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Growth stages of *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro, 1875) (Ammonitina, Aspidoceratidae) from the Oxfordian of southern Spain

ABSTRACT: Six ontogenic stages of *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro) are recognized within the newly collected material in southern Spain. The occurrences of this species appear to be limited to the Middle Oxfordian of the Mediterranean and of adjoining parts of the Submediterranean province.

INTRODUCTION

The species *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro, 1875), described for the first time over a hundred years ago from the Oxfordian of Sicily (Gemmellaro 1875), was hitherto known from some incomplete phragmocones and whorl fragments (*cf.* Miller 1968). In result of the author's studies in the Subbetic Zone of southern Spain (Sequeiros 1974) several relatively well-preserved representatives of this species have been collected. Their analysis indicates that this species is characterized by surprisingly high ontogenic changes.

PALEONTOLOGICAL DESCRIPTION

Family **Aspidoceratidae** Zittel, 1895
Subfamily **Euaspidoceratinae** Spath, 1931; emend. Miller, 1968
Genus *PARASPIDOCERAS* Spath, 1925
Subgenus *PARASPIDOCERAS* Spath, 1925
Paraspidoceras (Paraspidoceras) helymense (Gemmellaro, 1875)
(Text-figs 1—3 and Pls 1—2)

1875. *Aspidoceras helymense* Gemmellaro; Gemmellaro, p. 121, Pl. 13, Fig. 4 (*holotype*).
1917. *Aspidoceras helymense* Gemmellaro; Collot, p. 13, Pl. 2, Fig. 7 (*non* Pl. 1, Fig. 5).

1959. *Euaspidoceras (Euaspidoceras) helymense* (Gemmellaro); Christ, p. 169, Pl. 8, Fig. 1.

1962. *Paraspidoceras (Paraspidoceras) edwardsianum helymense* (Gemmellaro); Zeiss, p. 13, Pl. 1, Fig. 17, Pl. 3, Fig. 2, Text-fig. 4.

1968. *Clambites (Paraspidoceras) choffati* (de Loriol); Miller, Pl. 5, Fig. 2.

1974. *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro); Sequeiros, p. 270, Pl. 25, Fig. 2, Pl. 26, Figs 1—3, Text-figs II-122 — II-126.

Material: Eight well-preserved specimens and numerous fragments.
Dimensions (in *mm*):

Specimen	D	U	H	W	U/D	H/D	W/D	W/H	Ni	Ne
KA13/00/1	200	77	70	72	.39	.35	.36	1.03	17	17
	(130)	57	50	50	.44	.38	.38	1.0	20	20
KC4/21/10	95	34	34	—	.36	.36	—	—	—	20
	35	10	15	21	.29	.43	.60	1.4	—	10
KC5/22/2	85?	—	26	26	—	—	—	1.0	—	—
KG2/11/12	130	54	46	48	.42	.35	.37	1.04	—	21
	90	35	34	—	.39	.38	—	—	—	17
	57	20	23	26	.35	.40	.46	1.13	—	10
KM2/12/7	150?	—	36	40	—	—	—	1.1	—	—
KM2/13/1	200	90	70	70	.45	.35	.35	1.0	—	17
	(140)	55	51	54	.39	.36	.39	1.06	—	—
KQ8/3/12	72?	—	27	32	—	—	—	1.18	—	—
KH4/00/10	42	14	15	17	.33	.36	.40	1.13	—	10
KT1/00/2	118	48	44	44	.41	.37	.37	1.0	—	17
	96	39	31	42	.41	.32	.44	1.33	—	16
	62	25	24	25	.40	.39	.40	1.04	—	14
	55	24	18	—	.44	.33	—	—	—	12
KGA6/6/1	140	58	47	52	.41	.34	.37	1.11	—	19
	(112)	46	41	47	.41	.37	.42	1.15	—	17
KQ8/3/14	300	135	110	120	.45	.37	.40	1.09	17	17
	(285)	120	100	100	.42	.35	.35	1.0	17	17
	145	70	—	—	.48	—	—	—	—	—
Holotype (from figure)	137.5	55	51	52?	.40	.37	.37?	1.52	23	—

Description. — The specimens are large, about 200 mm in size, with final body chamber beginning at 112—140 mm diameter and occupying at least three-fourths of the last whorl. The exception is here an almost complete giant (KQ 8/3/14) with body chamber beginning at 285 mm diameter, and measuring about 300 mm and presumably originally reaching 400 mm in size (*cf.* Pl. 1).

Umbilical diameter regularly increases in relation to shell diameter along with shell growth (Text-fig. 2). Linear regression curve gives correlation coefficient equal 0.99 (very high correlation). A hypothetical planispiral shell pattern shows expansion rate (*W*) ranging between 2.5 and 3, at distance (*D*) of generating curve from the axis equal 0.3—0.4 (*see* mathematical models of Raup, 1967).

Aperture is still unknown. The suture appears to be of the euaspidoceratid type *sensu* Miller (1968).

The ontogenic variability is high, being expressed by drastic changes in whorl shape and ornamentation. The collected specimens display a fairly complete sequence of these changes and six ontogenic growth stages are thereby distinguishable (*see* Table 1):

Table 1

Ontogenic growth stages of *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro, 1875); detailed explanation and discussion in the text

Ontogenic stage	begins at	ends at	includes	Characteristics
1	5 mm	10— 15 mm	one whorl	without visible ornamentation
2	10— 15 mm	45— 60 mm	one whorl	ten marginal transverse elongate tubercles; trapezoidal whorl section
3	45— 60 mm	85—108 mm	at least one whorl	denser ornamentation, pyramidal tubercles; trapezoidal whorl section
4	85— 90 mm	100—145 mm	at least one whorl	external and radially elongate internal tubercles; polygonal whorl section
5	100—145 mm	120—285 mm	one whorl	two rows of pyramidal tubercles joined by coarse ribs; subrectangular whorl section
6	120—285 mm (body chamber)	at the aperture	at least 3/4 of whorl	two rows of tubercles; subcircular whorl section

ONTOGENIC STAGE 1 is confined to the innermost whorls, beginning at 5 mm and always ending at 15 mm diameter or earlier. It is characterized by slow coiling, flat whorl sides and shallow umbilicus. The whorls seem completely smooth and at these diameters neither "parabolic" nor "*Clambites*" stage (see Zeiss, 1961, and Miller, 1968, respectively) can be noted on Spanish specimens.

ONTOGENIC STAGE 2 usually begins at 10—15 mm diameter and comprises a whorl or more, ending at about 45—60 mm diameter. It is characterized by appearance of transversal elongate tubercles (*paddle tubercles* of Miller, 1968) at ventral margin and trapezoidal whorl section with the maximum whorl width close to the venter. Some tubercles are bilobate as they are formed of two strong irregular ribs (Pl. 2, Fig. 4). Ribs coarse, beginning at the paddle tubercles and crossing the venter. Tubercles about 10 in number per whorl. Umbilical margin smooth, umbilical wall high.

The appearance of external tubercles and the lack of umbilical ones marks the beginning of the *Paraspidoceras* stage, comprising ontogenic stages *2—4* (up to 100—145 mm diameter).

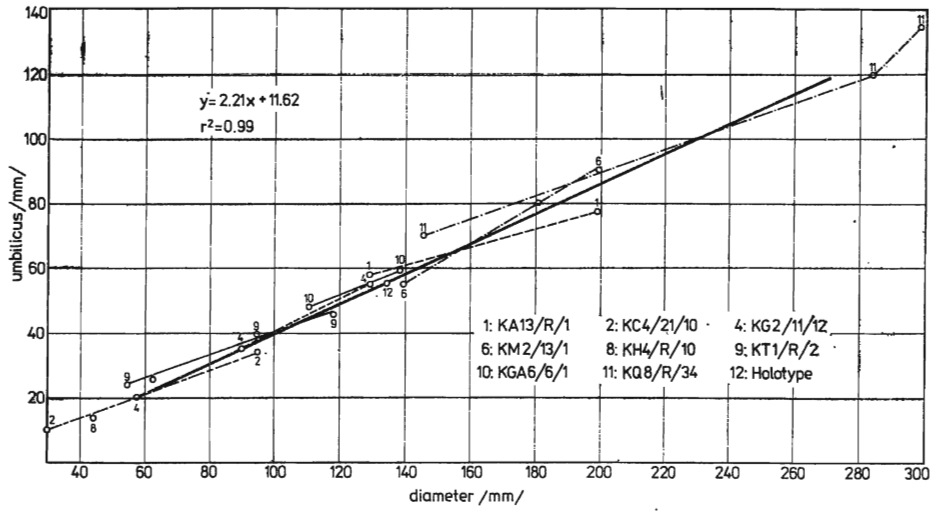


Fig. 1. Linear growth of umbilicus in some *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro) from the Middle Oxfordian of the Subbetic Zone in southern Spain

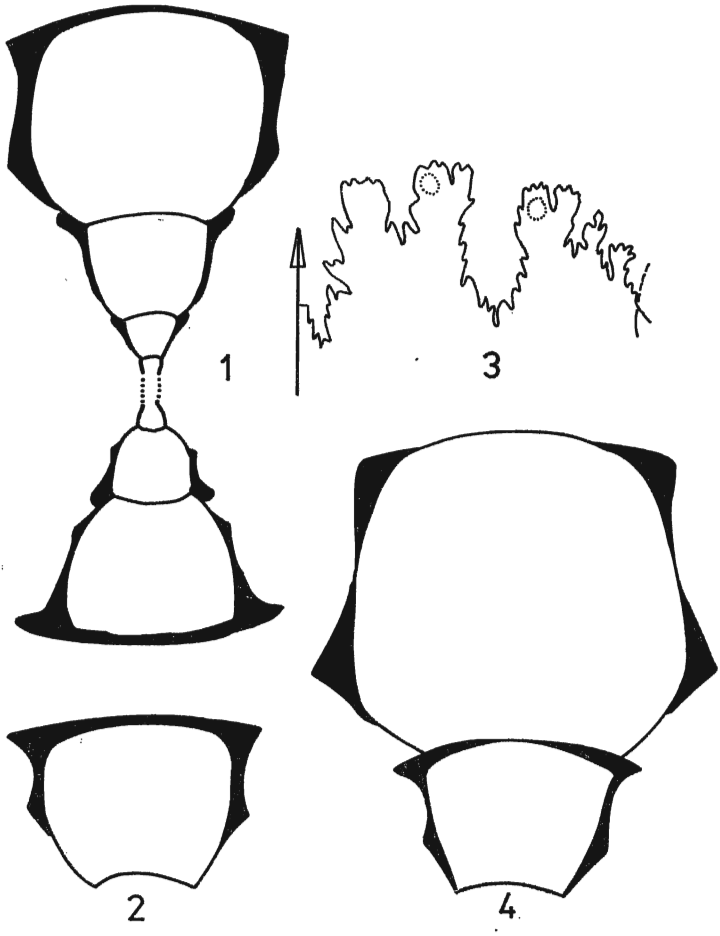


Fig. 2. Whorl sections and suture line of some *Paraspidoceras* (*Paraspidoceras*) *helymense* (Gemmellaro) from the Middle Oxfordian of the Subbetic Zone in southern Spain. Specimens: **1** — KG2/11/12, **2** — KM2/12/7, **3** — KA13/00/1, **4** — KA13/00/1

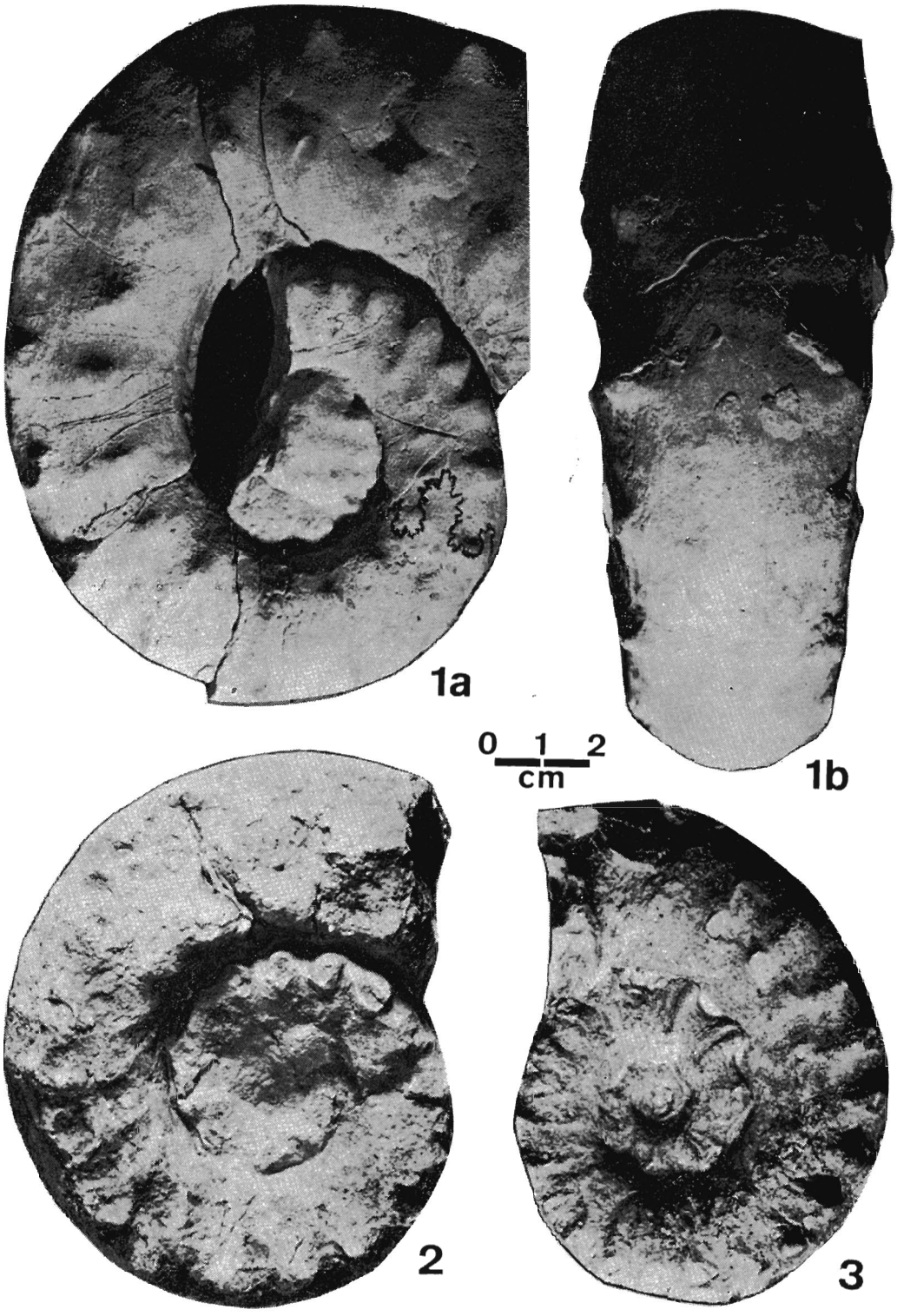
ONTOGENIC STAGE 3 begins at 45—60 mm and ends at 85—108 mm diameter, being characterized by increase in number of tubercles per whorl, from 12 to 19 at 90 mm diameter. The external tubercles change in shape from paddle-like to pyramidal and whorl section becomes clearly trapezoidal. This is the first ontogenic stage observable on the holotype as its inner whorls are not preserved.

ONTOGENIC STAGE 4 is the last *Paraspidoceras* stage, comprising interval from 85—90 mm to 100—145 mm. It is characterized by the appearance of umbilical row of tubercles. The tubercles are at first radially elongate but slowly evolve to those typical of the subsequent, *Euaspidoceras* stage, characteristic of the outer whorls. The whorl section gradually becomes polygonal, being the thickest close to the venter. It is difficult to draw the limit between the *Paraspidoceras* and *Euaspidoceras* stages as the change is gradual, taking place at diameters from 100 to 145 mm. Thus, this stage may be best described as transitional.

ONTOGENIC STAGE 5 (100—145 to 120—285 mm), truly *Euaspidoceras* one, comprises the final part of phragmocone. It is characterized by subrectangular whorl section and ornamentation of *Euaspidoceras*: two rows of spiniform tubercles joined by coarse ribs.

ONTOGENIC STAGE 6, connected with body chamber (from 120—285 mm diameter to aperture), is characterized by whorl shape and ornamentation still *Euaspidoceras*-like. Some

Paraspidoceras (P.) helymense (Gemmellaro); giant specimen (KQ8/3/14), Middle Oxfordian, Riazi Zone, Sierra Gorda (Loja, Granada)



Paraspidoceras (P.) helymense (Gemmellaro)

1*a,b* — Specimen no. KA13/00/1, Middle Oxfordian, Riazi Zone, Sierra Arana (Granada), *1b* slightly magnified to scale; **2** — Specimen no. KGA6/6/1, Middle Oxfordian, Sierra de Gaena (Córdoba); **3** — Specimen no. KG2/11/12, Middle Oxfordian, Riazi Zone, Sierra Gorda (Granada)

decrease in number of ribs is noted: from about 20 at the end of phragmocone to 16—17 close to the end of the body chamber.

It should be stated that the above discussed differences in particular stages are so strong that, for example, isolated outer whorls of *P. (P.) helymense* (Gemmellaro) may be easily misinterpreted as belonging to a representative of *Euaspidoceras* proper.

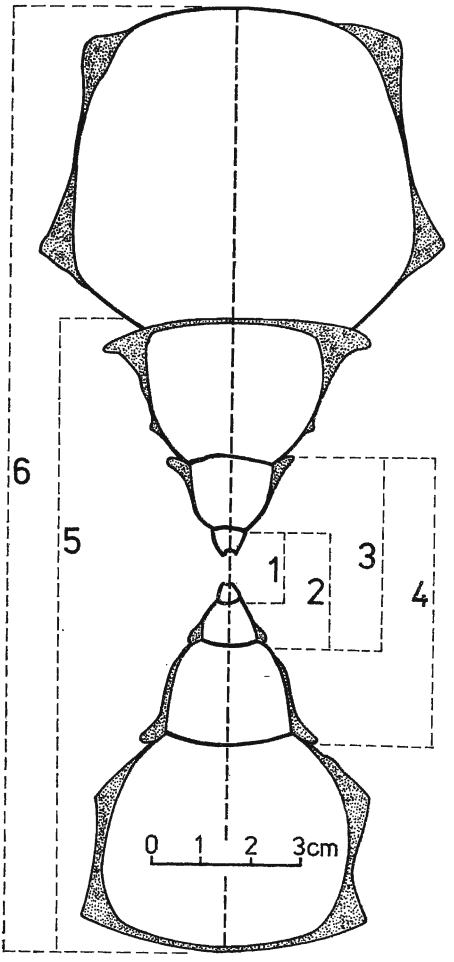


Fig. 3

Theoretical model of coiled shell of *Paraspidoceras (P.) helymense* (Gemmellaro), based on dimensions of Spanish specimens

ONTOGENIC STAGES:

1 — "parabolic" or *"Clambites"*, **2—4** — *"Paraspidoceras": 2* "Paddle-like tubercles", *3* pyramidal tubercles, **4** radially elongate periumbilical tubercles;
5—6 — *"Euaspidoceras"*

Affinities and comparisons. — The difficulty in interpretation of *P. (P.) helymense* (Gemmellaro, 1875) is primarily related to incompleteness of the holotype. The holotype, derived from Rocca chi Parra Trapany in Sicily, is about 141 mm in size. Unfortunately, its inner whorls are missing and the comparisons have to be limited to middle whorls and a part of the outer, characterized by heavy and densely spaced tubercles (23—24 per whorl) and trapezoidal whorl section. As it was stated above, the holotype displays ontogenic changes from the third stage onwards.

Collot (1917) described several specimens as *Aspidoceras helymense* Gemmellaro. Author's studies of the specimens housed at the Faculté des Sciences of the

Dijon University (France) showed that only one of the two figured (Collot 1917, p. 13, Pl. 2, Fig. 7) belongs to this species, being similar in dimensions and displaying its *Euaspidoceras* stage.

The specimen assigned to this species by Christ (1959) is 93 mm in size and displays ontogenic stages *3—5*.

The specimen figured as *Paraspidoceras edwardsianum helymense* (Gemmellaro) by Zeiss (1962) represents a whorl fragment of the ontogenic stage *3* but insufficient for any reliable comparison with the Gemmellaro holotype. The species *Ammonites edwardsianum* d'Orbigny illustrated by d'Orbigny (1842, Pl. 188) differs from *Paraspidoceras (Paraspidoceras) helymense* (Gemmellaro) in shallower umbilicus, subrectangular whorls, more evolute coiling and very regular ornamentation. The spire fragment figured by Zeiss (1962, Pl. 3, Fig. 3) as *P. edwardsianum edwardsianum* (d'Orbigny), 117 mm in size, displays ornamentation of outer whorls identical as that of the d'Orbigny holotype, differing in that of inner whorls. The specimen assigned as *Paraspidoceras (Paraspidoceras) edwardsianum blumbergense* Zeiss by Zeiss (1962, Pl. 3, Fig. 1) differs from *P. (P.) helymense* (Gemmellaro) in generally coarser ornamentation and better developed stage with paddle-like tubercles but, nevertheless, they seem hardly separable. It should be noted that the fragment figured by Zeiss (1962, Pls 9—10) shows features typical of the ontogenic stage *2* of *P. (P.) helymense* (Gemmellaro).

The species *Paraspidoceras choffati* de Loriol illustrated by de Loriol (1903, Pl. 12, Fig. 1) somewhat resembles *P. (P.) helymense* (Gemmellaro), differing in coarser ornamentation and the lack of the ontogenic stage *3*.

Biostratigraphic and paleogeographic position. — All the here described specimens have been found in the Oxfordian nodular limestones in the Subbetic Zone, southern Spain (Sequeiros 1974). Many of them were found together with *Perisphinctes (Perisphinctes) panthieri* Enay, *P. (P.) parandieri* de Loriol, *P. (P.) cuneicostatus* Arkell, *P. (Kranaosphinctes)* sp., *P. (Dichotomosphinctes) dobrogensis* Simionescu, *Euaspidoceras paucituberculatum* Arkell, *E. costatum* (Dorn), *E. oegir* (Oppel), *Paraspidoceras edwardsianum* (d'Orbigny), *Gregoryceras riazi-romani* (de Grossouvre), and some representatives of the genera *Ochetoceras*, *Trimarginites* and *Taramelliceras*, that is ammonite assemblage typical of the Riazi Zone of the Subbetic Middle Oxfordian (Sequeiros 1974). Other representatives of this species were found along with those of *Trimarginites arolicus* (Oppel), *T. stenorhynchus* (Oppel), *Perisphinctes (Dichotomoceras) bifurcatus* (Quenstedt), *Subdiscosphinctes* ex gr. *aeneas* (Gemmellaro), *Orthosphinctes* spp., *Euaspidoceras* of the *E. douvillei*, *E. sparsispinum*, *E. lenki* and other groups, *Paraspidoceras choffati* (de Loriol), *Clambites* spp., *Cubaspidoceras* spp., *Gregoryceras foquei* (Kilian) and others forming an assemblage indicative of the Bifurcatus Zone.

The holotype was described from the Transversarium Zone of Sicily, similarly as the specimens of Christ (1959) and Zeiss (1962). The above mentioned specimen of Collot (1917) was derived from the condensed ferruginous oolite bed of Côte-d'Or, sometimes dated at the Middle Oxfordian, so it may be assumed that this species is characteristic of the Middle Oxfordian. This, along with its highly peculiar appearance may make it useful for biostratigraphy.

Occurrence. — Spain: Sierra Arana and Sierra Gorda in Granada, Sierra de Cabra and Sierra de Gaena in Córdoba, and Torcal de Antequera in Málaga, as follows:

Sierra Arana (Granada): one specimen (KA13/00/1);
Sierra de Cabra (Córdoba): two specimens (KC/21/10, KC5/22/2);
Sierra Gorda (Loja, Granada): six specimens (KM2/12/7, KM2/13/1, KQ6/00/10, KQ8/3/12, KG2/11/12, KQ8/3/14);
Torcal de Antequera (Malaga): three specimens (KH4/00/10/, KH4/00/9, KT1/00/2);
Sierra de Gaena (Córdoba): one specimen (KG6/6/1).

Besides Sicily, wherefrom this species was originally described by Gemmellaro (1875), it is also known from Côte d'Or in France (Collot 1917), and southern parts of the Federal Republic of Germany (Zeiss 1962). As it was stated above, this species is characterized by highly peculiar appearance so the lack of records from the better known Oxfordian strata of more northerly parts of Europe suggests that it is limited to the Mediterranean province and adjoining parts of the Submediterranean province of the Tethyan Realm (sensu Cariou 1973; *see also* Pożaryska & Brochwicz-Lewiński 1974).

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ALGUNOS *PARASPIDOCERAS (PARASPIDOCERAS) HELYMENSE* (GEMMELLARO, 1875) (AMMONITINA, ASPIDOCERATIDAE) DEL OXFORDENSA DEL SUR DE ESPANA

(Resumen)

El holotipo de *Paraspidoceras helymense* (Gemmellaro, 1875), un Euaspidoceratinae muy tipico del dominio del Tethys, no está bien estudiado. En este trabajo se describen y figuran algunos ejemplares procedentes des Sur de Espana. Se han separado seis estadios ontogénicos; están presentes los estadios *"Parapidoceras"* y *"Euaspidoceras"*.

L. SEQUEIROS

STADIA WZROSTU U AMONITÓW *PARASPIDOCERAS (PARASPIDOCERAS) HELYMENSE* (GEMMELLARO, 1875) Z OKSFORDU POŁUDNIOWEJ HISZPANII

(Streszczenie)

Stosunkowo bogaty materiał z oksfordu strefy betyckiej południowej Hiszpanii pozwolił na prześledzenie ontogenezy amonitów należących do gatunku *Paraspidoceras (P.) helymense* (Gemmellaro). Wyróżniono 6 stadiów ontogenicznych, przy czym różnice pomiędzy tymi stadiami są tak znaczne, że fragmenty tego samego okazu mogą być zaliczone do osobnych rodzajów. Dotyczy to zwłaszcza skrętów zewnętrznych, które wykazują cechy typowe dla przedstawicieli rodzaju *Euaspidoceras* Spath, 1931. Analiza biostratygraficzna i paleobiogeograficzna wykazała, że badany gatunek może być uznany za skamieniałość przewodnią środkowego oksfordu prowincji medyterańskiej i przyległych części prowincji submedyterańskiej.
