

## ON OSTRACODE ZONATION OF THE EAST BALTIC UPPER SILURIAN

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Ostracodes are of great significance in the classification and correlation of the East Baltic Upper Silurian. Here special attention has been paid to the index-species which serve as a basis for the establishment of the ostracode zonation. The data for the present paper come from the borings of Stoniškiai, Virbalis, Kunkoiai, Ezere, Ventspils (pers. comm. by L. Gailite), Piltene-1, -31 and -32, Kolka-4 and -54, Ohesaa-re and Kaugatuma (see Fig. presenting more important ones of them).

For the first time ostracode zones of the Upper Silurian of the East Baltic were proposed by L. Gailite (Гайлите, 1964, 1965; Гайлите и др., 1967) using the sections of West Latvia. The distinguished subdivisions were defined more precisely in her later works (Гайлите, 1978; Гайлите и Ульст, 1974). D. Kaljo (1978) supplemented the zonation mainly on the basis of the Estonian data. The most important ostracode zones of the East Baltic Upper Silurian and their approximate analogous units on Gotland are given in the Table.

Analysing ostracode zonation of the East Baltic Upper Silurian we used also data obtained by A. Martinsson (1967) on ostracode successions in the Silurian of Sweden, and by E. Tomczykowa, E. Witwicka (1972) and B. Żbikowska (1973) on the Upper Silurian ostracode zones of North Poland.

*Craspedobolbina lietuvensis* Zone

The first Upper Silurian ostracode zone with *Craspedobolbina lietuvensis* has been determined in West Latvia and Lithuania in the Kolka-4, Virbalis and Kunkoiai and less distinctly in the Ventspils boring (see Гайлите, Ульст, 1974; Сарв, 1977). With this zonal species associate *Craspedobolbina percurrans*, *Beyrichia snoderniana*, *Paraparchites gregarius*, *Silenis ex. gr. subtriangulatus*. Stratigraphical position of the zone is still indistinct. L. Gailite compares it with the *Neodiversograptus nilssoni* and *Lobograptus scanicus* Zones, evidently increasing its extent. According to D. Kaljo (1978) the *C. lietuvensis* Zone corresponds to the uppermost Wenlockian and only to a part of the *N. nilssoni* Zone. Such a conclusion is more acceptable as it is confirmed by the distribution of *Beyrichia snoderniana* on Gotland, in the Halla and Mulde Beds (= uppermost Wenlock) and the lowermost Hemse Beds (Martinsson, 1962, 1967).

Evidently the topmost part of *C. lietuvensis* range overlap with the interval of the distribution of *Amphitoxotis curvata*. In the East Baltic the latter species occurs only in sections of the Kunkoiai and Virbalis borings. In Gotland *A. curvata* occurs in the lower part of the Hemse Beds, containing numerous graptolites (*Neodiversograptus nilssoni*, *Saetograptus chimaera*, etc.; Martinsson, 1967). It enables to correlate the interval with *A. curvata* in the East Baltic approximately with the topmost beds of the *N. nilssoni* and part of *Lobograptus scanicus* Zones.

## OHESAARE

## PILTENE -1

## VENTSPILS

## KOLKA -4

## EZERE

## KUNKOIAI

## VIRBALIS

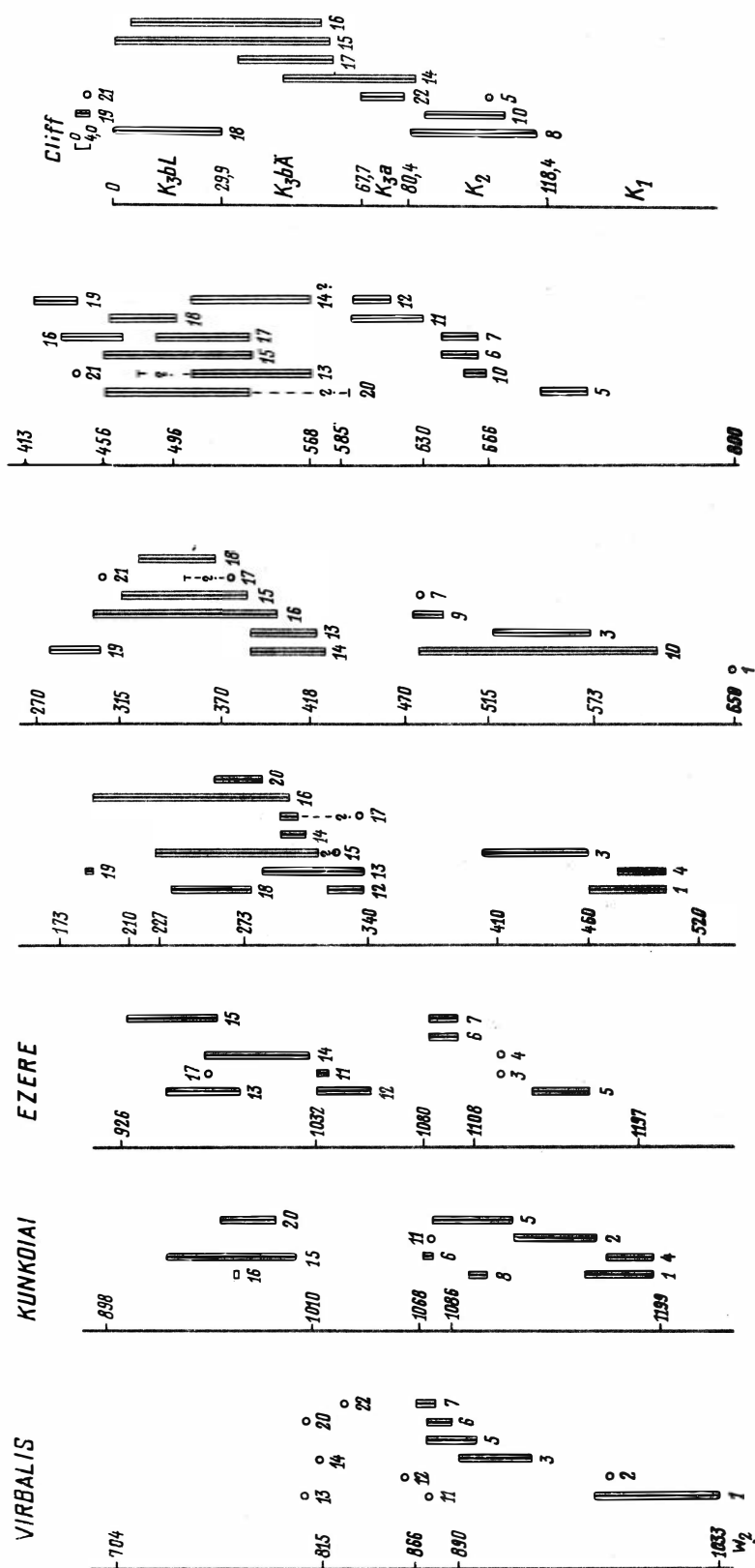


Fig. Distribution of zonal ostracode species in the main boring sections of the East Baltic Upper Silurian.  
 1 - *Craspedobolbina lietuvensis*, 2 - *Amphitoxotis curvata*, 3 - *Craspedobolbina exerensis*, 4 - *Beyrichia snoder-  
 niana*, 5 - *Hammariella pulcherrima*, 6 - *Neobeyrichia ctenophora*, 7 - *Neobeyrichia lauvensis*, 8 - *Neobeyrichia  
 nutans*, 9 - *Neobeyrichia sciassa*, 10 - *Hemstella hemstensis*, 11 - *Hoburgella tenerrima*, 12 - *Undulirete balti-  
 cum*, 13 - *Neobeyrichia alia*, 14 - *Hemstella margaritae*, 15 - *Neobeyrichia buchiana*, 16 - *Macrypilson salteria-  
 num*, 17 - *Frostiella groenvaliana*, 18 - *Nodibeyrichia tuberculata*, 19 - *Nodibeyrichia jurassica*, 20 - *Hemstella  
 maceoyana*, 21 - *Disygopleura opportuna*, 22 - *Plicibeyrichia numerosa*.

### *Craspedobolbina ezerensis* Zone

The following zonal species *Craspedobolbina ezerensis* occurs in sections of Virbalis, Ezere, Ventspils and Kolka-4 together with *Microcheilinella lacrima*, *Primitiopsis ezerensis*, *Pseudorayella acuta*, *Hammariella pulchrivelata*. It is of comparatively restricted vertical distribution but almost all accompanying species existed during a fairly long time. Only *Hammariella pulchrivelata* occupies in a number of sections a short interval but on different levels. For instance, in the Ezere boring it is found below the *C. ezerensis* Zone, in the Virbalis boring - together with *C. ezerensis*, *Hemsiella anterovelata* and *Neobeyrichia ctenophora* - *N. lauensis*, in the Ohesaare boring and on Gotland together with *Neobeyrichia nutans*. How far *H. pulchrivelata* occurs together with two zonal species (*C. ezerensis*, *N. ctenophora*) obviously of different ages it would be better not to use it as an index-species.

*Craspedobolbina ezerensis* does not occur anywhere together with *Amphitoxotis curvata*, however, their being of almost the same age is not excluded either. In the Kolka-4 boring *C. ezerensis* appears immediately after *C. lietuvensis*. In the Virbalis boring there is a noticeable interval between them, but the range of *C. ezerensis* is evidently restricted there. *A. curvata* has been also found in the Virbalis boring, however, only one specimen and in the topmost beds of the interval of distribution of *C. lietuvensis*.

The above Early Ludlow zonal species are known only from the sections of West Latvia and Lithuania. According to D. Kaljo and E. Jürgenson (Калъо и Юргенсон, 1977) this is the area of the transitional (=slope) facies belt of marls and clays with limestone nodules, being formed in rather offshore conditions. The above-mentioned zonal and some accompanying species were, evidently, tied to this facies belt and only rather rare occur in other ones. Therefore, they are not found from more northern sections of the East Baltic (Piltene-1, Kolka-54, Ohesaare, Kaugatuma).

### *Neobeyrichia ctenophora* - *N. lauensis* Zone

The zone *Neobeyrichia ctenophora* - *Neobeyrichia lauensis* follows immediately above the zone *C. ezerensis* in the Central and South East Baltic. It embraces a fairly small interval (up to 20 m) in the Piltene and Ezere borings and is seldom found in the Virbalis and Ventspils borings. In the latter together with *N. ctenophora* L. Gailite has identified *Neobeyrichia scissa*. They are accompanied by *Hemsiella hemsiensis*, *Hammariella pulchrivelata*, *Microcheilinella lacrima*, *Primitiopsis ezerensis* but in the Virbalis and Kunkoiai borings also by *Hoburgiella tenerrima*.

On Gotland *N. lauensis* and *N. scissa* mark the upper part of the Hemse Beds (Martinsson, 1967). *N. ctenophora* is there of wider vertical distribution occurring also in the overlying Eke, Hamra and Sundre Beds. In the Virbalis and Kunkoiai borings together with *Neobeyrichia ctenophora* and *N. lauensis* there are found *Hoburgiella tenerrima* and *Scaldianella personata*, rather wide-spread species in the overlying beds.

*Neobeyrichia lauensis* does not occur in sections of the Saaremaa Island. A probable find of *N. ctenophora* has been made from Kõrkküla outcrop (Paadla Stage, Uduvere Beds).

### *Neobeyrichia nutans* Zone

The zone contains a rich association of ostracodes with species characteristic of the Hemse Beds: *Hemsiella hemsiensis*, *Beyrichia eteliana*, *B. grogarniana*, *Calcaribeyrichia simplicior*, *Neobeyrichia nutans*, and numerous species of wider vertical distribution (Capp, 1971) occurring in the upper part of the Paadla Stage in the Ohesaare boring (Uduvere Beds).

A. Martinsson (1967) treated *Neobeyrichia nutans* together with *Hammariaella pulchri-velata* as an index-species for the middle part of Hemse Beds. In the Southern East Baltic this species occurs in the Kunkoiai boring in a short interval above the zone *Amphitoxotis curvata*, but below the occurrences of *Neobeyrichia* cf. *ctenophora* which approximately corresponds to the level of distribution of *Neobeyrichia nutans* on Gotland. In the Ohesaare boring the interval of the distribution of this species is wider and embraces the whole middle and upper parts of the Paadla Formation. However, *N. nutans* is lacking in the upper part of the Pagēgiai Formation of central and Southern East Baltic (Гайлите и Ульст, 1974) and cannot serve as a zonal species there. It may serve as a zonal species only for sections of the Saaremaa Island where it together with *Hemsiella hemsiensis*, *Moorea bisculata* and other species characterizes the middle and upper parts of the Paadla Stage.

Absence of *N. ctenophora* and *N. lauensis* in sections of the Saaremaa Island and scarcity of *N. nutans* in sections of the Central and Southern East Baltic can be explained by facies zonality of the basin - first two species are distributed in offshore, the latter more often in nearshore facies.

#### *Undulirete balticum* and *Plicibeyrichia numerosa* Zones

L. Gailite (Гайлите и Ульст, 1974) has distinguished both *Neobeyrichia nutans* and *Hoburgella anterovelata* as of the same age zonal species. The latter is evidently conspecific with *Hoburgella tenerrima* identified from the Eke, Hamra and Sundre Beds on Gotland. *H. anterovelata* (= *tenerrima*) is known in the sections Piltene-1 and Ezere, rarely also from the Virbalis and Kunkoiai sections. Frequently it occurs together with considerably wide-spread *Undulirete balticum*, which has also been proposed as zonal species (Kaljo, 1978). In the Northern East Baltic the *U. balticum* Zone is replaced by *Plicibeyrichia numerosa* Zone.

Age relations between species *Neobeyrichia ctenophora* and *N. lauensis*, *N. nutans*, *Hoburgella tenerrima* and *Undulirete balticum* are as follows. In the section of the Piltene-1 *H. tenerrima* appears somewhat earlier than *U. balticum* but not before the disappearance of *N. lauensis* and *N. ctenophora*. In the Virbalis boring *H. tenerrima* occurs in the same sample together with the last specimens of *N. lauensis* and *N. ctenophora*, whereas *U. balticum* is found somewhat higher in the section. In the Ezere boring *H. tenerrima* is met in a short interval together with the last specimens of *U. balticum*. *Neobeyrichia nutans* is older than *N. lauensis* and *N. ctenophora* but the upper part of its distribution coincides with the range of the latter.

#### *Hemsiella margaritae* - *Neobeyrichia alia* Zone

L. Gailite (Гайлите и Ульст, 1974) determined *Hemsiella margaritae* and *Neobeyrichia alia* as zonal species within the Minijsa Formation of the Central and South East Baltic. However, *H. margaritae* has rather noticeable intraspecific variation and it is doubtless closely related to *H. loensis* and *H. maccoyiana*. Thus the scope of *H. margaritae* is treated differently by different researchers. Vertical distribution of this species is wide. It has been determined in many sections already in the topmost beds of the Pagēgiai Formation (Stoniškiai, Kolka-54, Ventspils) but in the majority of cases in the lower half of the Minijsa Formation. In the Northern East Baltic it occurs in the Kuressaare Stage and in the lower half of the Aigu Beds of the Kaugatuma Stage (Capp, 1968, 1971).

*Neobeyrichia alia* is of the same age as *H. margaritae* and of analogous vertical distribution: the uppermost beds of the Pagēgiai and the lowermost beds of the Minijsa Formations in the sections of the Stoniškiai and Ventspils borings but in the Virbalis,

Ezere, Piltene-1 and -31, Kolka-4 sections it occurs only in the Minijs Formation. An exception is the Piltene-1 boring where *N. alia* has evidently been identified in one sample from the lowermost beds of the Jūra Formation (Гайлите и др., 1967).

In sections of the Virbalis, Ezere and Piltene-1 *Hemsiella margaritae* - *Neobeyrichia alia* appear immediately after the zonal species *Undulirete balticum* but in the Kolka-4 boring (Гайлите и Ульст, 1974) *N. alia* occurs together with *U. balticum* whereas *H. margaritae* appears somewhat later. The above serves as an evidence of inconstancy of the lower boundary of the zone *H. margaritae* - *N. alia*.

#### *Frostiella groenvalliana* Zone

Species characterizing the former zone occur together with *Frostiella groenvalliana* which, besides the sections of the North East Baltic (Ohesaare and Kaugatuma borings), is rarely found also in the sections of the Stonišķiai, Ezere and Ventspils borings but in the section of the Piltene-1 boring L. Gailite determined a similar species *Frostiella lebiensis*. Distinction of *F. groenvalliana* in the role of a zonal species (Kaljo, 1978) for the lower part of the Kaugatuma Formation and its analogs (the Minijs Formation) is justified as this species, despite its scarcity in the East Baltic, is known from the Upper Silurian of Southern Sweden, England and Canada. In the East Baltic together with it for the first time appear such wide-known species as *Neobeyrichia buchiana*, *Macrypsilon salterianum*, *Hemsiella maccoyana*.

#### *Nodibeyrichia tuberculata* Zone

The following *Nodibeyrichia tuberculata* Zone is more constant in the whole East Baltic. On the Saaremaa Island this species characterizes the Lõo Beds of the Kaugatuma Formation, in North-West Latvia it is distributed in masses in the lower part of the Jūra Formation which therefore are considered synchronous with the Lõo Beds. The zone is established in the Piltene-1 and -32, Kolka-4 and -54, Ventspils borings and also in some sections of the Southern East Baltic (Stonišķiai boring; Капс, 1967).

#### *Nodibeyrichia jurassica* Zone

The top of the East Baltic Silurian is considered by L. Gailite (Гайлите, 1965) *Nodibeyrichia jurassica* Zone. In the Piltene-1 boring the zone occupies the upper part of the Jūra Formation with the thickness of 43 m. Approximately of the same extent is this zone in the Piltene-32, Kolka-4 and -54, Ventspils borings. The *Nodibeyrichia jurassica* Zone in North-West Latvia and on the Saaremaa Island corresponds to the Ohesaare Stage. The distribution of zonal association besides index-species (*Dizygopleura opportuna*, *Juviella piltenensis*, *Kloedenia leptosoma* and some others) permits to assume that in the Ohesaare stratotype section the beds of *Nodibeyrichia jurassica* age, despite their relatively small thickness (6 m), contain the whole complex of characteristic ostracode species.

The above shows that differences in the distribution of zonal ostracode species in various areas of the Late Silurian Baltic basin existed in the Ludlow and, partially, in the Downton time. Thus the determination of zonal ostracode species for different areas of the mentioned basin will be expedient. The present paper gives such species separately for the North East Baltic and for the Central and South East Baltic areas (see Table).

Table. The ostracode zones in the Upper Silurian of the East Baltic

Group	Series	Regional Stratigraphy		Ostracode zones (Гайлите, 1965-1978; Kaljo, 1978; emend.)		Gotland (Martinsson, 1967)		
		Stage	Graptolite zone	North East Baltic	Central and South East Baltic	Stratigraphy	Ostracode succession	
Upper Silurian	Downton	Ohesaare		<i>Nodibeyrichia jurassica</i>	<i>Nodibeyrichia jurassica</i>	Jūra Formation	Sundre Hamra Burgsvik	<i>Kloed-Nodiplicul</i>
				<i>Nodibeyrichia tuberculata</i>	<i>Nodibeyrichia tuberculata</i>			
		Kaugatuma		<i>Frostiella groenvalliana</i>	<i>Hemsiella margaritae</i> - <i>Neobeyrichia alia</i>	Minija Formation		<i>groenvall-leb-kies</i>
				<i>Plicibeyrichia numerosa</i>	<i>Undulirete balticum</i>			<i>maccoy-regn</i>
	Ludlow	Kuressaare	<i>Monocl. ultimus</i> <i>M. formosus</i>					<i>juvens-regn</i>
								<i>semilaq tenerr</i>
		Paadla	<i>Monogr. balticus</i>	<i>Neobeyrichia nutans</i>	<i>Neobeyrichia ctenophora</i> - <i>N. lauensis</i>	Pagegial Form.	Hemse	<i>lau-sciss</i>
			<i>Monocl. tauragensis</i>		<i>Craspedobolbina ezerensis</i>	Dubysa Formation		<i>pulchri-nut</i>
		<i>L. scanicus</i>			<i>haidby</i>			
		<i>N. nilssoni</i>		<i>Craspedobolbina lietuvensis</i>		<i>curv-rob</i>		
		Rootsiküla	<i>M. ludensis</i>					

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К ЗОНАЛЬНОМУ РАСЧЛЕНЕНИЮ ВЕРХНЕГО СИЛУРА  
ПРИБАЛТИКИ ПО ОСТРАКОДАМ

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Остракодовые зоны верхнего силура Прибалтики установлены Л. К. Гайлите (1964, 1965, 1978; Гайлите и др., 1967; Гайлите и Ульст, 1974) в разрезах Западной Латвии и Литвы. Объем этих зон уточнен Д. Л. Кальо/Kaljo, 1978/; им же выделены некоторые новые зоны, в основном, в разрезах Эстонии.

В данной статье проведены ревизия верхнесилурийских остракодовых зон и переоценка их стратиграфической и корреляционной значимости на основе исследования 12-и буровых разрезов (см. рис.). Показана целесообразность выделения в разнофациальных отложениях некоторых участков разреза параллельных, более-менее одновозрастных остракодовых зон.

Раннелудловские зональные виды *Craspedobolbina lietuvensis* и *C. ezerensis* известны только из разрезов Средней и Южной Прибалтики. Там же распространяются позднелудловские *Neobeyrichia stenophora* - *N. lauensis* (см. табл.). Лудловские отложения Северной Прибалтики характеризуются зональным видом *Neobeyrichia nutans*. Разные остракодовые зоны выделены и в раннедаунтонских отложениях: в Северной Прибалтике зоны *Plicibeyrichia numerosa* и *Frostiella groenvalliana*, в Средней и Южной Прибалтики - зоны *Undulirete balticum* и *Hemsiella margaritae* - *Neobeyrichia alia*. Позднедаунтонские отложения Прибалтики содержат такие широкораспространенные зональные виды, как *Nodibeyrichia tuberculata* и *N. jurassica*.