

Annales Universitatis Paedagogicae Cracoviensis

Studia ad Didacticam Biologiae Pertinentia II (2012)

Dany Azar

Lebanese amber: a “Guinness Book of Records”

Introduction

Amber, a fossil vegetal resin renowned as being a splendid material for the conservation of biological inclusions in their minute 3-D details, occurs all over the world. During the last 15 years, known outcrops of amber have increased significantly in number, due to the growing scientific interest in such material. There is no doubt that “Jurassic Park” of 1993, the famous American science fiction adventure thriller directed by Steven Spielberg, and based on the novel of the same title by Michael Crichton, played a noticeable role in making amber more popular. Before this date, interest in amber was mainly restricted to Baltic and Caribbean countries, though amber occurrence was recognized from several localities worldwide. Amber is a gold mine for the palaeontologists as it contains a variety of biological inclusions in pristine, three-dimensional conditions (Poinar 2003).

The age of amber ranges from a few million to 320 million years (Mid Carboniferous) (Sargent Bray & Anderson 2009), but to date, the oldest one with intensive biological inclusions is the Lebanese one (Azar 1997a,b, 2000, 2007, Azar & Nel 1998; Azar *et al.* 2010; Poinar & Milki 2001; Grimaldi & Engel 2005). More than 375 outcrops have recently been discovered in Lebanon after intensive geological field research conducted in the last decade. Curiously, among these discoveries, only 21 outcrops yield biological inclusions (Figure 1).

Historical

Lebanon officially joined the club of the countries with fossil insect localities in 1888, when H. J. Kolbe described the trace of an insect larva (to which he gave a scientific name) in fossil wood from the Late Santonian lithographic limestone of Sahel Alma. Anton Handlirsch later (1906–1908) changed the name of the insect that is supposed to have made this trace. Of course, in present day naming an insect only after its trace seems unreasonable. The outcrop of Sahel Alma is worldly known for its fossil fishes, and the oldest written evidence of this site dates back to the 4th century AD, when Eusebius of Caesarea (*circa* 263–339 AD) (often called Eusebius Pamphili), the bishop of *Caesarea Palaestina*, recalled these mysterious

stones found in Lebanon and considered them the witnesses of the Deluge. The most famous mention of this site probably appears in the writings of Jean de Joinville (1224–1317 AD) – one of the great chroniclers of medieval France – who reported how a fossil fish was presented to king Louis IX (Saint Louis) (1214–1270) during one of his crusades to the Middle East.

Concerning the amber and the insects trapped inside, the oldest publications describing insects are those of Willi Hennig and Dieter Schlee, both in 1970. Prior to 1994, only one amber outcrop with fossil insects had been known. Recent field research of my team increased the amber localities with biological inclusions to 21.

Phoenicians were probably the first tradesmen of amber in the Mediterranean (McDonald 1940) and also the pioneers of the amber maritime route towards the shores of Northern Europe (Baltic area) to obtain the golden fossil resin in exchange of bronze between 13th and 16th century BC. According to some authors, basing on recent archaeological discoveries, amber was collected in Phoenicia (today Lebanon, Syrian coast and Northern Israel) and marketed in the Middle East by Phoenicians until the Baltic amber, which is of better gemological quality, became available (Williamson 1932, Nissenbaum 1975).

The mythical foundation of the ancient metropolis of Tyre (Southern Lebanon) is correlated to amber: it is believed that this biblical city was founded on two amber rocks (Figure 2).

The word “Lebanon” derives from “*Louban*”, which has two meanings: white, in relation to the Lebanese snowed mountains; and incense, in relation to cedars’ resin or perhaps to amber.

In the modern times, although the presence of amber in Lebanon has been documented several times since the beginning of the 19th century (Desmarest 1811, Kastner 1831, Botta 1831, Brucchi 1842, Russegger 1843, Ritter 1854, Fraas 1876, 1878, John 1878, Cuinet 1896) and in the 20th century (Zumoffen 1926, Dubertret 1950, 1951, 1953, 1955), it is only late in the 1960s that fossil insects were recorded in this material (Schlee & Dietrich, 1970). As a matter of fact, people in Lebanon during the 18th and 19th century were not very interested in amber itself (for its bad gemological quality) but in coal as a source of energy. Amber was mentioned by the above 19th century authors occasionally, while describing the coal or lignite extractions in the mines. The first geological maps of Lebanon made by Botta, then by Russegger (Figure 3) had as an aim location of the lignite and iron mines in order to be exploited for the energy and industry.

In 1962, Aftim Acra (Figure 4), while leading a fossil hunting expedition in the mountains in Daher-El-Baydar (Central Lebanon), accompanied by his son Fadi (who was nine years old) and Raif Milki, found a piece of amber. Since that time until the seventies, they found several amber outcrops, including the well-known one, Jezzine (Jouar Ess-Souss), which was discovered at the same time and independently by a German expedition organized in years 1968–69. The German mission was carried out after M. Warth gave Willi Hennig (in 1967) some samples of amber from Jezzine (Southern Lebanon) kept in the Ludwigsburg collection in Stuttgart Museum. These samples were the remnants of the collection of Oscar Fraas (Figure 5), a German geologist (1824–1897), who was invited by Rustem Pasha (Rustem Mariani 1810–

1885) (Figure 6) the Italian governor of Mount Lebanon (1873–1883), to study the geology in order to find coal mines.

From 1994 till the present day, Raymond Gèze, Kamil Ziadé and I found more than 350 amber deposits ranging from Late Jurassic to Cenomanian period.

Amber outcrops with fossil insects in Lebanon

Amber in Lebanon is found in more than 350 outcrops in all its area, among which 21 yielded fossiliferous amber (Table 1). Land that could potentially yield amber findings is estimated to make up even 10% of Lebanon's total surface (Figure 1).

Tab. 1. The different outcrops of amber with biological inclusions

Governorate	District	Outcrop	Number of inclusions
North Lebanon	<i>Sir Ed-Danniyeh</i>	<i>El-Dabsheh</i>	~ 250
		<i>Brissa</i>	~ 100
	<i>Bcharreh</i>	<i>near Bcharreh</i>	~ 1000
		<i>Beqaa Kafra</i>	6
		<i>Hadath El-Joubbeh - Tannourine</i>	~ 5
<i>El-Batroun</i>	<i>Tannourine</i>	47	
Mont Lebanon	<i>Kesserouan</i>	<i>Ouata El-Jaouz</i>	6
	<i>El-Matn</i>	<i>Daychouniyyeh</i>	11
	<i>Baabda</i>	<i>Kfar Selouan</i>	69
		<i>Mdeyrij-Hammana</i>	3165
	<i>Esh-Shouf</i>	<i>Ain Dara (two localities)</i>	130
		<i>Ain Zhalta</i>	20
<i>Aley</i>	<i>Sarhmoul</i>	29	
South Lebanon	<i>Jezzine</i>	<i>Roum – Aazour - Homsiyeh</i>	37
		<i>Jouar Es-Souss (Bkassine)</i>	~ 3000
		<i>Wadi Jezzine</i>	~ 20
		<i>Maknouniyeh</i>	14
Beqaa	<i>Baalbeck</i>	<i>Esh-Sheaybeh</i>	22
	<i>Zahleh</i>	<i>Bouarij</i>	220
	<i>Rashaiya</i>	<i>Aita El-Foukhar</i>	1

Geological settings

Amber in Lebanon is found in lenses of dark clay and shale associated with lignite and plant debris, sometimes in purely fluvial deposition system, i.e. in channels, or riversides, and sometimes the deposition is subject to marine influences, i.e. in a deltaic zone, or on the littoral (in the intertidal area). In fluvial cases, no palynomorphs of marine origin are found and amber deposition could mainly occur after storms, while several types of dinoflagellates and marine gastropods are incorporated into the sediments when the deposition undergoes marine influence.

Lebanese amber is often buried in its primary deposit, with lignite and fossil leaves from the resin producing tree (Figures 7–8). When transported, it is for short distances, as confirmed by the exceptional preservation state of the palynomorphs.

Till now, about 8500 biological inclusions (mainly insects) have been found in the amber from different Lebanese outcrops, in less than 10 kg of amber that had been screened for inclusions, and still more than 250 kg waits to be studied.

The age of Lebanese amber ranges from Late Jurassic to Albian. The fossiliferous outcrops have nearly the same age, *viz.* Late Barremian to Early Aptian (Azar 2007, Azar *et al.* 2003, 2010, 2011). This fact is confirmed by the presence of the same entomofauna in the different fossiliferous outcrops (see appendix table 1). The different aspects of biological inclusions in the amber and their significance, discussed herein, are true for any kind of amber. However, this paper deals more specifically with the inclusions from the Lebanese resources.

Lebanese amber inclusions

The most fascinating aspects of the Lebanese amber are the abundance and the outstanding preservation of the biological inclusions. In addition, the Lebanese amber is considered by most scientists to be the most important one, as it belongs to the Lower Cretaceous age, the time of appearance of flowering plants (Angiosperms) – which is a major event in the evolution – as angiosperms constitute today more than 3/4 of world flora. While the relationship between terrestrial arthropods (especially insects) and plants is so close, it is normal that, if we want to understand the origin of all recent and modern ecosystems, we have to go back to the epoch of their starting point, which is the Lower Cretaceous. Moreover, there are no extensive terrestrial fossil records that correspond to this era, except the Lebanese amber, which increases considerably the uniqueness of this material.

Inclusions could be found in Lebanese amber every 25 to 30 pieces. This amber rarely includes vertebrate remains (one lizard *Baabdasaurus xenorus* Arnolds *et al.*, 2002 (Figure 9), some reptile exuviae skin and few feathers (Figure 10) (Schlee 1973, Schlee & Glöckner 1878), but numerous arthropods and vegetal remains trapped while the resin exudation was fluid. A pupillid snail has been also found in the Lebanese amber and is considered as the earliest one (Figure 11) (Roth *et al.* 1996). Among arthropods, insects are largely dominant and most of the orders are represented (see appendix table 2) (19 orders: Archaeognatha, Blattodea (Figure 12), Coleoptera (Figure 13), Collembola, Dermaptera (Figure 14), Diptera (Figure 15), Ephemeroptera, Hemiptera (Figures 16, 17), Hymenoptera (Figure 18), Isoptera (Figure 19), Lepidoptera (Figure 20), Mantodea, Neuroptera (Figure 21), Odonata, Orthoptera, Psocodea (Figure 22), Thysanoptera (Figure 23), Thysanura, Trichoptera). To date 177 taxa were created from the Lebanese amber, including 165 insects, 8 arachnids (Figures 24–26) (see appendix table 2), other inclusions are still waiting their identification.

A single piece of amber can contain one or several inclusions. Some of those that are found alone may provide important indirect hints of other organisms' presence, or reflect a specific habitat or palaeogeography. Regarding the specimens where several inclusions (or syninclusions) are found together, some of them are present only in a hazardous manner, but a considerable number of them are assembled for an ecological behaviour such as mating (Figure 27) or parasitism (Figure 28) etc.

In general, when the amber is in its primary deposition site, the inclusions are almost contemporaneous, while when the amber deposit has been reworked, the

amber inclusions could have several ages. The inclusions found in a piece of amber are trapped mostly at the same time with a difference of very few days or weeks, depending on each flow of resin.

As is the case with other amber, there are size and habitat limitations on the types of organisms that can be trapped in Lebanese specimens. Some arthropods that are specific to certain hosts can provide clues to other organisms that existed at that time. Engel & Grimaldi (2006) described recently a sclerogibbid wasp (*Sclerogibbodes embioleia* Engel & Grimaldi 2006). Sclerogibbidae are obligate parasitoids of webspinners (Embioptera), and thus the recovery of this lineage from the Lebanese amber implies that webspinners were probably present in the palaeofauna. Another example is the presence of the Acari of the family Smarididae, which are generally parasites of Psocids, relatively well represented in the Lebanese amber. This situation is also the case of most of the parasitoids or parasites present in the Lebanese as in any amber; it simply indicates that some trophical specialization and relationship were most likely already established.

Some inclusions can provide indirect evidence of specific habitats, or climate. For example, chironomids (very common and diversified Diptera in the Lebanese amber), limonids, tipulids and psychodid flies, caddisflies (Trichoptera) provide evidence of aquatic or very humid habitats. In general, most of the Lebanese amber inclusions reflect a hot, dense and humid forest environment. The information given by the whole inclusions corroborate the data set by palynology: the palaeoenvironment of the amber deposits corresponds to a tropical, dense, warm and humid forest with an intense complex fluvial system, altogether close to the sea (Figure 29). In addition, most of the fauna entombed in the Lebanese amber is the one living on the lower- to mid-part of trees. This could be explained by the fact that this type of fauna has more chance to be trapped, since normally all the resin drops falling down from the tree pass inevitably and more frequently by this area. The study of the different inclusions allowed the reconstruction of the paleoenvironment (Figure 29).

Conclusion

Amber is a material that has always been fascinating and forever will be. It constitutes a wonderful 'natural time capsule', as termed by Ross (1998, 2010), and an original material that preserves not only superb biological inclusions in their pristine three-dimensional details, but also aspects of their mode of life and their ecology. Life forms' preservation in amber significantly increases our knowledge of the palaeobiodiversity, the palaeoenvironment, and the palaeoecology, and gives the amber the attribute, coined by Grimaldi (2003), of an exceptional „window to the past”.

Lebanese amber contains a lot of extinct families (some of them are known only from Lebanon) and the records of the oldest representatives of many modern families of terrestrial arthropods. Lebanese inclusions constitute most of the time the “missing links” between the old fauna and the modern one. The study of the Lebanese amber inclusions has been the only one so far that offers a clue in determining the North-East Gondwanian biodiversity and environment of the extremely significant Lower Cretaceous period. The recent discoveries of new, diverse outcrops of fossiliferous amber in Lebanon help to increase the possibility to meet the challenge of considerably enriching our knowledge of the Past.

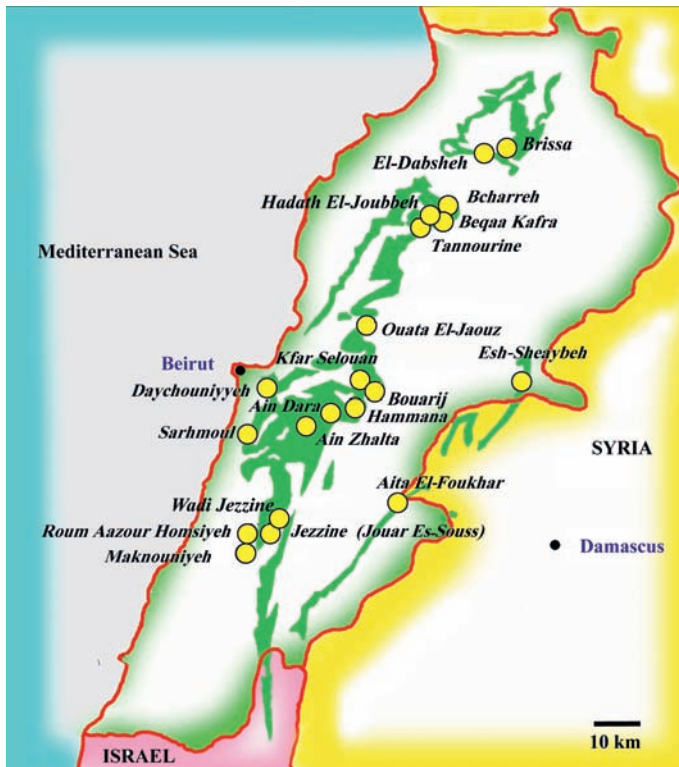


Fig. 1. Map of Lebanon with amber and fossil insects outcrops. Dark green areas indicate the distribution of the amber localities. Yellow circular spots indicate the emplacements of amber outcrops with insects' inclusions



Fig. 2. Roman coin (second century AD) representing the mythological foundation of the City of Tyre (in Southern Lebanon). *“From the beginning, the men lived here... I told them: Split the floods of the sea with your boats until reaching the chosen place to build your city. There you will find two floating rocks of amber tossed by the waves. Between them rises up an olive tree at the top of which perches an eagle. Tongues of fire escape from the tree. The olive tree burns but is not consumed. A typhoon is rolled up around the tree. Take the bird; offer it in holocaust to Poseidon God. Pour blood on the floating rocks. They will be immobilized, and will approach one the other*

to form only one island. Found a city in the heart of the sea. Fortify it from all sides. I told these divine words to the sons of this land”. These were the words of Melkart, the God founder of the city of Tyre to the God Bacchus



Fig. 3. Joseph Russegger



Fig. 4. Professor Aftim Acra (1922–2007), with his well known collection from the outcrop of Jouar Es-Souss (Jezzine)



Fig. 5. Oscar Fraas, a German geologist (1824–1897)



Fig. 6. Rustem Pasha (Rustem Mariani 1810–1885), the Italian governor of Mount Lebanon (1873–1883)



Fig. 7. Female cone of the amber producing plant



Fig. 8. Leaf of the amber producing plant

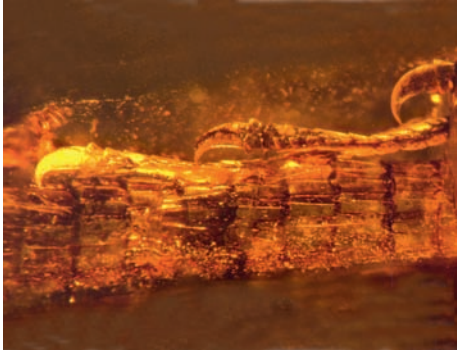


Fig. 9. *Baobdasaurus xenorus* Arnolds *et al.*, 2002.
The oldest reptile in amber

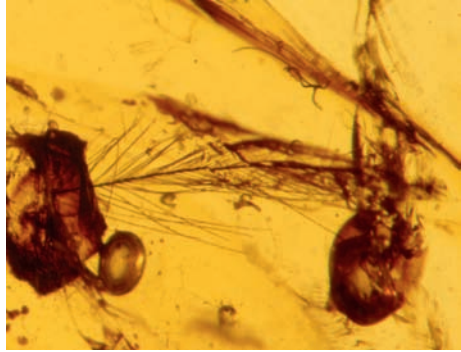


Fig. 10. The oldest feather in amber

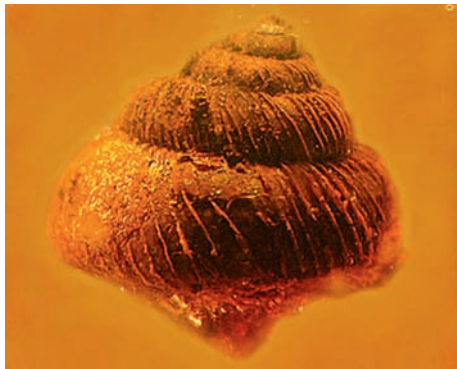


Fig. 11. The oldest pupillid snail



Fig. 12. A cockroach, the oldest in amber



Fig. 13. A coleopteran dermestid,
the oldest in amber

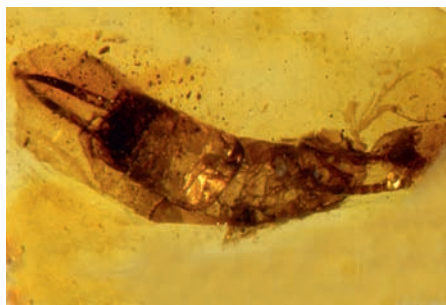


Fig. 14. *Rhadinolabis phoenicica* Engel, Ortega-Blanco & Azar, 2011, the oldest Dermaptera (Earwig) in amber



Fig. 15. A female dipteran ceratopogonid (biting midge), the oldest in amber



Fig. 16. *Enicocephalinus acragimaldii* Azar et al., 1999. The oldest assassin bug

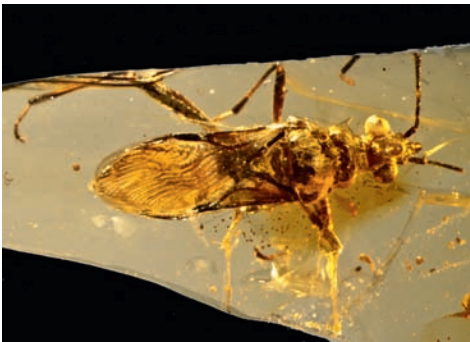


Fig. 17. *Yuripopovina magna* Azar et al., 2011, the unique representative of the pentatomomorphan extinct family of Yuripopoviniidae

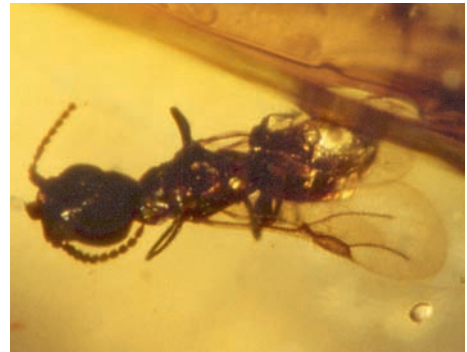


Fig. 18. A hymenopteran



Fig. 19. *Lebanotermes veltzae* Engel, Azar & Nel, 2011 in Engel et al., 2011, termite, the oldest social insect in amber



Fig. 20. A micropterigid moth, the oldest in amber



Fig. 21. *Raptorapax terribilissima* Petrolevičius, Azar & Nel, 2010, the oldest rhachiberotid neuropteran



Fig. 22. *Asphaeropsocites neli* Azar et al., 2010, the oldest sphaeropsocid psocodean



Fig. 23. The oldest thrips in amber



Fig. 24. *Archaeobuthus estephani* Lourenço, 2001. The oldest scorpion in amber



Fig. 25. The oldest liniphiid spider in amber



Fig. 26. The oldest Acari in amber



Fig. 27. Scatopsid flies *in cupulo*, the oldest preserved mating pair

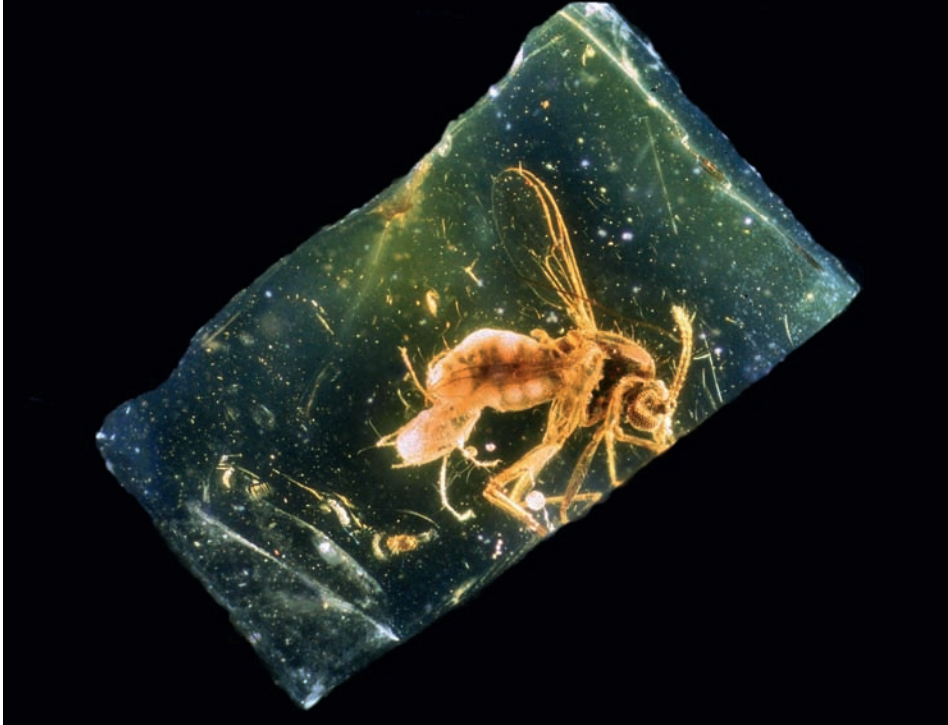


Fig. 28. A chironomid fly (non biting midge) parasitized by an Acari (on the abdomen)



Fig. 29. Reconstruction of the amber forest in Lebanon

Efforts are done to categorize this natural treasure on the list of Heritage of Humanity. The different Lebanese outcrops are not yet officially protected against vandalism. Their destruction or pillaging would be a great loss to the Human Heritage, and to the scientific knowledge.

Acknowledgements

I'm thankful to Dr hab. Katarzyna Potyrała and Dr hab. Robert Stawarz, from the Pedagogical University of Cracow, Poland, for their kind invitation to contribute to this special volume. This paper is a contribution to the project “Insects in the Lower Cretaceous Lebanese amber: taxonomy, palaeobiodiversity and evolution”, under cooperative agreements between the Lebanese University (Beirut); MIZ (Museum, and the Institute of Zoology), the Polish Academy of Sciences, Warsaw; the University of Gdansk; and the Polish Academy of Sciences, Cracow, in the project “Origin and evolution of biodiversity of Europe and Middle East”. It is also a part of the cooperative agreement between the Lebanese University and the Pedagogical University of Cracow. This paper is a contribution to the team project “Biodiversity: Origin, Structure, Evolution and Geology” awarded to the author by Lebanese University.

References

- Arnolds E. N., Azar D., Ineich I. & Ne, A., 2002, *The oldest reptile in amber: a 120 million year old lizard from Lebanon*, Journal of Zoology, London, 258, p. 7–10.
- Azar D., 1997a, *A new method for extracting vegetal and insect fossils from the Lebanese amber*, Palaeontology, 40, p. 1027–1029.
- Azar D., 1997b, *Lebanese Amber*, Meganeura, 1, 26–27.
- Azar D., 2000, *Les ambres mésozoïques du Liban*, Unpublished PhD thesis, Université Paris XI, Orsay, France.
- Azar D., 2007, *Preservation and accumulation of biological inclusions in Lebanese amber and their significance*, Comptes rendus – Palevol, 6 (1–2), p. 151–156.
- Azar D., Dejax J. & Masure E., 2011, *Palynological analysis of amber-bearing clay from the Lower Cretaceous of Central Lebanon*, Acta Geologica Sinica (English Edition), 85 (4), p. 942–949. DOI, 10.1111/j.1755-6724.2011.00497.
- Azar D., Engel M.S. & Grimaldi D.A., 2010, *A new genus of sphaeropsocid bark lice from the Early Cretaceous amber of Lebanon (Psocodea, Sphaeropsocidae)*, Annales de la Société Entomologique de France, 46 (1–2), p. 103–107.
- Azar D., Fleck G., Nel A. & Solignac M., 1999, *A new enicocephalid bug, Enicocephalinus acra-grimaldii, gen. nov., sp. nov., from the lower Cretaceous amber of Lebanon, (Insecta, Heteroptera, Enicocephalidae)*, Estudios del Museo de Ciencias Naturales de Alava, 14 (Número especial 2), p. 217–230.
- Azar D., Gèze R. & Acra F., 2010, Chapter 14, Lebanese amber pp. 271–298, [in:] D. Penney (Ed.), *Biodiversity of Fossils in Amber*, Siri Scientific Press.
- Azar D., Nel A., 1998, *Lebanese Lower Cretaceous amber*, Meganeura, 2, p. 18–20.
- Azar D., Nel A. & Gèze R., 2003, *Use of amber fossil inclusions in palaeoenvironmental reconstruction, dating and palaeobiogeography*, Acta Zoologica Cracoviensa, 46 (suppl. – Fossil Insects), p. 393–398.

- Azar D., Nel A., Enge, M.S., Garrouste R., Matocq A., 2011, *A new family of Coreoidea from the Lower Cretaceous Lebanese Amber (Hemiptera, Pentatomomorpha)*, Polish Journal of Entomology, 80, p. 627–644. DOI, 10.2478/v10200-011-0049-5
- Botta P.E., 1831, *Sur la Structure géognostique du Liban et de l'Anti-Liban*, Bulletin de la Société Géologique de France, 10, p. 234–239.
- Brucchi G.B., 1842, *Giornale delle osservazioni fatte ne viaggi in Egitto nella Siria e nella Nubia*, Bassano.
- Desmarest M., 1811, *Encyclopédie méthodique, ou par ordre de matières: par une société de gens de lettres, de savants et d'artistes*, Géographie Physique. Tome Quatrième, Agasse H. (Ed.), Paris.
- Cuinet V., 1896, *Syrie, Liban et Palestine, géographie administrative, statistique descriptive et raisonnée*, Leroux (ed.), Paris.
- Dubertret L., 1950, *Carte géologique au 1:50 000; Feuille de Djezzîne*, République Libanaise, Ministère des travaux publics, Beyrouth.
- Dubertret L., 1951, *Carte géologique au 1:50 000; Feuille de Beyrouth*, République Libanaise, Ministère des travaux publics, Beyrouth.
- Dubertret L., 1953, *Carte géologique au 1:50 000; Feuille de Zahlé*, République Libanaise, Ministère des travaux publics, Beyrouth.
- Dubertret L., 1955, *Carte géologique du Liban au 1:200 000*, République Libanaise, Ministère des travaux publics, Beyrouth.
- Fraas O., 1876, *Drei Monate am Libanon*, Levy & Müller (Eds), Stuttgart.
- Fraas O., 1878, *Geologisches aus dem Libanon*, Jahreshfte des Vereins für vaterländische Naturkunde in Württemberg, 34, p. 257–391.
- Engel M.S. & Grimaldi D.A., 2006, *The First Cretaceous Sclerogibbid Wasp (Hymenoptera: Sclerogibbidae)*, American Museum Novitates, 3515, p. 1–7.
- Engel M.S., Nel A., Azar D., Soriano C., Néraudeau D., Colin J.-P. & Perrichot V., 2011, *New, primitive termites (Isoptera) from Early Cretaceous ambers of France and Lebanon*, Palaeodiversity, 4, p. 39–49.
- Engel M.S., Ortega-Blanco J. & Azar D., 2011, *The earliest earwigs in amber (Dermaptera): A new genus and species from the Early Cretaceous of Lebanon*, Insect Systematics & Evolution, 42 (2), p. 139–148. DOI: 10.1163/187631211X555717
- Grimaldi D.A., 2003, *Amber: Window to the Past*, Abrams, H.N.(Ed.).
- Grimaldi D.A. & Engel M.S., 2005, *Evolution of the Insects*, Cambridge University Press.
- Handlirsch A., 1906–1908, *Die fossilen Insekten und die Phylogenie der rezenten Formen*, Leipzig.
- Hennig W., 1970, *Insektenfossilien aus der Unteren Kreide. 2. Empididae (Diptera, Brachycera)*, Stuttgarter Beiträge zur Naturkunde, 214, p. 1–12.
- John K., 1876, *Bernstein und Schraufit aus dem Libanon*, Verhandlungen der kaiserlich – königlichen Geologischen Reichsanstalt, Wien, 11, p. 255–257.
- Kastner K.W.G., 1831, *Archiv für die gesammte Naturlehre*, Vol. 21, Nürnberg.
- Kolbe H.J., 1888, *Zur Kenntnis von Insektenbohrungen in fossilen Holzern*, Zeitschrift der deutschen geologischen Gesellschaft, p. 40, p. 131–137.
- Lourenço W.R., 2001, *A remarkable scorpion fossil from the amber of Lebanon. Implications for the phylogeny of Buthoidea*, Comptes Rendus de l'Académie des Sciences, 332, p. 641–646.

- McDonald L.S., 1940, *Jewels and Gems*, Thos. Y. Crowell Company (Ed.), New York.
- Nissenbaum A., 1975, *Lower cretaceous amber from Israel*, *Naturwissenschaften*, 62 (7), p. 341–342.
- Petrolevičius J.F., Azar D. & Nel A., 2010, *A new thorny lacewing (Insecta: Neuroptera: Rhachiberothidae) from the Early Cretaceous amber of Lebanon (Neuroptera)*, *Acta Geologica Sinica (English Edition)*, 84 (4), p. 828–833.
- Poinar G.O.Jr., 2003, *Amber*, [in:] V.H. Resh, R.T. Cardé (Eds.), *Encyclopedia of Insects*, Academic Press, p. 9–12.
- Poinar G.O.Jr. & Milki R., 2001, *Lebanese Amber*, Oregon State University Press, Corvallis.
- Ritter C., 1854, *Die Erdkunde von Asien*, Vol. VIII, pt. 2, section 3, *Die Erdkunde im verhältniss zur Natur und zur Geschichte des Menschen Oder allgemeine vergleichende Geographie, als sichere Grundlage des Studiums und Unterrichts in physikalischen und historischen Wissenschaften*, Berlin.
- Ross A.J., 1998, *Amber: The Natural Time Capsule*, Natural History Museum, London.
- Ross A.J., 2010, *Amber: The Natural Time Capsule*, Natural History Museum, Earth Science Publications, London.
- Roth B., Poinar G.O. Jr., Acra A. & Acra F., 1996, *Probable pupillid land snail of early Cretaceous (Hauterivian) age in amber from Lebanon*, *Veliger*, 39, p. 78–79.
- Russeger, J. (1843). *Reisen in Europa, Asien und Afrika besonderer Rücksicht auf die naturwissenschaftlichen Verhältnisse der betreffenden Länder, unternommen in den Jahren 1835 bis 1841*, vol. 1, pt. 2, Stuttgart, p. 471–1102.
- Sargent Bray P. & Anderson K.B., 2009, *Identification of Carboniferous (320 Million Years Old) Class Ic Amber*, *Science*, 326, p. 132–134.
- Schlee D., 1970, *Insekten fossilien aus der unteren Kreide. 1: Verwandtschaftsforschung an fossilien und rezente Aleyrodina (Hemiptera)*, *Stuttgarter Beiträge zur Naturkunde (A)*, 213, p. 1–72.
- Schlee D. 1973, *Harzkonservierte Vogelferden aus der untersten Kreide*, *Journal für Ornithologie*, 114, p. 207–219.
- Schlee D. & Glöckner W., 1978, *Bernstein*, *Stuttgarter Beiträge zur Naturkunde (C)*, 8, p. 1–72.
- Williamson G.C., 1932, *The Book of Amber*, Ernst Benn Ltd. (Ed.), London.
- Zumoffen G., 1926, *Géologie du Liban*, Carte géologique au 200.000^{ième}, Barrière, Paris.

Lebanese amber: a “Guinness Book of Records”**Abstract**

In Lebanon, amber is found in more than 350 outcrops. It constitutes the oldest and most important amber with intensive biological inclusion. Formation of this amber corresponds to Lowermost Cretaceous, a period crucial for co-evolution between flowering plants and insects. This period witnesses the first occurrence and radiation of angiosperms. Most of the times biological inclusions in Lebanese amber represent records of the earliest representatives of modern living insect families or the youngest ones of extinct families. A list of the described taxa from Lebanese amber is given.

Dany Azar

Lebanese University, Faculty of Sciences II
Department of Natural Sciences
PO box 26110217, Fanar – Matn (Lebanon)
E-mail: azar@mnhn.fr

Appendix 1

Order	Family	Taxa	DA	BS	TA	BO	HA	SA	JE	HR	KF	AN	SH	BR	WJ
Coleoptera	Staphylinidae	<i>Libanoeuasthetus pentatarsus</i> Lefèvre et al., 2005	?	?	?	?	+	?	?	?	?	+	?		
Hemiptera	Enicocephalidae	<i>Enicocephalinus acragrimaldii</i> Azar et al., 1999	+	+	?	+	+	?	+	?	+	+	+		
	Psychodidae	<i>Libanophlebotomus lutfallahi</i> Azar et al., 1999	?	+	?	?	+	?	+	?	?	?	?		
		<i>Eophlebotomus gezei</i> Azar et al., 2003	?	?	?	+	+	?	?	+	?	?	?		
		<i>Paleopsychoda jacquelinea</i> Azar et al., 1999	?	?	?	+	+	?	+	?	?	?	+	+	+
Diptera	Empididae	<i>Phaetempis lebanensis</i> Grimaldi & Cumming, 1999	?	+	?	?	?	?	+	?	?	?	?		
	Chimeromiidae	<i>Chimeromyia intriguea</i> Grimaldi & Cumming, 1999	?	+	?	?	?	?	+	?	?	?	?		
		<i>Archiaustroconops ceratiformis</i> Szadziewski, 1996	?	+	?	?	?	?	+	?	?	?	?		
	Ceratopogonidae	<i>Archiaustroconops szadziewskii</i> Borkent, 2000	?	+	?	?	+	?	+	?	?	?	?		
		<i>Archiaustroconops harnus</i> Borkent, 2000	?	+	?	?	?	?	+	?	?	?	?		
		<i>Austroconops gondwanicus</i> Szadziewski, 1996	?	+	+	?	?	?	+	?	?	?	?		
		<i>Austroconops fossilis</i> Szadziewski, 1996	?	+	?	?	?	?	+	?	?	?	?		
	Archizelmiridae	<i>Zelmirarcha lebanensis</i> Grimaldi et al., 2003	+	?	+	?	+	?	?	?	?	+	?		
	Chironomidae	<i>Libanochilites neocomicus</i> Brundin, 1976	+	?	+	+	+	+	+	?	?	+	?	+	+
Neuroptera	Rhachiberothidae	<i>Raptorapax terribilissima</i> Petrolevičius, Azar & Nel, 2010				+									+

DA = El-Dabsheh; BS = Bcharreh; TA = Tannourine; BO = Bouarij; HA = Mdeyrij-Hammana; SA = Sarhmoul; JE = Jouar Es-Souss (Jezzine); HR = Roum – Aazour - Homsiyeh; KF = Kfar Selouan; AN = Ain Dara; SH = Esh-Sheabeh; BR = Brissa; WJ = Wadi Jezzine

Appendix 2. Taxa described from the Lebanese amber

Class	Order	Family	Taxa	Site name
Insecta	Archaeognatha	Meinertellidae	<i>Cretaceomachilis libanensis</i> Sturm & Poinar, 1998	Jouar Es-Souss
		Blattellidae	<i>Ocelloblattula ponomarenkoi</i> Anisyutin & Gorochov, 2008	Mdeyrij-Hammana
	Coleoptera	Mesoblattinidae	<i>Nymphoblatta azari</i> Vršanský & Grimaldi, 2004	Lebanon
		Umenocoleidae	<i>Pseudojantaroapterix lebani</i> (Vršanský & Grimaldi, 2003)	Lebanon
		Anthicidae	<i>Camelomorpha longicervix</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
	Cerophytidae		<i>Lebanophytum excellens</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
		Clambidae	<i>Eoclambus rugidorsum</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
	Curculionidae		<i>Cylindrobrotus pectinatus</i> Kirejtshuk <i>et al.</i> , 2009	Mdeyrij-Hammana
	Dermestidae		<i>Cretonodes antounazari</i> Kirejtshuk & Azar, 2009	Mdeyrij-Hammana
	Elodophthalimidae		<i>Elodophthalmus gracilis</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
			<i>Elodophthalmus harmonicus</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
	Hybosoridae		<i>Libanochrus calvus</i> Kirejtshuk, Azar & Montreuil, 2011	Bouarjij
	Kateretidae		<i>Lebanorettes andelmani</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
		Latridiidae	<i>Archelatrius marinae</i> Kirejtshuk & Azar, 2009	Mdeyrij-Hammana
	Micromalthidae		<i>Tetrameropsis mesozoica</i> Kirejtshuk & Azar, 2008	Mdeyrij-Hammana
			<i>Cretomalthus acaracrowsonorum</i> Kirejtshuk & Azar, 2008	Jouar Es-Souss
		Monotomidae	<i>Rhizophitoma elateroides</i> Kirejtshuk & Azar, 2009	Mdeyrij-Hammana
	Nemonychidae		<i>Libanorhinus succinus</i> Kuschel & Poinar, 1993	Jouar Es-Souss
		Staphylinidae	<i>Libanoeuaesthetus pentatarsus</i> Lefebvre <i>et al.</i> , 2005	Mdeyrij-Hammana

	Dermaptera	incertae sedis	<i>Rhadinolabis phoenicica</i> Engel, Ortega-Blanco & Azar, 2011	Mdeyrjij-Hammana
	Diptera	incertae sedis	<i>Xenopsychoda harbi</i> Azar & Ziadé, 2005	Tannourine
		Archizelmiridae	<i>Zelimircha lebanensis</i> Grimaldi et al., 2003	Mdeyrjij-Hammana
		Chaoboridae	<i>Libanoborus lukashevici</i> Azar, Waller & Nel, 2009	Mdeyrjij-Hammana
		Chimeromyiidae	<i>Chimeromyia acuta</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
			<i>Chimeromyia intriguea</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
			<i>Chimeromyia mediobscura</i> Grimaldi & Cumming, 2009	Mdeyrjij-Hammana
			<i>Chimeromyia piliitibia</i> Grimaldi & Cumming, 2009	Mdeyrjij-Hammana
			<i>Chimeromyia reducta</i> Grimaldi & Cumming, 1999	Jouar Es-Sous
		Chironomidae	<i>Cretadiamesa arieli</i> Veltz, Azar & Nel, 2007	Mdeyrjij-Hammana
			<i>Cretaelne kobeyssii</i> Azar, Veltz & Nel, 2008	Mdeyrjij-Hammana
			<i>Cretaelne inexpectata</i> Azar, Veltz & Nel, 2008	Mdeyrjij-Hammana
			<i>Cretapelopia salomea</i> Veltz, Azar & Nel, 2007	Mdeyrjij-Hammana
			<i>Lebanodiamesa deploegi</i> Veltz, Azar, & Nel, 2007	Mdeyrjij-Hammana
			<i>Lebanorthocladius furcatus</i> Veltz, Azar, & Nel, 2007	Mdeyrjij-Hammana
			<i>Libanochilites neocomicus</i> Brundin, 1976	Jouar Es-Sous
			<i>Libanopelopia cretatica</i> Veltz et al., 2007	Roum-Aazour-Homsiyeh
			<i>Haematotanypus libanicus</i> Azaret et al., 2008	Jouar Es-Sous
			<i>Paicheleleria magnifica</i> Azar & Nel, 2010	Mdeyrjij-Hammana
		<i>Wadelius libanicus</i> Veltz et al., 2007	Mdeyrjij-Hammana	
		<i>Ziadeus kamili</i> Azar & Nel, 2010	Mdeyrjij-Hammana	

	Dolichopodidae	<i>Sympycnites primaevus</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
	Empididae	<i>Atelestites senectus</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
		<i>Avenaphora hispida</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
		<i>Microphorites extinctus</i> Hennig, 1971	Jouar Es-Souss
		<i>Microphorites oculus</i> Grimaldi & Cumming, 1999	Jouar Es-Souss
		<i>Microphorites similis</i> Grimaldi & Cumming, 1999	Jouar Es-Souss
		<i>Phaetempis lebanensis</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
		<i>Trichinites cretaceous</i> Hennig, 1970	Jouar Es-Souss
	Ironomyiidae	<i>Lebambromyia acraei</i> Grimaldi & Cumming, 1999	Jouar Es-Souss
	Limoniidae	<i>Lebania levantia</i> Podenas <i>et al.</i> , 2001	Jouar Es-Souss
		<i>Lebania longaeva</i> Podenas <i>et al.</i> , 2001	Jouar Es-Souss
	Lygistorrhiniidae	<i>Lebanognoriste prima</i> Blagoderov & Grimaldi, 2004	Jouar Es-Souss
	Lonchoteridae	<i>Lonchopterites prisca</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
		<i>Lonchopteromorpha asetocella</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
	Psychodidae	<i>Cretapsychoda inexpectata</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Eophlebotomus gezei</i> Azar <i>et al.</i> , 2003	Mdeyrij-Hammana
		<i>Libanophlebotomus lutfallahii</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Libanopsychoda abillamai</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Mesophlebotomides hennigi</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Paleopsychoda inexpectata</i> Azar & Nel, 2002	Mdeyrij-Hammana
		<i>Paleopsychoda jacquelinae</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Paleopsychoda solignaci</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Parailbanopsychoda agnieszkae</i> Azar & Nel, 2002	Mdeyrij-Hammana
		<i>Phlebotomites brevijulis</i> Hennig, 1972	Jouar Es-Souss
		<i>Phlebotomites longijulis</i> Hennig, 1972	Jouar Es-Souss
		<i>Protopsychoda hammanaensis</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
		<i>Protopsychoda nadiiae</i> Azar <i>et al.</i> , 1999	Mdeyrij-Hammana
	Ptychopteridae	<i>Leptychoptera dimkina</i> Lukashevich & Azar, 2003	Mdeyrij-Hammana
		<i>Leptychoptera vovkina</i> Lukashevich, & Azar, 2003	Bcharreh Mountains
	Rhagionidae	<i>Mesobolbomyia acari</i> Grimaldi & Cumming, 1999	Jouar Es-Souss
		<i>Paleochrysopilus hirsutus</i> Grimaldi & Cumming, 1999	Bcharreh Mountains

	Sciadoceridae	<i>Archisciada lebanensis</i> Grimaldi & Cumming, 1999	Bcharreh Mountains
Ephemeroptera	Xylomyiidae	<i>Cretoxyla azari</i> Grimaldi & Cumming, 2011	Mdeyriji-Hammana
	Leptophlebiidae	<i>Conovirillus poinari</i> McCafferti, 1997	Jouar Es-Souss
Hemiptera	Aleyrodidae	<i>Bernaesa neocomica</i> Schlee, 1970	Jouar Es-Souss
		<i>Heidea cretatica</i> Schlee, 1970	Jouar Es-Souss
		<i>Baetylus kahramanus</i> Drohojowska & Szwedo, 2011	Mdeyriji-Hammana
	Cixiidae	<i>Karebobopoides aptianus</i> (Fennah, 1987)	Jouar Es-Souss
	Electrococcidae	<i>Aptiococcus minutus</i> Koteja & Azar, 2008	Mdeyriji-Hammana
	Enicocephalidae	<i>Enicocephalinus acragimaldii</i> Azar et al., 1999	Mdeyriji-Hammana
	Hammanococcidae	<i>Hammanococcus setosus</i> Koteja & Azar, 2008	Mdeyriji-Hammana
	Lebanococcidae	<i>Lebanococcus longiventris</i> Koteja & Azar, 2008	Mdeyriji-Hammana
	Liadopsyllidae	<i>Liadopsylla apedetica</i> Ouvrard et al., 2010	Mdeyriji-Hammana
	Neazoniidae	<i>Neazonia immature</i> Szwedo, 2007	Mdeyriji-Hammana
		<i>Neazonia imprinta</i> Szwedo, 2007	Jouar Es-Souss
		<i>Neazonia tripleta</i> Szwedo, 2007	Mdeyriji-Hammana
	Ortheziidae	<i>Cretorhezia hammanaica</i> Koteja & Azar, 2008	Mdeyriji-Hammana
	Progonomiciidae	<i>Ilahulgabalus endaidus</i> Szwedo, Azar & Ziadé, 2011	El-Dayshouniyyeh
	Putoidae	<i>Palaeotupo danielaee</i> Koteja & Azar, 2008	Mdeyriji-Hammana
		<i>Pennygullania electrica</i> Koteja & Azar, 2008	Mdeyriji-Hammana
Pennygullaniidae	<i>Libanohypselosoma papovi</i> Azar & Nel, 2010	Mdeyriji-Hammana	
Schizopteridae	<i>Palaeosteingelia acraei</i> Koteja & Azar, 2008	Mdeyriji-Hammana	
Steingeliidae	<i>Palaeosteingelia caudate</i> Koteja & Azar, 2008	Mdeyriji-Hammana	
	<i>Palaeosteingelia caudate</i> Koteja & Azar, 2008	Mdeyriji-Hammana	
Tajmyraphiidae	<i>Lebanaphis minor</i> Heie, 2000	Mdeyriji-Hammana	
	<i>Megarosttrum azari</i> Heie, 2000	Mdeyriji-Hammana	
Thelaxidae	<i>Gondvanocaphis estephani</i> Wegierek & Grimaldi, 2010	Bcharreh Mountains	

Hymenoptera	Yuripopoviniidae	<i>Yuripopovina magnifica</i> Azar et al., 2011	Bouarjij
	Dryinidae	<i>Aphelopus palaephaenicus</i> Olmi, 1999	Jouar Es-Souss
	Evanidae	<i>Eovernevania cyrtocera</i> Deans et al., 2004	Mdeyrij-Hammana
		<i>Lebanevania azari</i> Basibuyuk et al., 2002	Jouar Es-Souss
	Maimetshidae	<i>Protoparevania lourathi</i> Deans et al., 2004	Mdeyrij-Hammana
		<i>Ahiramaimetsha najlae</i> Perrichot et al., 2011	Maknouniyeh
	Scellionidae	<i>Cretaxenomerus jankotejai</i> Nel & Azar, 2005	Mdeyrij-Hammana
		<i>Proteroscello gravatus</i> Johnson et al., 2008	Mdeyrij-Hammana
	Sclerogibbidae	<i>Sclerogibbodes embioleia</i> Engel & Grimaldi, 2006	Bcharreh Mountains
	Scolebythidae	<i>Libanobythus milkii</i> Prentice & Poinar, 1996	Jouar Es-Souss
		<i>Uliobythus tersichore</i> Engel & Grimaldi, 2007	Mdeyrij-Hammana
	Isoptera	<i>Zapenesia libanica</i> Engel & Grimaldi, 2007	Mdeyrij-Hammana
		<i>Melgwartitermes myrrheus</i> Engel et al., 2007	Bcharreh Mountains
	Lepidoptera	<i>Lebanotermes veltzae</i> Engel, Azar & Nel, 2011	Mdeyrij-Hammana
		<i>Parasabatina aftimacrai</i> Whalley, 1978	Jouar Es-Souss
	Mantodea	<i>Gryllomantis libanensis</i> (Grimaldi, 2003)	Bcharreh Mountains
		<i>Banoberotha enigmatica</i> Whalley, 1980	Jouar Es-Souss
	Neuroptera	<i>Libanocomis fadiacra</i> (Whalley, 1980)	Jouar Es-Souss
		<i>Libanosemidalis hammanaensis</i> Azar et al., 2000	Mdeyrij-Hammana
	Rhachiberothidae	<i>Chimerhachiberotha acrasarii</i> Nel et al., 2005	Jouar Es-Souss
<i>Paraberrotho acra</i> Whalley, 1980		Jouar Es-Souss	
Odonata	<i>Raptorapax terribilissima</i> Petrolevičius, Azar & Nel, 2010	Bouarjij	
	<i>Spinberrotho mickaelacrai</i> Nel et al., 2005	Mdeyrij-Hammana	
Orthoptera	<i>Libanolestes flecki</i> Azar, Prokop & Nel, 2010	Ain Dara	
	<i>?Halotettigonia aenigmatosa</i> Gorokhov, 2010	Mdeyrij-Hammana	
Psocodea	<i>Libanomphientomum nudus</i> Choufani, Azar & Nel, 2011	Mdeyrij-Hammana	
	<i>Paramesopsocus lu</i> Azar et al., 2008	Mdeyrij-Hammana	
Prionoglaridae / Archaeatropidae	<i>Bcharrehglaris annunobi</i> Azar & Nel, 2004	Bcharreh Mountains	
	<i>Libanoglaris chehabi</i> Azar & Nel, 2004	Mdeyrij-Hammana	
Psyllipsocidae	<i>Libanoglaris mouawadi</i> Azar et al., 2003	Mdeyrij-Hammana	
	<i>Libanoglaris randatae</i> Azar & Nel, 2004	Jouar Es-Souss	
Sphaeropsocidae	<i>Setoglaris reemae</i> Azar & Nel, 2004	Mdeyrij-Hammana	
	<i>Libanopsyllipsocus alexanderasmitsyni</i> Azar & Nel, 2001	Mdeyrij-Hammana	
		<i>Sphaeropsocites libanensis</i> Grimaldi & Engel, 2006	Jouar Es-Souss

			<i>Asphaeropsocites nell Azar et al., 2010</i>	Mdeyrij-Hammama
		Mesoraphidiinae	<i>Lebanoraphidia nana</i> Bechly & Wolf-Schwenninger, 2011	Jouar Es-Souss
	Thysanoptera	Adiheterothripidae	<i>Neocomothrips hennigianus</i> zur Strassen, 1973	Jouar Es-Souss
			<i>Progonothrips horridus</i> zur Strassen, 1973	Jouar Es-Souss
			<i>Rhethinotrips elegans</i> zur Strassen, 1973	Jouar Es-Souss
			<i>Scaphothrips antennatus</i> zur Strassen, 1973	Jouar Es-Souss
			<i>Exitelothrips mesozoicus</i> zur Strassen, 1973	Jouar Es-Souss
			<i>Jezzinothrips cretacicus</i> zur Strassen, 1973	Jouar Es-Souss
		Moundthripidae	<i>Moundthrips beatificus</i> Nel, Azar & Nel, 2007	Jouar Es-Souss
		Phlaeothripidae	<i>Rohrthrips libanicus</i> Nel et al., 2010	Mdeyrij-Hammama
		Thripidae	<i>Tethystrrips libanicus</i> Nel et al., 2010	Mdeyrij-Hammama
Arachnida	Araneae	Deinopidae	<i>Palaeomicromennus lebanensis</i> Penney, 2003	Mdeyrij-Hammama
		Linyphiidae	Described but not named Penney & Selden, 2002	Mdeyrij-Hammama
		Oecobiidae	<i>Lebanoecobius schleer</i> Wunderlich, 2004	Jouar Es-Souss
			<i>Zamilia antecessor</i> Wunderlich, 2008	Mdeyrij-Hammama
		Plumorsolidae	<i>Plumorsolus gondwanensis</i> Wunderlich, 2008	Mdeyrij-Hammama
		Segestriidae	<i>Lebansegestria azari</i> Wunderlich, 2008	Mdeyrij-Hammama
			<i>Microsegestria poinari</i> Wunderlich & Milki, 2004	Jouar Es-Souss
	Scorpiones	Archaeobuthidae	<i>Archaeobuthus estephani</i> Lourenço, 2001	Bcharreh Mountains
Diplopoda	Polyxenida	Polyxenidae	<i>Electroxenus jezzinensis</i> Nguyen Duy-Jacquemin & Azar, 2004	Jouar Es-Souss
			<i>Libanoxenus hammamaensis</i> Nguyen Duy-Jacquemin & Azar, 2004	Mdeyrij-Hammama
Adenophorea	Mermithida	Mermithidae	<i>Heleidomermis libani</i> Poinar et al., 1994	Jouar Es-Souss
Reptilia	Squamata	Incertae sedis	<i>Baobdasaurus xenorinus</i> Arnolds et al., 2002	Mdeyrij-Hammama

165 insects, 8 arachnid, 89 families
177 taxa