

New insights into the phylogeny of *Tortopus* Needham and Murphy and *Tortopsis* Molineri (Ephemeroptera, Polymitaarcyidae) with description of three new species

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Appendix 1. Matrix, list of characters and states (modified from Molineri 2010), and list of synapomorphies defining the unique shortest tree (Fig. 71) found under implied weighting parsimony.

Char.	0	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	
<i>Ephoron</i>	0	0	0	0	0	0	-	-	0	0	0	0	0	0	0	0	0	0	-	0	2	0	1	0	0	0	-	0	0	0	1	
<i>Asthenopus</i>	1	0	0	0	0	1	2	0	0	0	3	2	0	0	0	0	0	0	-	1	2	0	0	0	0	0	-	0	0	0	2	
<i>C. segnis</i>	2	1	0	0	1	1	2	0	0	2	0	2	1	2	1	1	0	0	-	1	2	0	0	0	2	0	0	0	0	1	1	
<i>C. latipennis</i>	2	1	0	0	1	1	2	0	0	2	0	2	1	2	1	1	0	0	-	1	2	0	1	0	2	0	0	0	0	1	1	
<i>C. albifilum</i>	2	1	0	0	1	1	2	0	0	2	3	2	1	0	1	1	0	0	-	1	2	0	0	0	0	0	-	0	0	1	1	
<i>C. violaceus</i>	2	1	0	0	1	1	2	0	0	2	3	2	1	1	1	1	0	0	-	1	2	0	0	0	0	0	-	0	0	1	1	
<i>T. igaranus</i>	2	1	1	1	1	2	1	0	1	1	2	1	1	3	1	1	0	1	-	1	1	1	1	0	2	0	0	1	1	1	0	
<i>T. bellus</i>	2	1	1	1	1	2	1	0	1	1	2	1	1	3	1	1	0	1	-	1	1	1	1	0	1	0	0	1	1	1	0	
<i>T. arenales</i>	2	1	1	1	1	2	1	0	1	1	2	0	0	3	1	1	0	1	-	1	1	1	1	0	2	0	0	1	1	1	0	
<i>T. bruchianus</i>	2	1	1	1	2	2	0	1	0	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0
<i>T. sarae</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	0	1	0	0	1	0	3	0	2	1	0	1	0	
<i>T. obscuripennis</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	0	1	0	0	1	1	3	0	2	1	0	1	0	
<i>T. unguiculatus</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	1	1	0	0	1	0	3	0	3	1	0	1	0	
<i>T. limoncocha</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	0	1	0	0	1	0	3	0	1	1	0	1	0	
<i>T. harrisi</i>	2	1	1	1	1	2	1	0	1	1	2	1	1	3	1	1	0	1	-	1	1	1	1	0	1	0	0	1	1	1	0	
<i>T. parishii</i>	2	1	?	?	?	?	?	?	?	1	?	1	1	3	1	1	1	0	-	1	0	0	1	0	?	?	?	?	?	0	-	
<i>T. puella</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	0	1	0	0	1	1	3	0	2	1	0	1	0	
<i>T. circumfluis</i>	2	1	1	1	1	2	1	0	1	1	2	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0
<i>T. primus</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	0	1	0	0	1	0	3	0	2	1	0	1	0	
<i>T. zottai</i>	2	1	?	?	?	?	?	?	?	1	2	1	1	3	1	1	0	1	-	1	1	1	1	0	2	0	0	1	1	-	-	
<i>T. spatula</i>	2	1	1	1	2	2	3	1	0	1	1	1	1	3	1	1	1	0	2	1	0	0	1	0	3	1	2	1	0	1	0	
<i>T. ipixuna</i>	2	1	-	-	-	-	-	-	1	2	1	1	3	1	1	0	1	-	1	1	1	1	0	1	0	0	1	1	-	-		
<i>T. canum</i>	2	1	1	1	2	2	0	1	0	1	1	1	1	3	1	1	1	0	0	1	0	0	1	0	3	0	2	1	0	1	0	
<i>T. coreguaje</i>	2	1	?	?	?	?	?	?	?	1	2	1	1	3	1	1	0	1	-	1	1	1	1	0	2	0	0	1	1	?	?	
<i>T. andaki</i>	2	1	1	1	?	2	3	1	0	1	1	1	1	3	1	1	1	0	2	1	0	0	1	0	3	1	1	1	0	1	0	
<i>T. toro</i>	2	1	1	1	?	2	1	1	0	1	1	1	1	3	1	1	1	0	2	1	0	0	1	1	3	1	0	1	0	1	0	

Character 0. Fore wings, number of intercalary cubital veins (Kluge 2004). (0) four or more, small and sigmoid; (1) two located just on or posteriorly to tornus of wing; (2) two, one anterior and one posterior to tornus.

Character 1. Fore wings, vein CuA (Kluge 2004). (0) smoothly curved or sigmoid only on basal 1/4; (1) markedly sigmoid.

Character 2. Female wing veins (Traver 1950). (0) normal (as thick as in male); (1) thickened.

Character 3. Female hind wing anal sector. (0) normal (some cross veins may be present); (1) anastomosed.

Character 4. Female fore wing veins on R sector. (0) R₂, IR, R₃, and at least two intercalaries present; (1) R₂, IR, a somewhat reduced R₃, and a short intercalary present (Molineri 2010: figure 8); (2) without longitudinal or intercalary veins between IR and R₁ (some fused crossveins may be present, forming 1 or 2 short attached marginal intercalaries) (Molineri 2010: figure 44).

Character 5. Female parastyli receptors on abdominal sternum VIII: state 0= absent; state 1= single; state 2= paired.

Character 6. Female parastyli receptors (form). (0) C shaped (Molineri 2010: figures 46–52); (1) U-shaped (Molineri 2010: figures 6–7); (2) bottle-like; (3) V shaped (Molineri 2010: figure 78).

Character 7. Female parastyli receptors, sockets' opening towards. (0) anterior margin (Molineri 2010: figures 6–7); (1) median line (Figs 46–52).

Character 8. Female parastyli receptors with long furrows anterior to sockets. (0) no (Molineri 2010: figure 46–52); (1) yes (Molineri 2010: figure 6–7).

Character 9. Legs of imagos of both sexes (except male forelegs). (0) weak; (1) distorted; (2) flap or fin-like.

Character 10. Mesosternum, furcasternal protuberances. (0) contiguous; (1) contiguous on basal 1/3 (Molineri 2010: figure 45); (2) contiguous only on basal corner (Molineri 2010: figure 4); (3) separated.

Character 11. Male genitalia, number of forceps segments (without pedestals). (0) three segments; (1) two segments; (2) one segment.

Character 12. Male genitalia, styliger formed by. (0) median plate and pedestals; (1) only pedestals.

Character 13. Male genitalia, pedestals. (0) normal (subquadrate, without distal projections); (1) inner projected; (2) outer projected, projection lateral and blunt; (3) outer projected, projection dorsal and pointed.

Character 14. Male genitalia, pedestal muscles (Kluge 2004). (0) present; (1) absent.

Character 15. Male genitalia, articulation of penial arms (Kluge 2004). (0) ninth abdominal tergum; (1) ninth abdominal sternum and pedestals.

Character 16. Male genitalia, gonopore associated with a claw-like or spatulated spine (Fig. 30). (0) no; (1) yes.

Character 17. Male genitalia, gonopore associated with a sclerotized margin (Fig. 53). (0) no; (1)= yes.

Character 18. Male genitalia, penis (apical claw-like structure). (0)= slightly becoming thinner (Molineri 2010: figure 74); (1) with wide base, then abruptly thin or blunt (Molineri 2010: figure 43); (2) flat, spatulated (Figs 20, 30)

Character 19. Male genitalia, penis (general structure). (0) flat and apically divided structure; (1) same, added cylindrical subdistal finger (main portion of the penis of Asthenopodinae–Campsurinae)

Character 20. Male genitalia, fusion of penis. (0) separated (Fig. 19); (1) fused on basal 1/5 or less (Fig. 53); (2) fused on basal 1/2 or more.

Character 21. Male genitalia, penis (form). (0) cylindrical; (1) flattened (Fig. 53).

Character 22. Male genitalia, penis (curvature). (0) curved ventrally; (1) straight (Figs 19, 30, 53).

Character 23. Male genitalia, penis (width). (0) slightly becoming thinner toward apex (Figs 30, 53); (1) abruptly widening on apical 1/5-1/4 (Fig. 19)

Character 24. Male genitalia, parastyli length. (0) parastyli absent; (1) shorter or subequal to pedestal (Molineri 2010: figure 12); (2)= >2 but <3 times length of pedestals (Figs 53–54); (3) >5 times length of pedestals (Figs 3, 30).

Character 25. Male genitalia, parastyli longitudinal furrow. (0)= absent; (1) present.

Character 26. Male genitalia, parastyli curvature in lateral view. (0) straight (Figs 53); (1)= curved on apical 1/4 (Molineri 2010: figure 58); (2) smoothly curved from base (Molineri 2010: figure 65); (3) strongly curved (Molineri 2010: figure 42).

Character 27. Male genitalia, knob at forceps base (Molineri 2010: figure 24). (0) absent; (1) present.

Character 28. Male genitalia, ninth abdominal sternum. (0) entire, a median line may be present (Fig. 3); (1) almost separated in two portions by a median notch (Fig. 53).

Character 29. Egg, form. (0) entire (ovate to subquadrate); (1) bowl-shaped.

Character 30. Egg, number of polar caps. (0) none; (1) one cap; (2) two caps.

List of apomorphies for tree on Fig. 71. Number of nodes are shown in the tree at the end of this list.

Ephoron:

No autapomorphies

Asthenopus:

Char. 30: 1 --> 2

C. segnis:

No autapomorphies

C. latipennis:

No autapomorphies

C. albifilum:

No autapomorphies

C. violaceus:

Char. 13: 0 --> 1

T. igaranus:

No autapomorphies

T. bellus:

No autapomorphies

T. arenales:

Char. 11: 1 --> 0

Char. 12: 1 --> 0

T. bruchianus:

Char. 0: 0 --> 2

Char. 1: 0 --> 1

Char. 2: 0 --> 1

Char. 3: 0 --> 1

Char. 4: 0 --> 2

Char. 5: 0 --> 2

Char. 9: 0 --> 1

Char. 10: 0 --> 1

Char. 29: 0 --> 1

Char. 30: 1 --> 0

T. sarae:

No autapomorphies

T. obscuripennis:

No autapomorphies

T. unguiculatus:

Char. 18: 0 --> 1

Char. 26: 2 --> 3
T. limoncocha:
Char. 26: 2 --> 1
T. harrisi:
No autapomorphies
T. parishii:
Char. 0: 0 --> 2
Char. 1: 0 --> 1
Char. 9: 0 --> 1
Char. 11: 0 --> 1
Char. 12: 0 --> 1
Char. 13: 0 --> 3
Char. 14: 0 --> 1
Char. 15: 0 --> 1
Char. 16: 0 --> 1
Char. 19: 0 --> 1
Char. 20: 2 --> 0
T. puella:
No autapomorphies
T. circumfluus:
Char. 0: 0 --> 2
Char. 1: 0 --> 1
Char. 2: 0 --> 1
Char. 3: 0 --> 1
Char. 4: 0 --> 1
Char. 5: 0 --> 2
Char. 8: 0 --> 1
Char. 9: 0 --> 1
Char. 10: 0 --> 2
Char. 29: 0 --> 1
Char. 30: 1 --> 0
T. primus:
No autapomorphies
T. zottai:
No autapomorphies
T. spatula:
No autapomorphies
T. ipixuna:
No autapomorphies
T. canum:
No autapomorphies
T. coreguaje:
No autapomorphies
T. andaki:
No autapomorphies
T. toro:
Char. 23: 0 --> 1
Node 27:
No synapomorphies
Node 28:
Char. 10: 3 --> 0
Char. 13: 0 --> 2
Char. 24: 0 --> 2
Node 29:
Char. 1: 0 --> 1
Char. 4: 0 --> 1
Char. 9: 0 --> 2
Char. 12: 0 --> 1
Char. 14: 0 --> 1
Char. 15: 0 --> 1

Char. 29: 0 --> 1
 Node 30:
 Char. 22: 0 --> 1
 Node 31 (*Tortopus*):
 Char. 8: 0 --> 1
 Char. 17: 0 --> 1
 Char. 21: 0 --> 1
 Char. 28: 0 --> 1
 Node 32 (*Tortopus* + *Tortopsis*):
 Char. 2: 0 --> 1
 Char. 3: 0 --> 1
 Char. 5: 1 --> 2
 Char. 6: 2 --> 1
 Char. 9: 2 --> 1
 Char. 11: 2 --> 1
 Char. 13: 2 --> 3
 Char. 27: 0 --> 1
 Char. 30: 1 --> 0
 Node 33:
 Char. 24: 2 --> 1
 Node 34:
 Char. 6: 1 --> 0
 Node 35 (*Tortopsis*):
 Char. 4: 1 --> 2
 Char. 7: 0 --> 1
 Char. 16: 0 --> 1
 Char. 24: 2 --> 3
 Node 36:
 Char. 23: 0 --> 1
 Node 37:
 Char. 6: 1 --> 3
 Node 38:
 Char. 25: 0 --> 1

