

Ostracods of the Genus *Palaeocytheridea* Mandelstam in the Middle and Upper Jurassic of Europe: 3. Stratigraphy and Paleobiogeography

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Received: October 22, 2012

Abstract—The analysis of distribution of endemic and cosmopolitan ostracods of the genus *Palaeocytheridea* shows that, in the Bajocian and Bathonian, the Tethyan and Boreal–Atlantic regions of Western and Eastern Europe developed in partial isolation, while beginning from the middle of the Lower Callovian, these parts of the European paleobasin were connected. For the Middle Jurassic of Western and Eastern Europe and, in particular, for Ukraine, the ostracod zones are recognized based on stratigraphic distribution of species of the genus *Palaeocytheridea*.

Keywords: Ostracoda, *Palaeocytheridea*, stratigraphy, paleobiogeography

DOI: 10.1134/S0031030114010146

INTRODUCTION

The first paper devoted to the ostracod genus *Palaeocytheridea* considered the development of ideas concerning the volume and causes of the erroneous assignment to this genus of many species of different genera and families. As a result of revision of 93 forms that have been assigned to palaeocytherideans, only 11 valid species, one of which is new, were recognized. It has been shown that, based on the shell shape (elongated rectangular or elongated oval), members of the genus are divided with certainty into two new subgenera. Monographic descriptions of the genus *Palaeocytheridea* Mandelstam, 1947, new subgenera *P. (Palaeocytheridea)* sensu stricto and *P. (Malzevia)* Tesakova, 2013, and also the new species *P. (P.) kalandadzei* Tesakova, 2013 were provided (Tesakova, 2013a).

In the second paper, *P. (P.) bakirovi* Mandelstam, 1947, *P. (P.) carinilia* (Sylvester-Bradley, 1948), *P. (P.) pavlovi* (Lyubimova, 1955), *P. (M.) parabakirovi* Malz, 1962, and *P. (M.) blaszykina* Franz, Tesakova et Beher, 2009 were described following modern requirements; the data received by the study of original material under a scanning microscope were added (Tesakova, 1913b).

The third part of the study of European palaeocytherideans concerns their stratigraphic and chorologic distribution in Western and Eastern Europe and establishes on this basis several ostracod zones and subzones.

STRATIGRAPHY

Stratigraphic distribution of species of the genus *Palaeocytheridea* is shown in Table 1. Apart from a few exceptions, all palaeocytherideans occurred in the Middle Jurassic in the Boreal–Atlantic Region of Europe. Within each age, particular parts of the European paleobasin were simultaneously inhabited by several species of both subgenera.

P. (M.) blaszykina was the first to appear at the end of the Early Bajocian (*humphriesianum* Phase) in southwestern Germany (Tethyan Region) and survived almost to the end of the Late Bathonian (*orbis* Phase) (Franz et al., 2009). However, in the Bathonian, its range considerably expanded and it penetrated into the Boreal–Atlantic Region of Western Europe (northwestern Germany, Poland, Parisian Basin) (Malz, 1962; Błaszyk, 1967; Dépêche, 1984).

From the beginning of the Late Bajocian, *P. (M.) subtilis* (*niortense* Phase) appeared in the Dnieper–Donets Depression (DDD) and survived almost to the end of this age (*garantiana* Phase) (Permjakova, 1974; Pyatkova and Permjakova, 1978). In the middle of the Late Bajocian (*garantiana* Phase), the species *P. (M.) laevis* existed in this region (Permjakova, 1974; Pyatkova and Permjakova, 1978). The end of the Late Bajocian (*michalskii* Phase) was marked by the appearance of a number of palaeocytherideans, including *P. (P.) bakirovi*, which also occurred in the Mangyshlak Peninsula (Mandelstam, 1947), *P. (M.) rara*, and *P. (M.) priva* (Permjakova, 1974; Pyatkova and Permjakova, 1978). At the end of the Late Bajocian–Early Bathonian (*michalskii* and

Table 1. Stratigraphic distribution of species of the genus *Palaeocytheridea*

Genus	Subgenus	Species	Stratigraphic distribution
<i>Palaeocytheridea</i>	<i>P. (Palaeocytheridea)</i>	<i>P. (P.) bakirovi</i> Mandelstam, 1947	bs₃ Mangyshlak (<i>Parkinsonia doneziana</i> Zone), DDD (<i>michalskii</i> Zone)
		<i>P. (P.) kalandadzei</i> Tesakova, 2013	bs₃ – bt₁ Saratov and Penza regions (<i>michalskii</i> and <i>besnosovi</i> zones)
		<i>P. (P.) carinilia</i> (Sylvester-Bradley, 1948)	bt – cl₁ France bt₁₋₂, cl₁ , southern Germany bt₂ , England bt₃
		<i>P. (P.) pavlovi</i> (Lyubimova, 1955)	Samara Bend, Tatarstan, Saratov region cl₁ (<i>elatmae</i> Zone, <i>elatmae</i> Subzone, lower part of <i>subpatruus</i> Subzone)
	<i>P. (Malzevia)</i>	<i>P. (M.) laevis</i> Permjakova, 1974	bs₃ DDD (<i>garantiana</i> Zone)
		<i>P. (M.) subtilis</i> Permjakova, 1974	bs₃ DDD (<i>niortense</i> and <i>garantiana</i> zones)
		<i>P. (M.) blaszykina</i> Franz, Tesakova et Beher, 2009	bs₁³ (<i>humphriesianum</i> Zone)– bt₃ (<i>orbis</i> Zone) southwestern Germany; northwestern Germany, Poland, Paris. Basin bt
		<i>P. (M.) priva</i> Permjakova, 1974	bs₃ DDD (<i>michalskii</i> Zone)
		<i>P. (M.) rara</i> Permjakova, 1974	bs₃ DDD (<i>michalskii</i> Zone)
		<i>P. (M.) parabakirovi</i> Malz, 1962	cl₁ (<i>gowerianus</i> and <i>calloviense</i>) – cl₂ Germany, the Netherlands, England, DDD, central Russia
		<i>P. (M.) groissi</i> Schudack, 1997	t₁ southern Germany

besnosovi phases), they coexisted with *P. (P.) kalandadzei*, which occurred in the Volga Region near Saratov and central Russia.

In the Early and Middle Bathonian and at the beginning of the Early Callovian, *P. (P.) carinilia* (Dépêche, 1969, 1984) was present in France (Parisian Basin); in the Middle Bathonian, it expanded into southern Germany (Malz, 1975; Liebau, 1987) and, in the Late Bathonian, into England (Sylvester-Bradley, 1948). At the beginning of the Early Callovian (*elatmae* Phase), *P. (P.) pavlovi* occurred in the Volga Region (Lyubimova, 1955; Tesakova and Sel'tser, 2011, 2013) and, since the second part of the Early Callovian (*gowerianus* and *calloviense* phases), *P. (M.) parabakirovi* became widespread in Europe (Germany, England, the Netherlands, Ukraine, Belarus, central Russia) (Malz, 1962, 1975; Wienholz, 1967; Whatley, 1970; Pyatkova, Permjakova, 1978; Herngreen et al., 1983; Tesakova, 2003, 2010; Wilkin-

son and Whatley, 2009) and survived up to the end of the Middle Callovian.

The above description almost completely covers natural history of the genus *Palaeocytheridea*, at least its peak had irreversibly passed. The last occurrence of palaeocytherideans (as the first) falls in the Tethyan Region (southern Germany), where *P. (M.) groissi* was described in the Early Tithonian (Schudack, 1997). This is apparently a Lazarus species, which marks the final decline and extinction of the genus. Lazarus taxa appear in the fossil record at an interval from the point of flourishing, during which their ancestors were scarce and infrequent, so that they have not yet been recorded. It is hardly probably that the species *P. (M.) groissi* belongs to a different genus and only convergently resembles palaeocytherideans, because its shape, shell outline, and sculpture are rather similar to that of early larval stages of *P. (M.) blaszykina*, *P. (M.) parabakirovi*, *P. (P.) kalandadzei*, and *P. (P.) pavlovi* (see Tesakova, pls. V, VI).

Stage		Substage		Ammonite zones (general scale)		Ammonite zones, East European Platform		Tethyan Province of Western Europe		Boreal Province of Western Europe		Ukraine (Dnieper–Donets Depression)		Central Russia and Volga Region		Zones and subzones with ostracods		
Tithonian		Lower						P. (M.) blaszykina								Western Europe		
Callovian		Middle		coronatum		coronatum		P. (M.) groissi								Eastern European Platform		
		Lower		jason		jason										Ukraine (DDD)		
		Upper		calloviense		calloviense		P. (M.) blaszykina								Boreal Province		
		Middle		koenigi		gowerianus		P. (M.) blaszykina								Tethyan Province (southern Germany)		
		Lower		herveyi		elatmae		P. (M.) blaszykina								groissi		
Bathonian		Upper		discus		calyx		P. (P.) carinilia								parabakirovi		
		Middle		orbis				P. (P.) carinilia										
		Lower		hodsoni				P. (M.) blaszykina										
				morrisi				P. (M.) blaszykina										
				subcon-tractus				P. (M.) blaszykina										
				progracilis				P. (M.) blaszykina										
Bajocian		Upper		tenuipli-catus		ishmae		P. (M.) blaszykina										
		Lower		zigzag		besnosovi		P. (P.) carinilia										
				parkinsoni		michalskii		P. (P.) carinilia										
				garantiana		garantiana		P. (M.) blaszykina										
				niortense				P. (P.) carinilia										
				humphrie-sianum				P. (M.) blaszykina										
				propinqua				P. (M.) blaszykina										
				laeviuscula				P. (M.) blaszykina										
				discites				P. (M.) blaszykina										

Fig. 1. Distribution of palaeocytherideans in the Middle–Upper Jurassic of Europe and ostracod-based stratigraphic zonation.

The analysis of distribution of palaeocytherideans in the Jurassic beds of Europe shows that, during most of the Middle Jurassic (Bajocian and Bathonian), members of the genus developed in strongly isolated parts of the paleobasin and gave rise to at least four successions in the Boreal–Atlantic and Tethyan regions of Western Europe, Ukraine, and Eastern Europe (Fig. 1). In particular, the upper part of the Lower Bajocian–Upper Bathonian of the Tethyan Region of Western Europe is characterized by *P. (M.) blaszykina*; Middle Bathonian, by *P. (M.) blaszykina*; and the Lower Tithonian, by *P. (M.) groissi*. According to the distribution of index species, the following zones are recognized: *blaszykina* for the upper part of the Lower Bajocian–Upper Bathonian, with the *carinilia* Subzone for the Middle Bathonian and the *groissi* Subzone for the Lower Tithonian.

In the Bathonian of the Boreal–Atlantic Region of Western Europe, *P. (M.) blaszykina* co-occurs with *P. (P.) carinilia*; the bottom of the Lower Callovian is marked by the species *P. (P.) carinilia*; the middle and upper parts of the Lower Callovian and the Middle Callovian (*herveyi*, *koenigi*, *calloviense*, *jason*, and *coronatum* zones) are characterized by the presence of *P. (M.) parabakirovi*. Based on the distribution of

these taxa in particular sections, the following zones are recognized: the *carinilia* Zone for the Bathonian and basal Lower Callovian and the *parabakirovi* Zone for the middle and upper parts of the Lower Callovian and the Middle Callovian.

In the DDD, the palaeocytheridean sequence looks differently. The Upper Bajocian interval (*niortense* and *garantiana* zones) corresponds to *P. (M.) subtilis*, which gives the ostracod zone of the same name; in its upper part (*garantiana* Zone), the *P. (M.) laevis* Subzone is established. In the uppermost Upper Bajocian (*michalskii* Zone), the *bakirovi* Zone is established based on co-occurrence of *P. (P.) bakirovi*, *P. (M.) priva*, and *P. (M.) rara*. It remains uncertain whether or not the presence of *P. (P.) pavlovi* in the basal Lower Callovian of DDD is expected; this species occurred at that time east of DDD (in the Volga Region), although it has not been recorded in Western Europe. M.N. Permjakova, who studied Jurassic ostracods of Ukraine, has not recorded *P. (P.) pavlovi*. At the same time, Permjakova recorded the zonal form of the overlying *P. (M.) parabakirovi* Zone in the Middle Callovian of DDD. However, the presence of this species downward in the section, in the middle and upper parts of the Lower Call-

ovian of DDD, seems rather probable, because *parabakirovi* is recorded in the Lower Callovian both west (England, the Netherlands) and east (Kursk Region of central Russia) of DDD.

In Eastern Europe, it is proposed to recognize several palaeocytheridean zones considered below. In the middle and upper parts of the Upper Bajocian *michalskii* Ammonite Zone and Lower Bathonian *besnosovi* Zone of the Saratov Region and central Russia, *P. (P.) kalandadzei*, which is the index species of its zone, is widespread. In the basal Lower Callovian of the Volga Region (*elatmae* Zone, *elatmae* Subzone and the lower part of the *subpatruus* Subzone), the *P. (P.) pavlovi* Zone is established based on the index. Beginning from the upper part of the Lower Callovian *subpatruus* Subzone to the upper part of the Middle Callovian (including the *coronatum* Zone), the index species of the *P. (M.) parabakirovi* Zone is widespread.

PALEOBIOGEOGRAPHY

The above picture with endemic members of *Palaeocytheridea* observed in the Tethyan Region and in the western, central, and eastern parts of the Boreal–Atlantic Region of the Jurassic European paleobasin during the latter half of the Late Bajocian and Bathonian corresponds to the hypothesis of a rather low sea level at that time, which interfered with free movement of ostracods (Tesakova 2007; Tesakova et al., 2008). On the other hand, the presence in the Upper Bajocian and Lower Bathonian beds of the Saratov Region (Tesakova and Sel'tser, 2012) and central Russia of some West European taxa is evidence of free movement of the fauna between these regions during an earlier period, apparently in the Middle Bajocian, or in the first half of the Late Bajocian. From the middle of the Early Callovian (since the end of the *elatmae* Phase), with the beginning of a large-scale transgression, penetration of ostracods from one part of the paleobasin to the other was again strongly facilitated, which is supported by the occurrence of the *P. (M.) parabakirovi* Ostracod Zone throughout Europe (from England to the Volga Region) and many West European taxa recorded in the Lower Callovian of the Kursk Region (Tesakova et al., 2009; Tesakova, 2010).

The fact that the first and last occurrences of palaeocytherideans are in the Tethyan Region of Western Europe, i.e., they initially came from the south and retreated to the south, is evidence that they were thermophilic. If this is the case, subsequent northerly expansion in the Boreal–Atlantic Region suggests that rather warm water penetrated into their habitats, i.e., transgressions from the south had a great effect in the Middle Jurassic (since the middle of the Early Callovian). Thus, the absence from the beginning of the Late Callovian of palaeocytherideans in the boreal Jurassic of Western and Eastern Europe probably resulted from a general decrease in temperature in the paleobasin,

which was connected with intensified inflow of Arctic waters, i.e., strengthened transgression from the north at the end of the Middle–Late Jurassic (Late Callovian–Oxfordian).

CONCLUSIONS

Ostracods of the genus *Palaeocytheridea* Mandelstam, 1947 from the Middle Jurassic beds of the Kursk and Saratov regions of European Russia and Gomel Region of Belarus are investigated.

For the Middle Jurassic of Western and Eastern Europe and Ukraine, the ostracod zones are proposed based on stratigraphical distribution of species of the genus *Palaeocytheridea*.

The analysis of distribution of endemic and cosmopolitan *Palaeocytheridea* forms has shown partially (selectively) isolated development of Western and Eastern Europe and Ukraine in the Late Bajocian and Early Bathonian and the presence of faunal contact between these parts of the European paleobasin from the middle of the Early Callovian to the end of the Middle Callovian.

ACKNOWLEDGMENTS

I am grateful to M.A. Rogov (Geological Institute of the Russian Academy of Sciences, Moscow), L.M. Melnikova, and P.Yu. Parkhaev (Borissiak Paleontological Institute of the Russian Academy of Sciences, Moscow) for critical remarks and discussion of this paper and to L.A. Karimova (Belarussian Research Geological Prospecting Institute, Minsk) and V.V. Makhnach (Minsk State University) for placing specimens from Belarus to our disposal.

This study was supported by the Russian Foundation for Basic Research, project no. 12-05-00380.

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Translated by G. Rautian

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