MODERN LIMPET HOME SCAR ON THE DEVONIAN CLIFFS, NORTH COAST CENTRAL AND WEST CORNWALL (UNITED KINGDOM), AND LOWER CRETACEOUS *PATELLICHNUS* FROM ROMANIA

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Abstract. The coherence of substrate is the main factor of stability of the home scars. This dependence is demonstrated by the current impressions in Cornwall, illustrated by the Towan morphotype with the ratio L / w = 1.30, located on the hard rocks of the Bovisand Formation and by the St. Agnes morphotype with the ratio L / w = 1.19, located on hemipelagites of the Porthtowan Formation. The significant morphological difference is supported by the presence of two important features: convex depression bordered by the marginal furrow in the Towan morphotype and concave depression bordered by the marginal ridge in the St. Agnes morphotype.

Key words: Gastropoda, limpet, home scar, seashore, North Coast Cornwall, United Kingdom; *Patellichnus*, Lower Cretaceous, Romania

1. INTRODUCTION

1.1. Background and aim

It has been over 250 years since the father of modern taxonomy, the Swedish scientist Carol Linnaeus, inventoried, in the 10th edition of his work *Systema Naturae* (1758), 4,400 animal species and 7,700 plant species*. Quantifying the diversity of life on our planet is one of the fundamental questions that science is trying to answer, despite the still small number of biodiversity samples (Mora *et al.*, 2011). Thus, using a predictable model by which the total number of species in a taxonomic group can be assessed, in relation to their attribution to higher taxonomic categories (phylum, classes, order, family and genera), Mora *et al.* (2011) estimated that there are 8.7 million eukaryotic species globally, of which 2.2 million are marine. The authors state that, although the taxonomic classification records over 1.2 million existing species in a central database, the results suggest that 86% of terrestrial species and 91% of marine species await discovery, description and cataloguing. Covering about

70% of the globe's surface, marine waters, with a volume of about 10^9 km³, comprise an immense and remarkable biodiversity, distributed in the waters of shallow (<200 m), benthic and pelagic domains, comprising (without microbes) about 250,000 valid marine species (Widdicombe & Somerfield, 2012). Referring to marine gastropods, Geiger (2006) mentions a total of about 230,000 species, of which about 60,000 species with shell, about 13,000 without shell and more than 100,000 species other than these. According to Bagni (2016), in the WMSDB database (Worldwide Mollusc Species Data Base - version April 6, 2016), the Gastropoda Class, with a total of 103,700 species, has 8,100 genera with 75,940 current species and 3,575 genera with 27,760 species fossils. Almost 50 years ago, Christiaens (1973), based on the characters of the shell and the radula, inscribed in over 1500 works dedicated to the genus *Patella*, reduces, from over 240, to only 32 the number of valid species belonging to the subgenus *Patella*, *Patellastra*, *Ancistromesus*, *Cymbula* and *Laevipatella*. In WMSDB (Bagni, 2016), the Patellidae family records 9 genera, with 96 species and 28 current suspects and 3 genera, with 36 fossil species. According to Mollusca Base taxon details (2019), out of the 11 subclasses

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* https://en.wikipedia.org/wiki/Carl_Linnaeus

of gastropods, the subclass Patellogastropoda has two superfamilies: Nacelidae and Patellidae. To the Patellidae family is attributed 16 genera, the genus *Patella* Linnaeus 1758 having 460 current and fossil species. As can be seen, there is still serious controversy regarding the number of genera and species circumscribed to the family Patellidae. Among Arcaeogastropods (=basal Gastropods), Patellogastropoda (= limpets) is an important group that includes the families Patellidae, Lottiidae and Acmaeidae (Geiger, 2006).

According to Heller (2015), limps are primitive marine gastropods, with a low conical shell and wide opercular opening; it has a developed radula and sensitive tentacles arranged on the edge of the mantle. Usually, they populate the intertidal rocky shores, being strongly attached to the substrate on which they produce a characteristic depression („home scar"), and the latter being the object of our investigation, with a preliminary character. To this is added a brief commentary on some fossil traces of patellids, with an emphasis on the *Patellichnus* from the Lower Cretaceous in Romania.

1.2. Geographical, geological and biological settings

1.2.1. Geography

The Cornwall region forms the southwestern peninsula of the island of Great Britain (Fig. 1a), surrounded by the waters of the Atlantic Ocean, consisting of two coastal areas and an inland area*. Mainly, the coastline is composed of erosion-resistant rocks, giving rise in many places to high cliffs. The coastal areas, north and south, have different characteristics. The northern coast of the Celtic Sea, more exposed, has a wilder nature (Fig. 1b). However, here are many fine sandy beaches that form important tourist attractions, such as Bude, Polzeath, Watergate Bay, Perranporth, Porthtowan, Newquay, Fistral Beach, St. Agnes, St. Ives. The south coast, nicknamed the „Cornish Riviera", is more protected, with many wide estuaries bordering safe harbors (e.g., Falmouth, Fowey). The interior of the

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* https://en.wikipedia.org/wiki/Cornwall (accessed 22.02.2020)
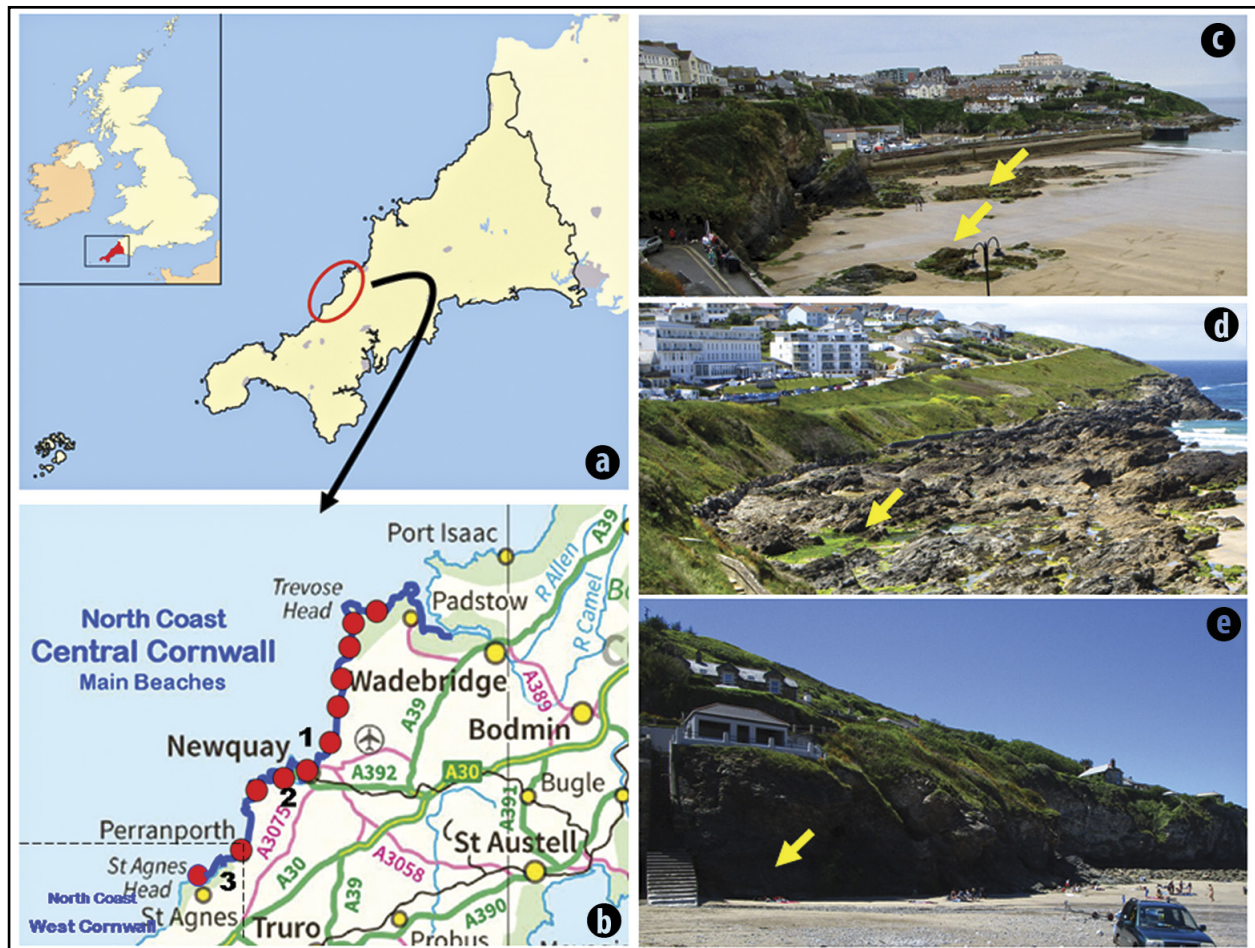
Fig. 1. (**a**) Cornwall outline map (source: commons.wikimedia.org); (**b**) Beaches of the Central, and partially West Corrwall (red circles) (source: http://www.cornwallbeaches.org.uk/North-Coast-Central-Cornwall.html, and http://www.cornwallbeaches.org.uk/North-Coast-West-Cormwall.html). *Patella* fieldwork locations (yellow arrows) in Newquay; (**c**) Towan Beach; (**d**) South Fistral Beach) and St. Agnes; (**e**) Trevaunance Cove Beach) (author's photos, June 18-21, 2019)

peninsula consists of a series of bare, infertile mountains, arranged along an east-west alignment, with a series of granite intrusions, such as Bodmin Moor, the highest ground in Cornwall (425 m) from where, to the west, the altitude gradually decreases. These intrusions represent the central part of the borders that form outcrops of the Cornubian Batholith that includes the Dartmoor area (in Devon) to the east and the Isles of Scilly to the west. The intrusion of granite into the sedimentary complex gave rise to a contact metamorphism with extensive mineralization, which made the Cornwall region one of the most important mining areas of Great Britain until the end of the 19th century (according to Enciclopaedia Britannica, Micropedia, III, 1979). These mountains are surrounded by fertile agricultural land, especially pastures. Near the south coast, the deep and wooded valleys, grafted mainly on Devonian deposits, offer the flora the conditions of a humid and mild climate. Northeast Cornwall is located on the carboniferous rocks of the Culm facies, and the Lizard Peninsula offers the only example in Britain of oceanic crust ophiolites, represented by green and red Precambrian serpentinites that form spectacular rocky landscapes.

A special mention of the South-West Coast Path, with the longest part (1,014 km) of the National Trail that completely surrounds the Cornwell Peninsula (National Trail = long distance walks through some of the very best landscapes in the UK). It includes two UNESCO World Heritage sites: Dorset Coast and East Devon, known as the Jurassic Coast and the Cornwall mining landscape (which also includes the St. Agnes Mining District) and West Devon*.

1.2.2. Geology

The SW region of Great Britain belongs to the Paleozoic Variscan Orogenic Province, part of the Devonian and Carboniferous basins extending more than 800 km to the east, between Cornwall and Germany (Leveridge & Hartley, 2006), on the geotectonic domain of the Rhenohercynic Zone (Leveridge & Shail, 2011). Recently, the stratigraphy and structure of the Newquay district were reviewed (Fig. 2a), the results being summarized by Hollick *et al.* (2006, p. 191). Simplifying, the Devonian successions are part of the Looe and Gramscatho basins, generally younger to the south of the area (Fig. 2b). The sedimentation of green and purple mudstones of the Whitsand Bay Formation (Dartmouth Group) began in the terminal Lochkovian and was concordantly succeeded by bioclastic sandstones, clays and limestones belonging to the Bovisand Formation (Meadfoot Group).

The deposits that build up the Trendrean Mudstone Formation (Meadfoot Group) belong to the Middle Emsian or may be younger. The three formations record the transition of the depositional environments from the lake / river, to the shallow and shelf / slope marine during the Middle Devonian of the Looe Basin.

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* https://en.wikipedia.org/wiki/South_West_Coast_Path
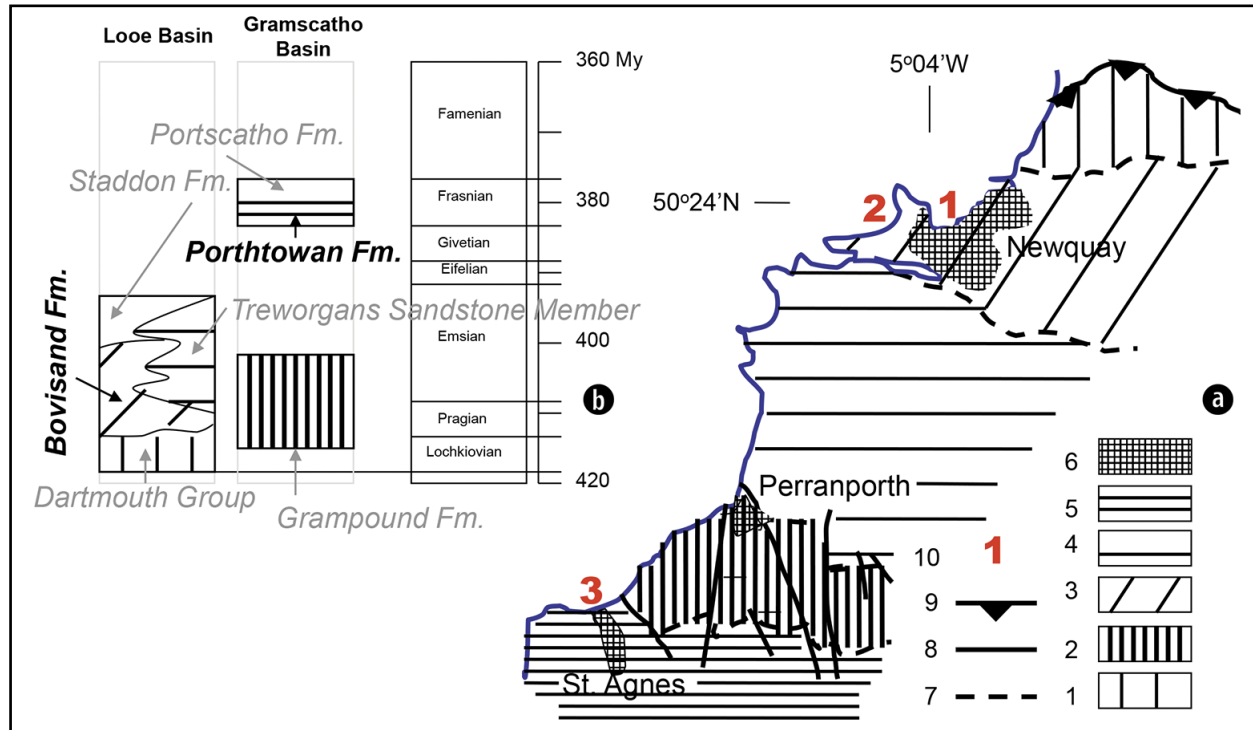
Fig. 2. (a) Geological sketch, and **(b)** Lithostratigraphic units of the Newquai-St. Agnes region (simplified after Hollick *et al.*, 2006): **1.** Dartmouth Group; **2.** Grampound Formation; **3.** *Bovisand Formation*; **4.** Treworgans Sandstone Member; **5.** *Porthtowan Formation*; **6.** Urban site; **7.** Boundary between lithostratigraphic unit; **8.** Normal fault; **9.** Thrust fault; **10.** Beach number (see Fig. 1)

The lower part of the Gramscatho Basin succession is represented by the undated Grampound Formation (Gramscatho group) which comes into tectonic contact with the Looe Basin succession. It predominantly comprises clays intercalated with sandstones (Treworgans Sandstone Member) accumulated on the slopes along the northern edge of the Gramscatho Basin. Over this succession, the Porthtowan Formation (Gramscatho group), which comprises clays (mudstones) and clay-sandstone couplets, accumulated in a deep sea, is present.

Some sedimentological aspects of the Bovisand and Porthtowan formations that emerge on the high cliff of the north coast of Cornwall, between Newquay and St. Agnes, are illustrated in Fig. 3.

1.2.3. Marine Biology

One of the harshest physical environments of the marine domain is that of the intertidal rocky area. In this habitat, marine organisms, especially invertebrates and algae, are alternately subjected to the action of waves, thermal extremes (at high tide and low tide), as well as selective pressures related to predation and competition for territory. The area of strong contrasts of the physical gradient and the spatially limited community, the rocky intertidal zone is a real "natural laboratory" ideal for the study of physical and biological factors that determine the abundance and distribution of organisms (Tomanek & Helmuth, 2002, p. 771).
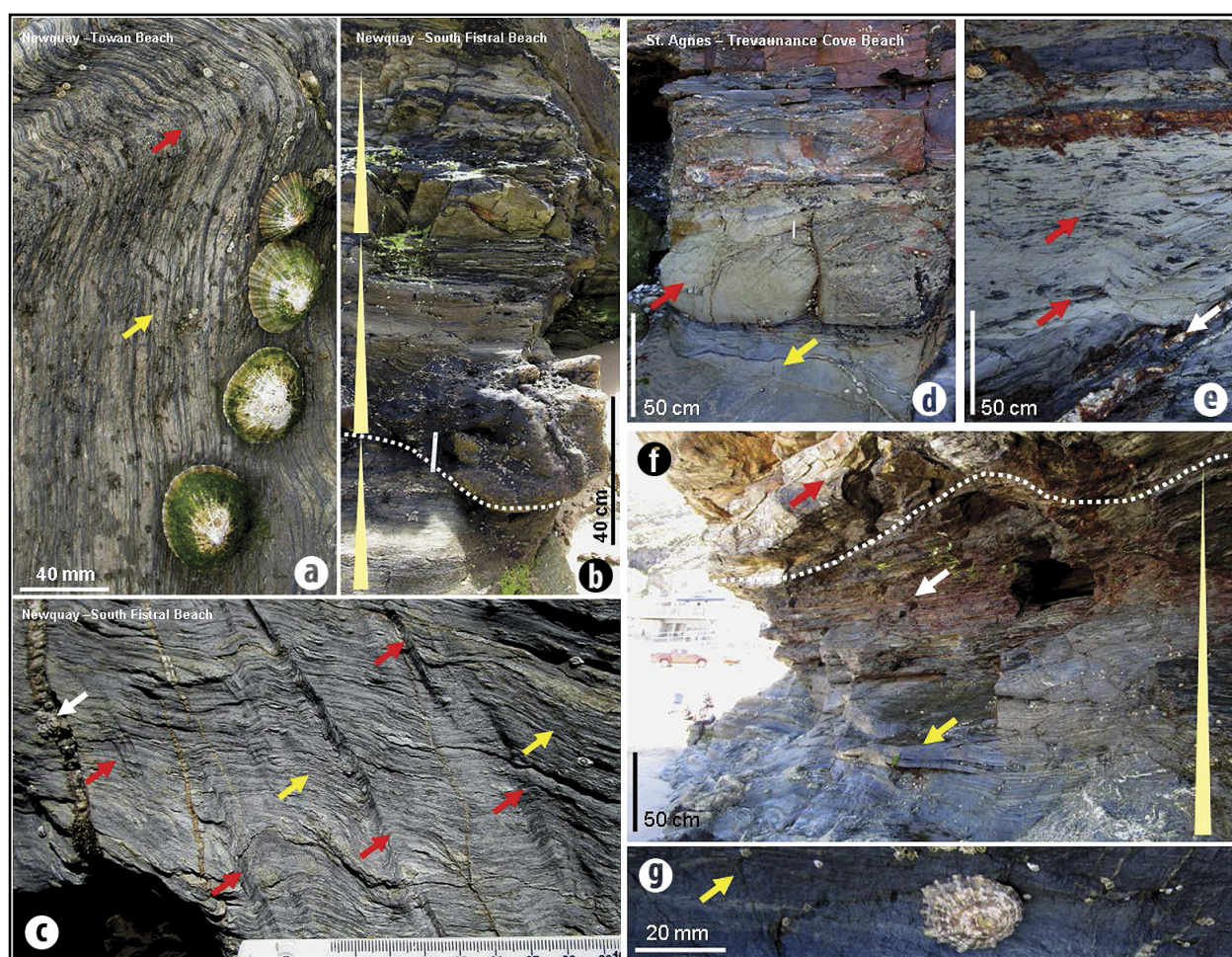
Fig. 3. Sedimentological marine Devonian features – Towan Beach, Bovisand Formation: (**a**) Siltstone with microfold (red arrow) and parallel lamination (yellow arrow); (**b**) South Fistral Beach, Bovisand Formation: Fining-upwards sequences with base of the erosional channel (dashed line); (**c**) Fine-satiny siltstone with bedding S_0 (yellow arrows), fanning cleavage S_1 (red arrows), and quartz vein with accorn barnacle (*Semibalanus balanoides*) domicile (white arrow); – St. Agnes, Trevaunance Cove Beach, Porthtowan Formation: (**d**) Microfolding hemipelagic blue mudstone (yellow arrow), sandstone boulder (red arrow) and heterolithic bedding; (**e**) Hemipelagic blue-greenish mudstone with black siltstone intraclasts (red arrows) and quartz vein (white arrow); (**f**) Blue-greenish mudstone (yellow arrow) and heterolithic bedding (white arrow) fining-upward sequence, and sandstone fill channel above contact base (dashed line); (**g**) *Hummocky*-like structure in mudstone (yellow arrow) (author's photos, June 18, and 21, 2019)

There are three subclasses of gastropods in the marine environment: Prosobranchia, Opisthobranchia and Pulmonata, predominating the representatives of the first subclass (Marshall, 1991), which, in the seas around the British Isles, comprises about 270 species (Crothers, 2003). Regarding the distribution of intertidal organisms along the shores of the Gulf of Cardigan and the English Channel, Evans (1948, 1953) and Crisp & Southward (1958) acknowledge the presence of populations of *Patella vulgata*, *P. depressa* and *P. aspera*, a fact later confirmed by Gaffney (1980) and Heppell *et al.* (1997). *Patella vulgata*, common to the English coast (Crisp & Southward, 1958; Poutiers, 2016), has been, like *Patella depressa*, the subject of thorough research on reproduction (Orton, 1928a; Southward & Orton, 1961), shell growth (Orton, 1928b), habitat and habits (Orton, 1929). Associated with intertidal macroalgae (Fig. 4a – c), patellids are mostly herbivorous animals (Ballantine, 1961; Jenkins *et al.*, 1999; Lorenzen, 2007; Notman *et al.*, 2016). An evaluation on a continental scale (Isle of Man – Portugal) by Coleman *et al.* (2006) reveal the existence of a clear trophic control of the grazing produced by limpetes that alters the overall macroalgal abundance. While it has long been thought that *Patella vulgata* consumes only microscopic propagules and germs through grazing, it has recently been found (Notman *et al.*, 2016) that by consuming adult algae it can directly control the macroalgal biomass attached to the shore. Recent Burgos-Rubio *et al.* (2015) reported that some patellids on artificial substrates (e.g., harbour infrastructure) in the Gibraltar area are omnivorous, consuming diatoms and cyanobacteria. In addition to numerous studies on shell morphology (Cabral, 2007), anatomy and radular apparatus (Haszprunar, 1988; Barber *et al.*, 2015; Ukmar-Godec *et al.*, 2015) and physiology (Arnold, 1957; Chapperon *et al.*, 2016), others address displacement in general (Jones & Trueman, 1970), crack refuge (Gray & Hodgson, 1998, 2004), flow-reflux locomotion (Davies *et al.*, 2006), density and orientation (Battelli, 2017) or homing (Beckett, 1968; McHuron, 1976; Garrity & Levings, 1983; Crothers, 2003; Coleman, 2007). A presentation of the British and European marine fauna and flora is included in the illustrated guide of the Collins collection (Preston-Mafham, 2014).

2. MATERIAL AND METHODS

The studied material is represented exclusively by photographs taken with the Canon IXUS 180 digital camera, in conditions of natural lighting and from the zenith position (top view), in order to avoid distortions. In this way, an appreciable number of automatically numbered photographs (e.g., 4589/3) were obtained, accompanied by a standard scale, graduated in cm / mm. From these, photographic frames were selected that include 54 "home scar" images produced by *Patella* (28 from Towan and 26 from St. Agnes, respectively), whose representative images are partially shown in Figs. 6-9. The method of direct observation was used, without sampling, and took place in the low tide conditions of the Newquay area, of only 1.1-1.8 m, on 18-22 June 2019 (according to Cornish Coast Time Tides, 2019). The rules of protection and conservation of the British natural heritage, strictly sanctioned in case of non-authorization or vandalism, were strictly obeyed. In the laboratory, measurements were made of the length (L) and width (w) of the "home scar" impressions left on the Devonian rocks by *Patella vulgata*, frequently associated with *Mytilus* and *Balanus* (Fig. 4d, e), with an estimated error of ± 0.5-1 mm. The numerical values obtained were summarized statistically, with the Excel program.

3. RESULTS

3.1. HOME SCAR MORPHOLOGIES

Except for works that mention the existence of "home scar" impressions produced by current patellids (e.g., Beckett, 1968; Branch, 1971; Garrity & Levings, 1983; Heller, 2015, and many others), neoichnological literature is virtually devoid of explicit references to the morphology of this type of structures. Regarding this aspect, McHuron (1976) observes three important features:

a) the shape of the scars that *overlaps exactly with the contour of the shell* of the trace-making animal;

b) *the scar cannot be attributed to a certain species*;

c) the presence of scars *indicates shallow, intertidal waters*.

Some animals that live in the rocky intertidum show a remarkable ability to return to the same place after a certain time, a behaviour known as „homing". Species with such behaviour, set by each individual, constantly return to the same place, exactly where they left off. From this point of view, the most eloquent examples are provided by limpets, especially *Patella vulgata*, which constantly returns to the home scar (Coleman, 2007). It should be noted that the mechanisms by which limps return home after feeding remain unknown (Schroeder, 2011).

Seen as a variable depth depression with a domichnia-type fossil footprint (Bromley, 1970), it is later considered a structure of bioerosion on a lithic substrate, called *a surface etching scar* (Bromley, 1994).

The analysis of photographs and statistical diagrams (Fig. 5), allowed the highlighting of two scarring morphotypes produced by patellids: the Towan morphotype and the St. Agnes morphotype, present on lithic substrates of different consistency.

3.1.1. The Towan morphotype

We attribute to this morphotype the impressions located on the dark-grey-blackish mudstone (Fig. 3a) of the Bovisand Formation that emerges on Towan beach during low tide (Fig. 1c). Out of the total of 28 specimens observed and photographed, most of them have an oval outline, some without ornamentation (Fig. 6a), and others, with one or more traces of the "horseshoe" muscle (Figs. 6b,c,e ; 6f, h). Rarely impressions that seem to keep the shape of paleale tentacles can be observed (Fig. 6d), but also almost circular specimens (Fig. 6g).
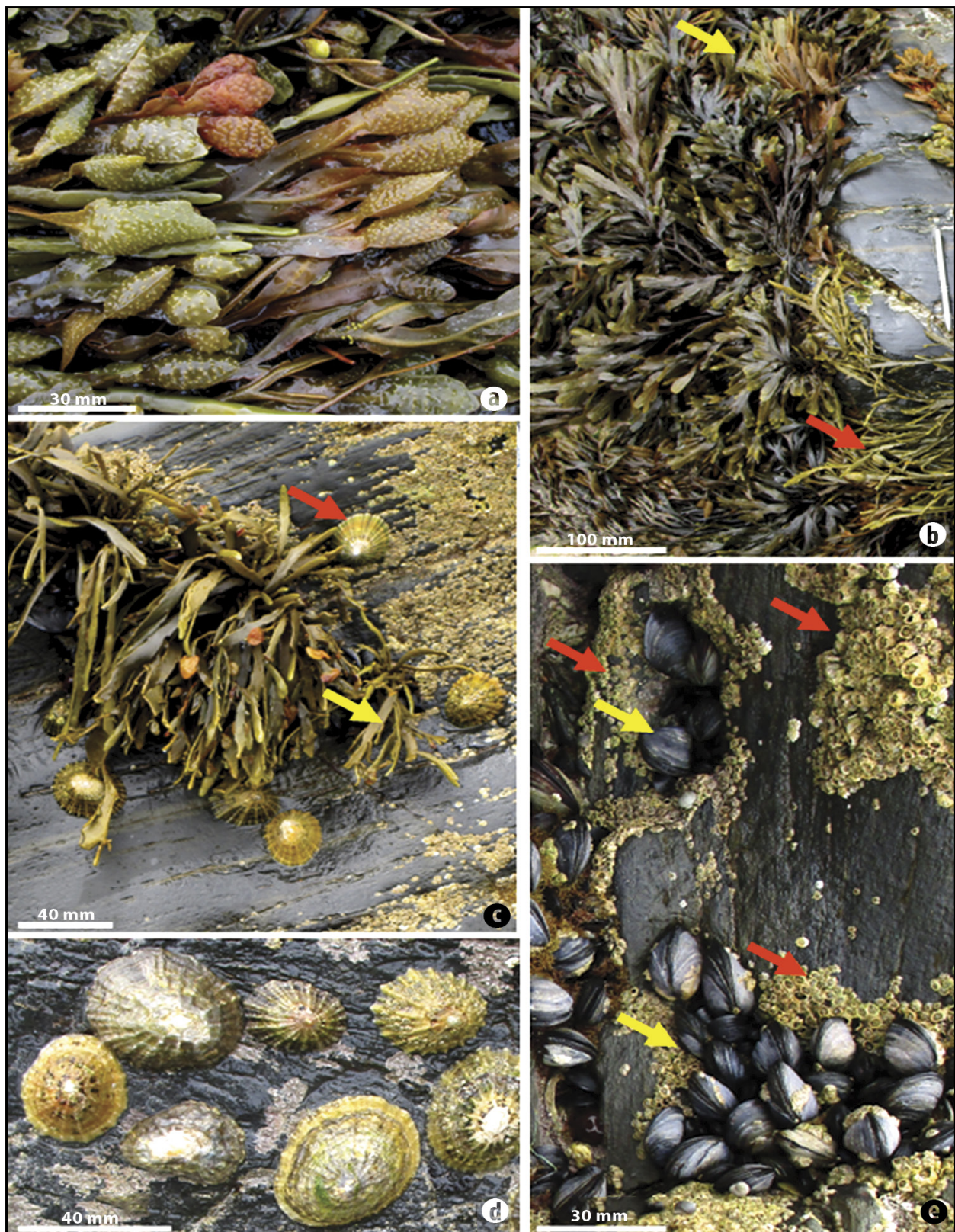
Fig. 4. Example of the seashore biodiversity, Newquay Towan Beach: (**a**) Knotted Wrack (*Ascophyllum nodosum*); (**b**) Knotted Wrack (*Ascophyllum nodosum*), Horned Wrack (*Fucus ceranoides* – red arrow) and Channelled Wrack (*Pelvetia canaliculata* – yellow arrow) (photo Anca Brustur, June 18, 2019); (**c**) Forked Rubberweed (*Bifurcaria bifurcata* – yellow arrow) and Common Limpet (*Patella vulgata* – red arrow); (**d**) Common Limpet (*Patella vulgata*); (**e**) Common Mussel (*Mytilus edulis* – yellow arrow) and Common Acorn Barnacle (*Semibalanus balanoides* – red arrow) (author's photos, June 18, 2019)
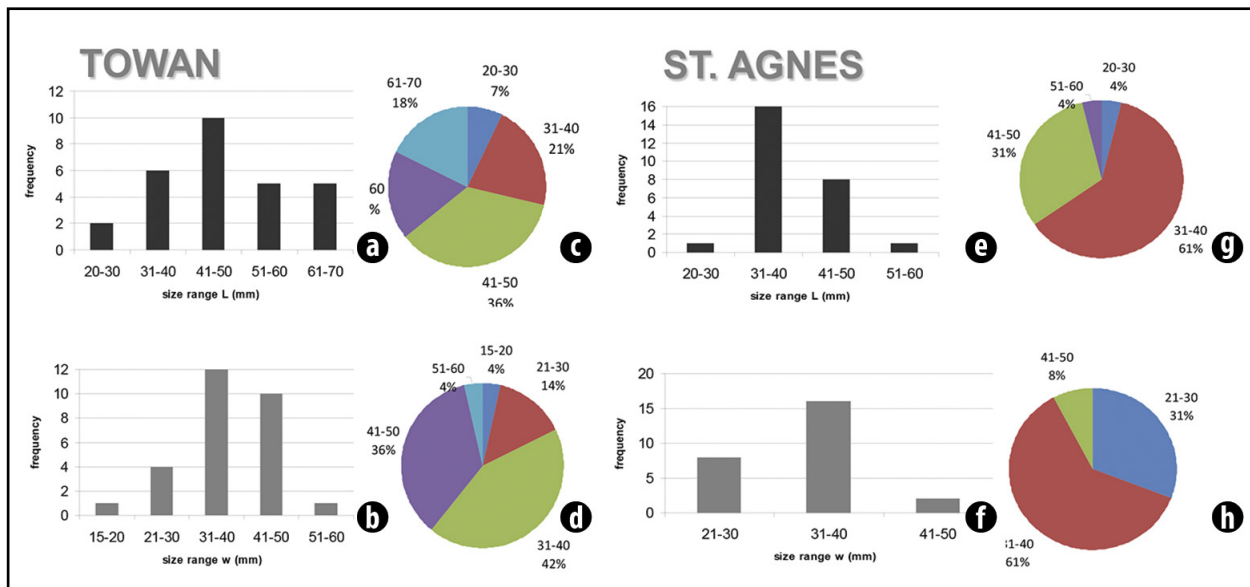
Fig. 5. Measurements of the *Patella* home scars: – Towan (n = 28): (**a**) – (**d**) Histogram of the size range frequency and size range percent of the length (L) and width (w); – St. Agnes (n = 26); (**e**) – (**h**) Histogram of the size range frequency and size range percent of the length (L) and width (w).

Apart from the frequently oval-elliptical contour, this morphotype has a marginal notch with a semicircular section, sometimes triangular. This notch clearly delimits the slightly convex bottom of the depression in relation to the surrounding space. On an artificial substrate (e.g., concrete dam) these impressions may have an oval outline, often fragmented (Fig. 6i) or vague and powdery in appearance (Fig. 6j). Dimensions (mm; n = 28). Length L (= large diameter): 20.7 - 70.0 (average = 45.6); width w (= small diameter): 17.2 - 53.0 (average = 35.3). L / w: 0.99 - 1.51. The polymodal frequency distribution of the 5 intervals (classes) of length L and width w (Fig. 5a, b) and the percentage distribution of the intervals confirm the greater dimensional variability of the specimens attributed to the Towan morphotype (Fig. 5c, d), with the mean value of the ratio L / w = 1.30.

3.1.2. The St. Agnes morphotype

To the beautiful resort of St. Agnes, located about 25 km west of Newquay, the tourist Coast Path passes South Fistral Beach (Fig. 1d) where the small home scar depressions of the patellids are encamped on the ankimetamorphic fine-satiny gray siltstone of the Bovisand Formation (Fig. 3b,c). Some of them have a piriform contour (Figs. 7a,b,d), circularly deformed (Fig. 7c) or are arranged linearly in the cavities of the microfolded rocks (Fig. 7d). These impressions were not the subject of our observations.

At St. Agnes, the high cliff bordering the southern end of Trevaunance Cove Beach (Fig. 1e) is placed on the blue-greenish hemipelagic mudstone belonging to the Porthtowan Formation whose sedimentological details are shown in Fig. 3d-g. On this lithic support, predominantly hemipelagic, there are numerous impressions, highlighted by obvious colour contrast and almost circular contour, marked by a semicylindrical ridge that circumscribes a slightly concave surface that we attribute to the morphotype St. Agnes (Figs. 8a-f; 9a-c). Some impressions are solitary (Fig. 8a), others double (Figs. 8c,d,e; Fig. 9b), grouped (Fig. 8b) or strung (Fig. 8f), without visible ornamentation. Rarely some fine wrinkles, arranged parallel to the contour of the impression, seem to mark the activity of the radular apparatus (Fig. 8b - 4908/2; 8f - 4913/4). An interesting case is that of the patellid "pivoting", marked by three successive impressions of the shell (Fig. 9c). In the presence of a harder substrate, the impressions are of the Towan type, with a well-marked marginal groove and often occupied by small individuals of *Balanus* (Fig. 9a). Dimensions (mm; n = 26): Length L (= large diameter): 32.5 - 53.0 (average = 37.8); width w (= small diameter): 24.0 - 43.0 (average = 32.3). L / w: 1.10 - 1.52. The frequency histogram of the 3 intervals (classes) of length L and width w (Fig. 5e,f) and their percentage distribution shows the smaller dimensional variability of the specimens attributed to this morphotype (Fig. 5g, h), with the average value of the ratio L / w = 1.19.

We can conclude that the morphology of the impressions left by the patellids is conditioned by the geomechanical characteristics of the substrate, its decisive role in the genesis and preservation of traces being amply demonstrated in works of neo- and paleoichnology (e.g., Crimes, 1975; Knox & Miller, 1985; Bromley, 1990 and others).

4. ROMANIAN LOWER CRETACEOUS PATELLICHNUS

In the WMSDB catalogue (Bagni, 2016), 3 genera of fossil patellids are inventoried: *Patella* (2 Permian, 8 Upper Triassic, 1
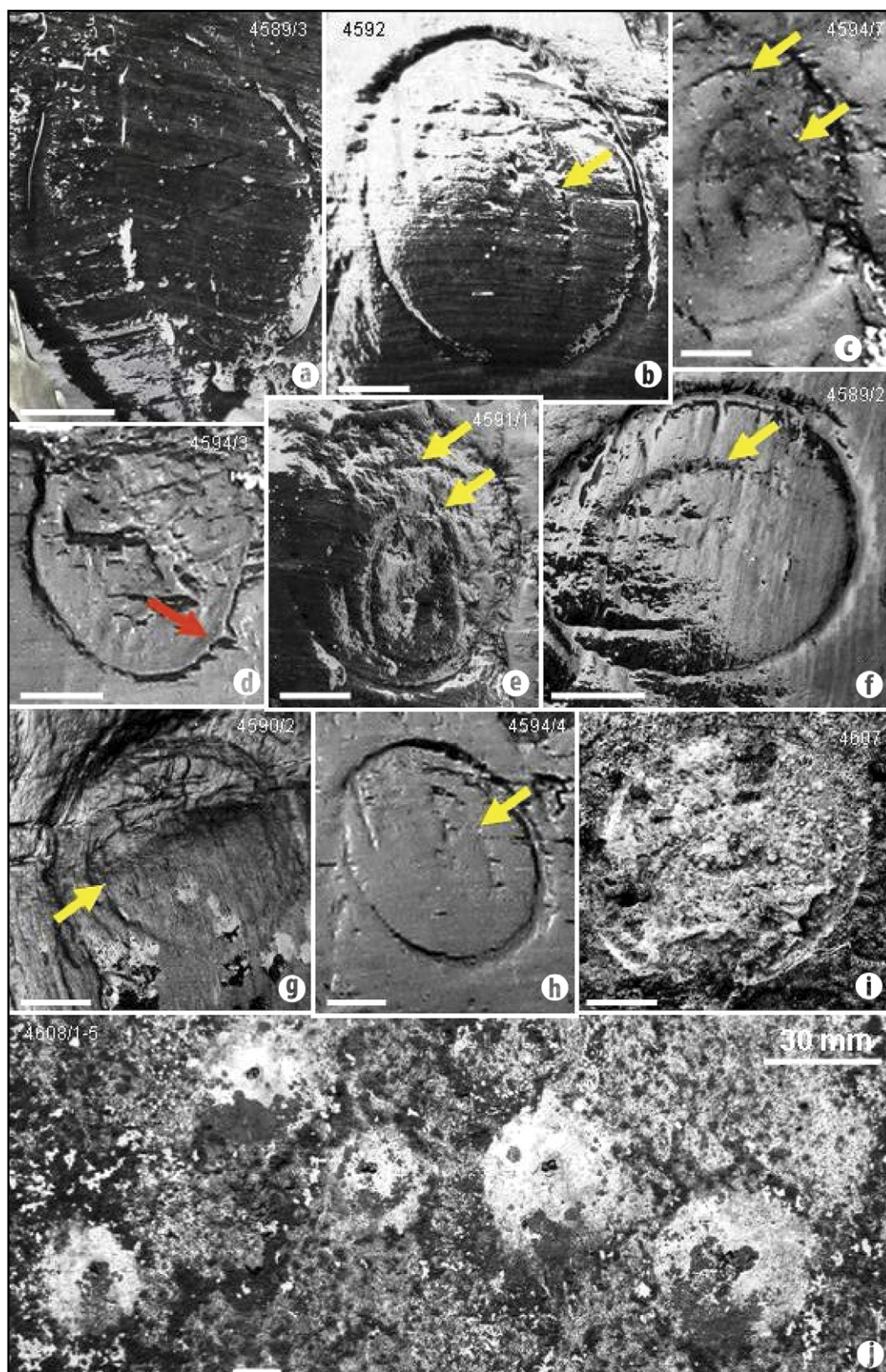
Fig. 6. *Patella* home scar on dark-grey-blackish mudstone on Newquai – Towan Beach morphotype: (**a**) Oval scar without ornamentation; (**b**), (**c**), (**e**), (**f**), (**h**) Oval scars with horseshoe-shaped muscle scar (yellow arrows); (**d**) Oval scar with paleal tentacle scars (red arrow); (**g**) Circular scar with vague horseshoe-shaped muscle scar; (**i**) Oval scar with unclear horseshoe-shaped muscle scar (scale bars in a-i images = 10 mm); (**j**) Probable home scars of *Patella* on the concrete wall of Towan harbour. In all these morphotypes, marginal furrow is present (photos Anca Brustur & Titus Brustur, June 18, 2019)
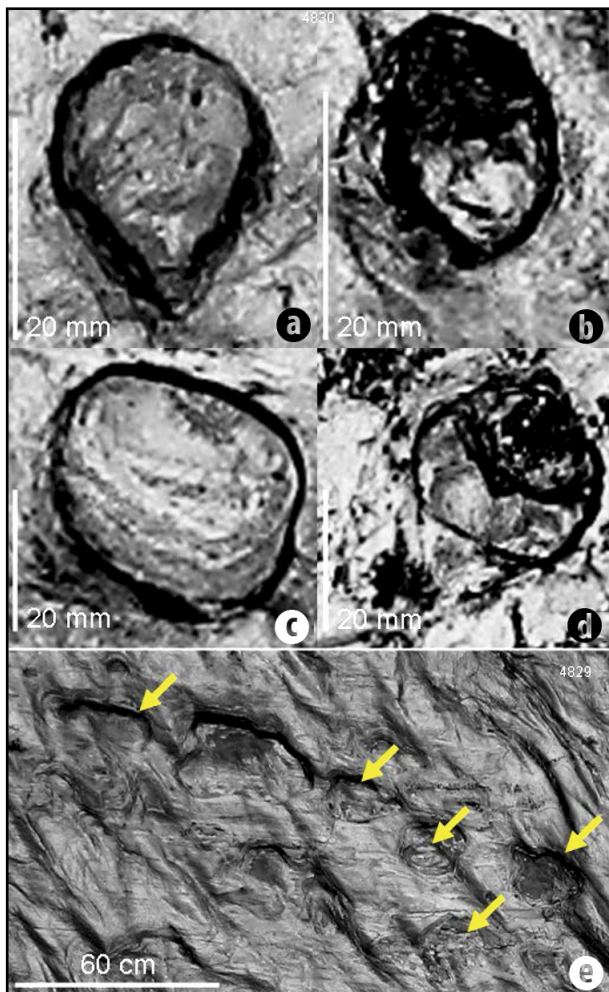
Fig. 7. *Patella* home scar on ankimetamorphic grey fine-satiny siltstone, Newquai, South Fistral Beach: (**a**), (**b**), (**d**) Piriform outline of scars; (**c**) Quasicircular scar; (**e**) Cluster of the irregular home scars (yellow arrows) (photos T. Brustur, June 19, 2019)

Lower Jurassic, 2 Jurassic, 3 Eocene, 1 Oligocene, 3 Miocene, 2 Pliocene, 2 Pleistocene), *Scutellastra* (2 Miocene) and *Helcion* (1 Miocene) with 36 species. The following fossil patellid species are known in Romania: *Patella coronensis* in the Triassic from Braşov (Jekelius, 1936), *Patella alta* and *Patella multicostata* from the Valaginian of Central Dobrogea (Pană, 1998), *Acmaea soceni* in the Sarmatian from Banat (Jekelius, 1944) and Fălticeni area (Ionesi, 2006). The Middle Sarmatian in the reef facies from the Moldavian Plateau provided the species *Acmaea angulata*, *A. enikalensis*, *A. pseudolaevigata*, *A. reussi*, *A. tenuissima*, *A. subcostata*, *A. sinzovi*, *A. striatocostata*, *A. compressiuscula* (Ionesi *et al.*, 2005).

In the following we bring to attention the ichnospecia *Patellichnus brusturii* described by Dragastan, but figured rather vaguely in pl. XXIX, fig. 6 (Dragastan *et al.*, 1998). Re-photography of the material shows the three impressions of the ichnospecies arranged on the edge of a colony of *Chaetopsis zonata* (Fig. 9d-f).

Being the first identification of a patellid ichnospecies in Romania in a work with limited circulation, we reproduce in the following the integral ichnotaxonomic presentation (Dragastan *et al.*, 1998), followed by a short comment.

Patellichnus n. igen., Dragastan

Derivatio nominis: From the shape of small depressions similar to the limpet holes (home depression) generated by recent genus *Patella* (Gastropoda).

Type species: *Patellichnus brusturii*, igen and n.isp.

Diagnosis: Circular to oval limpet holes, penetrated superficially on the surface of *Chaetetopsis zonata* colony (Demospongia). The pits do not preserve their complete outer shape because the most part of the shell was peeled off during excavation. The wall of the holes is steep, short and smooth, sometimes with the bottom uneven. No holes penetrated completely the true colony, but only superficially. The limpet hole look like small shallow hone-depressions. They are produced by patellogstropods.

Remarks: The superficialy shape of penetration is generated by the genus *Patella* (Gastropoda), well known from the Cretaceous deposits. Such home depressions (limpet-holes) were described on the colony surface of sponges, hexacorals and shells of ammonites (Shigeta & Futakami, 1994).

Patellichnus brusturii n. isp., Dragastan

Pl. XXIX, fig. 6 H & I

Derivatio nominis: Species dedicated to Dr. Titus Brustur for his contributions in the field of paleoichnology.

Holotype: Pl. XXIX, fig. 6 (see arrow I), Coll. L.P.B., Ichno. No. 70, Barremian-Early Aptian, Intorsura Buzăului, East Carpathians.

Isotypes: Pl. XXIX, fig. 6 (see arrow I), Coll. L.P.B., Ichno. No. 71 & 72, Barremian-Early Aptian, Intorsura Buzăului, East Carpathians.

Diagnosis: Elliptical to circular in shape, limpet holes disposed superficially in the marginal areas of the *Chaetetopsis* colony. The home depression are small, not so deep, with clear margins and bottom uneven. They are generated by patellogastropods with excavated superficially the surface of *Chaetetopsis* colony.

Description: Elliptical to circular in shape, limpet holes distributed preferentially to the margins of *Chaetetopsis* colony. The home depression are not so deep, variable in penetration between 0.5-1.0 mm and the bottom uneven. The pits have a variable diameter: the larger one is usually 4-5 mm and the shorter one is 3-4 mm. They are distributed predominantly to both lateral margins of the colony.

Remarks: By shape and dimensions, *Patellichnus* is very similar to recent limpet holes generated by palellogastropods group. The recent palellogastropods limpets are inhabitants of intertidal to shallow marine rocky shores. Their presence in the Barremian-Early Aptian of South Dobrogea and also the olistoliths of East Carpathians indicates a shallow marine environment of euphotic zone, being herbivorous organisms.
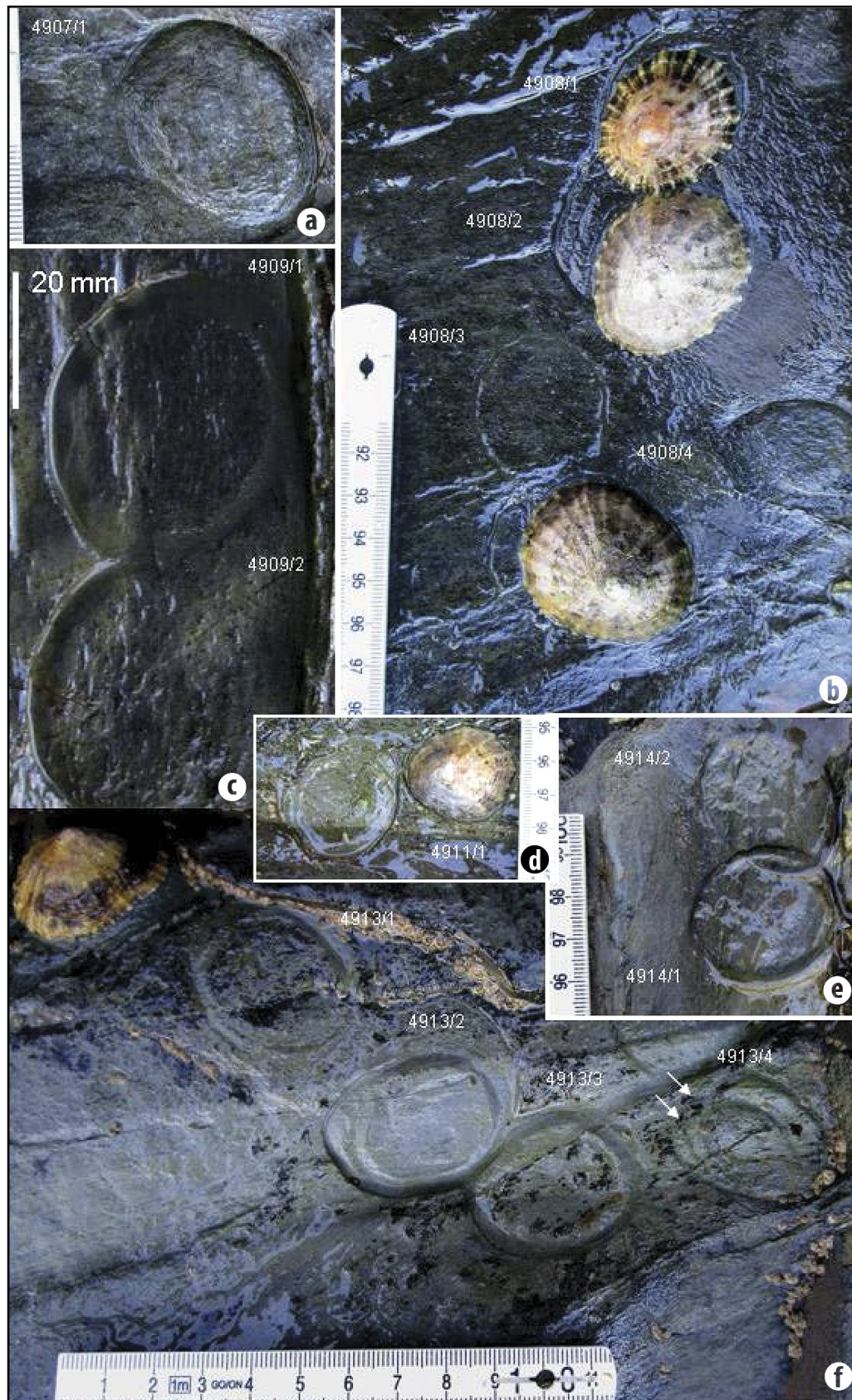
Fig. 8. Patella home scar on blue-greenish hemipelagic mudstone, Trevaunance Cove Beach St. Agnes morphotype: (**a**) Singular scar with marginal ridge; (**b**) Multiple scars; (**c**), (**d**), (**e**) Double scars; (**f**) Linear cluster scars (in 4913/4 probable successive radula traces - white arrows) (photos T. Brustur, June 21, 2019).

Fig. 9. *Patella* home scar on indurate blue-greenish hemipelagic mudstone, Trevaunance Cove Beach: (**a**) Circular and elliptical scars with marginal furrow (in 4926/3 barnacle domiciles); (**b**) Double scars (in 4925/1 double ridge – yellow arrow); (**c**) Four changes of the home scar place (author's photo, June 21, 2019); (**d**) *Patellichnus brusturii* Dragastan *et al.* (1998) on *Chaetetopsis zonata* Patrulius (Barremian – Lower Aptian, East Carpathians, Romania); (**e**) Holotype (H70) and isotype (I71): (**f**) Isotype (I72)

If on the diagnosis, description and age of the ichnospecies *Patellichnus brusturii* the presented aspects are clear, the following inadvertences can be signaled: a) the inaccuracy of the type locality ("*locus typicus*"), once Ciucaş-Zăganu (Dragastan *et al.*, 1998, p. 169 and explanation pl. XXIX, point 6), another time Întorsura Buzăului, East Carpathians (p. 208). However, on the label accompanying the sample *Chaetetopsis zonata* Patrulius No. 0022 from CLPB, IIIC, is recorded Pojülc Hill (? Pojülk n.n.), Întorsura Buzăului; b) the omission of the first author Tomoki Kase of the work "Limpet home depressions in Cretaceous ammonites", 1994 (p. 208); c) to the description and figuration of the species *Chaetetopsis zonata* Patrulius from South Dobrogea (pp. 168–169), the author adds in pl. XXIX the colony of *Chaetetopsis zonata* from Întorsura Buzăului, suggesting (p. 208) that *Patellichnus*, a good indicator of the intertidal domain, would be present in South Dobrogea - ultimately, an ambiguous statement.

5. DISCUSSION AND FINAL REMARKS

The mechanism of surface etching scar (*sensu* Bromley, 1994), as in the case of patellides, relied on the mechanism of single sucker attachment, as an effect of the suction produced by the leg muscles, but also of the mucus gel with the role of adhesive (cf. Smith, in Bromley & Heinberg, 2006).

Home scale patellids have been recognized in fossil form, on rock fragments embedded in conglomerates (Dragastan *et al.*, 1998; Uchman & Rattazzi, 2018) and on Neocretaceous Ammonites shells (Kase *et al.*, 1994; Kase *et al.*, 1998; Seilacher, 1998).

Being superficial impressions on the surface of a substrate, the coherence of the support is the main factor of their stability (e.g. Knox *et al.*, 1985).

This dependence is demonstrated by the current impressions in Cornwall, illustrated by the Towan morphotype, dimensional variable, with the ratio L / w = 1.30, located on the hard rocks of the Bovisand Formation and by the morphotype St. Agnes, relatively homogeneous dimensional, with the ratio L / w = 1.19, located on hemipelagites of the Porthtowan Formation (Fig. 10a). The significant morphological difference is supported by the presence of two important features: convex depression bordered by the marginal trench in the Towan morphotype and concave depression bordered by the marginal ridge in the St. Agnes (Fig. 10b).
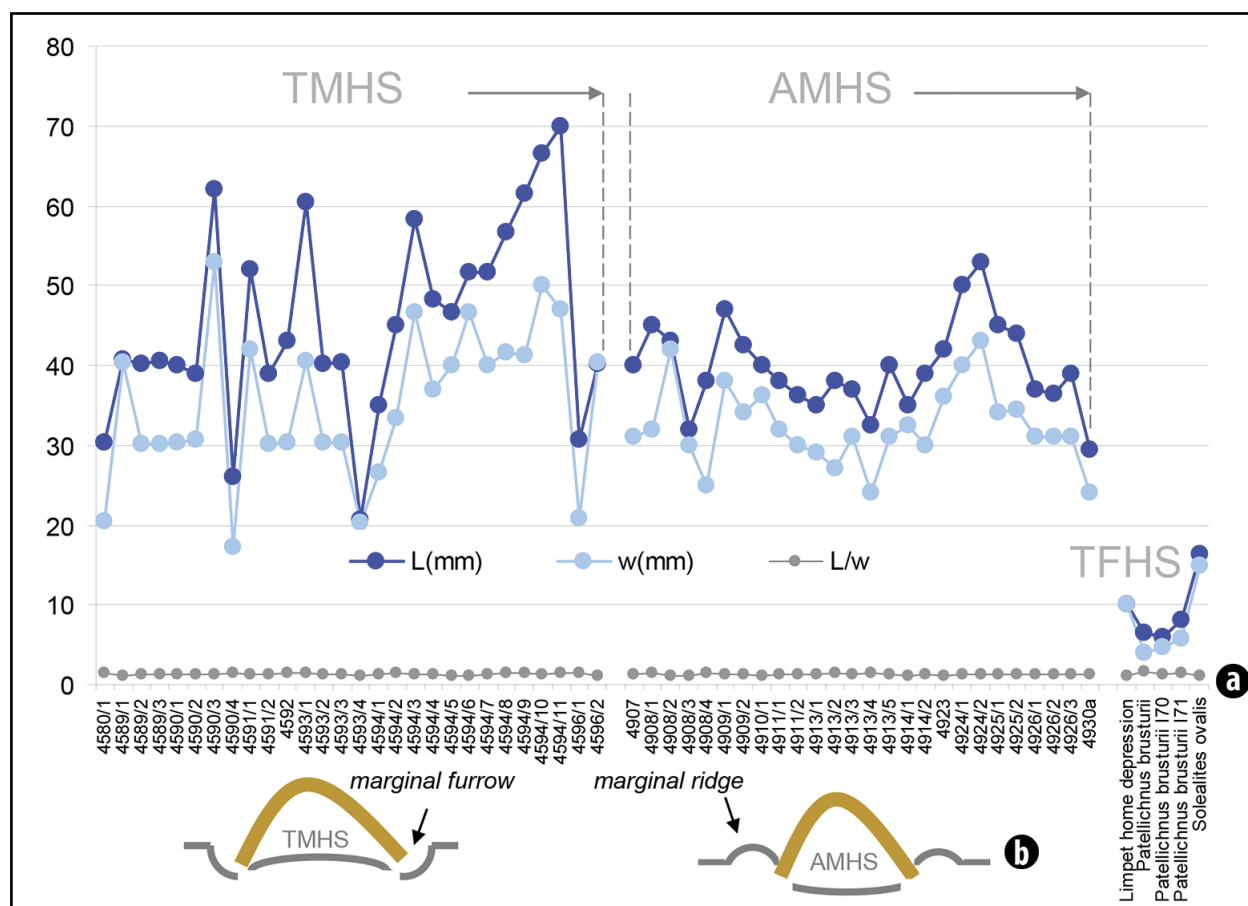
Fig. 10. Cornwall modern home scar morphotypes (TMHS, AMHS) *vs* trace fossil morphotypes (TFHS): (**a**) Graph comparing length (L), width (w) and L/w ratio of the TMHS, AMHS and TFHS; (**b**) Cross-sections in *Patella*-substrate relationship – TMHS Towan morphotype home scar with *marginal furrow* on the massive dark-grey mudstone with parallel lamina; – AMHS St. Agnes morphotype home scar with *marginal ridge* on the hemipelagic homogenous blue-greenish mudstone

Comparing the current home scar impressions with the fossil ones ("limpet home depression" - Kase *et al.*, 1994; *Patellichnus* - Dragastan *et al.*, 1998; *Solealites* - Uchman & Rattazzi, 2018) we notice the small size of the fossil traces, not exceeding 20 mm, with a variable L / w ratio, between 1 and 1.62 (Fig. 10a).

Organisms attached to intertidal environment, the patellids are subjected to strong mechanical stress due to the action of high tide, low tide and waves during storms, when their energy varies from a few W / m to MW / m (Kofoed, 2017).

Under these conditions, the contribution of wave pressure to the genesis of such impressions cannot be excluded. The marine abrasion, favouring the destruction of the rocky shore, provided the elements of conglomerates where traces of patellids such as those from the Lower Cretaceous in Romania (Dragastan *et al.*, 1998) and from the Italian Oligocene can be found (Uchman & Rattazzi, 2018). It is possible that future research will discover the presence of "home scar" traces of patellids on Barremian-Aptian reef limestones with *Chaetetopsis zonata* from Rarău and Dobrogea, from elements of Badenian and Sarmatian conglomerates from NW Transylvania (Baltres, 1970) or from Sarmatian reef facies from Moldavian Platform, where the presence of several species of patellids has been previously reported (Ionesi *et al.*, 2005; Ionesi, 2006).

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REFERENCES

ARNOLD D.C. (1957). The response of the limpet Patella vulgata to waters of different salinities. *J. mar. Biol. Ass. U.K.*, **36**: 121-129.

BAGNI L. (2016). WMSDB – Worldwide Mollusc Species Data Base, https:/::www.bagniliggia.it/ WMSD/HtmFamily/ PATELLIDAES.htm

BALTRES A. (1970). Asupra constituției conglomeratelor tortoniene şi sarmațiene din partea de NE a bazinului Transilvaniei. *D.S. Com. Stat Geol., Inst. Geol.*, **LV**(*1*): 215-226, București.

BALLANTINE W.J. (1961). The population dynamics of Pattela vulgata and other limpets. PhD Thesis, Univ. London. http://qmro.qmul.ac.uk/xmlui/handle/123456789/1459

BARBER A.H., LU D., PUGNO N.M. (2015). Extreme strength observed in limpet teeth. *J. R. Soc. Interface*, **12**: 20141326. http://dx.doi.org/10.1098/rsif.2014.1326

BATTELLI C. (2017). Density and petterns of orientation of Patella caerulea L. in the Bay of Koper (Gulf of Trieste, North Adriatic). *Studia Marina*, **30**(*1*): 5-16 UDC 594.3(262.3) Original scientific paper DOI: 10.5281/zenodo.820422.5

BECKETT T.W. (1968). Limpet movements. An investigation into some aspects of limpet movements, especially the homing behaviour. *Tane*, **14**: 43-63.

BRANCH G.M. (1971). The ecology of Patella Linnaeus from the Cape Peninsula, South Africa zonation, movements and feeding. *Zoologica Africana*, **6**(*1*): 1-38.

BROMLEY R.G. (1970). Borings as trace fossils and Entobia cretacea Portlok, as an example. *In*: Crimes T.P., & Harper J.C. (eds.) Trace fossils, *Geological Journal*, Spec. Issue No. **3**: 49-90.

BROMLEY R.G. (1994). The palaeoecology of bioerosion. *In*: Donovan S.K. (ed.), The palaeobiology of trace fossils, 134-154.

BROMLEY R.G., HEINBERG C. (2006). Attachment strategies of organisms on hard substrates: a palaeontological view. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **232**: 529-453.

BURGOS-RUBIO V., DE LA ROSA J., ALTAMIRANO M., ESPINOSA F. (2015). The role of petellid limpets as ominivorous grazers: a new insight into intertidal ecology. *Marine Biology*, **162**: 2093-2106.

CABRAL J.P. (2007). Shape and growth in European Atlantic Patella limpets (Gastropoda, Mollusca). Ecological implications for survival. *Web Ecol.*, **7**: 11-21.

CHRISTIAENS J. (1973). Revision du genre Patella (Mollusca, Gastropoda). Bull. Mus. Natn. Hist. nat., Paris, 3e sér., nº 182, sept.-oct., *Zoologie* **121**: 1307-1392.

CHLAPPERON C., VOLKENBORN N., CLAVIER J., SÉITÉ S., SEABRA R., LIMA F.P. (2016). Exposure to solar radiation drives organismal vulnerability to climate: evidence from an intertidal limpet. *Journal of Thermal Biology*, **57**: 92-100.

COLEMAN R.A. (2007). Homing. https://www.researchgate.net/publication /234071429_Homing/link/ 564502e208ae54697fb84df0/download

COLEMAN R.A., UNDERWOOD A.J., BENEDETTI-CECCCHI L., ABERG P., ARENAS F., ARRONTES J., CASTRO J., HARTNOLL R.G., JENKINS S.R., PAULA J., DELLA SANTINA P., HAWKINS S.J. (2006). A continental scale evaluation of the role of limpet grazing on rocky shores. *Oecologia*, **147**(*3*): 556-564. doi:10.1007/s00442-005-0296-9

CRIMES T.P. (1975). The production and preservation of trilobite resting and furrowing trace. *Lethaia*, **8**: 35-48.

CRISP D.J., SOUTHWARD A.J. (1958). The distribution of intertidal organisms along the coast of the English Channel. *J. mar. biol. Ass. U.K.*, **37**: 157-208.

CROTHERS J. H. (2003) Rocky shore snails as material for projects (with a key for their identification). *Field Studies*, **10**: 601-634.

DAVIES M.S., EDWARDS A.E.M., GRAY A.E., WILLIAMS A. (2006). Movement patterns of the limpet Cellana grata (Gould) observed over a continuous period through a changing tidal regime. *Marine Biology*, **149**(*4*): 775-787.

DRAGASTAN O., NEAGU TH., BĂRBULESCU AURELIA, PANĂ IOANA (1998). Jurasicul şi Cretacicul din Dobrogea centrală şi de sud. (Paleontologie şi stratigrafie). Supergraph, Cluj-Napoca, 249 p.

EVANS R.G. (1947). Studies on the biology of British limpets. *Journal of Zoology*, **117**(*2-3*): 411-423. https://doi.org/10.1111/j.1096-3642.1947.tb00526.x

EVANS R.G. (1953). Studies on the biology of British limpets – the genus Patella on the south coast of England. *Journal of Zoology*, **123**(2): 357-376 https://doi.org/10.1111/j.1096-3642.1953.tb00179.x

GAFFNEY R.M. (1980). On the number of Patella species in south-west England. *J. mar. biol. Ass. U.K.,* **60**(*3*): 565-574 DOI: https://doi.org/10.1017/S0025315400040261

GARRITY S.D., LEVINGS S.C. (1983). Homing to scars as defence against predators in the pulmonate limpet Siphonaria gigas (Gastropoda). *Marine Biology*, **72**: 319-324.

GEIGER D.L. (2006). Marine Gastropoda. *In*: Sturm C.F., Pearce T.A. & Valdés A. (eds.) The Mollusks: A guide to their study, collection and preservation, Chapter 24: 295-312. American Malacological Society, Universal Publishers, Inc., Boca Raton, Florida.

GREY D.R., HODGSON A.N. (1998). Foraging and homing behaviour in the high-shore crevice-dwelling limpet Helcion pectunculus (Prosobranchia: Patellidae). *Marine Biology*, **132**: 283-294.

GREY D.R., HODGSON A.N. (2004). The importance of a crevice environment to the limpet Helcion pectunculatus (Patellidae). *J. Moll. Stud.*, **76**: 67-72.

HASZPRUNAR G. (1988). Anatomy and relationships of the bone-feeding limpets, Cocculinella minutissima (Smith) and Osteopelta mirabilis Marshall (Archaeogastropoda). *Moll. Stud.*, **54**: 1-20.

HELLER J. (2015). Patellogastropoda: Limpets (abstract). *In*: Heller J. (ed.), Sea Snails. A natural History: 37-53, Springer.

HEPPELL D., SMITH S.M., PICTON B.E. (1997). Mollusca. *In*: Howson Cr. M. & Picton B.E. (eds.) The species directory of the marine fauna and flora of the British Isles and surrounding seas, 225 p. https://www.academia. edu/1402456/The_species_directory_ of_the_marine_fauna_and_flora_of_the_British_Isles_ andsurrounding_seas (accessed 11.10.2020)

HOLLICK L.M., SHAIL R.K., LEVERIDGE B.E. (2006). Devonian rift-related sedimentation and variscan tectonics – new data on the Looe and Gramscatho basins from the resurvey of the Newquay District. *Geoscience in south-west England*, **11**: 191-198.

IONESI L., IONESI B., ROŞCA V., LUNGU A., IONESI V., 2005. *Sarmaţianul mediu şi superior de pe Platforma Moldovenească*. Edit. Acad. Rom., Bucureşti, 558 p.

IONESI V. (2006). Sarmaţianul dintre valea Siretului şi valea Şomuzului Mare. Edit. Univ. "Al. I. Cuza", Iaşi, 238 p.

JEKELIUS E. (1936). Der weisee Triaskalk von Brasov und seine Fauna. *An. Inst. Geol. Rom., Bucureşti*, **XVII**: 1-106.

JEKELIUS E. (1944). Sarmat und Pont von Soceni (Banat). *Mem. Inst. Geol. Rom.*, **5**: 1-167, Bucureşti.

JENKINS S.R., HAWKINS S.J., NORTON T.A. (1999). Direct and indirect effects of a macroalgal canopy and limpet grazing in structuring a sheltered inter-tidal community. *Marine Biology*, **188**: 81-92.

JONES H.D., TRUEMAN E.R. (1970). Locomotion of the limpet Patella vulgata. *Journal of Experimental Biology*, **52**: 201-216.

KASE T., SHIGETA Y., FUTAKAMI M. (1994). Limpet home depression in Cretaceous ammonites. *Lethaia*, **27**: 49-58.

KASE T., JOHNSTON P.A., SEILACHER A., BOYCE J.B. (1998). Alleged mosasaur bite marks on Late Cretaceous ammonites are limpet (patellogastropod) home scar. *Geology*, **26**(*10*): 947-950.

KNOX L.W., MILLER M.F. (1985). Environmental control of trace fossil morphology. *In*: Curran H.A. (ed.) Biogenic structures: their use in interpreting depositional environments, *SEPM Spec. Publ.*, **35**: 167-176.

KOFOED J.P. (2017). The wave energy sector. *In*: Pecher A. & Kofoed J.P. (eds.) Handbook of ocean wave energy. *Ocean Engineering & Oceanography,* **7**: 17-44, DOI 10.1007/978-3-319-39889-1_2.

LORENZEN S. (2007). The limpet Patella vulgata L. at night in air: effective feeding on Ascophzllum nodosum monocultures and stranded seaweeds. *Journal of Molluscan Studies*, **73**(*3*): 267-274 https://doi.org/10.1003/mollus/eym022

LEVERIDGE B.E., HARTLEY A.J. (2006). The Variscan Orogeny: the development and deformation of Devonian/Carboniferous basins in SW England and South Wales. *In*: Brenchley P.J. & Rawson P.F. (eds.) The geology of England and Wales: 225-255. London, Geological Society of London.

LEVERIDGE B.E., SHAIL R.K. (2011). The marine Devonian stratigraphy of Great Britain. *Proceedings of the Geologyst Association*, **122**: 540-567.

MARSHALL D.J. (1991). Environmental physiology pf the intertidal limpets Patella (Prosobranchia) and Siphonaria (Pulmonata) with particular reference to their metabolic adaptations. PhD Thesis of Rhodes University, 201 p., South Africa (accessed July, 21, 2019).

MCHURON E.J. (1976). *Biology and paleobiology of modern invertebrate borers*. Rice University Ph.D., Xerox University Microfilme. https://scholarship.rice.edu/bitstream/handle/1911/15227/7621694.PDF?sequence=1

MORA C., TITTENSOR D.P., ADL S., SIMPSON A.G.B., WORM B. (2011). How many species are there on Earth and in the Ocean? *PloS Biol*, **9**(*8*): e1001127. doi:10.1371/journal.pbio.1001127.

NOTMAN G.M., MCGILL R.A.R., HAWKINS S.J., BURROWS M.T. (2016). Macroalgae contribute to the diet of Patella vulgata from contrasting conditions of latitude and wave exposure in the UK. *EcologyProgressSeries*, May 2016; https://www.researchgate,net/publication/297724523

ORTON J.H. (1928a). Observations on Patella vulgata. Part I. Sex-phenomena, breeding and shell-growth. *J. mar. biol. Ass. U.K.*, **15**(*3*): 851-862.

ORTON J.H. (1928b). Observations on Patella vulgata. Part II. Rate of growth of shell. *J. mar. biol. Ass. U.K.*, **13**(*3*): 863-874.

ORTON J.H. (1929). Observations on Patella vulgata. Part III. Habitat and habits. *J. mar. biol. Ass. U.K.*, **16**(*1*): 277-288.

PANÄ I. (1998). New taxa of small-sized gastropods from the Lower Cretaceous deposits of South Dobrogea. *Rev Roum. Géologie*, **42**: 69-90.

POUTIERS J.M. (2016). Patellidae. *In*: Carpenter K.E. & De Angelis N. (eds.) The living marine resources of the Eastern Central Atlantic, vol. 2, Bivalves, gastropods, sharks, batoid fishes and chimaeras: 929-946, Food and Agriculture Organisation of United Nations, Rome.

PRESTON-MAFHAN K. (2014). Seashore of Britain and Europe. HarperCollins Publ., London, 258 p.

SCHROEDER S.L. (2011). The behavioral ecology and territoriality of the limpet Lottia gigantea. PhD Thesis, University of Oregon, 141 p. http://www.bily.com/pnwsc/web-content/Articles/The-behavioral-ecology-and-territoriality-of-the-owl-limpet-Lottia-gigantea.pdf

SEILACHER A. (1998). Mosasaurs, limpets or diagenesis: how Placenticeras shells got punctured. *Mitt. Mus. Nat.kd. Berl., Geowiss. Reihe*, **I**: 93-102.

SOUTHWARD A.J., ORTON J.H. (1961). Studies on the biology of limpets. IV. The breeding of Patella depressa Pennant on the north Cornish coast. *J. mar. biol. Ass. U.K.*, **41**: 653-662.

TOMANEK L., HELMUTH B. (2002). Physiological ecology of rocky intertidal organisms: a synergy of concepts. *Integ. and Comp. Biol.*, **42**: 771-777.

UCHMAN A., RATTAZZI B. (2018). A new etching trace from the Savignone Conglomerate (Oligocene), NW Italy, probably produced by limpet gastrpods. *Acta Geologica Polonica*, **68**(*4*): 651-662.

UKMAR-GODEC T., KAPUN G., ZASLANSKY P., FAIVRE D. (2015). The giant keyhole limpet radular teeth: A naturally-grown harvest machine. *Journal of Structural Biology*, **192**(*3*): 392-402.

WIDDICOMBE S., SOMERFIELD P.J. (2012). Marine biodiversity: its past development, present status and future threats. *In*: Martin S.M., Aspden R.J. & Peterson D.M. (eds.) Marine Biodiversity ansâd Ecosystem Functioning. First Edition Oxford University Press, Publ. Oxford Univ. Press.

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