

**New Miocene fossil taxa illuminate the evolution and
paleobiogeography of the Ponto-Caspian gammaroid amphipod
radiation**

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Supplementary material

TABLE S1 List of taxa used in the phylogenetic analysis.

Family	Species	Name in matrix	Status
Behningiellidae	<i>Behningiella brachypus</i>	Behningiellabrachypus	extant
Behningiellidae	<i>Cardiophilus baeri</i>	Cardiophilusbaeri	extant
Behningiellidae	<i>Cardiophilus marisnigrae</i>	Cardiophilusmarisnigrae	extant
Behningiellidae	<i>Zernovia volgensis</i>	Zernoviavolgensis	extant
Caspicolidae	<i>Caspicola knipovitschi</i>	Caspicolaknipovitschi	extant
Gammaridae	<i>Akerogammarus contiguus</i>	Akerogammaruscontiguus	extant
Gammaridae	<i>Akerogammarus knipowitschi</i>	Akerogammarusknipowitschi	extant
Gammaridae	<i>Amathillina affinis</i>	Amathillinaaffinis	extant
Gammaridae	<i>Amathillina cristata</i>	Amathillinacristata	extant
Gammaridae	<i>Amathillina maximowiczi</i>	Amathillinamaximowiczi	extant
Gammaridae	<i>Amathillina pusilla</i>	Amathillinapusilla	extant
Gammaridae	<i>Amathillina spinosa</i>	Amathillinaspinosa	extant
Gammaridae	<i>Axelboeckia spinosa</i>	Axelboeckiaspinosa	extant
Gammaridae	<i>Baku paradoxus</i>	Bakuparadoxus	extant
Gammaridae	<i>Cephalogammarus macrocephalus</i>	Cephalogammarusmacrocephalus	extant
Gammaridae	<i>Chaetogammarus hyrcanus</i>	Chaetogammarushyrcanus	extant
Gammaridae	<i>Chaetogammarus ischnus</i>	Chaetogammarusischnus	extant
Gammaridae	<i>Chaetogammarus trichiatus</i>	Chaetogammarustrichiatus	extant
Gammaridae	<i>Chaetogammarus pauxillus</i>	Chaetogammaruspauxillus	extant
Gammaridae	<i>Chaetogammarus placidus</i>	Chaetogammarusplacidus	extant
Gammaridae	<i>Chaetogammarus warpachowskyi</i>	Chaetogammaruswarpachowskyi	extant
Gammaridae	<i>Derzhavinella cava</i>	Derzhavinellacava	extant
Gammaridae	<i>Derzhavinella macrochelata</i>	Derzhavinellamacrochelata	extant
Gammaridae	<i>Dikerogammarus bispinosus</i>	Dikerogammarusbispinosus	extant
Gammaridae	<i>Dikerogammarus caspius</i>	Dikerogammaruscaspus	extant
Gammaridae	<i>Dikerogammarus gruberi</i>	N/A	extant/excluded
Gammaridae	<i>Dikerogammarus haemobaphes</i>	Dikerogammarushaemobaphes	extant
Gammaridae	<i>Dikerogammarus istanbulensis</i>	Dikerogammarusistanbulensis	extant
Gammaridae	<i>Dikerogammarus oskari</i>	Dikerogammarusoskari	extant
Gammaridae	<i>Dikerogammarus villosus</i>	Dikerogammarusvillosus	extant
Gammaridae	<i>Gmelina aestuarica</i>	Gmelinaaestuarica	extant

Gammaridae	<i>Gmelina costata</i>	Gmelinacostata	extant
Gammaridae	<i>Gmelinopsis aurita</i>	Gmelinopsisaurita	extant
Gammaridae	<i>Gmelinopsis tuberculata</i>	Gmelinopsistuberculata	extant
Gammaridae	<i>Kuzmelina kusnezowi</i>	Kuzmelinakusnezowi	extant
Gammaridae	<i>Jugogammarus kusceri</i>	Jugogammaruskusceri	extant
Gammaridae	<i>Litorogammarus dursi</i>	Litorogammarusdursi	extant
Gammaridae	<i>Litorogammarus mazestiensis</i>	Litorogammarusmazestiensis	extant
Gammaridae	<i>Litorogammarus karadagiensis</i>	Litorogammaruskaradagiensis	extant
Gammaridae	<i>Lanceogammarus andrussowi</i>	Lanceogammarusandrussowi	extant
Gammaridae	<i>Scytaelina simplex</i>	Scytaelinasimplex	extant
Gammaridae	<i>Shablogammarus shablensis</i>	Shablogammarusshablensis	extant
Gammaridae	<i>Sowinskya macrocera</i>	Sowinskyamacrocera	extant
Gammaridae	<i>Spirogammarus major</i>	Spirogammarusmajor	extant
Gammaridae	<i>Yogmelina brachyura</i>	Yogmelinabrachyura	extant
Gammaridae	<i>Yogmelina laeviuscula</i>	Yogmelinalaeviuscula	extant
Gammaridae	<i>Yogmelina limana</i>	Yogmelinalimana	extant
Gammaridae	<i>Yogmelina pusilla</i>	Yogmelinapusilla	extant
Iphigenellidae	<i>Iphigenella acanthopoda</i>	Iphigenellaacanthopoda	extant
Pontogammaridae	<i>Compactogammarus compactus</i>	Compactogammaruscompactus	extant
Pontogammaridae	<i>Niphargogammarus aequimanus</i>	Niphargogammarusaequimanus	extant
Pontogammaridae	<i>Niphargogammarus borodini</i>	Niphargogammarusborodini	extant
Pontogammaridae	<i>Niphargogammarus intermedius</i>	Niphargogammarusintermedius	extant
Pontogammaridae	<i>Niphargogammarus quadrimanus</i>	Niphargogammarusquadrimanus	extant
Pontogammaridae	<i>Niphargoides boltovskoyi</i>	Niphargoidesboltovskoyi	extant
Pontogammaridae	<i>Niphargoides caspius</i>	Niphargoidescaspius	extant
Pontogammaridae	<i>Niphargoides corpulentus</i>	Niphargoidescorpulentus	extant
Pontogammaridae	<i>Niphargoides grimmi</i>	Niphargoidesgrimmi	extant
Pontogammaridae	<i>Obesogammarus acuminatus</i>	Obesogammarusacuminatus	extant
Pontogammaridae	<i>Obesogammarus boeoticus</i>	Obesogammarusboeoticus	extant
Pontogammaridae	<i>Obesogammarus crassus</i>	Obesogammaruscrassus	extant
Pontogammaridae	<i>Obesogammarus obesus</i>	Obesogammarusobesus	extant
Pontogammaridae	<i>Obesogammarus platycheir</i>	Obesogammarusplatycheir	extant
Pontogammaridae	<i>Obesogammarus subnudus</i>	Obesogammarussubnudus	extant
Pontogammaridae	<i>Pandorites podoceroideis</i>	Pandoritespodoceroideis	extant

Pontogammaridae	<i>Paraniphargoides derzhavini</i>	Paraniphargoidesderzhavini	extant
Pontogammaridae	<i>Paraniphargoides motasi</i>	Paraniphargoidesmotasi	extant
Pontogammaridae	<i>Pontogammarus abbreviatus</i>	Pontogammarusabbreviatus	extant
Pontogammaridae	<i>Pontogammarus aestuarius</i>	Pontogammarusaestuarius	extant
Pontogammaridae	<i>Pontogammarus borceae</i>	Pontogammarusborceae	extant
Pontogammaridae	<i>Pontogammarus robustoides</i>	Pontogammarusrobustoides	extant
Pontogammaridae	<i>Pontogammarus setosus</i>	Pontogammarussetosus	extant
Pontogammaridae	<i>Pontogammarus maeoticus</i>	Pontogammarusmaeoticus	extant
Pontogammaridae	<i>Pontogammarus sarsi</i>	Pontogammarussarsi	extant
Pontogammaridae	<i>Pontogammarus weidemanni</i>	Pontogammarusweidemanni	extant
Pontogammaridae	<i>Stenogammarus compressus</i>	Stenogammaruscompressus	extant
Pontogammaridae	<i>Stenogammarus compressosimilis</i>	Stenogammaruscompressosimilis	extant
Pontogammaridae	<i>Stenogammarus deminutus</i>	Stenogammarusdeminutus	extant
Pontogammaridae	<i>Stenogammarus macrurus</i>	Stenogammarusmacrurus	extant
Pontogammaridae	<i>Stenogammarus micrurus</i>	Stenogammarusmicrurus	extant
Pontogammaridae	<i>Stenogammarus similis</i>	Stenogammarussimilis	extant
Pontogammaridae	<i>Turcogammarus aralensis</i>	Turcogammarusaralensis	extant
Pontogammaridae	<i>Turcogammarus spandli</i>	Turcogammarusspandli	extant
Pontogammaridae	<i>Turcogammarus turcarum</i>	Turcogammarusturcarum	extant
Pontogammaridae	<i>Uroniphargoides spinicaudatus</i>	Uroniphargoidesspinicaudatus	extant
Pontogammaridae	<i>Wolgagammarus dzjubani</i>	Wolgagammarusdzjubani	extant
Pontogammaridae	<i>Andrussovia bogacevi</i>	Andrussoviabogacevi	fossil
Pontogammaridae	<i>Andrussovia sokolovi</i>	Andrussoviasokolovi	fossil
Pontogammaridae	<i>Andrussovia vassoievitschi</i>	Andrussoviavassoievitschi	fossil
Pontogammaridae	<i>Praegmelina andrussovi</i>	Praegmelinaandrussovi	fossil
Pontogammaridae	<i>Praegmelina archangelskii</i>	Praegmelinaarchangelskii	fossil
Pontogammaridae	<i>Eogmelina moldavica</i>	Eogmelinamoldavica	fossil
Pontogammaridae	<i>Eogmelina prisca</i>	Eogmelinaprisca	fossil
Gammaridae	<i>Pectenogammarus oliviiiformis</i>	Pectenogammarusolivii	outgroup

TABLE S2 List of morphological characters and their states used in the phylogenetic and phenetic analyses.

No.	Character	State
1	Rostrum	(0) absent
		(1) present
2	Head lateral protuberances	(0) absent
		(1) present
3	Anterior head lobes	(0) straight/rounded
		(1) mucronate
		(2) strongly angled
4	Eye shape	(0) longer than broad
		(1) as long as broad
5	Inferior antennal sinus depth	(0) less deeper/subequal with depth of superior antennal sinus
		(1) deeper than superior antennal sinus
6	A1 total length	(0) longer/subequal to head + first three pereonites
		(1) shorter than head + first three pereonites
7	A1 flagellum length	(0) longer than peduncle
		(1) shorter than peduncle
		(2) subequal to peduncle
8	A1 peduncle 1st article length	(0) shorter/subequal to articles 2+3 combined
		(1) longer than articles 2+3 combined
9	A1 peduncle 2nd article ventral swelling	(0) absent
		(1) present
10	A1 accessory flagellum number of articles	(0) at least 3 articles
		(1) 2 articles
		(2) 1 article
11	A1 accessory flagellum length	(0) shorter than 0.5 of primary flagellum
		(1) longer/subequal to 0.5 of primary flagellum
12	A2 total length	(0) shorter than A1

		(1) subequal/slightly longer than A1
13	A2 peduncular setae length	(0) shorter/subequal to peduncle diameter
		(1) longer than peduncle diameter
14	A2 peduncular setae shape	(0) straight
		(1) coiled
		(2) straight + coiled
		(3) curled
15	A2 3rd peduncular article length	(0) shorter/subequal to 0.5 of the 4th segment length
		(1) longer than 0.5 of the 4th segment length
16	A2 4th peduncular article ventral swelling	(0) absent
		(1) present
17	A2 4th peduncular article width	(0) thinner/subequal to A1 1st article
		(1) 2x broader than A1 1st article
18	A2 flagellum	(0) longer/subequal than peduncle article 5
		(1) shorter than peduncle article 5
19	Mandibular palp	(0) normal
		(1) reduced
20	Mandibular palp basal article setation	(0) absent
		(1) present
21	Mandibular palp 2nd article posterior margin setation	(0) absent
		(1) present
22	Mandibular palp distal article D setae	(0) present
		(1) absent
23	Molar process	(0) well developed, triturative
		(1) vestigial
24	Maxilla I palp	(0) normal
		(1) reduced
25	Maxilla I inner lobe	(0) normal
		(1) reduced
26	Maxilliped palp	(0) normal

		(1) reduced
27	Dorsal keel on pereonites (single or double)	(0) absent
		(1) present
28	Lateral tubercles on pereonites	(0) absent
		(1) present
29	Dorsal keel on pleonites	(0) absent
		(1) present
30	Lateral tubercles on pleonites	(0) absent
		(1) present
31	Coxal plates 1-4 setosity of ventral margin	(0) short and sparse setae (<0.2 coxa depth)
		(1) long and dense (>0.2 coxa depth)
		(2) short and dense (<0.2 coxa depth)
		(3) long and sparse (>0.2 coxa depth)
32	Coxal plate 1 height	(0) taller than the corresponding tergal segment
		(1) shorter than the corresponding tergal segment
		(2) subequal to corresponding tergal segment
33	Coxal plate 1 anterior lobe	(0) absent
		(1) present
34	Coxal plate 4 shape	(0) as deep as broad
		(1) deeper than broad
35	Coxa 5 width	(0) shorter/subequal to length of P5 basis
		(1) longer than length of P5 basis
36	Tergum 7 height	(0) < 2x taller than tergum 1 height
		(1) > 2x taller than tergum 1 height
37	Propodus of G1 length relative to G2 propodus (males only)	(0) shorter
		(1) subequal
		(2) longer
38	Palmar edge of G1 & 2 (males only)	(0) straight to slightly convex
		(1) concave
39		(0) shorter

	Propodus of G1 width relative to G2 propodus (males only)	(1) subequal
		(2) longer
40	Coiled setae on G1 & G2 propodus (males only)	(0) absent
		(1) present
41	Medial palmar spine on G1 & G2 (males only)	(0) present
		(1) absent
42	Palmar angle G1 (males only)	(0) $< 40^{\circ}$
		(1) $41-50^{\circ}$
		(2) $51-60^{\circ}$
		(3) $61-70^{\circ}$
		(4) $> 70^{\circ}$
43	Palmar length G1 (males only)	(0) shorter than diagonal
		(1) subequal to diagonal
		(2) longer than diagonal
44	Palmar angle G2 (males only)	(0) $< 40^{\circ}$
		(1) $41-50^{\circ}$
		(2) $51-60^{\circ}$
		(3) $61-70^{\circ}$
		(4) $> 70^{\circ}$
45	Palmar length G2 (males only)	(0) shorter than diagonal
		(1) subequal to diagonal
		(2) longer than diagonal
46	Coiled setae on P3 posterior margin	(0) absent
		(1) present
47	Posterior margin of P3 carpus and merus setae length	(0) up to 2x longer than width of propodus
		(1) more than 2x longer than width of propodus
48	Posterior margin of P3 carpus setal disposition	(0) in clusters
		(1) continuous fan
49	Posterior margin of P3 merus setal disposition	(0) up to 6 clusters
		(1) more than 6 clusters

		(2) continuous fan
50	Posterior margin of P4 carpus and merus setae length	(0) up to 2x longer than width of propodus
		(1) more than 2x longer than width of propodus
51	Posterior margin of P4 carpus setal disposition	(0) in clusters
		(1) continuous fan
52	Posterior margin of P4 merus setal disposition	(0) up to 6 clusters
		(1) more than 6 clusters
		(2) continuous fan
53	P3-4 carpus width	(0) similar to propodus
		(1) at least twice broader than propodus
54	P5 basis height	(0) greater/subequal to coxal plate 1 height
		(1) shorter than coxal plate 1 height
55	P5 basis shape	(0) longer than broad
		(1) as long as broad
56	P5 basis setae on inner surface	(0) absent
		(1) present
57	P5 basis anterior margin armature	(0) dominated by spines
		(1) dominated by setae
		(2) bare
58	P5 basis anterior margin setae length	(0) absent
		(1) setae shorter than ischium width
		(2) setae subequal/longer than ischium width
59	P5 basis posterior margin setation length	(0) absent
		(1) setae shorter than ischium width
		(2) setae subequal/longer than ischium width
60	P5 basis posterior margin setation density	(0) sparse/absent
		(1) dense
61	P6 basis shape	(0) not expanded, posterior margin straight/slightly convex

		(1) expanded proximo-posteriorly, posterior margin concave
		(2) expanded throughout, posterior margin convex, without downward projecting lobe
		(3) expanded throughout, posterior margin convex, with downward projecting lobe
62	P6 basis medial row of setal clusters	(0) absent
		(1) present
63	P6 basis anterior margin armature	(0) dominated by spines
		(1) dominated by setae
		(2) bare
64	P6 basis anterior margin setation length	(0) absent
		(1) setae shorter than ischium width
		(2) setae subequal/longer than ischium width
65	P6 basis posterior margin setation length	(0) absent
		(1) setae shorter than ischium width
		(2) setae subequal/longer than ischium width
66	P6 basis posterior margin setation density	(0) sparse/absent
		(1) dense
67	P7 length	(0) > 40% body length
		(1) < 40% body length
68	P7 basis length	(0) < height of pleosomite 1
		(1) > height of pleosomite 1
69	P7 basis shape	(0) not expanded in the distal half, posterior margin straight/slightly convex
		(1) partially expanded distally, posterior margin convex
		(2) expanded throughout, posterior margin convex, without downward projecting lobe
		(3) expanded throughout, posterior margin convex, with downward projecting lobe

70	P7 basis medial row of setal clusters	(0) absent
		(1) present
71	P7 basis anterior margin armature	(0) dominated by spines
		(1) dominated by setae
		(2) bare
72	P7 basis anterior margin setation length	(0) absent
		(1) setae shorter than ischium width
		(2) setae subequal/longer than ischium width
73	P7 basis posterior margin setation length	(0) absent
		(1) setae shorter than ischium width
		(2) setae subequal/longer than ischium width
74	P7 basis posterior margin setation density	(0) sparse/absent
		(1) dense
75	Overall setation on P5-7 meri, carpi and propodi	(0) poorly developed, setae shorter than underlying segment width
		(1) well developed, setae as long as/longer than underlying segment width
76	P5-7 dactylus shape	(0) strong and curved
		(1) slender and relatively straight
77	P5-7 propodus length	(0) subequal to carpus
		(1) at least 50% longer than carpus
78	P5-7 merus shape	(0) normal, not posteriorly expanded
		(1) expanded into a posterior lobe
79	Epimere 2 setal clusters on outer surface	(0) absent
		(1) present
80	Epimere 2 armature distal edge	(0) spines
		(1) setae
		(2) bare
		(3) spines + setae
81		(0) straight/mucronated

	Epimere 2 postero-inferior corner	(1) acute
82	Epimere 3 postero-inferior corner	(0) straight/mucronated
		(1) acute
83	Epimere 3 armature distal edge	(0) spines
		(1) setae
		(2) bare
		(3) spines + setae
84	Epimere 3 disto-posterior setal fan	(0) absent
		(1) present
85	Urosomite 1 length	(0) shorter/equal with combined length of urosomites 2 and 3
		(1) longer than combined length of urosomites 2 and 3
86	Urosomite 1 armature	(0) 2 latero-dorsal and 2-3 dorsal groups of elements (2, 2, 2, 2)
		(1) 2 latero-dorsal and 1 dorsal group (2, 2, 2)
		(2) 1 dorsal group
		(3) absent
87	Urosomite 1 dorsal shape	(0) flat
		(1) humped
		(2) prominent tubercle
88	Urosomite 1 lateral tubercles	(0) absent
		(1) present
89	Urosomite 2 armature	(0) 2 latero-dorsal and 2-3 dorsal groups of elements (2, 2, 2, 2)
		(1) 2 latero-dorsal and 1 dorsal group (1, 1, 1)
		(2) 1 dorsal group
		(3) absent
90	Urosomite 2 dorsal shape	(0) flat
		(1) humped

		(2) prominent tubercle
91	Urosomite 3 armature	(0) 2 latero-dorsal and 2 dorsal groups of elements (2, 2, 2, 2)
		(1) 2 latero-dorsal and 1 dorsal group (1, 1, 1)
		(2) 2 latero-dorsal groups (absent dorsal group)
		(3) absent
		(4) 1 dorsal group
92	Urosomite 3 dorsal shape	(0) flat
		(1) humped
93	Uropod 1 peduncle marginal spines	(0) at least 2 spines for any given margin
		(1) 0-1 spines for any given margin
94	Uropod 1 rami length	(0) shorter than peduncle
		(1) subequal to peduncle
		(2) longer than peduncle
95	Uropod 1 rami marginal spines	(0) at least 2 spines for any given ramus
		(1) 0-1 spines for any given ramus
96	Uropod 3 overall length	(0) extends beyond the distal tip of U1
		(1) does not extend beyond the distal tip of U1
97	Uropod 3 1st exopod article length	(0) longer than peduncle
		(1) subequal to peduncle
98	Uropod 3 1st exopod article shape	(0) rod-like, width at distal end > 50% width at proximal end
		(1) lanceolate, width at distal end < 50% width at proximal end
99	Uropod 3 1st exopod article general armature	(0) dominated by spines
		(1) dominated by setae
		(2) mixed – outer edge armed with spines, inner edge with setae
100	Uropod 3 1st exopod article setal patterns	(0) arranged in tufts
		(1) forming a continuous fan

101	Uropod 3 1st exopod article spine/setae length ratio	(0) spines as long as/longer than the accompanying setae
		(1) spines shorter than the accompanying setae
		(2) spines absent
102	Uropod 3 1st exopod article setae length	(0) shorter/subequal to exopod width
		(1) longer than exopod width
103	Uropod 3 exopod terminal article shape	(0) longer than broad
		(1) as long as broad
		(2) absent
104	Uropod 3 exopod terminal article setation	(0) absent/1-2 isolated setae shorter than article length
		(1) well developed with setae longer than article length
105	Uropod 3 endopod length	(0) shorter/subequal to 0.3 of exopod 1st article
		(1) longer than 0.3 of exopod 1st article
		(2) absent
106	Uropod 3 endopod armature	(0) apical spines/setae
		(1) well developed setal fan on inner edge and apically
107	Uropod 3 overall setae types	(0) simple
		(1) simple + plumose
108	Telson length	(0) does not/very little extends beyond distal edge of U3 peduncle
		(1) extends well beyond distal edge of U3 peduncle
109	Telson proportions	(0) broader than long
		(1) as long as broad
		(2) longer than broad
110	Telson lobes shape	(0) triangular, inner and outer margins straight/slightly convex
		(1) triangular, inner and outer margins strongly convex
		(2) rectangular, inner and outer margins straight
		(3) inner margin straight, outer margin convex
111		(0) present

	Lateral submedian spines on outer edge of telson lobes	(1) absent
112	Number of distal spines per telson lobe	(0) 2-3
		(1) 1
		(2) >3
		(3) absent
113	Placement of distal spines/setae on telson lobes	(0) terminal
		(1) subterminal
		(2) terminal + subterminal
114	Distal setae on telson lobes	(0) shorter than 50% of lobe length
		(1) longer than 50% of lobe length
		(2) absent