‘Nodibeyrichia jurassica’ and associated beyrichiacean ostracode species and their significance for the correlation of late Silurian strata in the Baltic and Britain

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ABSTRACT - Taxonomic revision reveals that the beyrichiacean ostracode ‘Nodibeyrichia jurassica’ can no longer be regarded as an index species for the uppermost (late Přidoli) ostracode ‘zone’ of the Silurian of the Baltic region embracing Estonia, Latvia and Baltic-floor derived erratic boulders. The taxon Nodibeyrichia jurassica Sarv, 1968 (non Gailite 1967) is regarded as a junior subjective synonym of Beyrichia protuberans Boll, 1862. Moreover, the material hitherto assigned to ‘Nodibeyrichia jurassica’ is herein considered to belong to two species: Nodibeyrichia protuberans (Boll, 1862) and Nodibeyrichia verrucosa Shaw, 1969. N. verrucosa occurs in England and Estonia, in the basal part and upper part of the Přidoli Series respectively. N. protuberans, as herein restricted, can be used to recognize the late Přidoli, uppermost ostracode assemblage level (N. jurassica Zone of previous literature) of the Silurian only in the central East Baltic (Latvia) and in erratic boulder material found in southern Baltic areas. J. Micropalaeontol. 13(2): 81–91, December 1994.

OSTRACODE BIOSTRATIGRAPHY IN THE SILURIAN

Study of palynomorphs, conodonts, ostracodes and other microfossil groups has resulted in the establishment of many biostratigraphical schemes to complement and challenge macrofossils as dating tools in the Silurian (see papers in Holland & Bassett, 1990). Over the last 25 years in particular, ostracodes have proved useful in refining stratigraphic resolution in the several Silurian ostracode biogeographical faunal regions now recognized (see Siveter, 1989).

No global ostracode biozonal scheme exists for the Silurian. Intra- and intercontinental correlations are attempted with respect to the ‘European’ (essentially Baltic–British), Appalachian, North American mid-continent, Cordilleran and Bohemian ostracode faunal regions (Siveter, 1989). Moreover, though some authors have identified so-called zones for their particular ‘local’ Silurian ostracode sequences, such schemes have not been formally defined in terms of range or other types of zones. Silurian ostracode biostratigraphy in these various regions is best demonstrated as a series of distinctive ostracode species associations within vertically successive ostracode faunas (Martinsson, 1967). Such biostratigraphical schemes have been best tested in the ‘European’ ostracode faunal region, which offers good interprovincial and intercontinental correlation in the region between Podolia in the Ukraine and New England, USA/Nova Scotia, Canada (for summary see Siveter, 1989; Hansch, 1993, in press). This ostracode faunal province embraces both the Baltic area and, sited in Britain, the stratotype areas for the three oldest of the four Series of the Silurian.

THE ‘N. JURASSICA’ ZONE – THE NATURE OF THE PROBLEM

The ‘Nodibeyrichia jurassica Zone’ has been used for the last 25 years to denote the youngest of the ostracode associations in the Silurian of the northern (Estonia), central (Latvia) and contiguous areas in the East Baltic (e.g. Gailite, 1965, 1967, 1978, 1986; Sarv, 1977, 1982; Meidla & Sarv, 1990; see also Hansch, 1985). It has been exclusively used by, for example, Gailite, Sarv, and also Abushik (1986) as a correlative of the later part of the Přidoli, the youngest Series of the Silurian. In the Baltic area much of the Silurian rocks of latest Ludlow Series and Přidoli age occur as submarine ‘exposures’ (e.g. see Martinsson, 1963a, b, 1965b), from which are derived the suites of ‘Beyrichien-kalk’ erratic boulders, including some recorded as containing ‘N. jurassica’ and associates, ubiquitously found along the southern Baltic and adjacent areas.

The term ‘Beyrichienkalk’ is sometimes used in a broad sense (e.g. see Hansch, 1985, 1993): for all the upper Silurian erratic boulders, characterized by several successive ostracode associations, which according to current correlations would span the late Ludlow to late Přidoli. Used in its more restricted sense, ‘Beyrichienkalk s.s.’ erratics are those of middle to late Přidoli age, between the early Přidoli Frostiella groenwalliana ostracode fauna and the assumed level of the Siluro-Devonian boundary. The taxonomy, faunal subdivision, occurrence and correlation of the Beyrichienkalk s.s. has been thoroughly treated by Martinsson (e.g. see 1963a, b, 1964, 1965a, b, 1967, 1977a, b; also Siveter, 1989; Hansch, 1985, 1986a, b, 1993, in press).

It was apparent from our studies on British and Baltic Silurian ostracode faunas that the taxonomic definition of...
the ‘species’ N. jurassica required revision and its value as an index species for the recognition and correlation of the late Pfidoli needed to be re-evaluated. The aim of this paper is to address both of these points. In doing so we also resolve the primary and complicated nomenclatorial problem of the availability, authorship and date of publication of the binomen Beyrichia jurassica Gallite, 1965 (nomen nudum).

We herein show that the valid binomen, authorship and date for the species in question is Nodibeyrichia jurassica Sarv, 1968, which we consider to be a junior subjective synonym of Nodibeyrichia protuberans (Boll, 1862). We also conclude that the late Pfidoli Estonian ostracodes previously assigned (e.g. by Sarv, 1968) to ‘Nodibeyrichia jurassica’ are conspecific with the early Pfidoli British species Nodibeyrichia verrucosa Shaw, 1969. The hitherto so-called Nodibeyrichia jurassica (=Nodibeyrichia protuberans) Zone is now restricted to only the late Pfidoli of the central (Latvia) and southern (‘Beyrichienkalk’; Sarv, 1968, which we consider to be a junior subjective synonym of N. jurassica nudum). The ‘Zone’ cannot be used, as hitherto, to also embrace the late Pfidoli strata in Estonia.

**SYSTEMATIC PALAEONTOLOGY**

Subclass Ostracoda Latreille, 1802

Order Palaeocopida Henningsmoen, 1953

Superfamily Beyrichiacea Matthew, 1886

Family Beyrichiidae Matthew, 1886

Subfamily Beyrichiinae Matthew, 1886

Genus Nodibeyrichia Henningsmoen, 1954

**Type-species.** Beyrichia pustulosa Hall, 1860, p. 157, text-fig. 19; subjective synonym of Beyrichia tuberculata Boll var. Gedanensis Kiesow, 1884 and Beyrichia Bronni Reuter, 1885. The latter was designated type-species of Beyrichia (Nodibeyrichia) by Henningsmoen, 1954, p. 26. B. pustulosa is from the Stonehouse Formation of Arisaig, Nova Scotia, Canada.

Other species. N. bifida Sarv, 1968; N. protuberans (Boll, 1862); N. tuberculata (Klöden, 1834); N. verrucosa Shaw, 1969; ? N. torosa Abushik, 1971.

**Diagnosis.** (Modified from Martinsson, 1965a: 122). Beyrichiinae in which the anterior lobe is generally well set off from other lobal elements and is divided into a cuspidal lobule and a usually prominent, rounded, anteroventral lobule. All kinds of lobular spines absent. Crumina with a tuberculate marginoventral field. Syllobium with usually one blunt cusp.

**Discussion.** The genera Neobeyrichia and Nodibeyrichia are closely related (Martinsson, 1965a). Nodibeyrichia differs from Neobeyrichia mainly by its tuberculate subcruminal ornament and by its rounded anteroventral lobule. The velar ridge is sometimes spinose in Neobeyrichia and often somewhat thicker, sparsely tuberculate and well set off from the lobes in Nodibeyrichia. Furthermore, Neobeyrichia often has a postcruminal velar process and a granulose ground ornament not common in typical Nodibeyrichia species such as N. tuberculata or N. pustulosa. Both Neobeyrichia and Nodibeyrichia have, in contrast to Beyrichia, an anterior lobe which is typically mostly, or entirely, isolated from other lobal elements and is characteristically differentiated into dorsal and anteroventral lobules; Neobeyrichia and Nodibeyrichia also lack prominent individual lobal spines. Such spines, together with the occurrence of a ventral ridge on the crumina, are important distinguishing characteristics of Calcaribeyrichia.

**Occurrence.** In Britain Nodibeyrichia is known only from the Pfidoli Series (Siveter, 1978, 1989). The genus occurs extensively in Pfidoli deposits in the Baltic area in general (for example, see Martinsson, 1965a, 1967, 1977a, b; Gallite, 1967, 1978, 1986; Witwicka, 1967; Sarv, 1968, 1970, 1971, 1977, 1982; Zbikowska, 1973, 1974; Tomczykowa & Witwicka, 1972, 1974; Hansch, 1985, 1986a, b, 1993, in press; Sidaraviciene, 1986; Siveter, 1989). It is also known from Pfidoli correlatives in the western USA and western Canada (Copeland, 1960, 1964; Martinsson, 1967, 1970, 1977b; Copeland & Berdan, 1977; Berdan, 1983, 1990) and possibly in Podolia (Abushik, 1971).

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**Nodibeyrichia protuberans** (Boll, 1862)

(Pl. 1, figs 1–11)

1862 Beyrichia protuberans Boll (1862), Boll: 122, 123, pl. 1, fig. 3.

1877 B. protuberans; Krause: 31, 33, 36.

1886 Beyrichia protuberans Boll; Jones & Holf: 343.

non 1888 Beyrichia Klodeni var. protuberans Boll; Kiesow: 10, 11, pl. 2, figs 4a–c, 5 (=

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**Explanation of Plate 1**

Figs 1–10: **Nodibeyrichia protuberans** (Boll, 1862). 

**Figs 1, 2, 4.** Neotype, female left valve, SGWG 80/1: fig. 1, lateral view (stereo-pair), ×25; fig. 2, detail of ornament of crumina (stereo-pair), ×200; fig. 4, ventral view, (stereo-pair), ×25. From erratic boulder, Boll collection no. BO1, from Neubrandenburg; stored in the Müritz Museum, Waren, ‘Beyrichiarkalk’ s.l., Pfidoli Series. 

**Fig. 3.** Male left valve, lateral view (stereo-pair), SGWG 80/2, ×25. From same erratic boulder as Neotype. 

**Figs 5, 9.** Female right valve, SGWG 78/11: fig. 5, lateral view (stereo-pair), ×25; fig. 9, ventral view, ×25. From erratic boulder, SGWG no. Bey, F4, from Jaroslawiec, Poland; ‘Beyrichiarkalk’, Pfidoli Series. 

**Fig. 6.** Male right valve, lateral view (stereo-pair), MB.O 27, ×25. Original of **Beyrichia borussica** Kiesow, 1892, pl. 24, fig. 10. From erratic boulder from Legowo, near Gdansk, Poland; ‘Beyrichiarkalk’ s.l., Pfidoli Series. 

**Figs 7, 8.** Female right valve, MB.O 30. Original of **Beyrichia borussica** Kiesow, 1892, pl. 24, probably fig. 14 (not fig. 13, errone in Hansch, 1986: 22): fig. 7, lateral view (stereo-pair), ×25; fig. 8, ventral view (stereo-pair), ×25. From erratic boulder from Legowo, near Gdansk, Poland; ‘Beyrichiarkalk’ s.l., Pfidoli Series. 

**Fig. 10.** Small tecnomorphic right valve, lateral view, SGWG, 92/1, ×25. From erratic boulder, SGWG no. Bey, F4, from Jaroslawiec, Poland; ‘Beyrichiarkalk’, Pfidoli Series. 

**Fig. 11.** Small tecnomorphic left valve, lateral view, SGWG, 80/3, ×25. From same erratic boulder as Neotype.
Plate 1

'Sodibeyrichia jurassica' in the Baltic and Britain
Neobeyrichia ctenophora & Beyrichia (Simplicibeyrichia) globifera, both Martinsson, 1962, respectively.

1891a Beyrichia protuberans Boll; Krause: 516.
1891b Beyrichia protuberans Boll; Krause: 12.
1892 Beyrichia borussica nov. sp., Kiesow: 101, 102, pl. 24, figs 10b, 11b, 12b, 12c, 13b, 14b.
1896 Beyrichia protuberans Boll; Gürich: 390 (cited in Bassler & Kellett, 1934).
1897 B. protuberans Boll; Grönwall: 52.
1908 Beyrichia kloedeni protuberans; Ulrich & Bassler: 285 (cited in Bassler & Kellett, 1934).
1909 B. borussica; Moberg & Grönwall: 61.
1910 Beyrichia protuberans Boll; Bonnema: 140.
1913 Beyrichia protuberans Boll; Bonnema: 72, fig. 4.
1914 Beyrichia protuberans Boll; Bonnema: 1106, 1109.
1924 Beyrichia borussica Kies.; Kummerow: 431.
1930 Beyrichia protuberans Boll; Bonnema: 116, 118, 120, fig. 13.
1934 Beyrichia borussica Kiesow; Bassler & Kellett: 187.
1934 Beyrichia protuberans Boll; Bassler & Kellett: 204.
1941 Beyrichia protuberans kloędzi Boll; Triebel: 304, pl. 3, figs. 29a–b (= Neobeyrichia ctenophora).
1962 N. protuberans; Martinsson: 19, 326.
1964 Beyrichia (Simplicibeyrichia) sp. n., Gailite: 66, 69.
1965 Simplicibeyrichia jurassica; sp. n., Gailite: 68, 70 (nomen nudum; = Piltene borehole). (Gailite’s summary, in English, implies that she regarded Simplicibeyrichia as a subgenus of Beyrichia.)
1967 Simplicibeyrichia jurassica; Martinsson: 378.
1967 Beyrichia (Beyrichia) ? protuberans (Boll), 1862; Gailite: 130, 131, pl. 9, figs 6a–c (= Piltene 1 borehole).
1968 Nodibeyrichia jurassica (Gailite); Sarv: 47 (partim, reference to holotype and Latvian material only), non pl. 17, figs 5–9 (= Nodibeyrichia verrucosa).
1970 N. jurassica (Gailite); Sarv: 159, tab. 18, 169 (= Estonian material).
1971 Nodibeyrichia jurassica (Gailite); Sarv: 353, 355, fig. 3 (= Ohesaare borehole, Estonia).
1972 N. jurassica Gailite; Gailite: 353 (= Kolka 4 borehole).
1977 Nodibeyrichia jurassica; Sarv: 164, fig. 2 (= Piltene 1 borehole), possibly also 161, text-fig. 1 (= Kolka 54 borehole), 173–176 (partim).
1978 Nodibeyrichia jurassica; Gailite: 16, 17, 20, 21, tabs 1 (Latvia only), 2 (Piltene 1 borehole; possibly also Piltene 31, 32, Kolka 4, 54 boreholes, e.g. text-fig. 5).
1982 Nodibeyrichia jurassica; Sarv: 75, 76 (table), fig. 1 (all partim e.g. Piltene 1 borehole).
‘Nodibeyrichia jurassica’ in the Baltic and Britain

Series of the Piltene Borehole, Latvia, under the name *Beyrichia* (Beyrichia) ? *protuberans* (Boll). She had previously assigned (Gailite, 1964, 1965), without description or illustration, this Latvian material to the binomen *Simplicibeyrichia jurassica* sp. n. (=*nomen nudum*; in the English summary to her paper she implied that she regarded *Simplicibeyrichia* as a subgenus of *Beyrichia*). Later, Sarv (1968) figured beyrichiines from Estonia under the binomen *‘Nodibeyrichia jurassica’* (Gailite) and, in doing so, selected a holotype for this taxon from amongst Gailite’s, 1967 (pl. 9, figs 6b, c) Latvian specimens. It follows that the authorship of the species *Nodibeyrichia jurassica* should be Sarv, 1968 (not Gailite, 1965), the publication in which the name first became ‘available’ (P. Tubbs & A. Gentry, International Commission on Zoological Nomenclature, London, pers. comm.). Based on its holotype and sympatric material the Latvian species *Nodibeyrichia jurassica* Sarv, 1968 is herein considered (see also Hansch, 1986a) a junior synonym of the beyrichiine *Nodibeyrichia protuberans* (Boll, 1862). Furthermore, the Estonian material, from the upper Päidioli Ohesaare ‘Stage’, which Sarv (e.g. 1968, pl. 17, figs 5–9; Meidla & Sarv, 1990, pl. 9, figs 1, 2; herein Pl. 2, figs 1–6) included within *N. jurassica* and *N. protuberans* respectively is herein assigned to *Nodibeyrichia verrucosa* Shaw, 1969, a species originally described from British strata of lower Päidioli age.

Of the borehole records from Latvia, it is possible to recognize *N. protuberans* or its synonyms with confidence only from the Piltene 1 borehole, the only locality for which there is figured material (Gailite, 1967). Other records, from similar horizons in Latvia (boreholes Piltene 31, 32, Kolka 4, 54 and Ventspils), probably represent conspecific material of the *Nodibeyrichia verrucosa* *Ohesaare* ‘Stage’, which Sarv (e.g. 1968, pl. 17, figs 5–9; Meidla & Sarv, 1990, pl. 9, figs 1, 2; herein Pl. 2, figs 1–6) included within *N. jurassica* and *N. protuberans* respectively is herein assigned to *Nodibeyrichia verrucosa* Shaw, 1969, a species originally described from British strata of lower Päidioli age.

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**Discussion.** Morphological features characteristic of *Nodibeyrichia* are less evident in *N. protuberans* than in other congeneric species. Its syllobium is entire and its anterior lobe is not completely isolated from its other lobes nor, except in small teconomorphs (Pl. 1, figs 10, 11), does that lobe show any sign of an anteroventral lobe. In many respects *N. protuberans* shows affinity with the beyrichiines *Beyrichia* (Beyrichia) and *Beyrichia* (*Simplicibeyrichia*). However, in that *N. protuberans* differs from such taxa by having a tuberculate rather than striate subcircular field, a lack of lobular spines and its albeit faint recall of an anteroventral lobe the species is best considered as a morphologically simple end member of *Nodibeyrichia*.

Like *N. protuberans*, the typical Baltoscandian Beyrichienkalk s.s. *Nodibeyrichia* species *N. tuberculata* in some specimens also shows a tendency to develop a callus on its lobular syllobium (e.g. see Martinsson, 1965a, fig. 11). In the case of *N. tuberculata* this development may be an ecophenotypic response, as such specimens always seem to occur together with the beyrichiacean ostracodes *Frostiella cornuta* Martinsson, 1965a and especially *Kloedenia lepotosoma* Martinsson, 1963a. Interestingly, females of such *N. tuberculata* specimens also in some cases show a slight

paracrinal swelling (Hansch unpublished information), a feature hitherto recorded only from the type-species of *Nodibeyrichia, N. pustulosa* (see Martinsson, 1965a).

**Occurrence.** Upper part of the Päidioli Series, upper Silurian; Baltic area. Beyrichienkalk s.s. erratic boulders (Beyrichienkalk ostracode association D of Hansch, 1985). Borehole Piltene 1 and possibly (recorded without illustrations) boreholes Piltene 31 and 32 (cf. Sarv, 1977, fig. 3 with Gailite, 1978, tab. 2), Kolka 4 and 54 and Ventspils (Gailite, 1967, 1978; Sarv, 1968, 1977, 1982; Bassett et al., 1989), Latvia; Jura Formation.

**Nodibeyrichia verrucosa** Shaw, 1969

(Pl. 2, figs 1–9)

1968 *Nodibeyrichia jurassica* (Gailite): Sarv: 47 [partim, non ‘holotype’ and Latvian material = *Nodibeyrichia protuberans* (Boll, 1862)], pl. 17, figs 5–9.

1969 *Nodibeyrichia verrucosa* n. sp. Shaw: 63, figs 7a–c.

1970 *N. jurassica* (Gailite): Sarv: 159, tab. 18, 169.

1971 *Nodibeyrichia jurassica* (Gailite): Sarv: 353, 355, fig. 3.

1978 *Nodibeyrichia verrucosa* Shaw, 1969; Siveter: 68, 86, pl. 9, figs 9, 10, tab. 2.

1982 *Nodibeyrichia verrucosa*; Bassett et al.: 8, 15, fig. 6.

1988 *Nodibeyrichia verrucosa*; Siveter: 35, text-fig. 7.

1989 *Nodibeyrichia verrucosa*; Siveter: 258, fig. 167.

1989 *Nodibeyrichia verrucosa*; Siveter et al.: 45, fig. 38.

1990 *Nodibeyrichia protuberans*; Meidla & Sarv: 71, tab. 11, pl. 9, figs 1, 2.

1990 *Nodibeyrichia protuberans* Nestor: 176, fig. 53.

**Holotype.** GSM 103262, teconomorphic left valve external mould; figured Shaw, 1969, figs 7a, b. From 1ft 9in. (53.5 cm) above the Ludlow Bone Bed, Platyschisma Shale Member of Downtown Castle Sandstone Formation; Forge Bridge, near Downtown, Hereford & Worcester, England.

**Material.** British material consists of mostly incomplete, internal and external moulds. Estonian material is preserved as calcareous shells.

**Diagnosis.** Species of *Nodibeyrichia* with a callus and two subequal cusps on the undissected syllobium. Ventral part of anterior lobe differentiated as a weakly elevated, rounded lobeule; dorsal part flatter, with a small cusp just above the hinge line. Preadductorial node slopes forward.

**Description.** Syllobium broadest at about mid-height, has two subequal-sized cusps above hinge line in adults and a diagonal callus above a faint syllobial groove. Preadductorial node elongate, sloping forward, terminates just below hinge line. Anterior lobe has weakly elevated, rounded anteroventral lobeule differentiated from dorsal, cuspidal part. Anteroventral depression moderately well developed but not discretely defined. Lobal connection from syllobium to preadductorial node and anterior lobe is poorly developed.

Velum present between cardinal corners, is narrow and inconsistently finely tuberculate. Crumina well developed, elongate along anterodorsal–posteroveental axis. All lobes, lobal connections and crumina have small tubecules.

**Measurements.** Hinge length–height of female valves from the Ludlow Bone Bed Member, Downtown Castle Sandstone Formation, England: 1950–1400μm (OS 6604),
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1875–1350 μm (OS 6605), 1760–1310 μm (OS 14095). Hinge length=height of valves from the Ohesaare ‘Stage’, Estonia: 2250–1650 μm (female left valve, Os 5378), 2200–1425 μm (tecmorphorphic left valve, Os 5379).

Synonymy. The beyrichiine valves from the upper Předolí of Estonia, which Sarv (1968) and Meidla & Sarv (1990) figured under Nodibeyrichia jurassica (Gailite) and Nodibeyrichia protuberans (Boll) respectively, have been examined (Pl. 2, figs 1–6). They are considered conspecific with the type and newly collected material (Pl. 2, figs 7–9) of N. verrucosa Shaw, 1969 occurring in the early Předolí of Britain. It is probable, though not certain (no illustrations given), that all the Estonian material previously cited as N. jurassica (e.g. in Sarv, 1970, 1971; Nestor, 1990) belongs to N. verrucosa.

Discussion. Although the mould nature of the material has not yet allowed confirmation of the female subcircular morphology in the British specimens, in the Estonian valves studied it is tuberculate and, thus, typical of the genus. The undissected nature of the syllobium and the valves studied it is tuberculate and, thus, typical of the genus. The undissected nature of the syllobium and the valves studied it is tuberculate and, thus, typical of the genus.

N. verrucosa differs from the upper Předolí N. protuberans (as restricted herein) chiefly by its bicuspidate syllobium and the presence on its anterior lobe of a ventral lobule and dorsal cusp. In addition, N. verrucosa tends to have a more forwardly inclined preadductorial node. The British material of N. verrucosa occurs in sandstones and siltstones (e.g. The Whitcliffe road sections; see Siveter et al., 1989); N. protuberans, as restricted herein, is known from dolomitic marl and limestone strata from the Baltic (Piltena 1 borehole, Gailite, 1967; Kolka 4 borehole, Gailite, 1972; Ventspils borehole, Bassett et al., 1989; Beyrichienkalk ostracode association D of Hansch, 1985: 281). Thus, as both this particular British and Baltic material occur in intertidal to shallow subtidal marine to possibly marine environments to that of the presumed conspecific material.

Occurrence. Předolí Series, upper Silurian; Welsh Borderland and Estonia. In the Welsh Borderland from the Ludlow (D.J.S. collections, see Siveter, 1978; Bassett et al., 1982) and Downton (Shaw, 1969) areas, Shropshire, and the Long Mountain region (Shaw, 1969) to the west. Collected by D.J.S. from the Ludlow Bone Bed Member (locs 69a, 69b of Siveter, 1980; = not 'Topmost Whitcliffe Beds' cf. Siveter, 1980: 8, in errore), Downton Castle Sandstone Formation (see Bassett et al., 1982). Shaw’s (1969) Downton area material is from the Platyshisma Shale Member, Downton Castle Sandstone Formation. The Estonian material is from the upper Předolí Ohesaare ‘Stage’, Isle of Saaremaa (Sarv, 1968, 1970, 1971; Meidla & Sarv, 1990; Nestor, 1990), where it has also been collected from the Ohesaare cliff section by the present authors.

BIOSTRATIGRAPHICAL SIGNIFICANCE OF TAXONOMIC REVISION

These new taxonomic opinions regarding N. protuberans (‘N. jurassica’) and N. verrucosa necessitate a revision of part of the informal ostracode ‘zonal’ scheme which has long been applied to the Upper Silurian of the East Baltic area and associated Beyrichienkalk drift boulder sequences. Fig. 1 outlines such a revised scheme for the various parts of Baltoscandia and the faunally associated area of Britain.

In the Baltoscandian area in general the oldest and most widespread ostracode assemblage of the basal part of the Předolí Series is the Frostiella groenvalliana association, which can be traced into correlatives in Britain and eastern North America (Fig. 1; see Siveter, 1989 and Hansch et al., 1990 for a summary of its distribution). The F. groenvalliana association is succeeded by a number of ostracode faunas which encompass the Beyrichienkalk s.s. faunas of traditional literature. Of the latter, the most widespread ostracode associations in the literature are the successive faunas characterized by Nodibeyrichia tuberculata and, in the late Předolí, either Nodibeyrichia pustulosa (gedanensis) or ‘N. jurassica’ depending on the area of Baltoscandia in question (for example, see Martinsson, 1967, Siveter, 1978, 1989, Hansch, 1985, 1993, in press). The two faunas with F. groenvalliana and N. pustulosa respectively are both recognized from Britain, the former from outcrops of

Explanation of Plate 2

Figs 1–9: Nodibeyrichia verrucosa Shaw, 1969. Figs 1, 2, 6. Female left valve, Os 5378. Original of Sarv, 1968, pl. 17, fig. 5: fig. 1, lateral view (stereo-pair), ×19; fig. 2, anterior view (stereo-pair), ×19; fig. 6, ventral view (stereo-pair), ×19. From Ohesaare Cliff, Saaremaa, Estonia; Ohesaare Formation, Předolí Series. Collected L. Sarv, 1959. Figs 3, 4, 5, Male left valve, Os 5379. Original of Sarv, 1968, pl. 17, fig. 6: fig. 3, lateral view (stereo-pair), ×19; fig. 4, anterior view (stereo-pair), ×19; fig. 5, ventral view (stereo-pair), ×19. Locality and horizon as for fig. 1. Fig. 7. Silicone rubber cast of external mould of male left valve, lateral view (stereo-pair), OS 6606, ×23. From Ludford Lane, Ludlow, Shropshire (collected D.J.S.); Ludlow Bone Bed Member (loc. 69a of Siveter, 1980; = not ‘Topmost Whitcliffe Beds’ cf. Siveter, 1980, p. 8, in errore), Downton Castle Sandstone Formation, Předolí Series. Fig. 8. Silicone rubber cast of external mould of female left valve, lateral view (stereo-pair), OS 6604, ×20. Locality and horizon as for fig. 7. Fig. 9. Silicone rubber cast of external mould of male left valve, lateral view (stereo-pair), OS 6608, ×23. Locality and horizon as for fig. 7.
### Fig. 1. Correlation of latest Ludlow–Přédolf ostracode faunas of Baltoscandia, Britain and Czechoslovakia (modified from Siveter, 1989, fig. 164; see also Hansch, 1985, fig. 3, 1993, in press). Symbols denote the presence (mostly only the earliest occurrence) of a fauna within a stratigraphical unit, not their exact positions. Vertical columns not to scale. The only firm time line is the Ludlow/Přédolf boundary. Correlation agrees with Martinsson (1967) and Bassett et al., (1982, 1989). The Scanian succession (from Jeppsson & Laufeld, 1987) and the base of the Přédolf with respect to the Minija Formation follows Bassett et al., (1989).

**Monograptus parultimus**, the basal Přédolf graptolite in the Bohemian stratotype, is not recorded from Polish sequences; that level is coeval with the base of the Lower Podlasie Beds (Bassett et al., 1989). The last occurrence of the conodont *O. crispa* in Bohemia is immediately below the first occurrence of *Monograptus parultimus*. The inference (Viira, 1982, see also Schönlaub, 1986) that *O. crispa* ("*Spathognathodus* aff. **sp.??**") ranges into the lowermost Kaugatuma Formation in Estonia – northern Latvia, thus suggesting that the Ludlow/Přédolf boundary occurs in the lowermost part of the Kaugatuma Formation, is denied by the now confirmed, exclusively Upper Paadla Formation occurrence of *O. crispa* in Estonia (Männik & Viira, 1990); the Kaugatuma/Kuressaare formational boundary therefore is given as a solid line. Based on Baltic ostracodes and conodonts from Beyrichienkalk boulders and the Přédolf stratotype area (Jeppsson, 1981, 1988) there is no resolvable hiatus between the *Nodibeyrichia jurassica* (gedanensis)*/Kloedenia wikkensiana* ostracode fauna of the Beyrichienkalk and the Silurian–Devonian boundary (Hansch, 1993, in press).

**Nodibeyrichia regnans** in the upper Ludlow Siedlce beds of Poland (cf. Tomczykowa & Witwicka, 1974) is based on Zbikowska (1973) and Martinsson (1964, 1967). Plots of the fauna with *Hemiella hians (loensis)* &/or *Hemiella maccoviana* (alongside that containing *Neobeyrichia regnans*) are additional to data of Siveter, 1989: *Hemiella maccoviana* from the upper Ludlow of Scania (Moberg & Grönwall, 1909: ‘Ramsåsa lag 3 & 4’, ‘Klinta lag 1 & 3’, ‘Bjäringsjölagård lag 1 & 3’), Estonia (H. cf. *maccoviana* of Sarv, 1968: Kuressaare and Kaugatuma strata) and the Ludlow (Upper Whitcliffe Formation; Siveter, 1980: 49) and Kerry areas (Cfen Einion Formation; G. Miller, Leicester University, pers. comm.) of the Welsh Borderland; *Hemiella hians (loensis)* from the upper Ludlow of Estonia (Sarv, 1968: Paadla and Kuressaare strata).

**Abbreviations**: B M of Klinta Fm – Bjäringsjölagård Member of Klinta Formation; Downton CS Fm – Downton Castle Sandstone Formation; LBBM – Ludlow Bone Bed Member; Oved-Ramsåsa Gp – Oved-Ramsåsa Group; Oved Sst. Fm – Oved Sandstone Formation; PSM – Platschisma Shale Member; SM – Sandstone Member.

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possible ‘quasi-marine’ deposits in an overall regressive sequence and the latter from fully marine deposits in a borehole.

During the last 25 years, the ‘*Nodibeyrichia jurassica* Zone’ has been used, with various degrees of refinement, to denote the youngest of the ostracode faunal associations in the Silurian of the northern and central East Baltic (Estonia and Latvia respectively; land outcrop and boreholes) and contiguous areas (Baltic submarine exposures and Beyrichienkalk s.s. boulders). The ‘Zone’ has been uniformly used to identify horizons equivalent to the Ohesaare Regional ‘Stage’ (i.e. the Ohesaare Formation in Estonia
and the upper part of the Jura Formation in parts of Latvia; e.g. Sarv, 1977: 178) which, it is commonly agreed, correlates with the upper part of the Předolí Series. The stratigraphical interval in question was first identified as the [Beyrichia] Simplicibeyrichia sp. nov. Zone and later, from the Piltīte 1 borehole in Latvia, as the [Beyrichia] Simplicibeyrichia jurassica Zone (Gailite, 1964, 1965). Though nomenclatorial opinions changed, the same interval was subsequently identified again in West Latvian boreholes (Beyrichia ?protuberans Zone of Gailite, 1967; Nodibeyrichia jurassica Zone of Sarv, 1977, 1982; Gailite, 1978, 1986), in a borehole and Cliff Section on Saaremaa Island, Estonia (Nodibeyrichia jurassica Zone of Sarv, 1968, 1971, 1977; Nodibeyrichia protuberans Zone of Meidla & Sarv, 1990) and from the Beyrichienkalk erratic boulder sequence (Nodibeyrichia protuberans fauna of Hansch, 1985, 1986a).

The taxonomic revisions herein have the following consequences for the Upper Silurian ostracode biostratigraphy in the Baltic–British ostracode faunal region:

1. The ‘Nodibeyrichia jurassica Zone’ should be termed the Nodibeyrichia protuberans Zone.
2. Nodibeyrichia protuberans, and therefore its ‘Zone’, can still be identified from the central East Baltic (Latvia) and from the submarine floor of the Baltic (Beyrichienkalk s.s. erratic boulder sequence).
3. Nodibeyrichia protuberans, and therefore its ‘Zone’, can no longer be identified from the Silurian of the northern East Baltic (Estonian) sequence.
4. Nodibeyrichia verrucosa is no longer confined to the lower Předolí Downton Castle Sandstone Formation of the Welsh Borderland. Conspicuous material also characterizes the late Předolí Ohesaare Formation (Ohesaare Regional ‘Stage’) of Estonia.
5. Considering the ostracode faunal succession of the East Baltic area in general, it is possible to recognize three, broadly defined, successive faunas which are relatively widespread: characterized by the beyrichiaceans F. groenvalliana, N. tuberculata and N. pustulosa repsectively (Fig. 1 herein; see also Hansch, 1993, in press for a summary). The oldest and youngest of these three associations are also present in Britain (Siveter, 1978, 1989).

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