #240

293) Position of the fourth trochanter along the length of the femur: in the proximal half (0) or straddling the midpoint (1).  
Sarahsaurus (0)  
Upchurch #241

294) Symmetry of the profile of the fourth trochanter of the femur: subsymmetrical without a sharp distal corner (0), or asymmetrical with a steeper distal slope than the proximal slope and a distinct distal corner (1).  
Sarahsaurus (1)

295) Shape of the profile of the fourth trochanter of the femur: rounded (0) or subrectangular (1).  
Upchurch #242

296) Position of fourth trochanter along the mediolateral axis of the femur: centrally located (0), or on the medial margin (1).  
Sarahsaurus (1)  
Upchurch #243

297) Exterior depression on anterior surface of the distal end of the femur: absent (0), or present (1).  
Sarahsaurus (0) check

298) Size of the medial condyle of the distal femur: subequal to (0), or larger than (1), the fibular + lateral condyles.  
Sarahsaurus (0)

299) Tibia : Femur length ratio: greater than 1.0 (0), between 0.6 and 1.0 (1), or less than 0.6.  
Sarahsaurus (1)  
Upchurch # 251

300) Orientation of cnemial crest: projects anterolaterally (0), or projecting laterally (1).  
Sarahsaurus (0).  
Upchurch #253

301) Paramarginal ridge on lateral surface of cnemial crest: absent (0) or present (1).  
Sarahsaurus (0).

302) Position of tallest point of cnemial crest: close to the proximal end of the crest (0), or about half-way along the length of the crest, creating an anterodorsally sloping proximal margin of the crest (1).

Sarhsaurus (0)

303) Proximal end of the tibia with a flange of bone that contacts the fibula: absent (0), or present (1).

Sarhsaurus (0)

304) Position of the posterior end of the fibular condyle on the proximal articular surface of the tibia: anterior to (0), or level with (1) the proximal margin of the proximal articular surface.

Sarhsaurus (0)

305) Shape of the proximal articular surface of the tibia: ovoid, anteroposteriorly longer than transversely wide (0), or subcircular and as wide transversely as anteroposteriorly long (1).

Sarhsaurus (1)

306) Transverse width of distal tibia: subequal to (0), or greater than (1), its craniocaudal length.

Sarhsaurus (0)

Upchurch #255

307) Anteroposterior width of the lateral side of the distal articular surface of the tibia: as wide (0), or narrower than (1) than the anteroposterior width of the medial side.

Sarhsaurus (0)

308) Relationship of the posterolateral process of the distal end of the tibia with the fibula: not flaring laterally and not making significant contact with the fibula (0), or flaring laterally and backing the fibula (1).

Sarhsaurus (0)

309) Shape of the distal articular end of the tibia in distal view: ovoid (0) or subrectangular (1).

Sarhsaurus (1)

310) Shape of the anteromedial corner of the distal articular surface of the tibia: forming a right angle (0) or forming an acute angle (1).

Sarhsaurus (0)

311) Position of the lateral margin of descending caudoventral process of the distal end of the tibia: protrudes laterally at least as far as (0), or set well back from (1), the craniolateral corner of the distal tibia.

Sarhsaurus (0) check

312) A triangular rugose area on the medial side of the fibula: absent (0), or present (1).  
Sarahsaurus (0)  
Upchurch #257

313) Transverse width of the midshaft of the fibula: greater than 0.75 (0), between 0.5 and 0.75 (1), or less than 0.5 (2) of the transverse width of the midshaft of the tibia.  
Sarahsaurus (1)

314) Position of fibula trochanter: on anterior surface of fibula (0), laterally facing (1), or anteriorly facing but with strong lateral bulge (2).  
Sarahsaurus (0)

315) Depth of the medial end of the astragalar body in cranial view: roughly equal to the lateral end (0), or much shallower creating a wedge-shaped astragalar body (1).  
Sarahsaurus (0)

316) Shape of the posteromedial margin of the astragalus in dorsal view: forming a moderately sharp corner of a subrectangular astragalus (0), or evenly rounded without formation of a caudomedial corner (1).  
Sarahsaurus (0)

317) Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus: present (0) or absent with a largely vertical fibular facet (1).  
Sarahsaurus (1)

318) Pyramidal dorsal process on the posteromedial corner of the astragalus: absent (0), or present (1).  
Sarahsaurus (1)

319) Shape of ascending process of the astragalus: anteroposteriorly deeper than transversely wide (0), or transversely wider than anteroposteriorly deep (1).  
Sarahsaurus (1)

320) Posterior extent of ascending process of the astragalus: well anterior to (0), or close to the posterior margin of (1), the astragalus.  
Sarahsaurus (0)

321) Sharp medial margin around the depression posterior to the ascending process of the astragalus: absent (0), or present (1).  
Sarahsaurus (1)

322) Buttress dividing posterior fossa of astragalus and supporting ascending process: absent (0) or present (1).  
Sarahsaurus (1)

- 323) Vascular foramina set in a fossa at the base of the ascending process of the astragalus: present (0), or absent (1).  
Saransaurus (0)  
Upchurch #259
- 324) Transverse width of the calcaneum: greater than (0) or less than (1), 30 percent of the transverse width of the astragalus.  
Sarahsaurus (1)
- 325) Lateral surface of the calcaneum: simple (0) or with a fossa (1).  
Sarahsaurus (?)
- 326) Medial peg of calcaneum fitting into astragalus: present, even if rudimentary (0), or absent (1)  
Sarahsaurus (1)
- 327) Calcaneal tuber: large and well developed (0), or highly reduced to absent (1).  
Sarahsaurus (1)
- 328) Shape of posteromedial heel of distal tarsal four (lateral distal tarsal): proximodistally deepest part of bone (0) or no deeper than the rest of the bone (1).  
Sarahsaurus (1)
- 329) Shape of posteromedial process of distal tarsal four in proximal view: rounded (0) or pointed (1).  
Sarahsaurus (1)
- 330) Ossified distal tarsals: present (0) or absent (1).  
Sarahsaurus (0)
- 331) Proximal width of the first metatarsal: is less than (0), or at least as great as (1), the proximal width of the second metatarsal.  
Sarahsaurus (1)
- 332) Orientation of proximal articular surface of metatarsal one: horizontal (0) or sloping proximolaterally relative to the long axis of the bone (1).  
Sarahsaurus (1)
- 333) Orientation of the transverse axis of the distal end of metatarsal one: horizontal (0), or angled proximomedially (1).  
Sarahsaurus (?)
- 334) Shape of the medial margin of the proximal surface of the second metatarsal: straight (0), or concave (1).  
Sarahsaurus (1)

335) Shape of the lateral margin of the proximal surface of the second metatarsal: straight (0), or concave (1).

Sarhsaurus (1)

336) Length of the third metatarsal: greater than (0) or less than (1), 40 per cent of the length of the tibia.

Sarhsaurus (0)

337) Minimum transverse shaft diameters of third and fourth metatarsals: greater than (0), or less than (1), 60 per cent of the minimum transverse shaft diameter of the second metatarsal.

Sarhsaurus (0)

338) Transverse width of the proximal end of the fourth metatarsal: less than (0), or at least (1), or twice the anteroposterior depth of the proximal end.

Sarhsaurus (1)

339) Transverse width of the proximal end of the fifth metatarsal: less than 25 percent (0), between 30 and 49 percent (1), or greater than 50 per cent (2), of the length of the fifth metatarsal.

Sarhsaurus (1)

340) Transverse width of distal articular surface of metatarsal four in distal view: greater (0), or less than (1), anteroposterior depth.

Sarhsaurus (0)

341) Pedal digit five: reduced, non-weight bearing (0), or large (fifth metatarsal at least 70 per cent of fourth metatarsal), robust and weight bearing (1).

Sarhsaurus (0)

342) Length of non-terminal pedal phalanges: all longer than wide (0), proximal most phalanges longer than wide while more distal phalanges are as wide as long (1), or all non-terminal phalanges are as wide, if not wider, than long (2).

Sarhsaurus (0)

343) Length of the first phalanx of pedal digit one: greater than (0), or less than (1), the length of the ungual of pedal digit one.

Sarhsaurus (?)

344) Length of the ungual of pedal digit one: less than at least some non-terminal phalanges (0), or longer than all non-terminal phalanges (1).

Sarhsaurus (1)

345) Shape of the ungual of pedal digit one: shallow, pointed, with convex sides and a broad ventral surface (0), or deep, abruptly tapering, with flattened sides and a narrow ventral surface (1).

Sarhsaurus (0)

346) Shape of proximal articular surface of pedal unguals: proximally facing, visible on medial and lateral sides (0) or proximomedially facing and visible only in medial view, causing medial deflection of pedal unguals in articulation (1).

Sarhsaurus (0)

347) Penultimate phalanges of pedal digits two and three: well-developed (0), or reduced to disc-shaped elements if they are ossified at all (1).

Sarhsaurus (0)

348) Shape of the unguals of pedal digits two and three: dorsoventrally deep with a proximal articulating surface that is at least as deep as it is wide (0), or dorsoventrally flattened with a proximal articulating surface that is wider than deep (1).

Sarhsaurus (1)

349) Length of the unguual of pedal digit two: greater than (0), between 90 and 100 per cent of (1), or less than 90 per cent of (2), the length of the unguual of pedal digit one.

Sarhsaurus (1)

350) Size of the unguual of pedal digit three: greater than (0), or less than (1), 85 per cent of the unguual of pedal digit two in all linear dimensions.

Sarhsaurus (1)

351) Number of phalanges in pedal digit four: four (0), or fewer than four (1).

Sarhsaurus (0)

Upchurch #282

352) Phalanges of pedal digit five: present (0), or absent (1).

Sarhsaurus (0)

Upchurch # 283; polarity reversed

353) Femoral length: less than 200mm (0), between 200 and 399mm (1), between 400 and 599 mm (2), between 600 and 799 mm (3), between 800 and 1000 mm (4), or greater than 1000 mm (5).

Sarhsaurus (1)

354) Lateral extent of ventrolateral flange on plantar surface of metatarsal II in proximal aspect: similar in development to ventromedial flange (0); or well-developed, extending further laterally than ventromedial flange extends medially (1)

Sarhsaurus (?)

355) Distal articular surface of astragalus: relatively flat or weakly convex (0); or extremely convex and “roller-shaped” (1).

Sarhsaurus (?)



356) Distal surface of tibiofibular crest: as deep anteroposteriorly as wide mediolaterally or deeper (0); wider mediolaterally than deep anteroposteriorly (1).

Sarhsaurus (0)

357) Well-developed facet on proximolateral corner of plantar ventrolateral flange of metatarsal II for articulation with the medial distal tarsal: absent (0), or present (1).

Sarhsaurus (?)

358) Proximal outline of metatarsal III: subtriangular with acute or rounded posterior border (0); or subtrapezoidal, with posterior border broadly exposed in plantar view (1).

Sarhsaurus (?)

359) Angle formed by the anterior and anteromedial borders of metatarsal IV: obtuse (0), or acute or at right angle (1).

Sarhsaurus (?)

360) Well-developed tibiofibular crest in distal femur: absent (0), or present (1).

Note: all mature archosaurs have a well-developed tibiofibular crest; this character is meaningless.

Sarhsaurus (1)

361) Shaft of metatarsal I: closely appressed to metatarsal II throughout its length (0); or only closely appressed proximally, with a space between metatarsals I and II distally (1).

Note: polarity on this is probably backward.

Sarhsaurus (1)



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**Agnosphitys**

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**Anchisaurus**

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**Antetonitrus**

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**Barapasaurus**

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**Blikanasaurus**

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**Camelotia**

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Gongxianosaurus

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Glacialisaurus

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Guaibasaurus

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Herrerasaurus

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Isanosaurus

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Jingshanosaurus

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??0011100?1??0000000000000??10??01000000001000000?0010??11201011100??00?  
?0011?3100100?010001020000100031000002111001002??110010110?0100110100001  
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Lessemsaurus

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101???011011001??????????11??12111??00??0???311?????1

Lufengosaurus

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100110111101113100101201000102000010003110000211101100210110010110000101  
101000010211101010000110110010011110?0001?1110101110012010110000{12}{01}  
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Mamenchisaurus

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Massospondylus

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Melanorosaurus

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11

Neosauropoda

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0112221110010111120{01}200000102011100001201000{02}111111{02}12{01}112{0  
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Neotheropoda

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Plateosaurus ingens

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Plateosauravus

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Riojasaurus

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Ruehleia

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Saturnalia

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Shunosaurus

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1100001011021?0?001?0201210000?11?00?100111011001?111?1?000211001100?1100  
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Silesaurus

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Staurikosaurus

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Tazoudasaurus

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Thecodontosaurus

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?00110000000000000000?1000?0101100?01000?00?010011211000101001100012010  
001100001010000010100000021000001??0?000?011??01010?0000111100001011000  
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Unaysaurus

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Vulcanodon

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Yunnanosaurus

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0011000110000000001000000?010110100000?00?0??0??001?0??11200?11100??01??0  
011?2101100201000{01}020?001000310000001110100010?110010111?001011010000  
1011010101000010011001?011010100011110010111001??11?0000110?2?0??11?

Sarhsaurus

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111001?110111111??1?10?10010?????011001010100001?101111011001110111011111  
001001010010111000001000001111100001100001001000000100001010210011111110  
1111011001111?0111000012021000003111010210011100111110110111021100110101  
0101110010000010001000100011101101?1111011?110011000?1000111001??0??11

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END;

Table 9  
Character List from Upchurch et al. 2007

This character list and character state scores for *Sarhsaurus aurifontanalis* are based on Upchurch et al. 2007 (and references cited therein), with minor modifications as noted.

- 1) Skull length: > 50% of femur length (0); < 50% of femur length.  
*Sarhsaurus* (1)
- 2) Caudal rim of external naris: lies rostral to the rostral margin of the antorbital fenestra (0); lies caudal to the rostral margin of the antorbital fenestra (1).  
*Sarhsaurus* (0)
- 3) External naris is: <50 percent of maximum diameter of orbit (0); > 50 percent of orbit diameter (1).  
*Sarhsaurus* (0)
- 4) External narial shape: oval/elliptical (0); subtriangular with right-angle at caudoventral corner (1).  
*Sarhsaurus* (?)
- 5) External narial margin formed by the premaxilla and nasal alone, with a broad sutured contact between these processes (0); there is a point contact, or a gap between these elements filled by the maxilla (1).  
*Sarhsaurus* (1)
- 6) Contact between premaxilla and nasal at the caudoventral margin of external nares: is a broad sutured contact or reduced to a point contact (0); is lost and replaced by a portion of the maxilla contributing to the margin (1).  
*Sarhsaurus* (1)
- 7) Internarial bar: wide (transverse width equals or exceeds rostrocaudal length) (0); or laterally compressed (transverse width is less than rostrocaudal length) (1).  
*Sarhsaurus* (?)
- 8) Dorsal (ascending) process of premaxilla: curves dorsocaudally throughout its length (0); becomes horizontal in its caudal half (1).  
*Sarhsaurus* (?)
- 9) Distal end of premaxillary dorsal (ascending) process: tapers to a slender point (0); maintains or even increases its transverse width (1).  
*Sarhsaurus* (?)
- 10) Caudolateral process of the premaxilla: present (0); or absent (1).  
*Sarhsaurus* (0)

11) Profile of the rostradorsal margin of the premaxilla in lateral view: convex (0) has an inflection at the base of the dorsal process (1)

*Sarhsaurus* (?)

12) Lateral plate on premaxilla, maxilla and dentary (supporting the bases of the tooth crowns labially): absent (0); or present (1).

*Sarhsaurus* (0)

13) Profile of the rostral end of the maxilla in lateral view: slopes continuously towards the rostral tip (0); has an inflection at the base of the ascending process which creates a rostral process with parallel dorsal and ventral margins (1).

*Sarhsaurus* (1)

14) Length of the rostral process of the maxilla: less than its dorsoventral height (0); greater than its dorsoventral height (1).

*Sarhsaurus* (0)

15) Neurovascular foramina on the lateral surface of the maxilla: numerous (0); or reduced to 5-6 large foramina (1).

*Sarhsaurus* (1).

16) Size of neurovascular foramina at the caudal end of the lateral maxillary row: not larger than the others (0); distinctly larger than others (1).

*Sarhsaurus* (0)

17) Direction of the neurovascular foramen at the caudal end of the lateral maxillary row: opens ventrally, laterally and rostrally (0); opens caudally (1).

*Sarhsaurus* (1)

18) Arrangement of lateral maxillary neurovascular foramina: linear (0); irregular (1).

*Sarhsaurus* (0)

19) Lamina from the back edge of the maxillary ascending process creates an antorbital fossa: present (0); or absent (1).

*Sarhsaurus* (0)

20) Shape of rostral margin of the antorbital fenestra in lateral view: strongly concave, creating a narrow antorbital fossa (0); straight or slightly concave, creating a broad subtriangular antorbital fossa (1).

*Sarhsaurus* (0)

21) Lateral lamina (extending caudally from the ascending process of the maxilla, along the ventral rim of the antorbital fenestra): absent (0); or present (1).

*Sarhsaurus* (1)

22) Maxillary lateral lamina: short (its rostrocaudal length is less than twice its height) (0); long (rostrocaudal length is more than twice its height) (1).

*Sarhsaurus* (1)

23) Dorsally open neurovascular canal on the floor of the antorbital fossa: absent (0); or present (1).

*Sarhsaurus* (0)

24) Maxilla-lachrymal contact above antorbital fenestra: visible in lateral view (0); obscured in lateral view by overhanging portion of the nasal (1).

*Sarhsaurus* (0)

25) Rostrocaudal length of the antorbital fossa: greater than that of the orbit (0); less than that of the orbit (1).

Note: We interpret “antorbital fossa” to mean “antorbital fenestra” in this instance.

*Sarhsaurus* (1)

26) Shelf-like area lateral to the external naris, extending onto rostral end of maxilla: absent (0); or present (1).

*Sarhsaurus* (?)

27) Rostrolateral process of the nasal: has a basal width equal to that of the rostromedial process (0); is 50 % wider than the rostromedial process (1).

*Sarhsaurus* (?)

28) Median nasal depression: absent (0); present (1).

*Sarhsaurus* (1)

29) Pointed caudolateral process of the nasal overlapping the lachrymal: absent (0); or present (1).

*Sarhsaurus* (?)

30) Dorsal exposure of the lachrymal: present (0); or absent (1).

*Sarhsaurus* (0)

31) Length of the dorsal process of the lachrymal compared to its ventral process:  $> 0.5$  (0);  $< 0.5$  (1).

*Sarhsaurus* (1)

32) Extension of the antorbital fossa onto the ventral end of the lachrymal: present (0); or absent (1).

*Sarhsaurus* (1)

33) Prefrontal ventral process: short, lies on the caudal surface of the lachrymal (0); long and extends down the medial side of lachrymal (1).

*Sarhsaurus* (1)

34) Prefrontal: frontal length ratio: < 0.75 (0); > 0.75 (1).

*Sarhsaurus* (0)

35) Jugal contribution to the antorbital fenestra: absent (0); or present (1).

*Sarhsaurus* (1)

36) Profile of the rostral end of the jugal in lateral view: blunt (0); or sharply pointed (1).

*Sarhsaurus* (0)

37) Ratio of the minimum depth of the jugal beneath the orbit to the length of the jugal from its rostral tip to the rostroventral corner of the infratemporal fenestra: < 0.2 (0); > 0.2 (1).

*Sarhsaurus* (1)

38) Transverse width of the ventral process of the postorbital: is less than its rostrocaudal width at mid-shaft (0); greater than its rostrocaudal width at mid-shaft (1).

*Sarhsaurus* (0)

39) Angle between the rostral and dorsal rami of the quadratojugal: 90 degrees or more (0); c. 60 degrees or less (1).

*Sarhsaurus* (1)

40) Length of the rostral process of the quadratojugal: less than or equal to that of the dorsal process (0); longer than the dorsal process (1).

*Sarhsaurus* (?)

41) Distal end of the quadratojugal rostral process: tapers to a point (0); or is dorsoventrally expanded (1).

*Sarhsaurus* (?)

42) Rounded caudoventral heel-like caudoventral process of the quadratojugal; present (0); absent (1).

*Sarhsaurus* (?)

43) Rostral margin of infratemporal fenestra: lies caudal to the orbit (0); or lies below the orbit (1).

*Sarhsaurus* (1)

44) Rostral margin of infratemporal fenestra: lies below the midpoint of the orbit or more caudally (0); lies level with the rostral margin of the orbit (1).

*Sarhsaurus* (0)

45) Frontal contribution to dorsal margin of the orbit: substantial (0); or small or absent (as a result of the prefrontal and postorbital approaching close to each other) (1)

Note: The original description cites the “the prefrontal and postfrontal” as approaching in state (1), but we interpret the latter bone to be the “postorbital” and not the “postfrontal,” which is absent in sauropodomorphs.

*Sarhsaurus* (0)

46) Frontal exposure between prefrontal and nasal: absent (0); or present (1).

Note: We interpret this to mean the nasal with caudal process lying between the frontal and prefrontal.

*Sarhsaurus* (1)

47) Frontal contribution to supratemporal fossa: present (0); or absent (1).

*Sarhsaurus* (0)

48) Supratemporal fenestra: obscured laterally by the postorbital bar (0); visible in lateral view because the postorbital bar lies substantially below the dorsal rim of the orbit (1).

*Sarhsaurus* (1)

49) Supratemporal fenestra: longer rostrocaudally than wide transversely (0); wider transversely than rostrocaudally (1).

*Sarhsaurus* (0)

50) Parietals paired, sutured on midline (0); or fused on the midline (1).

Note: We follow Upchurch et al. in the way we scored this character; however presence of an unfused suture may be an indication of immaturity in the referred skull, and a more appropriate score might be to treat this as missing data, and scored as (?).

*Sarhsaurus* (0)

51) Ventral process of the squamosal: is tab-like (0); or is strap-like (1).

*Sarhsaurus* (1)

52) Quadratojugal process of the squamosal is: less than four times as long as its basal width (0); more than four times as long as its basal width (1).

*Sarhsaurus* (1)

53) Squamosal-quadratojugal contact: present (0); or absent (1).

*Sarhsaurus* (1)

54) Position of the quadrate foramen: deeply incised into, and partly encircled by the quadrate (0); lies on the quadrate-quadratojugal suture (1).

Note: For consistency, in scoring *Sarhsaurus* we follow Upchurch et al. who defend the polarity for this character; however we believe that polarity is probably backwards and that Yates, among others, has shown that the foramen lying at the suture to be the plesiomorphic state for Dinosauria.

*Sarhsaurus* (1)

55) Proportion of the length of the quadrate that is occupied by the pterygoid wing: 0.7 or more (0); < 0.7 (1).

*Sarhsaurus* (1)

56) Location of the foramen for the vena capitis media: between the parietal, supraoccipital and exoccipital-opisthotic complex (0); fully enclosed by the supraoccipital (1).

*Sarhsaurus* (0)

57) Postparietal fenestra between the parietal and supraoccipital: absent (0); present (1).

*Sarhsaurus* (1)

58) Supraoccipital: is inclined at 75 degrees to the vertical so its rostral tip lies caudal to the basiptyergoid process (0); or is inclined at 45 degrees so that its rostral tip lies above the basiptyergoid process (1).

*Sarhsaurus* (1)

59) Shape of the supraoccipital in caudal view: diamond-shaped, at least as high as wide (0); semilunate and wider than high (1).

*Sarhsaurus* (1)

60) Notch in prootic, above the opening for cranial nerve V, for a separate exit of the vena cerebialis medialis: absent (0); or present (1).

*Sarhsaurus* (?)

61) Deep transverse wall of bone between basiptyergoid process: absent (0); or present but deep (1); or present but shallow (2).

*Sarhsaurus* (2)

62) Shape of the floor of the braincase in lateral view: relatively straight with the basal tubera, basiptyergoid processes and parasphenoid rostrum roughly aligned (0); bent with the basiptyergoid processes and parasphenoid rostrum below the level of the occipital condyle and the basal tubera (1); bent with the basal tubera below the occipital condyle and the parasphenoid rostrum above it (2).

*Sarhsaurus* (0)

63) Ridge formed along the junction of the parabasisphenoid and the basioccipital, between the basal tubera: present with a smooth rostral face (0); present with a median fossa on the rostral face (1); absent with the basal tubera separated by a deep fossa that opens caudally into a U-shaped fossa (2).

*Sarhsaurus* (1)

64) Ossification of the extremity of the basal tubera: complete, so that the basioccipital and parabasisphenoid form a single rugose tuber (0); unossified, with the basioccipital forming a ventrally facing platform of unfinished bone that abuts a similarly unfinished caudally facing wall of the parabasisphenoid (1).



*Sarhsaurus* (0)

65) Shape of the basal tubera: knob-like, with the basisphenoid component rostral to the basioccipital component (0); or with a transverse ridge with the basisphenoidal component lying lateral to the basioccipital component (1).

*Sarhsaurus* (0)

66) Dorsoventral depth of the parasphenoid rostrum: much less than its transverse width (0); or approximately equal to its transverse width (1).

*Sarhsaurus* (?)

67) Length of basipterygoid process (from top of the parabasisphenoid to the tip of the process): less than the height of the braincase (from the top of the parabasisphenoid to the top of the supraoccipital) (0); greater than the height of the braincase (1).

*Sarhsaurus* (0)

68) Shape of the jugal process of the ectopterygoid: gently curved (0); strongly recurved and hook-like (1).

*Sarhsaurus* (1)

69) Pneumatic fossa on the ventral surface of the ectopterygoid: present (0); or absent (1).

*Sarhsaurus* (1)

70) Position of the maxillary articulating surface of the palatine: on the lateral margin of the bone (0); at the end of a narrow rostromedial process (1).

*Sarhsaurus* (?)

71) Medial process of pterygoid forming a hook around the basipterygoid process: absent (0); flat and blunt ended (1); pointed and bent upward (2).

*Sarhsaurus* (1)

72) Rostral end of dentary: is narrower dorsoventrally than the caudal portion (0); is wider dorsoventrally, and more robust, than the caudal portion (1).

*Sarhsaurus* (0)

73) Dentary in lateral view: is essentially straight or curves slightly upwards towards its rostral tip (0); curves ventrally towards its rostral tip (1).

*Sarhsaurus* (1)

74) Ridge on lateral surface of dentary (possibly associated with a fleshy cheek in life): absent (0); or present (1).

*Sarhsaurus* (1)

75) Outline of lower jaw in dorsal view: the rami meet each other at an acute angle (0); the rostral ends of the dentaries curve toward each other creating a U-shaped outline (1).

*Sarhsaurus* (0)

76) Height : Length ratio of dentary: < 0.2 (0); or > 0.2 (1).

*Sarhsaurus* (0)

77) Long diameter of external mandibular fenestra: is 10-15 per cent of mandible length (0); or is 5 per cent of mandible length or less (1).

*Sarhsaurus* (0)

78) External mandibular fenestra: present (albeit in a reduced form) (0); closed (1).

*Sarhsaurus* (0)

79) Jaw articulation: lies above the dorsal margin of the dentary (0); lies well below the dorsal margin of the dentary (at or close to the level of the ventral margin of the dentary) (1).

*Sarhsaurus* (1)

80) Retroarticular process length divided by its height at its base: <1.0 (0); or > 1.0 (approaching 2.0) (1).

*Sarhsaurus* (1)

81) Stout triangular medial process of the articular behind the glenoid: present (0); absent (1).

*Sarhsaurus* (?)

82) Strong medial embayment behind the glenoid of the articular in dorsal view: absent (0); present (1).

*Sarhsaurus* (?)

83) Number of teeth in the premaxilla: 4 (0); 5 or more (1).

*Sarhsaurus* (0)

84) Adjacent tooth crowns: are aligned to they do not overlap in lateral view (0); or are angled relative to the long axis of the jaw so tooth crowns appear to overlap in lateral view (each tooth has its mesial margin lying lingual to the distal margin of the crown immediately in front) (1).

*Sarhsaurus* (1)

85) Adjacent tooth crowns: not in contact (0); or in contact (1).

*Sarhsaurus* (1)

86) Tooth crown serrations: project approximately perpendicular to the long axis of the crown (0); or project at approximately 45 degrees to the long axis of the crown (1); or serrations absent (2).

*Sarhsaurus* (1)

87) First dentary tooth lies at extreme rostral end of the dentary (0); or is inset a short distance from the rostral tip of the dentary (1).

*Sarhsaurus* (1)

88) Lingual surface of tooth crowns: are convex or flat mesiodistally (0); have a concave area (either mildly concave or strongly concave) (1).

*Sarhsaurus* (1)

89) Lingual surfaces of tooth crowns: are convex, nearly flat, or slightly concave mesiodistally (0); or are deeply concave mesiodistally (1)

*Sarhsaurus* (0)

90) Prominent grooves near the distal margin of the labial surface of each tooth crown: absent (0); or present (1).

*Sarhsaurus* (0)

91) Prominent grooves near the mesial margin of the labial surface of each tooth crown: absent (0); or present (1)

*Sarhsaurus* (0)

92) Tooth crowns: are all recurved (0); or are lanceolate in at least the middle and caudal part of the tooth row (1).

*Sarhsaurus* (1)

93) Number of dentary teeth: 10 or more (0); 17 or fewer (1).

*Sarhsaurus* (1)

94) Orientation of dentary tooth crowns: erect (0); or procumbent (1).

*Sarhsaurus* (0)

95) Orientation of maxillary tooth crowns: erect (0); or procumbent (1).

*Sarhsaurus* (0)

96) Teeth with basally constricted crowns: absent (0); or present (1).

*Sarhsaurus* (1)

97) Tooth-tooth occlusion: absent (0), or present (1).

*Sarhsaurus* (0)

98) Tooth crown enamel: smooth (0); or wrinkled (1).

*Sarhsaurus* (0)

99) Tooth crown serrations: distributed along the mesial and distal margins of the crown (0); or restricted to the apical half of the crown (1).

*Sarhsaurus* (0)

100) Number of cervical vertebrae: nine or fewer (0); or ten or more (1).

*Sarhsaurus* (1)

101) Number of cervical vertebrae: ten or fewer (0); 12 or more (1).

*Sarhsaurus* (0)

102) Shallow dorsally facing fossa on the atlantal neuropophysis: absent (0); present (1).

*Sarhsaurus* (?)

103) Axial postzygapophyses: project caudally beyond end of centrum (0); are flush with end of centrum (1).

*Sarhsaurus* (1)

104) Length : Height ratio of axis centrum: < 3.0 (0); 3.0 or more (1).

*Sarhsaurus* (1)

105) Length : height ratio of longest postaxial cervical centrum: < 3.0 (0); 3.0 or more (1).

*Sarhsaurus* (1)

106) Articulations between cervical centra: are amphicoelous/amphiplatyan (0); are opisthocoelous (1).

*Sarhsaurus* (0)

107) Dorsal excavation of the cervical parapophyses: absent (0); present (1).

*Sarhsaurus* (0)

108) Strong lateral compression of cranial cervical vertebrae: absent (0); present (1).

*Sarhsaurus* (1)

109) Ventral keels on caudal cervical vertebrae: present (0); absent (1).

*Sarhsaurus* (0)

110) Height of neural arches of mid-cervicals: is less than centrum diameter (0); is equal to or greater than centrum diameter (1).

*Sarhsaurus* (0)

111) Height of mid-cervical neural arches: is equal to, or less than, centrum diameter (0); is greater than centrum diameter (1).

*Sarhsaurus* (0)

112) Centrodiphyseal lamina system: is restricted to the dorsal vertebrae and caudal cervicals (0); is found on all presacral vertebrae (1).

*Sarhsaurus* (1)

- 113) Short cranially projected pedicels bearing axial prezygapophyses: absent (0); present (1).  
*Sarhsaurus* (0)
- 114) Epipophyses overhanging the rear margin of the postzygapophyses: present (0); absent (1).  
*Sarhsaurus* (1)
- 115) Caudal ends of cranial postaxial epipophyses: with a free pointed tip (0); joined to the postzygapophyses along their entire length (1).  
*Sarhsaurus* (1)
- 116) Length : height ratios for caudal dorsal centra: < 1.0 (0); >1.0 (1).  
*Sarhsaurus* (1)
- 117) Lateral surfaces of dorsal centra: with at most a shallow depression (0); strongly excavated (either deep fossae or true pleurocoels) (1).  
*Sarhsaurus* (0)
- 118) Lateral surfaces of dorsal centra: have a shallow or deep depression (0); have a deep pleurocoel that is sharp-edged and ramifies within the centrum (1).  
*Sarhsaurus* (0)
- 119) Height of dorsal neural arch (i.e., from top of centrum to the level of the zygapophyses): low (less than that of the centrum) (0); high (i.e., subequal to, or greater than, the height of the centrum) (1).  
*Sarhsaurus* (0)
- 120) Cranial face of dorsal neural arch: is flat or shallowly excavated (0); is deeply excavated, forming a large cavity above the neural canal (1).  
*Sarhsaurus* (0)
- 121) Cranial dorsal transverse processes are directed: laterally or slightly upwards (0); strongly dorsolaterally (1).  
*Sarhsaurus* (0)
- 122) Laminae (prezygodiapophyseal) linking the prezygapophyses to the transverse processes on caudal dorsal vertebrae; present (0); absent (1).  
*Sarhsaurus* (1)
- 123) Prezygodiapophyseal lamina on cranial dorsals: present (0); absent (1).  
*Sarhsaurus* (0)
- 124) Spinodiapophyseal lamina on middle and caudal dorsal vertebrae: absent (0); present (1).  
*Sarhsaurus* (0)

125) Laterally expanded tables at the mid-length of the distal surface of the neural spines: absent in all vertebrae (0); present on the cervical vertebrae (1).

*Sarhsaurus* (1)

126) Laterally expanded tables at mid-length on the distal surface of the neural spines: absent, or present on cranial dorsal vertebrae alone (0); present on cervical and cranial dorsal vertebrae (1).

*Sarhsaurus* (1)

127) Dorsoventral height of the hyposphene: much less than the dorsoventral height of the neural canal (0); equal to the dorsoventral height of the neural canal (1).

*Sarhsaurus* (0)

128) Ratio of the height of the neural spine to its craniocaudal basal width:  $> 1.5$  (0);  $< 1.5$  (1).

*Sarhsaurus* (1)

129) Cross-sectional shape of dorsal neural spines: narrow and elliptical (0); broad and triangular (1).

*Sarhsaurus* (0)

130) Composite lateral laminae on dorsal neural spines: absent (0); present (1).

*Sarhsaurus* (0).

131) Spinoprezygapophyseal laminae: absent (0); present on caudal or all dorsal vertebrae (1).

*Sarhsaurus* (0).

132) Spinoprezygapophyseal laminae: absent, or present as low ridges on caudal dorsal vertebrae only (0); present on all dorsals as thin laminae (1).

*Sarhsaurus* (0)

133) Well-developed spinoprezygapophyseal laminae: absent (0); present on at least the caudal dorsal vertebrae (1).

*Sarhsaurus* (0)

134) Well-developed spinoprezygapophyseal laminae: absent or restricted to the caudal dorsal vertebrae (0); present on all dorsal vertebrae (1).

*Sarhsaurus* (0)

135) Accessory infrapostzygapophyseal laminae on dorsal vertebrae: present (0); absent (1).

*Sarhsaurus* (1)

136) Hindlimb:trunk ratio: is 1.0 or lower (0);  $> 1.0$  (1).

*Sarhsaurus* (0)

137) Last presacral rib: free (0); fused to vertebra (1).

*Sarhsaurus* (1)

138) Sacral number is two (0); or 3 (1) (via addition of caudosacral).

*Sarhsaurus* (?)

139) Sacral number is two (0); or 3 (1) (via addition of dorsosacral).

*Sarhsaurus* (?)

140) Sacral number: four or fewer (0); five or more (1).

*Sarhsaurus* (0)

141) Sacricostal yolk (distal ends of sacral ribs fuse together): absent (0); or present (1).

*Sarhsaurus* (1)

142) Scaricostal yoke: does not contribute to the dorsal rim of the acetabulum (0); or contributes to the dorsal margin of the acetabulum (1).

*Sarhsaurus* (0)

143) Strong constriction between the sacral rib and transverse process of the first primordial sacral (and dorsosacral if present) in dorsal view: absent (0); or present (1).

*Sarhsaurus* (1)

144) Caudal centrum length : height ratio: > 1.0 (0); 1.0-0.7 (1); < 0.7 (2)

Note: Upchurch et al. score this as ordered; we score as unordered.

*Sarhsaurus* (0/1)

145) Length of mid-caudal centra compared with height of the cranial articular face: > 2.0 (0); < 2.0 (1).

*Sarhsaurus* (0)

146) Longitudinal sulcus on the ventral surface of caudal centra: absent (0); or present (1).

*Sarhsaurus* (1)

147) Caudal hyosphene ridge: absent (0); or present (1).

*Sarhsaurus* (0)

148) Length of base of the proximal caudal neural spines: greater than (0); or less than (1) half the length of the neural arch.

Note: on Caudal 1 this state does not apply, but it does to more posterior caudals.

*Sarhsaurus* (0)

149) Position of postzygapophyses in proximal caudal vertebrae: protruding with an interpostzygapophyseal notch visible in dorsal view (0); placed on either side of the base of the neural spine, without an interpostzygapophyseal notch (1).

*Sarhsaurus* (0)

150) Disappearance of caudal ribs occurs: on caudal 20 or more distally (0); on caudals 14-16 or more cranially (1).

*Sarhsaurus* (0)

151) Forked or skid-like middle and distal chevrons: absent (0); present (1).

*Sarhsaurus* (0)

152) Mid-caudal chevrons with ventral midline slit: absent (0), or present (1).

*Sarhsaurus* (0)

153) Length of the longest chevron divided by the length of the centrum preceding it: < 1.0 (0); > 1.0 (1).

*Sarhsaurus* (1)

154) Longitudinal ridge along the dorsal surface of the sternal plate: absent (0); present (1).

Note: the ridge is on the superficial or ventral surface, not dorsal as Upchurch et al. assert.

*Sarhsaurus* (1)

155) Craniocaudal length of the acromion process of the scapula: < 1.5 (0); or > 1.5 times the minimum width of the scapula blade.

*Sarhsaurus* (0)

156) Minimum width of the scapula divided by the scapular length: < 0.2 (0); or > 0.2 (1).

*Sarhsaurus* (0)

157) Scapular blade in lateral view: with strap-shaped midsection that has straight, subparallel margins (0); or waisted with curved margins (1).

*Sarhsaurus* (1)

158) Caudal margin of the acromion process of the scapula rises at an angle to the blade that, at its steepest point is: < 65 degrees (0); or > 65 degrees (1).

*Sarhsaurus* (0)

159) Flat caudoventrally facing surface on the coracoid between the glenoid and the coracoid tubercle: absent (0); or present (1).

*Sarhsaurus* (1)

160) Coracoid tubercle: present (0), or absent (1).



*Sarhsaurus* (0)

161) Forelimb : Hindlimb length ratio is: < 0.60 (0); or 0.60 or more (1).

*Sarhsaurus* (0)

162) Forelimb : Hindlimb length ratio is: < 0.75 (0); or 0.75 or more (1).

*Sarhsaurus* (0)

163) Deltopectoral crest: slants at 45-60 degrees to the transverse axis of the distal condyles (0); is perpendicular to the transverse axis of the distal condyles (1).

*Sarhsaurus* (0)

164) Deltopectoral crest: terminates less than 50% of humerus length from its proximal end (0); or terminates at least at 50% of humerus length from the proximal end (1).

*Sarhsaurus* (1)

165) Deltopectoral crest is: visible in caudal view (because the crest projects laterally beyond the rest of the shaft) (0); or is not visible in caudal view (1).

*Sarhsaurus* (0)

166) Deltopectoral crest: prominent (0); or reduced to a low ridge (1).

*Sarhsaurus* (0)

167) Craniolateral margin of the deltopectoral crest in cranial view: straight (0); or sigmoid (1).

*Sarhsaurus* (1)

168) Humerus : Femur length ratio: < 0.55 (0); or > 0.55 (1).

*Sarhsaurus* (1)

169) Humerus : Femur ratio: < 0.65 (0); or > 0.65 (1).

*Sarhsaurus* (0)

170) Humerus : Femur ratio: < 0.8 (0); or > 0.8 (1).

*Sarhsaurus* (0)

171) Well-defined semicircular fossa on the distal flexor surface of the humerus: present (0); or absent (1).

*Sarhsaurus* (0)

172) Ratio of the transverse width of the distal end to total humerus length: < 0.33 (0); or > 0.33 (1).

*Sarhsaurus* (1)

- 173) Proximal end of the ulna is: subtriangular in outline and lacks a groove for the radius (0); triradiate because of a deep groove for reception of the radius (1).  
*Sarhsaurus* (1)
- 174) Olecranon process: present as a prominent projection (0); or almost completely absent (1).  
*Sarhsaurus* (1)
- 175) Ratio of lengths of the craniomedial and craniolateral processes of the proximal end of the ulna: c. 1.0 (0); or > 1.0 (1).  
*Sarhsaurus* (?)
- 176) Radius : Humerus length ratio: < 0.80 (0); or 0.80 or more (1).  
*Sarhsaurus* (0)
- 177) Distal condyle of radius: is subcircular or oval in outline (0); or is subrectangular with a flattened caudal margin for articulation with the ulna (1).  
*Sarhsaurus* (0)
- 178) Proximal carpals: present as ossifications (0); or absent or fail to ossify (1).  
*Sarhsaurus* (0)
- 179) Maximum linear dimensions of ulnare and radiale: exceed those of at least one of the first three distal carpals (0); or are less than any of the distal carpals (1).  
*Sarhsaurus* (1)
- 180) First distal carpal: is narrower transversely than metacarpal I (0); or is subequal to, or greater than the transverse width of metacarpal I (1).  
*Sarhsaurus* (1)
- 181) Lateral end of first distal carpal: abuts the second distal carpal (0); or overlaps the second distal carpal (1).  
*Sarhsaurus* (1)
- 182) Proximal end of first metacarpal: flush with the proximal ends of the other metacarpals (0); or inset into the wrist (1).  
*Sarhsaurus* (0)
- 183) Second distal carpal: completely covers the proximal end of the second metacarpal (0); does not cover this surface completely (1).  
*Sarhsaurus* (1)
- 184) Length of the manus divided by humerus + radius length: > 0.45 (0); < 0.45 (1).  
*Sarhsaurus* (0)

185) Length of the manus divided by humerus + radius length: > 0.40 (0); < 0.40 (1).  
*Sarhsaurus* (0)

186) Proximal width of metacarpal I divided by proximal width of metacarpal II: < 1.0 (0); or > 1.0 (1).  
*Sarhsaurus* (1)

187) Proximal width of metacarpal I divided by proximal width of metacarpal II: < 0.65 (0); or > 0.65 (1).  
*Sarhsaurus* (1)

188) Proximal width of metacarpal I divided by metacarpal length: <0.8 (0); or > 0.8 (1).  
*Sarhsaurus* (0)

189) Proximal width of metacarpal I divided by metacarpal length: <1.0 (0); or > 1.0 (1).  
*Sarhsaurus* (0)

190) Strong asymmetry in the lateral and medial condyles of the first metacarpal: absent (0); or present (1).  
*Sarhsaurus* (1)

191) Deep distal extensor pits on the distal end of metacarpals II and III: present (0), or absent (1).  
*Sarhsaurus* (0)

192) Shape of metacarpal V: longer than wide at the proximal end, with a flat proximal surface (0); nearly as wide as long with a strongly convex proximal surface (1).  
*Sarhsaurus* (1)

193) Metacarpal V: is reduced or absent (0); or is large, robust and approximately 90% of the length of longest metacarpal (1).  
*Sarhsaurus* (?)

194) Proximal heel on first phalanx of manual digit I: absent (0), or present (1).  
*Sarhsaurus* (1)

195) First phalanx of manual digit I: has its proximal and distal articular surfaces with their axes in the same plane (0); or has proximal and distal articular axes twisted so that they are at approximately 45 degrees to each other (1).  
*Sarhsaurus* (0)

196) First phalanx of manual digit I: has its proximal and distal articular surfaces with their axes in the same plane or twisted by no more than 45 degrees (0); or has proximal and distal articular surfaces with their axes twisted so that they are at approximately 60 degrees to each other (1).  
*Sarhsaurus* (0)

197) Length of manual digit I divided by length of manual digit II:  $< 1.0$  (0); or  $> 1.0$  (1).  
*Sarhsaurus* (0)

198) Length of ungual on manual digit II divided by length of ungual on manual digit I:  
 $> 1.0$  (0); or  $< 1.0$  (1).  
*Sarhsaurus* (1)

199) Length of ungual on manual digit II divided by length of ungual on manual digit I:  
 $> 0.75$  (0); or  $< 0.75$  (1).  
*Sarhsaurus* (1)

200) Length of ungual on manual digit II divided by the length of ungual on manual digit I:  
 $> 0.75$  (0); ungual on manual digit II absent (1).  
*Sarhsaurus* (0)

201) Shape of non-terminal phalanges: longer than wide (0); or as wide as long (1).  
*Sarhsaurus* (0)

202) Phalangeal formula of manual digits IV and V: less than 2-0 (0); or at least equal to or greater than 2-0, respectively (1).  
*Sarhsaurus* (1)

203) Cranial process of the ilium: lacks a scar (0); or scar present (1)  
*Sarhsaurus* (1)

204) Cranial process of ilium: terminates behind the level of the distal end of the pubic process (0); or projects further cranially than the distal end of the pubic process (1).  
*Sarhsaurus* (0)

205) Cranial process of ilium: is long and slender or very short (0); is relatively large and has a broad triangular outline in lateral view (1).  
*Sarhsaurus* (0)

206) Depth of the cranial process of the ilium: much less than the depth of the ilium above the acetabulum (0); is approximately the same depth as the ilium immediately above the acetabulum (1).  
*Sarhsaurus* (0)

207) Length of cranial process of the ilium divided by its maximum depth:  $< 2.0$  (0); or  $> 2.0$  (1).  
*Sarhsaurus* (0)

208) Area between the cranial process of the ilium and the pubic peduncle: is gently curved in lateral view (0); or is acute in lateral view (1).  
*Sarhsaurus* (0)

209) Iliac portion of acetabulum: partially backed by wall of bone (0); almost completely open (1).

*Sarhsaurus* (1)

210) Concave area on lateral surface of ilium: extends ventrally to a point close to the acetabular margin (0); or is restricted to the dorsal half of the blade (1).

*Sarhsaurus* (0)

211) Dorsal margin of ilium is smoothly convex (mildly or strongly) in lateral view (0); or has step-like sigmoid profile in lateral view (1).

*Sarhsaurus* (0)

212) Lateral profile of the dorsal margin of the ilium: is straight or sinusoidal (0); is strongly convex (1).

*Sarhsaurus* (0)

213) Length of pubic peduncle of ilium divided by the craniocaudal width of the peduncle:  $< 2.0$  (0); or  $> 2.0$  (1).

*Sarhsaurus* (1)

214) Ischial peduncle of the ilium: is subequal in length to the pubic peduncle, giving the long axis of the iliac blade a nearly horizontal orientation (0); or is reduced so that the long axis of the iliac blade slopes strongly craniodorsally in lateral view (1).

*Sarhsaurus* (1)

215) Caudally projecting heel at the distal end of the ischial peduncle of the ilium: absent (0); or present (1).

*Sarhsaurus* (1)

216) Length of the postacetabular process of the ilium divided by the total length of the ilium:  $> 0.30$  (0); or  $< 0.30$  (1).

*Sarhsaurus* (0)

217) Well-developed brevis fossa with sharp margins on the ventral surface of the postacetabular process of the ilium: absent (0); or present (1).

*Sarhsaurus* (0)

218) Shape of the caudal margin of the postacetabular process of the ilium: rounded and bluntly pointed (0); square ended (1); or with a pointed ventral corner and a rounded caudodorsal margin (2).

*Sarhsaurus* (2)

219) Pubic acetabular margin: is approximately subequal in length to the ischial acetabular margin (0); is approximately half the length of the ischial acetabular margin (1).

Note: Upchurch et al. probably mean pubic acetabular margin is twice (not half) the length of the ischial margin, based on how they scored *Massospondylus* with state (1).  
*Sarhsaurus* (1)

220) Pubis in cranial view: lateral margin of the apron is straight or bows laterally (0); or has a concave profile (1).  
*Sarhsaurus* (1)

221) Ischium : Pubis length ratio: < 0.90 (0); or 0.90 or more (1).  
*Sarhsaurus* (0)

222) Pubic obturator foramen: is absent or very small (0); or is large, at least 50% of acetabulum diameter (1); or has 2 obturator foramina (2).  
*Sarhsaurus* (2)

223) Pubic obturator foramen: partially obscured in cranial view of the pubis (0); or is completely visible in cranial view of the pubis (1).  
*Sarhsaurus* (1)

224) Middle and distal portions of the pubis: form a transverse sheet of bone that is twisted with respect to the proximal end (0); or lies in approximately the same plane as the proximal end (1).  
*Sarhsaurus* (0)

225) Pubic tubercle on the lateral surface of the proximal pubis: present (0); or absent (1).  
*Sarhsaurus* (0)

226) Width of the conjoined pubes divided by their length: < 0.7 (0); or > 0.7 (1).  
*Sarhsaurus* (1)

227) Minimum transverse width of the pubic apron divided by the width across the pubic peduncles of the ilium: > 0.4 (0); or < 0.4 (1).  
*Sarhsaurus* (1)

228) Craniocaudal length of the distal pubic expansion divided by pubis length: < 0.15 (0); or > 0.15 (1).  
*Sarhsaurus* (1)

229) Notch separating caudoventral end of the ischial obturator plate from the ischial shaft: present (0); or absent (1).

Note: presence of a notch may be artifact of breakage of thin ischial plate.

*Sarhsaurus* (1)

230) Elongate inter ischial fenestra: present (0); or absent (1).  
*Sarhsaurus* (1)

231) Long axes of the distal ends of the ischia: are set at an angle to each other (0); or are co-planar (1).

*Sarhsaurus* (0)

232) Distal end of ischium: is only slightly expanded relative to the rest of the shaft (0); is strongly expanded dorsoventrally (so that the thickness of the shaft appears to have doubled at the distal end in lateral view) (1).

*Sarhsaurus* (1)

233) Distal end of ischium: maximum thickness is less than three times the minimum thickness (0); or maximum thickness is at least three times minimum thickness (1).

*Sarhsaurus* (0)

234) Outline of the distal end of ischium: rounded or flattened (0); or subtriangular (1).

*Sarhsaurus* (0)

235) Proximal end of the lesser trochanter: terminates below femoral head (0); or terminates level with femoral head (1).

*Sarhsaurus* (0)

236) Lesser trochanter: all of lateral edge lies medial to the lateral edge of femur (0); or projects beyond the lateral edge of the femur so that it is visible in caudal view (1).

*Sarhsaurus* (0)

237) Lesser trochanter on the femur: is well developed (0); or is absent or greatly reduced (1).

*Sarhsaurus* (1)

238) Lesser trochanter: is well developed or is reduced to a still visible ridge (0); or is completely absent (1).

*Sarhsaurus* (0).

239) Lesser trochanter: is a ridge-like structure or reduced (0); or is developed into a prominent sheet-like structure (1).

*Sarhsaurus* (0)

240) Fourth trochanter: is a prominent plate-like structure (0); or is reduced to a low ridge (1).

*Sarhsaurus* (1)

241) Fourth trochanter on the femoral shaft: lies in the proximal half (0); or lies over the midpoint (1).

*Sarhsaurus* (0)

242) Profile of the fourth trochanter is lateral/medial view: rounded and symmetrical (0); or asymmetrical with the distal margin steeper than the rounded dorsal margin (1).  
*Sarhsaurus* (1) change in matrix (TR 5/15/2010)

243) Fourth trochanter of the femur: lies centrally on the caudal surface (0); or lies near the caudomedial margin (1).  
Note: polarity may be backwards on this character as described.  
*Sarhsaurus* (1)

244) Femoral head: projects medially or ventromedially (0); projects dorsomedially (1).  
Note: polarity may be backwards on this character as described.  
*Sarhsaurus* (0)

245) Proximal end of femur in cranial or caudal view: merges smoothly with the lateral margin of the shaft (0); meets the lateral margin at an abrupt angle (approximately 90 degrees) (1).  
*Sarhsaurus* (0)

246) Femoral shaft: has a sigmoid curve (0); is straight (in cranial or caudal view) (1).  
*Sarhsaurus* (1)

247) Cranial face of femur in lateral view: is convex (0); or is straight (1).  
*Sarhsaurus* (1)

248) Horizontal cross-section through the femoral shaft: is subcircular (0); is elliptical or subrectangular (with the transverse diameter wider than the craniocaudal diameter) (1).  
*Sarhsaurus* (1)

249) Angle between the long-axis of the femoral head and the transverse-axis of the distal end: close to 30 degrees (0); or close to 0 degrees (1).  
*Sarhsaurus* (1)

250) Tibia : Femur length ratio: 1.0 or more (0); or < 1.0 (1).  
*Sarhsaurus* (1)

251) Tibia : Femur length ratio: approximately 0.65 or higher (0); or < 0.65 (1)  
*Sarhsaurus* (0)

252) Extensor depression on the distal end of the femur: absent (0); or present (1).  
*Sarhsaurus* (1)

253) Cnemial crest on the tibia: is directed cranially (0); or is directed laterally (1).  
*Sarhsaurus* (0)

254) Medial malleolus of the tibia: extends caudoventrally to cover astragalus in caudal view (0); or is reduced, exposing the posterior fossa of the astragalus in caudal view (1).



*Sarhsaurus* (1)

255) Transverse width of the distal tibia: subequal to its craniocaudal width (0); greater than its craniocaudal width (1).

*Sarhsaurus* (0)

256) Trigonal striated articular crest on medial surface of the proximal end of the fibula: absent (0); or present (1).

*Sarhsaurus* (0)

257) Muscle scar/trochanter on the lateral surface of fibula (at mid-length): absent (0); or present (1).

*Sarhsaurus* (1)

258) Ascending process of the astragalus: extends dorsally in front of the distal end of the tibia (0); or keys into the distal end surface of tibia (1).

Comment: polarity of this character is backwards as described.

*Sarhsaurus* (1)

259) Depression and vascular foramina in front of the base of the astragalar ascending process: present (0); or absent (1).

*Sarhsaurus* (0)

260) Caudal fossa of the astragalus: is undivided (0); or is divided into lateral and medial portions by the presence of a ridge or crest that descends ventromedially from the apex of a ridge or crest that descends ventromedially from the apex of the ascending process (1).

Note: this character is meant to separate sauropods; this feature is incipiently present in *Sarhsaurus* type right astragalus.

*Sarhsaurus* (1)

261) Depth of the medial end of the astragalus in cranial view: equal to the depth of the lateral end (0); or much less than the lateral view, making the astragalus wedge-shaped (1).

*Sarhsaurus* (0)

262) Shape of the caudomedial margin of the astragalus in dorsal view: forms a moderately sharp corner of a subrectangular outline (0); or is smoothly rounded without a caudomedial corner (1).

*Sarhsaurus* (0)

263) Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus: present (0); or absent so that the fibular facet faces laterally and is vertical (1).

*Sarhsaurus* (0)

264) A lateral horizontal groove on the calcaneum: absent (0); or present (1).

*Sarhsaurus* (?)

265) Transverse width of the calcaneum divided by the transverse width of the astragalus: > 0.3 (0); < 0.3 (1).

*Sarhsaurus* (?)

266) Number of ossified distal tarsals: two or more (0); none (1).

*Sarhsaurus* (0)

267) Metatarsal III length : tibia length ratio: 0.4 or higher (0); < 0.4 (1).

*Sarhsaurus* (0)

268) Metatarsal III length: tibia length ratio: > 0.3 (0); OR < 0.3 (1).

*Sarhsaurus* (0)

269) Metatarsal I length : width ratio: > 1.5 (0); or < 1.5 (1).

*Sarhsaurus* (0)

270) Proximal ends of metatarsals I and V: are smaller in area than those of metatarsals II and IV (0); have areas equal to or larger than metatarsals II and IV (1).

*Sarhsaurus* (0)

271) Medial margin of the proximal end of metatarsal II: straight or convex (0); concave (1).

*Sarhsaurus* (1)

272) Lateral margin of the proximal end of metatarsal II: straight or convex (0); concave (1).

*Sarhsaurus* (1)

273) Metatarsals II and III have proximal width : length ratios of: < 0.25 (0); or 0.25 or higher (1).

*Sarhsaurus* (1)

274) Metatarsal IV proximal end transverse width : dorsoventral height ratio: < 2.0 (0); or > 2.0 (1).

*Sarhsaurus* (?)

275) Metatarsal IV proximal end transverse width : dorsoventral height ratio: < 3.0 (0); or approximately 3.0 (1).

*Sarhsaurus* (?)

276) Minimum shaft widths of metatarsals III and IV divided by minimum shaft width of metatarsal II: < 0.6 (0); or > 0.6 (1)

*Sarhsaurus* (0)

277) Metatarsal V in dorsal (cranial) view: has proximal and distal ends approximately subequal in width (0); or has a transversely widened proximal end and narrowed distal end so that the metatarsal is funnel or paddle shaped (1).

*Sarhsaurus* (1)

278) Metatarsal V length: < 50 percent of metatarsal III length (0); or > 50 per cent of metatarsal III length (1).

*Sarhsaurus* (1)

279) Proximal width : length ratio of metatarsal V: < 0.25 (0); or > 0.25 (1).

*Sarhsaurus* (1)

280) Proximal width : length ratio of metatarsal V: < 0.5 (0); or > 0.5 (1).

*Sarhsaurus* (1)

281) At least some pedal phalanges, apart from unguals: are longer proximodistally than their transverse widths (0); or are wider transversely than their proximodistal lengths (1).

*Sarhsaurus* (0)

282) Number of pedal phalanges on pedal digit IV: four (0); or fewer than four (1).

*Sarhsaurus* (0)

283) Phalanges on pedal digit V: absent (0); or present (1).

Note: polarity is questionable.

*Sarhsaurus* (1)

284) Ungual on pedal digit I: is shorter than other pedal unguals (0); or is longer than other pedal unguals (1).

*Sarhsaurus* (?)

285) Ungual on pedal digit I: is shorter than other pedal phalanges (0); is subequal to, or longer than, all other pedal phalanges (1).

*Sarhsaurus* (1)

286) Ungual on pedal digit I: shorter than metatarsal I (0); or longer than metatarsal I (1).

*Sarhsaurus* (0)

287) Shape of unguual on pedal digit I: shallow, pointed, with convex sides and broad ventral surface (0); or deep, abruptly tapering with flat sides and a narrow ventral surface (1).

*Sarhsaurus* (0)

288) Proximal ends of unguals on pedal digits II and III: have subequal transverse and dorsoventral diameters (or oare dorsoventrally compressed) (0); or are transversely compressed (1).

*Sarhsaurus* (0)

289) Length of ungual on pedal digit II divided by length of ungual on pedal digit I: > 1.0 (0); < 1.0 (1).

*Sarhsaurus* (1)

290) Length of ungual on pedal digit II divided by length of ungual on pedal digit I: >0.9 (0); or < 0.9 (1)

*Sarhsaurus* (1)

291) Length of ungual on pedal digit III divided by length of ungual on pedal digit II: > 0.85 (0); or < 0.85 (1).

*Sarhsaurus* (0)

292) Pedal unguals: directed forwards (0); or deflected forwards and laterally, so that the articular surfaces of the unguals are only visible in lateral view (1).

*Sarhsaurus* (?)



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Barapasaurus

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**Blikanasaurus**

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**Camarasaurus**

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**Camelotia**

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**Chinshakiangosaurus**

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**Efraasia**

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**Gyposaurus**

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Jingshanosaurus

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Kotasaurus

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Lessemsaurus

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Lufengosaurus

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Massospondylus

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Melanorosaurus

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Mussaurus

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Plateosaurus

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Riojasaurus

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Saturnalia

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Shunosaurus

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Thecodontosaurus

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Vulcanodon

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Yunnanosaurus

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Sarhsaurus

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