COMPARATIVE DATA ON PALEO-BIODIVERSITY OF GASTROPODS IN LATTAKIA REGION, SYRIA IN CORELATION WITH THEIR LIVING ENVIRONMENTS

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Abstract. Lattakia is a region located on the eastern coast of the Mediterranean Sea. It is a great and important area from a geological, geomorphological, biogeographical, palaeontological and biodiversity point of view, in many scientific and practical aspects. This paper presents data on the diversity of fossil gastropods identified so far in Lattakia Region in correlation with the current situation. Also, this paper is intended to be a reconstruction of palaeo-environment during the Cretaceous in Latakia Region today. These data represent preliminary results of research carried out during 1985-2014 in Region Lattakia, Syria.

Keywords: fossil gastropods, palaeo-biodiversity, data of palaeo-ecology, Lattakia (Syria).

Rezumat. Date comparative privind paleo-biodiversitatea gasteropodelor din Regiunea Lattakia, Siria în comparaţie cu mediile lor de viaţă. Lattakia este o regiune situată pe coasta estică a Mării Mediterane. Este o zonă deosebită din punct de vedere geologic, geomorfologic, biogeographic, paleontologic şi al biodiversităţii, şi importantă prin multe aspecte ştiinţifice şi practice. Lucrarea prezintă date privind diversitatea gasteropodelor fosile identificate până în prezent din Regiunea Lattakia în corelatie cu situaţia actuală. Lucrarea se doreşte a fi şi o reconstituire a paleomediului din timpul Cretacicului în regiunea Lattakiei de astăzi. Aceste date reprezintă rezultate preliminarii ale cercetărilor desfăşurate în perioada 1985-2014 în Regiunea Lattakia, Siria.

Cuvinte cheie: gasteropode fosile, paleo-biodiversitate, date de paleo-ecologie, Lattakia (Syria).

INTRODUCTION

Lattakia Region is located in northwest Syria, in the Middle East of Asia. It occupies an area of 2,297 km^2, of a total of approximately 184,920 km^2 of the Syrian Arab Republic. The region is bordered by the Mediterranean Sea to the west, the Anti-Lebanon Mountains to the south, Al Ghab Valley and the El-Asi (Orontes) River to the east and the Nur-Dağ Mountains to the north. It is composed of two subunits, each with distinctive physical-geographical, soil and climate features: continental Lattakia (Lattakia Mountains) (also named Jabal an Nusayryah or Alawite Mountains) and maritime Lattakia (HARDENBERG, 2003).

The continental subunit is represented by Jabal an Nusayryah Mountains. Between 0 and 60 m altitude, in the east, it has a geological structure dominated by sand, rocks sand, limestone and conglomerate. From 60 m to 200 m, the geological structure is of the Paleogene and Neogene age, composed of limestone, marl and clay. A filitic complex of rocks occurs in contact with the Alkabir Alshimali River (serpentine, peridotite, radiolarians, gabbro). The mountain slopes are covered mainly by forests of oak and cedar.

The maritime subunit belongs to the Levantine Basin of the Mediterranean Sea. It is located in the eastern Mediterranean, or the *Mare mediterraneum* (in Latin) that means the "sea in the middle of the land". This basin is the largest (2,969,000 km^2) and deepest (average 1,460 m, maximum 5,267 m) enclosed sea on Earth (AL-AZKI, 2002; 2006; 2008).

MATERIAL AND METHODS

During the research carried out between 1985 and 2014, different stations were established for field observations, identification of species and collecting of material from the region.

For species identification, there were widely used field observations and photographs taken by us, during the field trips. Specimens were taken from marine sedimentary deposits belonging to the Cretaceous Period, of carbonate rocks (limestone and dolomite).

They were then examined in the laboratory of "Dr. Fawaz Azki" Geological Museum, Kismin, Lattakia - Syria. Fossil gastropods were determined by means of binocular magnifier and specimens of each genus were counted.

The nomenclature of taxa and data processing is according to the data from literature as well as to national and international legislation.

RESULTS AND DISCUSSIONS

Lattakia Region ($33^0 36` 55.02``$ N, $36^0 44` 39.71``$ E) (Figs. 1; 2), part of the Middle East, is distinguished by spectacular landscape beauty and is characterized by rich and diverse assemblage, with many rare, endemic, relict species specific to the Levantine Basin and Western Arabian Province, and species on the edge of their geographical area, actual and fossil species. Its particular scientific significance is also derived from its geological, geomorphological, and paleontological characteristics (AXINI, 2011; 2012).

Figure 1. Earth map (from Google Earth, accessed: March 24, 2014) emphasizing the position of Lattakia Region in Asia.

Lattakia Region hosts many species of invertebrates and vertebrates fossils, of which, so far, we have identified over 135 species and genera, belonging to 4 classes and 2 phyla of invertebrates (Trilobita – Arthropoda; Gastropoda, Bivalvia, Cephalopoda – Mollusca) and 3 classes and 1 phylum of vertebrates (Osteichthyes, Reptilia, Mammalia – Chordata) (AL-AZKI 2012b, 2012c, 2012d; AL-AZKI & AXINI 2012a, 2012b; AL-AZKI, 2013; AL-AZKI & AXINI, 2013; AL-AZKI & AL-AZKI, 2014). Of fossil molluscs, gastropods occupy the first place, followed by ammonites and bivalves.

Of the fossil gastropods identified so far, the 16 genera include taxa among which 16 families grouped in 5 orders (AL-AZKI 2010-2011a, 2010-2011b; 2012a; BEGG & GRANT-MACKIE, 2003; BOUCHET & al., 2005; COX, 1960; COX & KNIGHT, 1960; DAYRAT & TILLIER, 2002; GARDNER, 1945; KNIGHT, 1956; MALAQUIAS & REID, 2008; MONTFORT, 1810; PONDER & LINDBERG, 1996, 1997; POPPE & TAGARO 2006; SCHMIDT & BELLEC, 1994; STEWART, 1927; TRACEY et al., 1993; WHITE, 1877) (Table 1).

The fossil gastropods genera were taken from sedimentary deposits belonging to the Cretaceous (AUBRY et al., 2009).

Figure 2. Geographical position of Lattakia Region (in the east of Cyprus, Nicosia) and with Palestine (in northern Jerusalem and in the northeast of Amman) (image from Google Earth).

Table 1. The taxonomic position of identified fossil gastropods.

Order	Family	Genus
Archaegastropoda (Bellerophontida)?	Bellerophontidae	*Bellerophon* sp. (Montfort 1808)
Archaegastropoda	Pleurotomariidae	*Pleurotomaria* sp. (Sowerby 1821)
Caenogastropoda (?Hypsogastropoda, ?Littorinimorpha)	Naticidae	*Natica* sp. (Scopoli 1777)
	Buccinidae	*Neptunea* sp. (Röding 1798) (syn. *Chrysodomus* sp. Swainson 1840, *Costaria* sp. Golikov 1977)
	Conidae	*Conus* sp. (Linnaeus 1758)
	Hipponicidae	*Hipponix* sp. (Defrance 1819)
	Cypraeidae	*Umbilia* sp. (Jousseaume 1884)
	Viviparidae	*Viviparus* sp. (Montfort 1810)
	Cassidae	*Cassis* sp. (Scopoli 1777) (syn. *Cassidea* Bruguière 1789)
	Pachychilidae	*Brotia* sp. (H. Adams 1866) (syn. *Antimelania* P. Fischer & Crosse, 1892)
	Strombidae	*Rimella* sp.(Agassiz 1841**)**
	Ficidae	*Ficopsis* sp. (Conrad 1866)
	Pseudomelaniidae	*Bourguetia* sp. (Deshayes 1871)
Opisthobranchiata	Bullidae	*Bulla* sp. (Linnaeus 1758)
Euomphalina	Euomphalidae	*Euomphalus* sp. (J. De C. Sowerby 1814) (syn. *Phymatifer*, *Schizostoma*, *Paromphalus*)
Neritimorpha	Neritidae	*Velates* sp. (Montfort 1810)

In the Mesozoic Era, there occurred the breaking of the megacontinental landmass, Pangaea, into two supercontinents, Laurasia and Gondwana and the formation of the Tethys Ocean. From the Jurassic to the Miocene, this ocean separated the two supercontinents. Fragmentation of Gondwana by the Early Miocene allowed the annexation of India to Asia. This led to the closure of the Indo-Mediterranean-Atlanto Seaway, in parallel with the annexation of Africa to Europe. These tectonic events led to the isolation of the Mediterranean basin from the rest of the global ocean, and therefore isolation of its biodiversity (KWEAKASON, 2008). This has affected the species of gastropods, such as those of the genera *Bulla*, *Conus*, *Natica* (DEUSSEN, 1924; EDDIE'S, 2014; HALL, 2002; HOCUTT, 1987; NCBI, 2014; TAVIANI, 2002).

Umbilia sp. is a genus largely disappeared today. The 4 existing species present in Australian waters are cold water species (DARRAGH, 2002; WILSON & CLARKSON, 2004). This indicates that during the Cretaceous, there was a time when the Thetis Ocean presented ecological conditions similar to those of the current cold regions.

The current species of the Fam. Neritidae live in saltwater, freshwater, marine water, or brackish water as amphibious, either on rocks or mangrove trees. This demonstrates that the species of *Velates* genus lived in the Thetis Ocean or led an amphibious life on rocks or mangrove trees from stagnant or flowing waters on the shores of the ocean.

The species of the *Viviparus* genus lived in mud or on the macrophytes of stagnant or flowing terrestrial waters. The presence of fossil gastropods of this genus, identified by us in the Cretaceous deposits in Lattakia Region, indicates that the species of this genus, in that period, lived in mud or on macrophytes from stagnant waters on the Thetis Ocean shore or in its tributary rivers (GAN & DINELAY, 1997; GLAUBRECHT, 2010; NEGREA, 2002; DRABETT, 2012; STRAUS, 1996).

Today, the species of *Brotia* occur in freshwater habitats of Southeast Asia, ranging from Northern India in the west through to Sumatra in the east (India, Myanmar, Bangladesh, Thailand, Laos, Vietnam, China, Cambodia, Malaysia and Indonesia - Sumatra and Borneo only). They are found predominantly in fast flowing, well oxygenated rivers, also, occasionally in lakes. The presence of this genus of gastropods in Cretaceous deposits in Syria indicates that, at that time *Brotia* species were living in swift and well-oxygenated waters flowing into the Thetis Ocean (ADAMS, 1866; GAN & DINELAY, 1997; GLAUBRECHT, 2010; KÖHLER & DEEIN, 2010; KÖHLER & GLAUBRECHT, 2001, 2006; KÖHLER et al., 2009, 2010; RABETT, 2012; STRAUS, 1996).

Gastropod populations occupy an important place in the aquatic biocoenosis structure, by the specific and numerical diversity and biomass (CHIRIAC & UDRESCU, 1965). They are among the first organisms to be investigated when examining waters. They indicate the oxygen content of the water of these basins. Their occurrence in surface water shows low levels of oxygen in water. The presence of these gastropods, in Cretaceous, shows us a high biodiversity in this geological period.

Also, the analysis of fossil gastropods species identified until now in this region indicates that the region climate in the Cretaceous was-like that of the current tropical areas and the Thetis Ocean waters, that covered the palaeo-biogeographical area in the Cretaceous period, presented ecological conditions like those of the current tropical

ocean waters. Predatory gastropods were benthic species, such as those of the genus *Conus* and *Natica*. They had a maximum development during this period. Prosobrachiates, such as those of the genera *Natica*, *Bellerophon*, *Euomphalus* were first and developed a number of marine types existing now (except *Bellerophon* and *Euomphalus*) (BRANSON, 1948; GILLULY, 1932; SMITH & CALKINS, 1904; THIRIOT-QUIEVREUX, 1983; WELLER, 1898; WESTGATE & KNOPF, 1932). All studied genera showed a high diversity in that period; that is indicated by the presence of multiple specimens in the sampling areas.

During the Cretaceous geological periods and until now, these gastropods contributed - by calcium carbonate present in the composition of their shells, to form the Cretaceous calcareous sedimentary rocks that make up largely this biogeographical region unique due to its natural history, geological structure, and palaeo-biodiversity.

While the Mediterranean Sea is a marine biodiversity hot spot, the Levantine Basin biodiversity is very little known (COLL et al., 2010).

It is well known that the current territory of Syria is the "cradle" of civilization. Here, after its appearance, the man ceased to migrate and started the first human settlements and for the first time here, he domesticated animals and cultivated wheat, invented the first alphabet and musical notes ... and the examples may continue. For this reason, this territory was strongly affected by human evolution from the beginning, with consequences on its biodiversity.

The actual communication between the Mediterranean, through the Levantine Basin, on the one hand, and the Red Sea and the Indo-Pacific Ocean, on the other hand - a communication created by man through the Suez Canal, created the possibility of many Indo-Pacific species migrating in the Levantine Basin. Its powerful damage due to invasive species has made the Levantine basin to be endangered. This can lead to the disruption of gastropods species existing in the Levantine Basin.

The analysis of the geographical elements of fossil gastropods from Lattakia Region (DEDIU, 2010a, 2010b, 2010c; PÂRVU, 2005) shows that the "Extinct in the wild" elements dominate with 7 taxa, followed by "Tethyan Relict" elements with 4 taxa and "Extinct in the region" elements with 3 taxa, and then "Tethyan Paleoendemit", Southeast Asian, Indo-Pacific, Palaearctic, "not-evaluated in the region" elements, each with 1 taxon (Table 2).

Analysing the geological periods, we see that most genera appeared in the Mesozoic Era: Cretaceous – Pliocene (7 taxa), followed by Jurassic – Cretaceous age and Jurassic – Pliocene (by 2 taxa), and Cretaceous – Oligocene, Cretaceous – Miocene (by 1 taxon). 4 taxa appeared in the Palaeozoic Era: Early Cambrian - Early Cretaceous, Early Ordovician - Late Cretaceous, Carboniferous – Eocene, Carboniferous – Pliocene (NASSER, 2014).

Table 2. Comparative data on zoogeographical elements, ecological data and geological age of gastropods from Lattakia Region.

Genera	Zoogeoelements (original)	Actual ecological data/palaeo-ecological data (original)	Geological Age (original)
Bellerophon sp.	EW	P, SW, H, T, ST, OOS, PE, CA	ECA – EC
Bourguetia sp.	EW	EF	J – C
Brotia sp.	SA, ER	L, RW, SW, WO, VI	C - P
Bulla sp.	TR	SW, CL, T, PE, TI, C, N, HE, AL, PH, PS, TI	CAR – P
Cassis sp.	IP, ER	SW, T, TE, IT, H, PS, N, PR, STI	C - P
Conus sp.	TPE	SW, T, TI, IT, STI, WW, DW, PR, VE, CAR, EF, LI, PS, CA	C – P
Euomphalus sp.	EW	SW, STI, CA, DW, CL, CA, STI, PS, PER, EF, TER	EOR - LC
Ficopsis sp.	EW	SW, EF, STI, CAR, CL, TI, CA	C - M
Hipponix sp.	TR	SW, T, TE, CL, TI, EF, CA	C - P
Natica sp.	TR	SW, T, AMW, PR, EF	C - P
Neptunea sp.	TR	SW, T, IT, AMW, OM, PR, SC	J – P
Pleurotomaria sp.	EW	SW, T, DW, EF, PR	J – C
Rimella sp.	EW	SW	C - O
Umbilia sp.	ER	SW, T, STI, DW, CW, EF, PR, CAR	C - P
Velates sp.	EW	SW, L, B, EF, PH, LI, A, SAW, CL, TI, EU, FS	CAR - E
Viviparus sp.	P, NE	L, RW, PE, PH, EF	J – P

Abbreviations used:

Zoogeoelements: EW - Extinct in the wild; ER - Extinct in the region; SA - Southeast Asian; IP - Indo-Pacific; TR - Tethyan Relict (in the region); TPE - Tethyan Palaeoendemit (in region); P - Palaearctic; NE - not-evaluated in the region.

Actual ecological data/palaeo-ecological data (AXINI & AL-AZKI, 2012; WoRMS, 2014): A - amphibious; AL - algaephilous; AMW - artic marine waters; CA - calciphilous; H - holoplanktonic snails; OOS - open oceans and seas; P - primitive snails; PE - pelagic living; ST - subtropical waters; SW - seawater snails; T - tropical waters; EF - epifaunal snails; L - freshwaters, VI - viviparous; RW - running waters; B - brackish, PE - pelophilous; PH - phytophilous, LI - lithophilous; SW - stagnant waters; WO - well oxygenated rivers; TI - tidal zones; IT - intertidal zones; STI - subtidal zones; PER - peritidal; N - nocturnal; HE - herbivorous; CL - coastlines; PS - psammophilous; TE - temperate waters; PR - predatory snails; VE - venomous; CAR - carnivorous; DW - bathyal zone; TER - terrestrial; SC - "scavenger" snails; OM - omnivores; CW - cool-waters; WW - warm-waters; SAW - salt waters; EU - eurybiont; FS - factor in speciation.

Geological Age: ECA - Early Cambrian; EOR - Early Ordovician; CAR - Carboniferous; J - Jurassic; EC- Early Cretaceous; C - Cretaceous; LC - Late Cretaceous; E - Eocene; O - Oligocene; M - Miocene; P - Pliocene.

CONCLUSIONS

The data presented in this work were compiled from field and laboratory studies conducted in 1985 - 2014.

Currently, there is no research on the palaeo-diversity of Latakia Region and Syria, in general. Our findings are unique . In the future, they will be upgraded with new data and research of laboratory and field. Also, the Levantine Basin biodiversity is very little known.

Moreover, our research on fossil species - plants and animals (invertebrates and vertebrates) are singular. No literature data were found in this field in Syria.

A total of 16 genera of fossil gastropods was identified in this time. Of these Mollusca, seven are extinct in the wild, three are extinct in the region, four are relict and one is a palaeo-endemit. Most genera appeared in the Mesozoic Era and they are marine snails.

The fossil and actual species that have been discovered in this area gives us the possibility of palaeo-environments reconstitution in this region (and also in the whole Syria) correlated with current environments, and also of the natural history of extinct and existing species of mollusks in Lattakia.

These fossils are part of the mollusks collections of the "Dr Fawaz Azki" Geological Museum, Kismin - Lattakia, Syria.

At present, there are many sites in this region which does not have a designated conservation status. Human impacts on different aspects may contribute to future declines and even disappearance of some gastropods (fossils or actual) in this bio-geographical region, many important species to science and human well-being, some of which have not been described yet.

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