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LATE QUATERNARY MOLLUSC-BEARING DEPOSITS FROM BECHAR (ALGERIA)

Stefan Witold ALEXANDROWICZ

Chair of Stratigraphy and Regional Geology, Academy of Mining and Metallurgy, al. Mickiewicza 30, 30-059 Kraków, Poland

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Abstract: Two subfossil assemblages of molluscs were found in terrigenous sediments forming two terraces of Wadi Bechar (Western Algeria). The older one, connected with the Late Pleistocene terrace of Saourien, is dated at 18500 years BP. It comprises 28 taxa of land and water snails including species, living recently in Africa and around the Mediterranean as well as Holarctic/Palearctic species. The younger fauna derives from the Holocene terrace of Guirien, dated at 5140 years BP, is poorer (11 snail species) and devoid of Holarctic/Palearctic taxa. Late Quaternary mollusc-bearing sediments from Bechar and from other localities known in Africa and Near East correspond with three phases of the humid climate (pluvials), correlated with the interpleniglacial and the ascending stage of pleniglacial of the Vistulian, with the Late Vistulian and with the climatic optimum of the Holocene.

Abstrakt: W terrygenicznych osadach tworzących terasy uedu Bechar (zachodnia Algeria) zostały znalezione dwa zespoły subfosylnej malakofauny. Starszy z nich, występujący w terasie młodoplejstoceńskiej, zaliczonej do Saourienu, jest datowany na 18500 lat BP. Obejmuje on 28 gatunków ślimaków lądowych i wodnych, żyjących współcześnie w Afryce i wokół Morza Śródziemnego, a także gatunki holarktyczne i palearktyczne. Młodsza fauna pochodzi z holoceńskiej terasy zaliczonej do Guirienu, datowanej na 5140 lat BP. Jest ona uboższa (11 gatunków ślimaków) i nie zawiera taksonów holarktycznych i palearktycznych. Osady późnoczwartorzędowe z malakofauną, znalezione w okolicy Bechar oraz cytowane z wielu stanowisk z obszaru Afryki i Bliskiego Wschodu, odpowiadają trzem kolejnym fazom wilgotnego klimatu, wyróżnianym jako pluwiały. Można je korelować odpowiednio z interpleniglacjałem i wstępującą fazą plenivistulianu, z późnym glacjałem oraz z klimatycznym optimum holocenu.

Key words: Algeria, Western Sahara, mollusc fauna, Upper Vistulian-Holocene, pluvials.

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INTRODUCTION

Late Quaternary lacustrine and fluviatile sediments containing more or less rich assemblages of subfossil molluscs have been reported from several localities distributed in the whole area of Northern Africa, Sahara and Near East. Shells of water snails and bivalves dominate in lacustrine chalk and in diatomites while in terrigenous deposits forming terraces of temporary river valleys, shells of both land snails and water molluscs occur. Most of the mentioned sediments were accumulated during the last thirty thousand years in the course of climatic changes implied by pluvial and interpluvial phases. According to numerous radiocarbon datings presented by different authors they can be attributed to the Upper Vistulian (Upper Würm), the Late Vistulian (Late Würm) and the Holocene.

Quaternary formations of Wadi Bechar were described in detail by Chavaillon (1964). The large terrace spread around the town Bechar is formed of gravel, sandy-loamy gravel, sand and loams distinguished by the mentioned author as Saourien. These sediments, divided into five beds (Saourien I–V), were accumulated during the pluvial corresponding with the last glaciation. The low terrace distinguished locally at the bottom of the wadi, encloses sediments of Guirien, accumulated during the development of Neolithic cultures (Holocene). Shells of subfossil molluscs found in these Quaternary deposits were mentioned and described by Pallary (1924), Chavaillon (1964) and Chevallier (1969) but assemblages connected with particular formations of different age have not been distinguished and characterised.

Results of both field investigations in Wadi Bechar and malacological studies carried out by the author at the British Museum of Natural History in London are presented in this paper. Radiocarbon analyses were made by Prof. M. Pazdur in the Radiocarbon Laboratory of the Silesian Technical

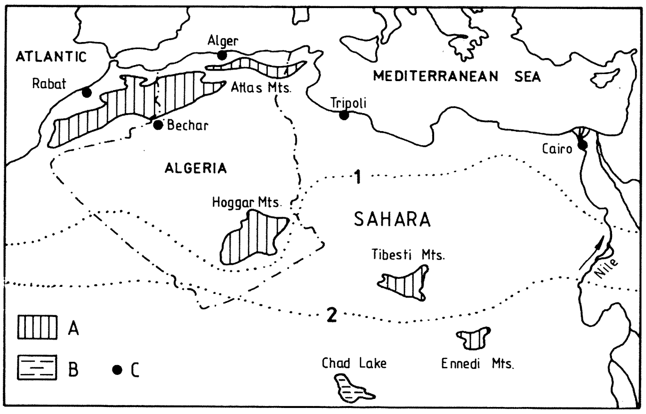

Fig. 1. Location map. *A* – mountain ranges, *B* – lake, *C* – main towns; southern range limit of Holarctic/Palearctic mollusc during Pleistocene (*dotted lines*): 1 – after Sparks & Grove (1961), 2 – after Böttcher *et al.* (1972)

University in Gliwice. A preliminary contribution has already been published (Alexandrowicz, 1986a).

SEDIMENTS

Several outcrops of Late Quaternary deposits can be observed on both sides of the dry valley in the vicinity of Bechar. Seven of them situated between the town centre and Bechar Djedid (about 4 km to the south) have been described and sampled (Fig. 1). All these deposits are developed as gravel, sand and loam, locally cemented with calcium carbonate.

Gravel and conglomerates occur mostly in the lowermost part of the profiles. They are composed of coarse- or medium-grained material with sandy and loamy-sandy matrix. In the middle and upper part of profiles the content of matrix is much higher therefore coarse-grained sand or loamy sand (sandstone) with a considerable admixture of pebbles or with intercalations enriched in gravel (cailloutis) replace typical conglomerates. Numerous mollusc shells can be found in these sediments.

Medium- and coarse-grained sand locally cemented occur in almost all outcrops in lower as well as in upper parts of particular profiles. The deposits are either completely devoid of fossils or contain only a poor molluscan fauna, mainly the shell detritus.

Sandy loams, loams and loamy marls are another type of the sediment. They are grey, yellowish-grey or reddish-grey, more or less distinctly bedded and locally alternated with thin intercalations of sand. Sandy loams with an admixture of small pebbles have been distinguished in particular outcrops. A relatively rich fauna of molluscs occurs in all the types of the mentioned loamy deposits.

Outcrops 1–4 are distributed between the road passing across the wadi and last houses of Bechar Djedid. Deposits forming the 4–6 m high terrace are accessible in these profiles. The sequence of particular types of sediments changes from one outcrop to another. In profiles situated close to the centre of the town (outcrops 1 and 2) loams and sandy loams

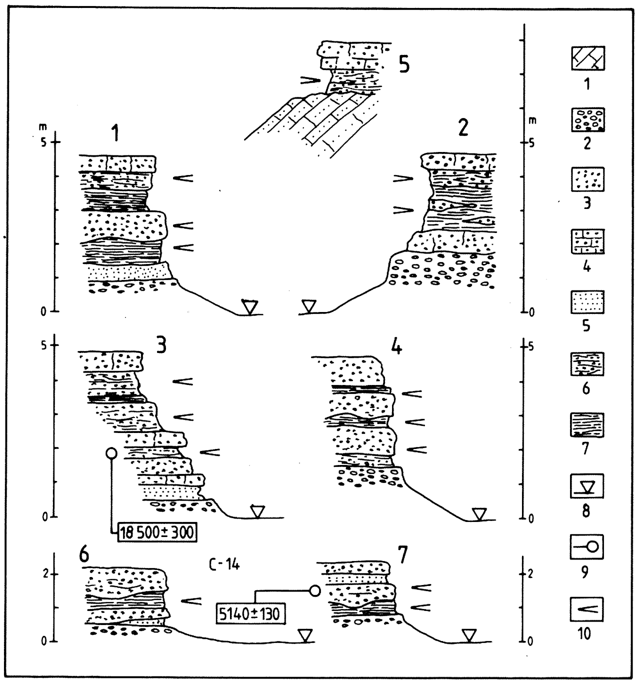

Fig. 2. Profiles of terrigenous deposits forming terraces of Wadi Bechar (1-5 – numbers of outcrops mentioned in the text). *1* – rock-socle (Carboniferous sandstones), *2* – gravel, *3* – gravel with loamy-sandy matrix (caillotis), *4* – layers of cemented gravel, *5* – sand, *6* – sandy loam with pebbles, *7* – loam and silty loam, *8* – bottom of wadi, *9* – sample radiocarbon dated, *10* – samples tacked for malacological analysis

are considerable components of sequences while near Bechar Djedid coarse-grained sediments alternated with sand prevail (outcrops 3 and 4). Rich assemblages of subfossil molluscs were collected in these outcrops mainly in loams and sandy loams containing small pebbles as well as in gravel and conglomerates with sandy-loamy matrix (Fig. 2, 1–4). Snail shells from the middle part of the profile 3 situated close to the south of Bechar Djedid are radiocarbon dated at 18500 ± 300 years BP (Gd-2145).

Outcrop 5 is situated on the left bank of the wadi near the hotel in Bechar. Quaternary sediments overlay a rocky-socle formed of Carboniferous sandstones and rise 6–8 m above the valley bottom. These are mollusc-bearing sandy loams covered with sand with an admixture of pebbles, locally cemented with calcium carbonate (Fig. 2, 5).

Outcrops 6 and 7 represent deposits forming the low terrace rising 2–3 m above the bottom of the wadi. They are developed as gravel and conglomerates with intercalations of sand and loam. The fauna was sampled in both localities. It occurs both in loams and in gravel with sandy matrix (Fig. 2, 6–7). Shells of snails collected from sandy gravel in the profile 6 (Bechar Djedid) were dated with the radiocarbon method at 5 140 ± 130 years BP (Gd-2144).

The sequence of deposits described by Chavaillon (1964) from few outcrops in Bechar includes two levels of marls, sandy marls and conglomerates (cailloutis) with shells of molluscs distinguished as Saourien II and Saourien IV (lacustrine and fluviatile facies). They alternate with eolian-fluviatile sand of Saourien I, III and V. The lower level

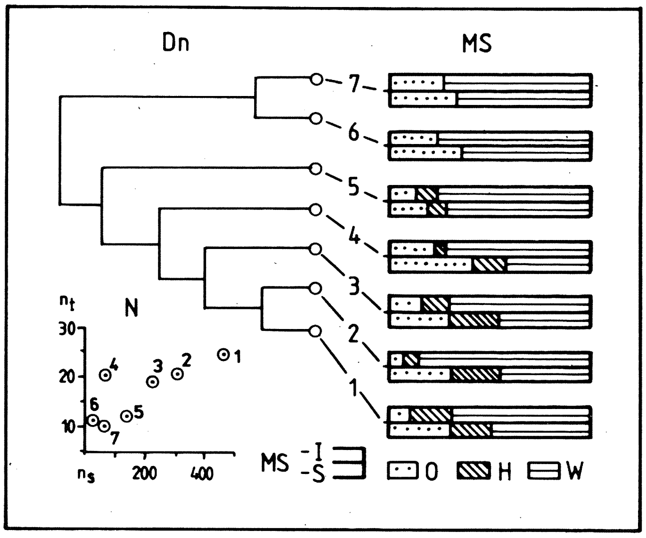

Fig. 3. Taxonomical diagram and malacological spectra: Dn – dendrogram, MS – malacospectra, *MSI* – malacospectra of specimens, *MSS* – malacospectra of species, *O* – snails of open habitats, *H* – hygrophilous snails, *W* – water molluscs; 1-7 – numbers of profiles; N – number of taxa (n_t) and of specimens (n_s)

of mollusc-bearing sediments rises 2–4 m above the valley bottom while the upper one occurs a few metres higher. The former can be compared with terrigenous deposits from profiles 1–4 (lower part of Saourien), while the latter with sandy loams from profile 5 (upper part of Saourien). Equivalents of Guirien are accessible in profiles 6 and 7.

MALACOFAUNA

The analysed fauna was found in 15 samples weighting 2–3 kg each, taken from 7 described outcrops (Fig. 2). The material comprises about 1300 specimens and numerous shell fragments, partly determinable. They represent 16 species of land snails, 14 species of water snails and 2 taxa of bivalves identified to the generic level (Tab. 1). Standard methods of malacological study described by Ložek (1964) and by the author (Alexandrowicz, 1987) including ecological and geographical spectra as well as taxonomic analysis according to the Steinhaus formula (Alexandrowicz, 1977) have been used.

Three main ecological groups of molluscs have been distinguished: land snails living in open, sunny and mostly dry habitats (O), land snails connected with moderately humid, humid or even moist environments (H) and water molluscs (W). A few taxa occur in all samples (*Melanopsis praemorsa*, *Bulinus truncatus*, *Ancylus fluviatilis*, *Rumina decollata*) and few other, as accessory components of the fauna are limited to a single locality (*Valvata tilhoi*, *Haufenia tellini*, *Lymnaea palustris*, *Euconulus fulvus*). The most numerous are water snails: *Melanopsis praemorsa*, *Bulinus truncatus*, *Galba truncatula*, and land snails: *Vallonia pulchella*, *Oxyloma elegans*.

The occurrence of species connected with quite different habitats is an important feature of described assemblages

Table 1

Malacofauna of Late Quaternary deposits from Wadi Bechar. 1-7 – outcrops described in the text. Number of specimens: I – 1-3, II – 4-9, III – 10-31, IV – 32-99, V – 100-316. E – ecological groups of molluscs: O – snails of open habitats, H – snails of humid habitats, W – water molluscs; G – geographical groups of molluscs: A – African species, M – Mediterranean species, N – Holarctic/Palearctic species

E	G	TAXON	1	2	3	4	5	6	7
W	M	*Valvata tilhoi* Germain					I		
W	M	*Hauffenia tellini* (Pollonera)					III		
W	A	*Melanoides tuberculata* (Müller)	II		I	II	I	I	I
W	M	*Melanopsis praemorsa* (Linnaeus)	V	V	IV	IV	III	IV	III
H	N	*Carychium minimum* Müller	II	I	I	I			
W	A	*Lymnaea natalensis* Krauss	II	II	III	I	II	I	II
W	N	*Lymnaea palustris* (Müller)	I						
W	N	*Lymnaea truncatula* (Müller)	III	III	III	I	IV		
W	A	*Anisus dalloni* (Germain)	III	III					II
W	A	*Gyraulus ehrenbergi* (Beck)	II		III	I			
W	N	*Armiger crista* (Linnaeus)	IV	III	II	I	II		
W	A	*Planorbarius metidjenses* (Forbes)	I						
W	A	*Bulinus truncatus* (Audouin)	IV	V	II	II	I	I	II
W	N	*Ancylus fluviatilis* (Müller)	III	III	I	I	II	I	II
W	A	*Ferrisia isseli* (Bourguignat)	I	I					
H	N	*Oxyloma elegans* (Risso)	III	II	III	I	III		
H	N	*Vertigo antivertigo* (Drapamaud)	II	II	II	I			
X	A	*Pupoides coenopictus* (Hutton)	I						
X	M	*Granopupa granum* (Drapamaud)	I	I					
X	N	*Vallonia pulchella* (Müller)	III	III	III	II	III		
H	M	*Vallonia enniensis* (Gredler)	IV	II	I	I			
X	M	*Zebrina detrita* (Müller)						I	II
H	N	*Zonitioides nitidus* (Müller)		I	I				
H	N	*Eoconulus fulvus* (Müller)	I						
X	M	*Cecilioides acicula* (Müller)	III	I	I	I			
X	M	*Rumina decollata* (Linnaeus)	II	I	III	II	I	II	II
X	M	*Sphincterochila candidissima* (Drapamaud)	I		I	I		I	I
X	A	*Helicella hoggarensis* (Pallary)	II	I	I	I			
X	A	*Helicella lemoinei* (Debeaux)		I				II	I
X	A	*Otala ceardi* (Pallary)	I			I			
W	A	*Caleatura* sp.						I	I
W		*Pisidium* sp	I	I	I				

(Fig. 3, MS). They are composed mainly of molluscs living in both stagnant and flowing water with a considerable admixture of land snails, typical of dry open habitats and of humid places. Such assemblages can be interpreted as thanatocenoses, either allocenoses or mixocenoses (Alexan-

Table 2

Assemblages of molluscs from sediments of particular pluvials in Northern Africa and Near East. F-1 – F-4 – mollusc assemblages as in Table 1

F	Maghreb	Sahara	Egypt – Near East
F-4	*Melanoides tuberculata*	*Melanoides tuberculata*	*Melanoides tuberculata*
	Lymnaea natalensis	*Melanopsis praemorsa*	*Cleopatra bulinoides*
	Biomphalaria pfeifferi	*Lymnaea natalensis*	*Lymnaea natalensis*
	Bulinus truncatus	*Bulinus truncatus*	*Gyraulus ehrenbergi*
	Sphincterochila candidissima	*Rumina decollata*	*Biomphalaria alexandrina*
	Helicella lemoinei	*Sphincterochila candidissima*	*Segmentorbis angustus*
		Helicella lemoinei	*Bulinus truncatus*
F-3		*Melanoides tuberculata*	
		Lymnaea natalensis	
		Lymnaea truncatula	
		Gyraulus costulatus	
		Oxyloma elegans	
		Vertigo antivertigo	
		Pupoides coenopictus	
		Vallonia pulchella	
		Eoconulus fulvus	
F-2		*Melanoides tuberculata*	*Valvata saulcyi*
		Melanopsis praemors	*Lymnaea truncatula*
		Lymnaea natalensis	*Lymnaea palustris*
		Lymnaea truncatula	*Gyraulus piscinarus*
		Armiger crista	*Armiger crista*
		Oxyloma elegans	*Oxyloma elegans*
		Verigo antivertigo	*Vertigo antivertigo*
		Vallonia pulchella	*Sphaerium corneum*
		Vallonia enniensis	*Pisidium casertanum*
		Euconulus fulvus	
		Cecilioides acicula	
F-1			*Melanoides tuberculata*
			Lymnaea truncatula
			Lymnaea palustris
			Vertigo moulinsiana
			Vallonia costata
			Pisidium casertanum

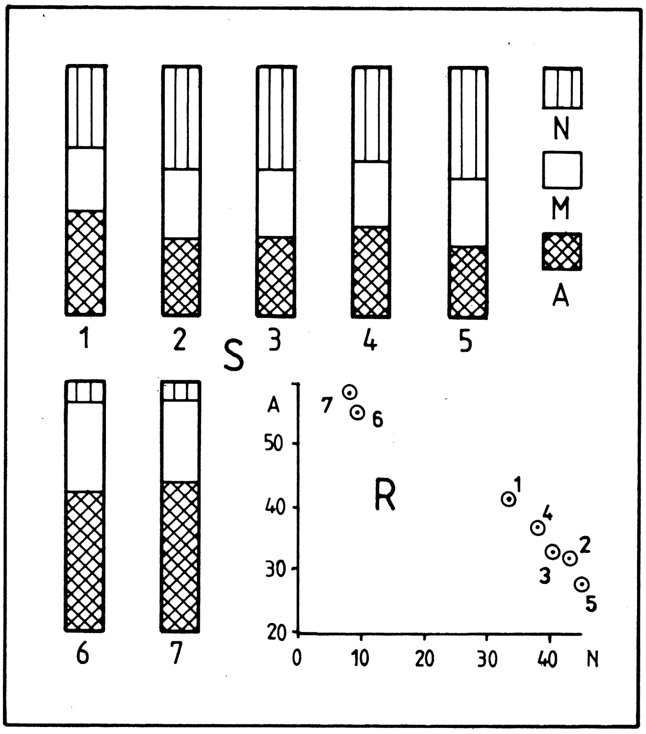

Fig. 4. Geographical malacospectra of species: *N* – Holarctic/Palearctic species, *M* – Mediterranean species, *A* – African species; **R** – relations between Holarctic/Paleartic species (N) and African ones (A), **S** – zoogeographical spectra

drowicz, 1987). Shells of molluscs inhabiting water bodies distributed within the valley bottom as well as shells of land snails accepting both dry and humid habitats spread over the valley floor, terraces of the wadi and on surrounding slopes, were accumulated by perennial or temporary rivers during floods, after longer or shorter transport.

According to the taxonomic diagram the whole set of samples from the described localities may be divided into two groups (Fig. 3, Dn). The first one comprises profiles 1–5 and is considerably differentiated. The other group includes profiles 6 and 7, representing the low terrace. The fauna from outcrop 1 is quite similar to those from outcrop 2, because both are joined at the lowest level. Mollusc assemblages from profiles 3 and 4 are attached to the two profiles previously mentioned, forming the subset corresponding with sediments of the main terrace. The snail community from outcrop 5 belongs to the first group but it is slightly more different from the mentioned four. It represents somewhat younger sediments of the main terrace of Wadi Bechar, covering the rocky-socle of carboniferous sandstones.

Fauna of molluscs from profiles 1–4 are the richest. It contains 19–25 taxa and 75–450 specimens respectively. Water molluscs prevail but in MSS spectra they reach less than 50% of species. *Melanopsis praemorsa* and *Bulinus truncatus* accompanied by *Galba truncatula, Lymnaea natalensis*, *Vallonia pulchella* and *Oxyloma elegans* are the most numerous components of this assemblage. The following species occur only in the mentioned fauna in three or four localities: *Carychium minimum*, *Vertigo antivertigo*, *Vallonia enniensis*, *Gyraulus ehrenbergi* and *Helicella hogarensis*. This assemblage characterizes the terrace of Saourien, particularly its lower part.

Mollusc fauna of profile 5 comprises 10 taxa and 152 specimens. Water snails are the most numerous both in MSS and MSI spectra. *Valvata tilhoi* and *Hauffenia tellini* were found only in this locality while 5 taxa occur both in the described assemblage and that from outcrops 1–4 (*Galba truncatula*, *Armiger crista*, *Oxyloma elegans*, *Vallonia pulchella*, *Cecilioides acicula*). The mentioned fauna is connected with the upper part of the Saourien terrace.

Malacofauna from outcrops 6 and 7 comprises 9–10 taxa and 44–66 specimens of water and open country species at a ratio of ca. 2:1 (hygrophilous snails were not recorded). Two taxa: *Zebrina detrita* and *Coleatura* sp. (? *Coleatura acuminata* Adams) were found only here, while the remaining ones are common in the whole analysed material. This is the molluscan assemblage of sediments forming the low terrace (Guirien).

Beside species of molluscs found in the described material (Tab. 1), the following ones were noted by Pallary (1924, 1934), Chavaillon (1964) and Chevallier (1969) from the Pleistocene and Holocene deposits of the Bechar area:

1. *Melanopsis tingitana* (Morelet), *M. maroccana* (Chemitz), *M. dufouri* Ferussac, *M. maresi* (Bourgignat) – these taxa reflect the variability of shells (from nearly smooth to strongly sculptured) defined here according to a suggestion of Tchernov (1973) and Brown (1980) as *Melanopsis praemorsa* (Linnaeus).
2. *Bulinus contortus* (Michaux) is a local form of *Bulinus truncatus* (Audouid) distinguished in Maghreb and in Iberian peninsula (Brown 1980), mentioned from NW Sahara by Chavaillon (1964).
3. *Cochlicella barbara* (Linnaues) found by Pallary (1924) in the Pleistocene deposits of Wadi Bechar.
4. *Otala bailloni* (Debeaux) described by Pallary (1924) and Chevallier (1969).

The geographical range of the mentioned species is quite varied (Ehrmann, 1956; Jaeckel, 1962; Germain, 1969; Brown, 1980; Kerney *et al.*, 1983; Cossignani, 1995). African snails typical of the warm, subtropical and even tropical climate have been distinguished as the first group (A), species distributed largely around the Mediterranean Sea including Southern and even Central Europe represent the second group (M), while Holarctic and Palearctic species living in Europe, including its northern part, belong to the third group (N). Species of the first group (African snails) are numerous: *Melanoides tuberculata*, *Lymnaea natalensis*, *Anisus dalloni*, *Gyraulus ehrenbergi*, *Planorbarius metidiensis*, *Bulinus truncatus*, *Ferrisia isseli*, *Pupoides coenopictus*, *Helicella hogarensis*, *Helicella lemoinei* and *Otala ceardi*. The Mediterranean–South-European group (M) is represented by 9 taxa: *Valvata tilhoi*, *Hauffenia tellini*, *Melanopsis praemorsa*, *Granopupa granum*, *Vallonia enniensis*, *Zebrina detrita*, *Cecilioides acicula*, *Rumina decollata* and *Sphincterochila candidissima*. Some of them are connected more with the African fauna (*Valvata*, *Melanopsis*, *Sphincterochila*) and some rather with the European fauna (*Vallonia*, *Cecilioides*). The following species belong to the Palearctic group (N): *Carychium minimum*, *Lymnaea palustris*, *Lymnaea truncatula*, *Armiger crista*, *Ancylus fluviatilis*, *Oxyloma elegans*, *Vertigo antivertigo*, *Vallonia pulchella*, *Zonitoides nitidus* and *Euconulus fulvus* as well as *Lymnaea palustris* noted from Quaternary deposits of Wadi Bechar by Chevallier (1969).

The lists of species representing particular geographical groups of snails in the sediments of the two described terraces of Wadi Bechar is different. In the older terrace (Saourien) the proportion of African and Holarctic/Palearctic species is nearly the same. The first mentioned group reaches 28–42% while the other one 38–45%. Relations between these components (A/N) vary from 0.62 to 1.27 respectively (the mean value is 0.87). In the younger terrace (Guirien) the percentage of African snails is considerably higher (55–59%) while Holarctic/Palearctic species reach less than ten percent. Values of the A/N relation in the two described profiles are 6.11 and 7.38. The number of species representing the circummediterranean group of snails (M) is nearly stable in all the profiles, amounting to 26–36% (Fig. 4).

Mollusc faunas described from the Late Quaternary deposits dated with the radiocarbon method enable to determine both changes of the geographical range of particular groups of species and the differentiation of assemblages living in Northern Africa during the last thirty thousand years. Four types of mollusc communities (F-1 – F-4) have been distinguished.

The oldest assemblage (F-1) was found in El Jafr Depression in Jordan, attributed to the Lisan period, in sediments accumulated 28000–26000 years ago (Huckriede & Wiesenmann 1968). It comprises Palearctic species: *Lymnaea palustris*, *Lymnaea truncatula*, *Vallonia* cf. *costata* and *Pisidium casertanum*, Atlantic/Mediterranean species – *Vertigo moulinsiana* and African species – *Melanopsis tuberculata*. The absence of Ethiopian snails (*Biomphalaria*, *Bulinus*) is noteworthy.

Holarctic/Palearctic species accompanied by snails living around the eastern part of the Mediterranean Sea dominate in sediments dated at 23000–19000 years BP (F-2). The fauna described from Damascus Basin (Kaiser *et al.*, 1973) Includes: *Armiger crista*, *Acroloxus lacustris*, *Oxyloma elegans*, *Vertigo antivertigo*, *Sphaerium corneum* and *Pisidium casertanum*, as important components of the assemblage. The mollusc community from the sediments forming the main terrace of Wadi Bechar, attributed to the same time span (18500 years BP), contains four mentioned taxa of snails, beside other species of the Holarctic/Palearctic group (*Carychium minimum*, *Vallonia pulchella*, *Zonitoides nitidus*, *Euconulus fulvus*) as well as numerous Mediterranean and African species. The last mentioned components distinguish the two mentioned assemblages from one another.

Sediments deposited during the late stage of the last glaciation (15000–11000 years ago) are rich in subfossil shells of molluscs (F-3). Assemblages of this age are known mainly from Sudan and Central Sahara (Tibesti, Hoggar). In the former region it is the fauna with numerous species of African snails (e.g. *Lanistes carinatus*, *Cleopatra bulimoides*, *Melanoides tuberculata*, *Gyraulus costulatus*, *Segmentorbis angustus*) accompanied by a Palearctic species – *Vertigo antivertigo* (Huckriede & Venzlaff 1962, Huckriede 1972). In Tibesti Mts. African species are represented by water snails: *Valvata tilhoi*, *Melanoides tuberculata*, *Anisus dalloni*, *Gyraulus costulatus*, *Biomphalaria pfeifferi*, *Segmentorbis angustus*, *Bulinus truncatus*, *Lymnaea natalensis*, and by land snails: *Pupoides coenopictus*, *Zootectus insularis*. The admixture of the following Holarctic/Palearctic molluscs is noteworthy: *Armiger crista*, *Lymnaea truncatula*, *Oxyloma elegans*, *Cochlicopa lubrica*, *Vertigo antivertigo*, *Vallonia pulchella*, *Zonitoides nitidus* and *Euconulus fulvus*. Another species of land snail, found in Wadi Bechar – *Vallonia enniensis* – was noted, too (Jaeckel, 1971; Molle, 1971; Böttcher *et al.*, 1972).

Holocene mollusc-bearing deposits with assemblages dominated by African snails (F-4) have been described from several localities. Relatively rich and differentiated fauna occurs in lacustrine chalk and sand of the Fayum Depression in Egypt (Gardner, 1932; Alexandrowicz, 1986b). The sequence of sediments dated at about 9000–5000 years BP (Ginter *et al.*, 1983) contains the fauna composed mainly of snails representing the African group (A): *Theodoxus niloticus*, *Valvata nilotica*, *Melanoides tuberculata*, *Cleopatra bulimoides*, *Lymnaea natalensis*, *Gyraulus ehrenbergi*, *Biomphalaria alexandrina*, *Segmentorbis angustus* and *Bulinus truncatus* (Alexandrowicz, 1986b). Lacustrine sediments (chalk and diatomites) of the same age were reported from Chad (Faure, 1966) and Mali (Petit-Maire, 1991). They contain African species of water snails (*Melanoides*, *Biomphalaria*, *Bulinus*). Sand, gravel and silty deposits forming terraces along watercourses of Maghreb, attributed in Morocco to the time interval 7000–4500 years BP (the Oasis Terrace – Andres, 1977) and dated in Tunisia at 8000–5500 years BP (the Lower Prehistoric Holocene Terrace – Ballais, 1995) include shells of *Melanoides*, *Lymnaea natalensis*, *Biomphalaria pfeifferi*, *Sincterochila candidissima*, *Helix melanostoma* and *Eobania vermiculata*. The fauna is completely devoid of Holartic/Palearctic species. Similar but richer assemblages have been reported from Holocene fluviatile deposits of Algeria, found in the lower terrace in Guir Valley and in Saoura Valley (Chavaillon, 1964). The mollusc fauna of the Guirien Terrace from Bechar is composed of 11 species of snails with predominance of African species (*Melanoides tuberculata*, *Lymnaea natalensis*, *Bulinus truncatus*, *Helicella lemoinei*).

DISCUSSION AND CONCLUSIONS

The deposition of Late Quaternary sediments in Northern Africa and Near East was controlled mainly by changes of the climate. During the last thirty thousand years a few phases of humid and dry conditions distinguished as pluvials and interpluvials followed after one another. They have been recognised and characterised in many profiles basing on lithology, mollusc assemblages and archaeological investigations. Results of about 50 radiocarbon dating of both lake and fluviatile sediments, published by several authors create an opportunity to infer about the course of evolution of the environment and habitats.

Four phases of the increased accumulation can be distinguished according to the mentioned data, as the following time spans: 29000–26000, 22000–18000, 15000–11000 and

9000–4000 years BP (Fig. 5, Dt). They are connected with the growing activity of fluviatile processes as well as with formation and expansion of lakes (Fig. 5, Ph). Three of them can be attributed to the last glaciation, both the pleniglacial (interpleniglacial – pleniglacial) of Vistulian and Late Vistulian (30000–10000 years BP). Sediments of this age represent the Saourien described from north-western Africa by Chavaillon (1964) and distinguished also in Maghreb. During the late stage of this span the "Loam Terrace" was formed in Morocco (Andres, 1977). In the area of Near East, deposits connected with the humid climate of the pluvial represent the Lisan period, corresponding to interplenivistulian and plenivistulian. It is followed by the dry phase of Post-Lisan passing again into the humid phase of Young Würm (Huckriede & Wiesemann, 1968) or Late Vistulian. Mollusc-bearing lacustrine deposits accumulated 15000–10000 years ago have been distinguished in Tibesti as equivalents of the pluvial, called "full pluvial" or "northern pluvial" (Böttcher *et al.*, 1972).

The last phase of accumulation of fluviatile and lacustrine sediments falls on the Holocene. It was synchronised with the development of Neolithic cultures during the Atlantic Phase a well as the Boreal Phase and a part of Subboreal Phase. In Western Sahara the terrace of Guirien was formed (Chavaillon, 1964) while in Morocco the "Oasis Terrace" was distinguished and described by Andres (1977) from the Anti Atlas area. Well developed terrace of nearly the same age, containing mollusc-bearing deposits occurs in Tunisia (the "Lower Prehistoric Terrace"). It is followed by two younger Late Holocene terraces named "the very low main historic terrace" and "the very low post-Islamic terrace" (Ballais, 1995). Sediments of the "Mediterranean Pluvial" have been mentioned from the Tibesti Mts. by Böttcher *et al.* (1972).

The sequence of climatic changes comprising a few alternating cold-humid and warm-dry periods (pluvials and interpluvials) has been described and discussed by several authors (e.g. Butzer, 1959; Chavaillon, 1964; Fairbridge, 1965; Faure, 1966; Vita-Finzi, 1969; Brosche & Molle, 1975; Andres, 1977; Horowitz, 1979; Pachur & Hoelzmann, 1991). It can be presented in a simplified and generalised version as a curve with three humid and three arid stages (Fig. 5, Cl).

The pluvial corresponding with the last glaciation is bipartite and can be attributed to the Upper Vistulian (Upper Würm). The older part of this pluvial (Pleni-Vistulian Pluvial, Fig. 5, VP) encloses the span (35000) 30000–19000 years BP. The deposition of fluviatile sediments was most effective in its late part and was locally prolonged up to two thousand years. Mollusc assemblages with a considerable admixture of Holarctic/Palearctic species were found in these sediments (Fig. 5, F-1, F-2). The older fauna from Wadi Bechar represents such an assemblage. The younger stage of the pluvial that arrived after the phase of a dry climate lasted 4–5 thousand years. It is documented by fluviatile and lacustrine deposits abounding in shells of molluscs. The fauna described from Sahara comprises both African and Holarctic/Palearctic species of snails (Fig. 5, F-3). This period comprises the interval 15000–11000 years BP and can be related to the Late Glacial (Late Vistulian Pluvial, Fig. 5, LP).

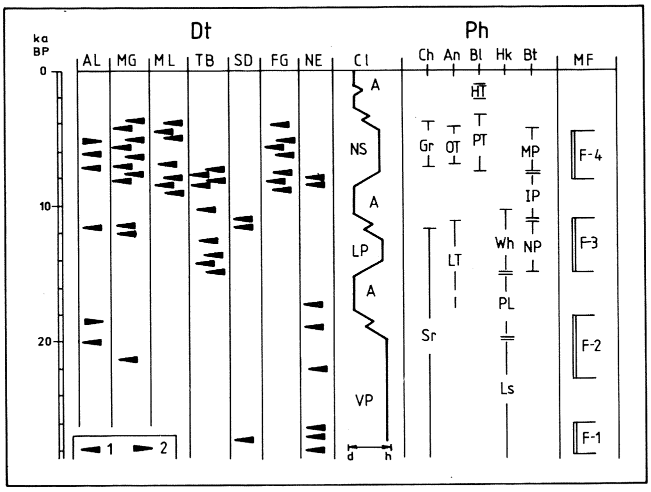

Fig. 5. Changes of the malacofauna and environment during the last thirty thousand years. kaBP – age in thousand years, **Dt** – radiocarbon dating of sediments and mollusc assemblages: AL – Algeria, MG – Maghreb, ML – Mali, TB – Tibesti Mts., SD – Sudan, EG – Egypt, NE – Near East, *1* – data published by different authors, *2* – data from Wadi Bechar; Cl – changes of the climate: d – dry conditions, h – humid conditions, VP – Vistulian Pluvial, LP – Late Vistulian Pluvial, NS – Holocene Puvial (Neolithic Subpluvial), A – arid interpluvials; **Ph** – phases of deposition, Ch – Chavaillon (1964): Sr – Saourien, Gr – Guirien; An – Andres (1977): LT – Loam Terrace, OT – Oasis Terrace; BL – Ballois (1995): PT – Prehistoric Holocene Terrace, HT – Historic Holocene Terrace; Hk – Huckriede & Wiesemann (1968): Ls – Lisan, PL – Postlisan, Wh – humid phase of Würm (Vistulian); Bt – Böttcher *et al.* (1972): NP – Vistulian Pluvial, IP – interpluvial, MP – Neolithic Subpluvial; MF – mollusc fauna: F-1 – F-4 - mollusc assemblages from particular humid phases

The next interpluvial representing the period of desertification lasted 2–3 thousand years during the termination of Vistulian and the lowermost Holocene. It was followed by the humid period distinguished as the Holocene Pluvial or the Neolithic Subpluvial (Fig. 5, NS). It corresponds with the Boreal Phase, the climatic optimum (Atlantic Phase) and a part of the Subboreal Phase of the Holocene. The climate was considerably warmer than during the preceding pluvials and therefore the flora and fauna were composed only of African and Mediterranean species, without Holarctic/Palearctic ones. Assemblages of molluscs containing the mentioned groups of taxa have been found in the lower terrace of Wadi Bechar as well as in Holocene terraces and lacustrine sediments in other localities (Fig. 5, F-4).

The last phase of desertification arrived about three thousand years ago and continues till now. Episodes of increased watercourses activity leading to the aggradation of valley bottoms were reported from Maghreb. In Tunisia sediments with shells of molluscs and pottery form two terraces dated at the preceding and the current millennium (Ballois, 1995).

The relation between pluvials/interpluvials and phases of glaciation divided by warming of the climate as well as the related migration of mollusc species were discussed by Butzer (1959), Sparks & Grove (1961), Fairbridge (1965), Böttcher *et al.* (1972), Horowitz (1979), Petit-Maire (1991) and other authors. The analysis of mollusc assemblages found in the dated deposits of Wadi Bechar and their relation to other mentioned data lead to the following suggestions.

1. The main pluvial (Vistulian Pluvial) corresponds with the interpleniglacial of the Vistulian since the Denecamp Interstadial till the beginning of the last pleniglacial. In turn the maximum extension of the ice sheet in Northern and Central Europe was synchronous with the arid phase between two pluvials noted in Northern Africa and in Near East.

2. The following humid period distinguished as the second phase of the pluvial (Late Vistulian Pluvial) can be attributed to warm and cold interphases of the Late Glacial since the Old Dryas till the Alleröd. Changes of the climate at the Pleistocene/Holocene boundary can be correlated with the relatively dry climate, clearly expressed in Africa.

3. The Holocene Pluvial (the Neolithic Subpluvial) corresponds with the Atlantic Phase while the deterioration of climatic conditions in Europe during Subboreal and Subatlantic Phases passed parallel to the progressive desertification of Sahara and Near East.

4. During Vistulian pluvials (VP and LP) a considerable part of Sahara was covered with vegetation, characterised by an admixture of Holarctic plants (Lauer & Frankenberg, 1979) and inhabited by a mollusc fauna composed of African and Mediterranean species as well as Holarctic/Palearctic ones, migrating from Europe southward. The last mentioned taxa turned back to the north with progressing aridization of the climate.

5. The Holocene (Neolithic) Pluvial expressed by increased humidity brought ecological conditions favourable for molluscs living in the subtropics but not acceptable for species connected with the zone of the temperate climate.

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Streszczenie

PÓŹNOCZWARTORZĘDOWE OSADY ZAWIERAJĄCE FAUNĘ MIĘCZAKÓW Z BECHAR (ALGERIA)

Stefan Witold Alexandrowicz

Jeziorne i rzeczne osady późnego czwartorzędu obfitujące w skorupki mięczaków były notowane w wielu stanowiskach na obszarze Północnej Afryki, Sahary i Bliskiego Wschodu. Wyniki datowań radiowęglem wskazują, że większość z nich wiąże się z okresem ostatnich trzydziestu tysięcy lat i charakteryzuje zmiany klimatyczne, następujące w kolejnych fazach pluwialnych i interpluwialnych. Charakterystyczne zespoły subfosylnej malakofauny zostały znalezione przez autora w terrygenicznych osadach, tworzących terasy uedu Bechar w pobliżu miasta o tej nazwie (Fig. 1). W dolnych częściach profilów opisanych z 7 odsłonięć osady te są wykształcone jako żwiry, żwirowce piaszczyste i zlepieńce, natomiast w ponad nimi występują piaski średnio- i gruboziarniste, lokalnie spojone węglanem wapnia, przekładane mułkami piaszczystymi i marglistymi. W odsłonięciach 1–4 oraz w odsłonięciu 5 reprezentują one starszą terasę uedu o wysokości 4–6 m a nawet 6–8 m natomiast w odsłonięciach 6 i 7 tworzą terasę młodszą, wznoszącą się 2–3 m ponad dno suchej doliny (Fig. 2). Wiek tych osadów został określony na podstawie datowania metodą radiowęgla skorupek ślimaków z odsłonięć 3 i 7, a uzyskane wyniki są następujące: osady budujące terasę wyższą, zaliczone do saorienu – 18500 ± 300 lat BP (Gd-2145); osady budujące terasę niższą, zaliczone do guirienu – 5 140 ± 130 lat BP (Gd-2144).

Analiza malakologiczna objęła 15 próbek, w których uzyskano ponad 1300 skorupek i ich oznaczalnych fragmentów, reprezentujących 16 gatunków ślimaków lądowych, 14 gatunków ślimaków wodnych i dwa taksony małżów, zidentyfikowane do rangi rodzaju (Tab. 1). Spektra malakologiczne zostały zestawione z uwzględnieniem trzech grup ekologicznych: O – ślimaki preferujące siedliska otwarte a nawet kserotermiczne, H – ślimaki typowe dla siedlisk wilgotnych, W – mięczaki wodne (Fig. 3, MS). Dendrogram taksonomiczny wskazuje, że cały opracowany zbiór zespołów rozdziela się na dwie grupy próbek (Fig. 3, Dn). Najbogatsza fauna występuje w osadach z profilów 1–4 (terasa starsza, zaliczona do saorienu). Licznie reprezentowane są tu ślimaki wodne z gatunków *Melanopsis praemorsa* i *Bulinus truncatus* oraz ślimaki lądowe – *Vallonia pulchella* i *Oxyloma elegans*. Wyłącznie w tym zespole występują: *Carychium minimum*, *Vertigo antivertigo*, *Vallonia enniensis*, *Gyraulus echrenbergi* i *Helicella hoggarensis*. Podobny zespół mięczaków charakteryzuje osady z odsłonięcia 5, a odznacza się on obecnością *Valvata tilhoi* i *Hauffenia tellini*. Fauna z osadów młodszej terasy, reprezentującej guirien, jest mniej bogata a odznacza się ona obecnością *Zebrina detrita* i *Coleatura* sp.

Zasięg geograficzny taksonów znalezionych w osadach czwartorzędowych uedu Bechar pozwala na wyróżnienie trzech grup mięczaków: A – gatunki afrykańskie, M – gatunki śródziemnomorskie, N – gatunki holarktyczne i palearktyczne, żyjące obecnie w Europie. Udziały taksonów reprezentujących te grupy w osadach wyższej i niższej terasy są różne (Fig. 4). W zespole fauny saorienu zawartość gatunków afrykańskich oraz holarktyczno-palearktycznych jest zrównoważona a proporcja A/N przyjmuje wartości 0,62–1,27, natomiast w zespole fauny guirienu gatunki afrykańskie zdecydowanie przeważają, co wyraża się wartościami wskaźnika A/N, zawartymi w przedziale 6,11–7,38. Udział składnika śródziemnomorskiego w obu faunach jest niemal ustabilizowany (Fig. 4).

Badania malakologiczne osadów reprezentujących ostatnie 30 tysięcy lat, występujących w północnej Afryce i na Bliskim Wschodzie pozwoliły na wyróżnienie czterech typów zespołów fauny, związanych z okresami, w których panowały warunki sprzyjające rozwojowi mięczaków (Tab. 2). Fauny te zostały znalezione w sedymentach deponowanych w przedziałach czasu odpowiadających fazom pluwialnym, a zostały one określone symbolami: F-1, F-2, F-3 i F-4. Zespoły mięczaków opisane z osadów uedu Bechar odpowiadają faunom F-2 i F-4. Gatunki holarktyczne i palearktyczne występują w asocjacjach wyróżnionych jako F-1, F-2 i F-3, natomiast brak ich w asocjacji F-4. Wymienione cztery okresy depozycji osadów zawierających skorupki mięczaków mają klimatyczne uwarunkowanie i są równowiekowe ze wzrostem aktywności procesów fluwialnych oraz z rozszerzaniem się jezior (Fig. 5). Okres pluwialny odpowiadający ostatniemu zlodowaceniu (w szczególności jego młodszej części) jest dwudzielny. Jego pierwsza faza, określona jako pluwiał przypadający na plenivistulian, zawiera się w przedziale wiekowym (35000) 30000–19000 lat BP, a faza młodsza (pluwiał późnego vistulianu) odpowiada okresowi 15000–11000 lat BP. Ostatni okres pluwialny przypadający na środkową część holocenu, wyróżniany jako subpluwiał neolityczny, zamyka się w przedziale czasu 9000–5000 lat BP (Fig. 5).

Wyniki analizy malakologicznej osadów późnoczwartorzędowych z ouedu Bechar, nawiązane do danych opisanych przez różnych autorów, pozwalają na sformułowanie następujących wniosków:

1. główny okres pluwialny odpowiadający górnemu vistulianowi trwał od interstadiału denekamp po początek ostatniego pleniglacjału;
2. drugi okres zwilgocenia klimatu odpowiada schyłkowi vistulianu (starszy dryas – alleröd);
3. pluwiał (subpluwiał) neolityczny był związany z fazą atlantycką holocenu;
4. podczas trwania pluwiałów vistuliańskich znaczna część Sahary była pokryta roślinnością, odznaczającą się domieszką gatunków holarktycznych, a ten sam element biogeograficzny jest reprezentowany w zespołach mięczaków;
5. warunki klimatyczne panujące w czasie trwania pluwiału neolitycznego sprzyjały gatunkom afrykańskim i śródziemnomorskim, eliminowały jednak możliwość rozwoju faun holarktycznych.