

# Campanian-Maastrichtian pelagic crinoids from NE Belgium and SE Netherlands: preliminary observations

by John W.M. JAGT

## Abstract

During recent years unexpectedly rich and diverse faunules of diminutive, pelagic crinoids of the order Roveacrinida SIEVERTS-DORECK *in* MOORE, LALICKER & FISCHER, 1952 have been collected from early and late Campanian and late Maastrichtian strata in the Maastrichtian type area (southern Limburg, The Netherlands, and contiguous areas). Most, if not all, of these forms appear to be still undescribed. Occurrences known to date are briefly discussed; a taxonomic study with detailed descriptions of the various species is under way.

**Key-words:** Crinoidea, Roveacrinida, Campanian-Maastrichtian, NE Belgium, SE Netherlands.

## Résumé

Au cours des dernières années, des faunules, d'une richesse et d'une diversité inattendues, de minuscules crinoïdes pélagiques ont été récoltées dans des couches du Campanien Inférieur et Supérieur ainsi que du Maastrichtien Supérieur dans sa région-type (Sud du Limbourg, Pays-Bas et régions contiguës). Ces formes appartiennent à l'ordre des Roveacrinida SIEVERTS-DORECK *in* MOORE, LALICKER & FISCHER, 1952 et la plupart, sinon toutes, n'ont pas encore été décrites. Leur distributions telles qu'elles sont actuellement connues sont brièvement discutées; leur étude taxinomique est en cours.

**Mots-clefs:** Crinoidea, Roveacrinida, Campanien-Maastrichtien, NE Belgique, SE Pays-Bas.

## Introduction

Amongst late Cretaceous crinoids those assigned to the order Roveacrinida are generally found in fairly large numbers at distinct levels in the stratigraphic column (see *e.g.* PECK, 1943, 1955; BERTHOU & BENGTON, 1988; ROBASZYNSKI *et al.*, 1990); yet their classification is still unsatisfactory, and taxa are in need of revision. When compared with Triassic representatives of this order (Somphocrinidae, see KRISTAN-TOLLMANN, 1970, 1977, 1987, 1988) their stratigraphic potential has apparently not been fully realised, although several authors have pointed out this attribute (PECK, 1943, 1948, 1955, 1973; GRIFFITHS, 1989). The disjunct distribution seen in their stratigraphic range (see SIMMS, 1988, fig. 21.2) is the main reason why their derivation

and evolutionary history are still a matter of speculation. SIMMS (1988) considered derivation from the stemless Marsupitidae d'ORBIGNY, 1852 unlikely, but suggested derivation through paedomorphosis from some other group of articulate crinoids and remarked that the three groups currently classed in the Roveacrinida, *viz.* Somphocrinidae PECK *in* RASMUSSEN, 1978, Roveacrinidae PECK, 1943 and Saccocomidae d'ORBIGNY, 1852, might even be less closely related to each other than to other articulates. MILSOM (1989) pointed out that because of the strong brachial musculature seen in roveacrinids these were probably active swimmers, whereas the lack of such strong musculature suggests saccocomids may have been possibly benthic and adapted to living on very soft substrates.

In the literature (*e.g.* RASMUSSEN, 1978; SIMMS, 1988) the Roveacrinida are assumed to have become extinct during the Campanian, with the youngest representative to have been recorded so far being the saccocomid *Applinocrinus cretaceus* (BATHER, 1924). Recent collecting from the early Maastrichtian white chalk of Rügen (northeastern Germany, M. Kutscher Collection), and now also from the late Maastrichtian extends the known range of the Roveacrinida. In the Maastrichtian type area (Fig. 1) roveacrinid and saccocomid faunules have turned out to be fairly common at some levels, and to be of an unexpected diversity. Occurrences known to date are briefly described below; detailed descriptions of the various species are deferred to another occasion (JAGT & VAN BIRGELEN, *in prep.*).

The Campanian-Maastrichtian crinoid faunas of the area are still poorly known, and recent studies include RASMUSSEN's 1961 monograph (see also RASMUSSEN, 1965) and short papers by JAGT (1986, 1990) on holopodids and comatulids, respectively. Material collected from bulk samples taken at various carefully selected spots in (disused) quarries and exposures in the area is copious and includes many species (*c.* 10) which either have not yet been recorded from the area or are new to science.

Pelagic crinoids appear to have been recorded from the area for the first time by CUPEDO (1970) and are also mentioned in an unpublished report by N.M. DE



KOP, 1963; RASMUSSEN, 1961, 1971; SCHMID, 1971; SCHNEIDER, 1988; SCOTT *et al.*, 1977; SIEVERTS, 1933a, b; VALETTE, 1917). Admirably detailed studies on German late Cretaceous Roveacrinidae are those by SCHNEIDER (1987, 1989), who commented on the systematics of the subfamily Roveacrininae and described the ontogeny of one of its members. NEKVASILOVÁ & PROKOP (1964) described late Cretaceous (latest Cenomanian-earliest Turonian) brachials which they referred to saccocomids, while KUTSCHER & HARY (1991) referred a single brachial from the early Lias with a query to the Roveacrinidae.

The genus *Pseudosaccocoma* (see REMEŠ, 1905; BACHMAYER, 1958), which was referred to the Saccocomidae until recently (see RASMUSSEN, 1978), has been removed from this family and referred to Isocrinida by KÄSTLE (1982).

### Campanian occurrences

#### VAALS FORMATION

From the early Campanian Vaals Formation (JAGT, 1989) at the SA Ciments Portland Liégeois quarry (Fig. 1, locality 1) at Haccourt (Liège, NE Belgium) a single roveacrinid secundibrachial (IIBr) comparable with specimens found in the upper part of the overlying Zeven Wegen Member, is available for study. This unit has so far not yielded any other crinoids.

#### GULPEN FORMATION

##### *Zeven Wegen Member (late Campanian)*

A fairly extensive material has recently been collected by processing bulk samples of the late Campanian Zeven Wegen Member as exposed at the SA Ciments Portland Liégeois, Ciments Belges Réunion (CBR-Lixhe) and Heure-le-Romain quarries (Fig. 1, localities 3 and 2, respectively). From this unit numerous isolated brachials of various types of Roveacrinidae are before me, in addition to a specimen from the uppermost 4 metres (Jagt Collection), in which IBr1, IBr2 (axillary), IIBr1/IIBr1-4 are still in contact. Unfortunately, thecae or thecal fragments have not yet been found. Other crinoids from this unit include several species of bourgueticrinids (3 or 4), comatulids (2) and isocrinids (1 or 2).

##### *Pre-Valkenburg strata*

Strata in eastern southern Limburg which are in part correlatable with the Zeven Wegen Member, the Benzenrade sandy chalk and Pre-Valkenburg strata (JAGT *et al.*, 1987; FELDER & BLESS, 1989), at Benzenrade and Ubachsberg (de Wingerd; Fig. 1, localities 4 and 5) have yielded quite different crinoid faunules. One of the species (a single rather poorly preserved specimen) encountered is very similar to, if not conspecific with, the saccocomid *Applinocrinus cretaceus* (BATHER) (see BATHER, 1924; RASMUSSEN, 1961, p. 390, pl. 57, figs 9,

10; WRIGHT & SMITH, 1987, p. 211, pl. 45, figs 5, 6). In southeastern England, this species appears to be confined to a distinct horizon within the early Campanian (GASTER, 1932; MORTIMORE, 1983). It is also known from Mississippi, Texas, Florida, Mexico and the West Indies (APPLIN & APPLIN, 1967; PECK, 1953, 1973). Others are typical Roveacrinidae (Fig. 2m) that do not show any resemblance with genera described so far, the thecae of which show well-developed radials with fairly large articula and numerous openings and a star-like base.

This unit has also yielded rare bourgueticrinids, isocrinids and comparatively many comatulids (Conometridae, Pterocomidae, and Notocrinidae, with at least four species).

### Maastrichtian occurrences

#### GULPEN FORMATION

##### *Lanaye Member (late Maastrichtian)*

The Lanaye Member (especially between flint beds 20 and 21) at the CBR-Romontbos quarry at Eben-Emael (Bassenge) (Fig. 1, locality 6) has yielded the first complete saccocomids that show their close relationship to *Applinocrinus cretaceus*. These specimens (Fig. 2d-f, j-l) represent a new species which is characterised by a discrete central plate and a well-developed basal circlet (see Fig. 2c, d, n), the plates of which are larger than those seen in *A. cretaceus* (see JAGT, 1988).

At Lanaye-Vogelreservaat (Fig. 1, locality 7) this unit has also yielded a few Roveacrinidae that are closely related to, if not conspecific with, forms collected from the upper Meerssen Member (see below). Unfortunately, their rather poor preservation (with recrystallisation tending to obliterate surface details) precludes a thorough study of their structure.

#### MAASTRICHT FORMATION

##### *Valkenburg, Gronsveld and Schiepersberg Members (late Maastrichtian)*

Samples taken at the Ankersmit Holding BV quarry (Nekami) at Bemelen and at the disused Schiepersberg quarry nearby (Fig. 1, localities 12 and 11, respectively) for ecostratigraphic purposes by P.J. FELDER and M.J.M. BLESS have yielded small numbers of isolated brachials of pelagic crinoids. This material is apparently conspecific with specimens from the Kunrade Limestone facies.

##### *Emael Member (late Maastrichtian)*

From the base of this member numerous saccocomid specimens (*Applinocrinus* n. sp., see above) and two species of Roveacrinidae have been collected at the Ankersmit Holding BV quarry (Nekami). One of these roveacrinids is also known from the middle Maastricht Formation as penetrated in the Thermae 2000 borehole

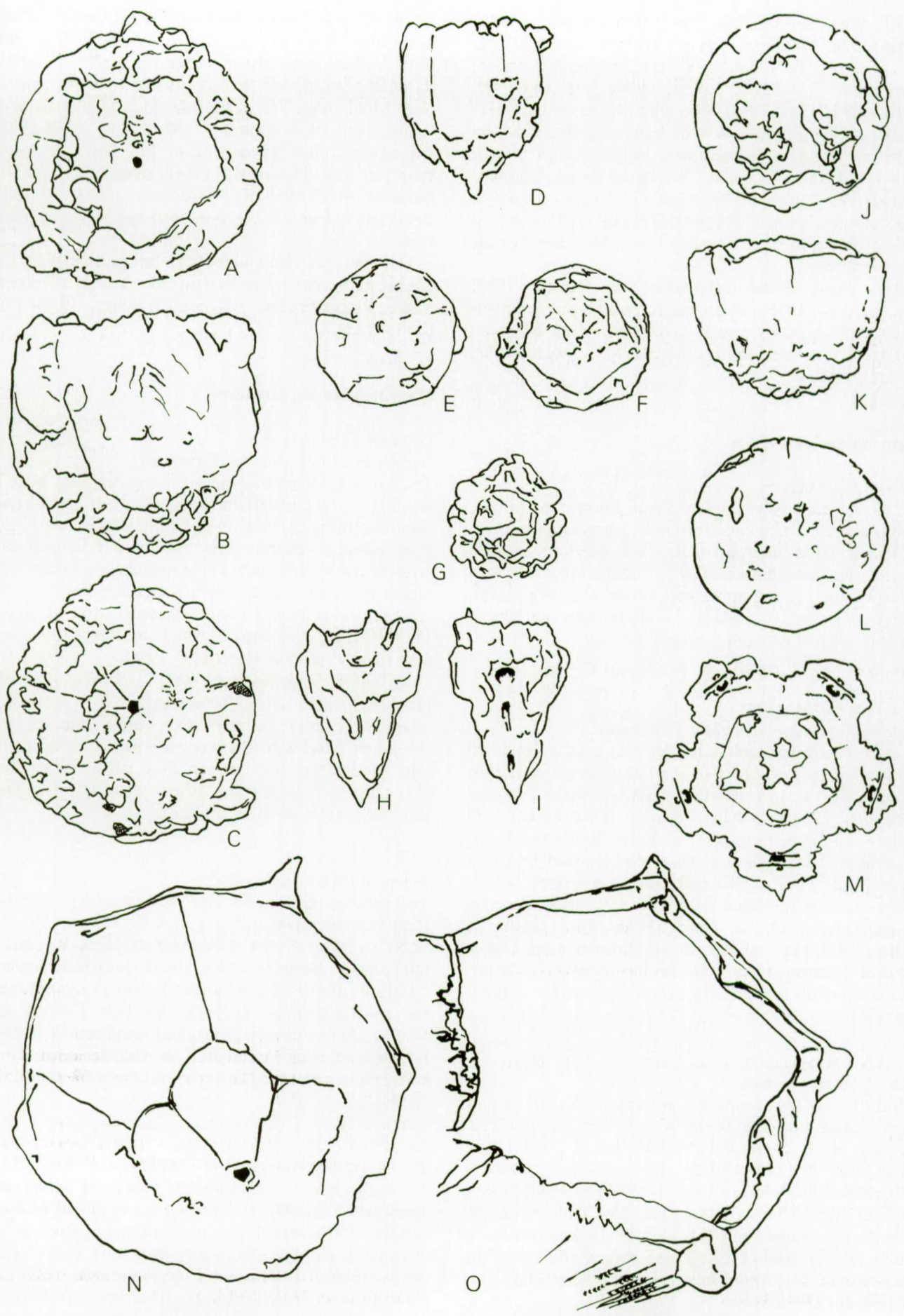


Fig. 2 — Camera lucida drawings (adoral, aboral, lateral and oblique aboral and oblique adoral views) of several types of roveacrinid and saccocomid crinoids encountered: a-f, j-l, n, o *Applinocrinus* n. sp. [a-c, n, o in Voigt Collection, Meerssen Member, ENCI NV quarry, x 25 and x c 52, respectively; d-f, j-l in Jagt Collection, Lanaye Member, CBR-Romontbos quarry, x 25]; g-i Roveacrinidae n. gen. (?), n. sp., Jagt Collection, Meerssen Member, ENCI NV quarry, x 25; m Roveacrinidae n. gen., n. sp., Jagt Collection, Benzenrade sandy chalk, Benzenrade, x 25. A.W. Janssen del.

(Fig. 1, locality 15) (BLESS *et al.*, 1986; KRINGS *et al.*, 1987).

#### *Meerssen Member (late Maastrichtian)*

The upper Meerssen Member as exposed at the ENCI NV quarry, south of Maastricht (stratotype of the Maastrichtian Stage, Fig. 1, locality 14), has yielded a considerable number of thecae (Fig. 2g-i) of the type of roveacrinid illustrated by CUPEDO (1970). Superficially, these thecae are reminiscent of somphocrinid taxa (see KRISTAN-TOLLMANN, 1970, 1977). It has not yet been possible to determine whether the thecae consist of radials only or of a radial and a basal ring.

Saccocomids (*Applinocrinus* n. sp., Fig. 2a-c, n, o) from the base of this unit are also known from the Blom quarry (Fig. 1, locality 13) at Berg en Terblijt, municipality of Valkenburg aan de Geul.

#### *Kunrade Limestone facies (Maastricht Formation)*

Samples taken from sections of the Kunrade Limestone along the RW 76 motorway (Fig. 1, locality 8) near Benzenrade (late Maastrichtian, see FELDER & BLESS, 1989), which are correlatable with the Lanaye Member (Gulpen Formation), the section exposed at the former Zevensprong quarry (Craubeek-Klimmen; lower-middle

Maastricht Formation; Fig. 1, locality 10) and that exposed at the Kunderberg (middle Maastricht Formation; Fig. 1, locality 9) have been shown to contain Roveacrinida as well. These specimens are conspecific with the ones that are known from the tuffaceous chalk facies of the Maastricht Formation, with the exception of saccocomids.

As a sequel to the taxonomic study of the above-mentioned Campanian-Maastrichtian roveacrinids and saccocomids from the Maastrichtian type area, a thorough search of samples of all exposures and boreholes in the area for these crinoids will be carried out to test whether events can be recognised in their stratigraphic distribution.

#### Acknowledgements

I wish to thank M. JÄGER, M.J.M. BLESS, E. VOIGT, M.J. VAN BIRGELEN, J.H.F. REYNDERS, J.H. VERGOOSSEN and P.J. FELDER for making material available for study; A.W. JANSSEN and P. BERG for preparing drawings; C.R.C. PAUL and A.B. SMITH for expressing his views on material from the Maastrichtian type area and for demonstrating comparative material in his care, respectively; M. KUTSCHER for showing me early Maastrichtian roveacrinids from Rügen and M. JÄGER and C.R.C. PAUL for critical reading of the manuscript.

#### References

- APPLIN, P.L. & APPLIN, E.R., 1967. The Gulf Series in the Subsurface in Northern Florida and Southern Georgia. *Professional Papers of the United States Geological Survey*, 524-G: G1-G 35, pls. 1-8.
- BACHMAYER, F., 1958. *Pseudosaccocoma* (Crinoidea) aus dem Korallenriffkalk (Obermalm) von Ernstbrunn (Niederösterreich). *Paläontologische Zeitschrift*, 32 (1-2): 40-51, pls. 5-7.
- BATHER, F.A., 1924. *Saccocoma cretacea* n. sp., a Senonian crinoid. *Proceedings of the Geologists' Association*, 35 (3): 111-121.
- BERTHO, P.-Y. & BENGTON, P., 1988. Stratigraphic correlation by microfacies of the Cenomanian-Coniacian of the Sergipe Basin, Brazil. *Fossils and Strata*, 21: 1-88.
- BIESE, W., 1935-1937. Crinoidea jurassica, 1-3. In: POMPECKI, F. (Editor), *Fossilium Catalogus, I. Animalia*, 70, 73, 76: 739 pp. Junk (Berlin).
- BLESS, M.J.M., BOUCKAERT, J., FELDER, P.J., LANGGUTH, H.R. & MEESSEN, J.P.M.T., 1986. Gesteenten, fossielen en water van de proefboring Thermae 2000 te Valkenburg aan de Geul, 40 pp., 5 pls. Valkdrukk (Valkenburg)/Natuurhistorisch Museum Maastricht.
- CUPEDO, D.F., 1970. Fossielanalyses in het Kunrader Krijt. Mogelijkheden tot fijnrelatie. Verslag doctoraal bijvak, Katholieke Universiteit Nijmegen, augustus 1969-maart 1970: 93 pp. (unpublished).
- DESTOMBES, P., 1984. Roveacrinidae nouveaux de l'Albien du Bassin de Paris. *Bulletin trimestrielle de la Société géologique de Normandie et Amis du Muséum du Havre*, 71 (2-3): 9-16, 2 pls.
- DOUGLAS, J.A., 1908. A Note on some new Chalk Crinoids. *Geological Magazine*, (5) 5: 357-359, pl. 17.
- FARINACCI, A. & SIRNA, G., 1960. Livelli a Saccocoma nel Malm dell'Umbria e della Sicilia. *Bollettino della Società Geologica Italiana*, 79 (1): 59-88, pls. 1-6.

- FELDER, P.J. & BLESS, M.J.M., 1989. Biostratigraphy and ecostratigraphy of Late Cretaceous deposits in the Kunrade area (South-Limburg, SE Netherlands). *Annales de la Société géologique de Belgique*, 112 (1): 31-45.
- GASSE, W. & WERKMANN-HÜGEL, W., 1985. *Roveacrinus communis* Douglas, 1908 ein Microcrinoide aus dem Unter-Turon von Bochum in Westfalen. *Münstersche Forschungen zur Geologie und Paläontologie*, 63: 183-201, 4 pls.
- GASTER, C.T.A., 1932. The zones of the Chalk of the Arun Gap, Sussex: With description of new species of *Bicavea*. *Proceedings of the Geologists' Association*, 43 (3), 212-223, pl. 9.
- GLUCHOWSKI, E., 1987. Jurassic and Early Cretaceous articulate Crinoidea from the Pieniny Klippen Belt and the Tatra Mts, Poland. In: BIRKENMAJER, K. (Editor), Geology of the Pieniny Klippen Belt, Carpathians, Poland. Part 8. *Studia Geologica Polonica*, 94: 6-102, pls 1-42.
- GRIFFITHS, A., 1989. Roveacrinid biostratigraphy of Britain and Texas. *Palaeontological Association, Annual Conference, Liverpool 1989, Abstracts, Liverpool University*: 7.
- HESS, H., 1972. Planktonic crinoids of Late Jurassic age from Leg 11, Deep Sea Drilling Project. In: HOLLISTER, C.D., EWING, J.I. et al. (Editors), Initial Reports of the Deep Sea Drilling Project, 11: 631-643, pls. 1-4. Washington DC.
- HOLZER, H.-L. & POLTNG, W., 1980. Erster Nachweis einer Radialplatten-Fossilagerstätte der Schwebcrinoide *Saccocoma* im oberostalpinen Malm (Ostkarawanken, Kärnten). *Carinthia II*, 170/90: 201-216, 3 pls.
- JAEKEL, O., 1892. Ueber Plicatocriniden, Hyocrinus und Saccocoma. *Zeitschrift der deutschen geologischen Gesellschaft*, 44 (4): 619-696, pls. 25-30.
- JAGT, J.W.M., 1986. *Cyathidium vlieksi*, a new holopodid crinoid from the Upper Maastrichtian (Late Cretaceous) of southern Limburg, The Netherlands. *Geologie en Mijnbouw*, 65 (3): 215-221.
- JAGT, J.W.M., 1988. Some stratigraphical and faunal aspects of the Upper Cretaceous of southern Limburg (The Netherlands) and contiguous areas. In: STREEL, M. & BLESS, M.J.M. (Editors), The Chalk District of the Euregio Meuse-Rhine. Selected papers on Upper Cretaceous deposits, pp. 25-39, 3 pls. Natuurhistorisch Museum Maastricht/Laboratoires de Paléontologie de l'Université de Liège.
- JAGT, J.W.M., 1989. Ammonites from the early Campanian Vaals Formation at the CPL quarry (Haccourt, Liège, Belgium) and their stratigraphic implications. *Mededelingen van de Rijks Geologische Dienst*, 43 (1): 1-33, 7 pls.
- JAGT, J.W.M., 1990. Gregariousness amongst late Maastrichtian comatulid crinoids. *Natuurhistorisch Maandblad*, 79 (5): 178-182.
- JAGT, J.W.M. & BIRGELEN, M.J. VAN, in prep. Late Cretaceous pelagic crinoids from the Low Countries.
- JAGT, J.W.M., FELDER, P.J. & MEESSEN, J.P.M.T., 1987. Het Boven-Campanien in Zuid-Limburg (Nederland) en Noordoost België. *Natuurhistorisch Maandblad*, 76 (4): 94-110.
- JURKOVŠEK, B. & KOLAR-JURKOVŠEK, T., 1988. Krinoidi iz titonijsko-valanginijskih plasti vzhodno od Vrsnika (Julijske Alpe). *Geologija*, 30 (1987): 5-21, 3 pls.
- KÄSTLE, B., 1982. Zur Morphologie und Systematik von *Pseudosaccocoma* (Crinoidea). *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, 1982(1): 12-24.
- KNAUER, J., 1966. A Lombardia kéréds. *Földtani Közölym*, 96 (2): 195-199.
- KRINGS, S., BLESS, M.J.M., CONIL, R., FELDER, P.J. & MEESSEN, J.P.M.T., 1987. Stratigraphic interpretation of the Thermae boreholes (Valkenburg a/d Geul, The Netherlands). In: BLESS, M.J.M., BOUCKAERT, J., LANGGUTH, H.-R. & STREEL, M. (Editors), Upper Cretaceous and Dinantian geology and hydrogeology of the Thermae boreholes of Valkenburg aan de Geul (South-Limburg, The Netherlands). *Annales de la Société géologique de Belgique*, 110 (1): 9-38, pls 1-5.
- KRISTAN-TOLLMANN, E., 1970. Die Osteocrinusfazies, ein Leithorizont von Schwebcrinoiden im Oberladin-Unterkarn der Tethys. *Erdöl und Kohle, Erdgas, Petrochemie*, 23 (12): 781-789.
- KRISTAN-TOLLMANN, E., 1977. Zur Gattungsunterscheidung und Rekonstruktion der triadischen Schwebcrinoiden. *Paläontologische Zeitschrift*, 51 (3-4): 185-198.
- KRISTAN-TOLLMANN, E., 1987. Triassic of the Tethys and its relations with the Triassic of the Pacific Realm. In: MCKENZIE, K.G. (Editor), Shallow Tethys. Proceedings of the International Symposium on Shallow Tethys 2, Wagga Wagga/15-17 September 1986: 169-186, pls. 1-7. Rotterdam (A.A. Balkema).
- KRISTAN-TOLLMANN, E., 1988. Unexpected communities among the crinoids within the Triassic Tethys and Panthalassa. In: BURKE, R.D., MLADENOV, P.V., LAMBERT, P. & PARSLEY, R.L. (Editors), Echinoderm Biology. Proceedings of the Sixth International Echinoderm Conference, Victoria/23-28 August 1987: 133-142. Rotterdam (A.A. Balkema).
- KUTSCHER, M. & HARY, A., 1991. Echinodermen im Unteren Lias (*bucklandi*- und *semicostatum*-Zone) zwischen Ellange und Elvange (SE-Luxemburg). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 182 (1): 37-72.
- LEFELD, J. & RADWANSKI, A., 1960. Planktoniczne liliowce Saccocoma Agassiz w malmie i neokomie wierchowym Tatr Polskich. *Acta geologica polonica*, 10 (4): 593-614, pls. 38-41.
- MANNI, R. & NICOSIA, U., 1985. *Saccocoma vernioryi* n.sp., a new saccocomid from the Upper Jurassic of the central Italy (*sic*). *Geologica Romana*, 23 (1984): 91-97.
- MANNI, R. & NICOSIA, U., 1986. *Saccocoma schwertschlagerei* Walther, 1904 junior synonym of *Saccocoma tenella* (Goldfuss), 1829. Evidence of autotomy in fossil crinoids. *Bollettino della Società Paleontologica Italiana*, 24 (2-3) (1985), 181-183.
- MILSON, C., 1989. In search of truly pelagic crinoids. *Palaeontological Association, Annual Conference, Liverpool 1989, Abstracts, Liverpool University*: 13.
- MOORE, R.C., LALICKER, C.G. & FISCHER, A.G., 1952. Invertebrate Fossils, xiii + 766 pp. New York/Toronto/London (McGraw-Hill).
- MORTIMORE, R.N., 1983. The stratigraphy and sedimentation of the Turonian-Campanian in the Southern Province of England. *Zitteliana*, 10, 27-41.
- MÜLLER, A.H., 1969. Zum *Lumbricaria*-Problem (Miscellanea), mit einigen Bemerkungen über *Saccocoma* (Crinoidea, Echinodermata). *Monatsberichte der deutschen Akademie der Wissenschaften Berlin*, 11 (10): 750-758.
- NEKVASILOVÁ, O. & PROKOP, R., 1963. Roveacrinidae (Crinoidea) from the Upper Cretaceous of Bohemia. *Vestník Ustředního ústavu geologického*, 38 (1): 49-52, 1 pl.
- NEKVASILOVÁ, O. & PROKOP, R., 1964. *Saccocoma Agassiz*, 1835 (Crinoidea, Articulata) from the Upper Cretaceous of

- Bohemia. *Vestník Ustředního ústavu geologického*, 39: 215, 216, 1 pl.
- NICOSIA, U. & PARISI, G., 1979. *Saccocoma tenella* (Goldfuss). Distribuzione stratigrafica e geografica. *Bollettino della Società Paleontologica Italiana*, 18 (2): 320-326.
- ORBIGNY, A.D. d', 1850-1852. Prodrome du paléontologie stratigraphique universelle des animaux mollusques et rayonnés faisant suite au cours élémentaire de paléontologie et de géologie stratigraphique, 1 (1849 [1850]), 392 pp.; 2 (1850 [1852]), 427 pp.; 3 (1852), 196 + 189 pp. Paris (Victor Masson).
- PATRULIUS, D., 1964. Răspîndirea algelor *Globochaete* și *Eothryx*, și a microfaciesului cu "Lombardia" (Saccocomidae) în Carpații orientali. *Dări de Seamă ale Ședințelor*, 50 (2)(1962-1963): 337-346, pls. 1-3.
- PECK, R.E., 1943. Lower Cretaceous crinoids from Texas. *Journal of Paleontology*, 17 (5): 451-475, pls. 71-76.
- PECK, R.E., 1948. A Triassic crinoid from Mexico. *Journal of Paleontology*, 22 (1): 81-84, pl. 20.
- PECK, R.E., 1953. Crinoid *Saccocoma cretacea* Bather in the Gulf Coast Cretaceous. *Bulletin of the Geological Society of America*, 64 (12): 1462.
- PECK, R.E., 1955. Cretaceous microcrinoids from England. *Journal of Paleontology*, 29 (6): 1019-1029, pls. 105, 106.
- PECK, R.E., 1973. *Applinocrinus*, a new genus of Cretaceous microcrinoids and its distribution in North America. *Journal of Paleontology*, 47 (1): 94-100, 1 pl.
- PISERA, A. & DZIK, J., 1979. Tithonian crinoids from Rogoźnik (Pieniny Klippen Belt, Poland) and their evolutionary relationships. *Eclogae geologicae Helvetiae*, 72 (3): 805-849, 5 pls.
- RASMUSSEN, H.W., 1961. A monograph on the Cretaceous Crinoidea. *Biologiske Skrifter fra Danske Videnskabernes Selskab*, 12 (1): 3-428, 60 pls.
- RASMUSSEN, H.W., 1965. The Danian affinities of the Tuffeau de Ciplu in Belgium and the "Post-Maastrichtian" in the Netherlands. *Mededelingen van de Geologische Stichting, nieuwe serie*, 17: 33-40, pls. 8, 9.
- RASMUSSEN, H.W., 1971. Cretaceous Crinoidea (Comatulida and Roveacrinida) from England and France. *Bulletin of the Geological Society of Denmark*, 20: 285-294, 4 pls.
- RASMUSSEN, H.W., 1978. Articulata. In: MOORE, R.C. & TEICHERT, C. (Editors), *Treatise on Invertebrate Paleontology*, Part T, Echinodermata 2, Crinoidea 3: T 813-T 927. The Geological Society of America and University of Kansas Press, Boulder and Lawrence.
- REMÉS, M., 1905. Nachträge zur Fauna von Stramberg. VI. Crinoiden-, Asteriden- und Echinoiden-Reste aus dem weissen Kalkstein von Stramberg. *Beiträge zur Geologie und Paläontologie von Österreich und Ungarn*, 18: 59-63, pl. 7.
- ROBASZYNSKI, F., CARON, M., DUPUIS, C., AMÉDRO, F., GONZALEZ DONOSO, J.-M., LINARES, D., HARDENBOL, J., GARTNER, S., CALANDRA, F. & DELOFFRE, R., 1990. A tentative integrated stratigraphy in the Turonian of central Tunisia: formations, zones and sequential stratigraphy in the Kalaat Senan area. *Bulletin des Centres de Recherche et Exploration-Production d'Elf-Aquitaine*, 14 (1): 213-384, 44 pls.
- SCHMID, F., 1971. Mesofaunen aus dem Alb von Hannover. 2. *Styracocrinus peracutus* (Peck), ein Microcrinoide aus dem Alb von Hannover. *Berichte der naturhistorischen Gesellschaft zu Hannover, Beiheft 7*, 71-77, pl. 1.
- SCHNEIDER, H.L., 1987. Zur Kelchmorphologie und Systematik der Roveacrininae Peck, 1943 (Crinoidea, Oberkreide). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 175 (2): 181-206.
- SCHNEIDER, H.L., 1988. *Roveacrinus alatus* Douglas 1908, ein Crinoid aus der Oberkreide von Nordrhein-Westfalen. *Aufschluss*, 39: 277-281.
- SCHNEIDER, H.L., 1989. Zur Morphologie und Ontogenese von *Roveacrinus geinitzi* n. sp. (Crinoidea, Oberkreide). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 178 (2): 167-181.
- SCOTT, R.W., ROOT, S.A., TENERY, J.H. & NESTELL, M., 1977. Morphology of the Cretaceous microcrinoid *Poecilocrinus* (Roveacrinidae). *Journal of Paleontology*, 51 (2): 343-349, 2 pls.
- SIEVERTS, H., 1933a. Über die Crinoidengattung *Drepanocrinus* Jaekel. *Jahrbuch der preussischen geologischen Landesanstalt*, 53 (1932): 599-610.
- SIEVERTS, H., 1933b. *Drepanocrinus* Jaekel, ein Synonym von *Roveacrinus* Douglas, und ein neuer Vertreter dieser Gattung aus der deutschen Kreide. *Zentralblatt für Mineralogie, Geologie und Paläontologie*, B 1933: 54-59.
- SIMMS, M.J., 1988. The phylogeny of post-Palaeozoic crinoids. In: PAUL, C.R.C. & SMITH, A.B. (Editors), *Echinoderm Phylogeny and Evolutionary Biology*: 269-284. Oxford (Oxford University Press).
- TURNER, J., 1965. Upper Jurassic and Lower Cretaceous microfossils from the Hautes-Alpes. *Palaeontology*, 8 (3): 391-396, pls. 51, 52.
- VALETTE, A., 1917. Note sur les crinoïdes de la craie blanche. *Bulletin de la Société des Sciences histoires naturelles*, 70 (1916): 79-178.
- VERNIORY, R., 1955. Répartition stratigraphique et géographique de *Saccocoma* Agassiz entre l'Oberland bernois et la Provence. *Archives des Sciences*, 8 (1): 97-101.
- VERNIORY, R., 1960. Présence (et variétés) de *Saccocoma tenella* Goldfuss à Talloires (Haute-Savoie). *Archives des Sciences*, 13 (2): 250-257, 1 pl.
- VERNIORY, R., 1961. Présence de *Saccocoma quenstedti* Doreck (in coll.) dans les gorges de la Méouge (Sisteron-Provence). *Archives des Sciences*, 14: 315-320, 1 pl.
- VERNIORY, R., 1962a. Quelques considérations sur les Saccocomidés (échantillonnage, statistique, stratigraphie). *Archives des Sciences*, 15: 388-390.
- VERNIORY, R., 1962b. Une nouvelle forme de *Saccocoma* (Montbrand, Hautes-Alpes, France). *Archives des Sciences*, 15: 391-397, 1 pl.
- WRIGHT, C.W. & SMITH, A.B., 1987. Echinoderms. In: SMITH, A.B. (Editor) & OWEN, G. (Compiler), *Fossils of the Chalk*: 201-237, pls. 44-53. *Field Guides to Fossils: Number 2*. London (The Palaeontological Association).

John W.M. JAGT  
Dienst KCO  
Natuurhistorisch Museum  
Postbus 882,  
NL-6200 AW Maastricht  
(The Netherlands)

Typescript received 9 September 1991  
Revised typescript received 17 December 1991

