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 Chevalier (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
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 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 Chavallon (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 (lastruntrine and fluvialite facies). They alternate with eolian-fluvialite sand of Saourien I, III and V. The lower level
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.

MALACOFUANA

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 tilhii, Hauffenia tellini, Lymnaea palustris, Euconeus fulvis). The most numerous are water snails: Melanopsis praemorsa, Bulinus truncatus, Galba truncatula, and land snails: Vallonia pulchella, Oxylyma elegans.

The occurrence of species connected with quite different habitats is an important feature of described assemblages (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 thanatocenes, either allocenes or mixocenes (Alexan-

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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

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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-soil 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 Bulimus truncatus accompanied by Galba truncatula, Lymnaea natalensis, Vallonia pulchella and Oxylyma 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 antvertigo, 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 cristata, Oxylyma elegans, Vallonia pulchella, Cecilioides acicula). The mentioned fauna is connected with the upper part of the Saourien terrace.

Malaco fauna 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 detrata and Coleautra sp. (? Coleautra 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).

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

1. Melanopsis tingitana (Morelet), M. maroccana (Cheïnitz), M. dufouri Ferussac, M. marais (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. Bulimus contortus (Michaux) is a local form of Bulimus truncatus (Audouin) distinguished in Maghreb and in Iberian peninsula (Brown 1980), mentioned from NW Sahara by Chavaillon (1964).

3. Cochlicella barbar (Linnaeus) found by Pally (1924) in the Pleistocene deposits of Wadi Bechar.

4. Otala baeloni (Debeaux) described by Pally (1924) and Cheavallier (1969).

The geographical range of the mentioned species is quite varied (Ehmann, 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 dailoni, Gyraulus ehrenbergi, Planorbis mediterran, Bulimus truncatus, Ferrisia isseli, Pupoides coenopicus, Helicella hogarensis, Helicella lamomini and Otala ceardii. The Mediterranean–South-European group (M) is represented by 9 taxa: Valvata tilhoi, Hauffenia tellini, Melanopsis praemorsa, Granupupa granum, Vallonia enniensis, Zebrina detrata, Cecilioides acicula, Ruminia decollata and Thinenterricholita candidissima. Some of them are connected more with the African fauna (Valvata, Melanopsis, Thinenterricholita) 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 cristata, Ancylus fluviatilis, Oxyyla 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 Holartic/Palaearctic 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 Holartic/Palaearctic 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 Jafar Depression in Jordan, attributed to the Lisan period, in sediments accumulated 28000–26000 years ago (Huckriede & Wiesemann 1968). It comprises Palaearctic species: Lymnaea palustris, Lymnaea truncatula, Vallonia cf. costata and Pisidium casertanum, Atlantic/Mediterranean species – Vertigo molinensis and African species – Melanopsis tuberculata. The absence of Ethiopian snails (Biophammeria, Bulinus) is noteworthy.

Holarctic/Palaearctic 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 cristata, Acroloxus lacustris, Oxyyla 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, besides other species of the Holarctic/Palaearctic 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 bulboides, Melanoides tuberculata, Gyraulus costulatus, Segmentorbis angustus) accompanied by a Palaearctic 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, Biophammeria pfeifferi, Segmentorbis angustus, Bulinus truncatus, Lymnaea natalensis, and by land snails: Popoides coenopicus, Zootectus insularis. The admixture of the following Holarctic/Palaearctic molluscs is noteworthy: Armiger cristata, Lymnaea truncatula, Oxyyla elegans, Cochlicopa hibrina, 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; Huckriede, 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 bulboides, Lymnaea natalensis, Gyraulus ehrenbergi, Biophammeria 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, Biophammeria, Bulimus). 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, Biophammeria pfeifferi, Sinterochila candidissima, Helix melanostoma and Eobania vermiculata. The fauna is completely devoid of Holarctic/Palaearctic species. Similar but richer assemblages have been reported from Holocene fluvialite deposits of Algeria, found in the lower terrace in Guir Valley and in Saouara Valley (Chavailleon, 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 fluvialite 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 interplenivis tulian 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 as 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, CI).

The pluvial corresponding with the last glaciation is bi-partite and can be attributed to the Upper Vistulian (Upper Würm). The older part of this pluvial (Pleist-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](image-url) 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, / - data published by different authors, 2 - data from Wadi Bechar, CI - changes of the climate: d - dry conditions, h - humid conditions, VP - Vistulian Pluvial, LP - Late Vistulian Pluvial, NS - Holocene Pluvial (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; H: Ls - Lisan, PL - Postlisan. Wh - humid phase of Würm (Vistulian); Bt - Böttcher et al. (1972); NP - Vistulian Pluvial, IP - interpluvial, MP - Neolithic Subpluvial; MP - 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 aggravation 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 interpleniaglacial of the Vistulian since the Deneburg Interglacial till the beginning of the last pleniaglacial. 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 a admixture of Holarctic plants (Lauer & Frankenber, 1979) and inhabited by a mollusc fauna composed of African and Mediterranean species as well as Holarctic/Paleartic 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.

REFERENCES


Streszczenie

PÓZNOCZWARTORZEDOWE OSADY ZAWIERAJĄCE FAUNĘ MIĘCZAKÓW Z BECHAR (ALGERIA)

Stefan Wtold Alexandrowicz

Jeziornie i rzeczne osady późnego czwartorzędu obfitujące w skorupki mięczaków były notowane w wielu stanowiskach na obszarze Północnej Afryki, Sahary i Bliskiego Wschodu. Wyniki doświadczeń radiowegiem wskazują, że większość z nich wiąże się z okresem ostatnich trzynastu tysięcy lat i charakteryzuje zmiany klimatyczne, następujące w kolejnych fazach pluwalnych i interpluwalnych. Charakterystyczne zespoły subfosylnych malakofaun zostały znalezione przez autorów w terenygenicznym obszarze, tworzącym terasy uchu Bechar w pobliżu miasta o tej nazwie (Ryc. 1). W dolnych częściach profilu opisanych z 7 odsłonięć osady te są wykształcone jak zywy, zwierzęce piaszczyste i zlepieńce, natomiast w ponad nimi występują piaszczysto-gruboziarniste, lokalnie spojone węglanem wapnia, przekładane mulkami piaszczystymi i marnistymi. W odsłonięciu 1–4 oraz w odsłonięciu 5 reprezentują one starszą terasę uchu o wysokości 4–6 m a nawet 6–8 m natomiast w odsłonięciu 6 i 7 tworzą terasę młodszą, wznoszącą się 2–3 m ponad dno suchej doliny (Ryc. 2). Wiek tych osadów został określony na podstawie datowania metodą radiowęglów skorupek ślimaków z odsłonięcia 3 i 7, a uzyskane wyniki są następujące: osady budujące terasę wyższą, zaliczone do saarioen – 18500 ± 300 lat BP (Gd-2145); osady budujące terasę niższą, zaliczone do guirien – 5140 ± 130 lat BP (Gd-2144).

Analiza malakologiczna objęła 15 próbek, w których uzyskano ponad 1300 skorupek i ich oznaczanych fragmentów, reprezentujących 16 gatunków ślimaków ludowych, 14 gatunków ślimaków wodnych i dwa taksony malakofaun. Zidentyfikowane do rangi rodzaju (Tab. 1) Spektrum malakologiczne zostały zestawione z uwzględnieniem trzech grup ekologicznych: O – ślimaki preferujące siedliska otwarte a nawet kserotermiczne, H – ślimaki typowo dla siedlisk wilgotnych, W – mięczaki wodne (Fig. 3, MS). Dendrogram taksonomiczny wskazuje, że cały opracowany zbiór zwojów rozdziela się na dwie grupy próbek (Fig. 3, Dn). Najboczná fauna występuje w osadach z profilów 1–4 (towarzy starań, zaliczona do saarioen). Licznie reprezentowane są tu ślimaki wodne z gatunków Melanopsis praenorsa i Bulinus truncatus oraz ślimaki lądowe – Vallonia pulchella i Oxyloma elegans. Wyłączne w tym zespole występują: Carchylium minimum, Ferrigo antvergina, Vallonia enniensis, Gyraulus echenbergi i Helicella hoggurensis. Podobny zespół mięczaków charakteryzuje osady z odsłonięcia 5, a odnosi się on obecnością Felosa tilhoi i Haniffia tellina. Fauna z osadów młodszej terasy, reprezentującej guirien, jest mniej bogata a odnosi się ona obecnością Zebrina detrita i Coelastria sp. Zasięg geograficzny taksonów znalezionych w osadach czwartorzędowych uchu Bechar pozwala na wyróżnienie trzech grup mięczaków: A – gatunki afrykańskie, M – gatunki środziemnomorskie, N – gatunki holarktyczne i palearktyczne, żyjące obecnie w Europie. Udało się zauważyć, że w niedawnych warunkach doznało taksonów reprezentujących te grupy w osadach wyższych i niższych terasy są różne (i Fig. 4). W zespole fauny saarioen zawartość gatunków afrykańskich oraz holarktyczno-palearktycznych jest zróżowana, co oznacza że w „A/N” przyjmuje wartości 0,62–1,27, natomiast w zespole fauny guirien gatunki afrykańskie zdobywają nadzorem, co wyraża się wartością wskaźnika A/N, zawsze w przedziale 6,11–7,38. Udał składniki śródziemnomorskiego w obu faunach jest niemal ustabilizowany (Fig. 4).

Badania malakologiczne osadów reprezentujących ostatni 30 tysięcy lat, występujących w późnej Afryce i na Bliskim Wschodzie pozwoliły na wyróżnienie czterech typów zwojów fauny, związanych z okresami, w których panowały warunki sprzyjające rozwojowi mięczaków (Tab. 2). Fauny te były znane w sedimentach deponowanych w przedziale czasu odpowiadających fazom pluwalnym, a zostały określone na podstawie wielkości, długości, szerokości skorupek ślimaków. Zespoly mięczaków opisane z osadów uchu Bechar odpowiadają faunom F-1 i F-4. Gatunki holarktyczne i palearktyczne występują w obszarach zróżowanych jako F-1, F-2 i F-3; natomiast F-2 i F-3, natomiast brak ich w obszarach F-4. Wymienione cztery okresy depozycji osadów zawierających skorupki mięczaków mają klimatyczne uwarunkowanie i są równowagowe ze względem aktywności procesów pluwalnych oraz z rozszarpaniem się niej (Fig. 5). Okres pluwalny odpowiadający ostatnim 15000–11000 lat BP. Ostatni okres pluwalny przypadający na środkową część holocenu, zauważyć można w przedziale czasu 9000–5000 lat BP (Tab. 3).

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

1. Główny okres pluwalny odpowiadający górnemu wspinaniu trwał od interstadiów denekamp po początkach ostatniego pleniglacialu;
2. drugi okres zwilgocenia klimatu odpowiada schwykowym wstępnym (starszy dryas – allerød);
3. pluwalny (subpluwalny) neolityczny był związany z fazą altymacką holocenu;
4. podczas trwania pluwialny wspinia się zaczynając od południowego wzniesienia Sahary była pokryta roślinnością, oznaczającą się domieszką gatunków holarktycznych, a ten sam element biogeograficzny jest reprezentowany w zespołach mięczaków;
5. warunki klimatyczne panujące w czasie trwania pluwalnego neolitycznego sprzyjały gatunkom afrykańskim i śródziemnomorskim, eliminowały jednak możliwość rozwoju gatunków holarktycznych.