

A review of entomological research on sandy beaches in Morocco, with an emphasis on Coleoptera

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Abstract. Sandy beaches provide a transitional zone between the sea and land. They are regarded as extreme environments due to the harshness of some of their habitat characteristics. These have produced considerable adaptations in insects, many of which are restricted to these habitats. Despite the vast extent of coastline in Morocco (3500 km), insects of sandy beaches are known only from fragmentary publications derived from occasional sampling before the eighties. Nevertheless, more comprehensive studies have been subsequently achieved on sandy beaches insects in the Atlantic and the Mediterranean coasts. In order to carry out this review of entomological research on sandy beaches in Morocco, we consulted the Moroccan entomological bibliography (1870 to 1975) and our own database on entomological publications dealing with Morocco. Previous publications on the sandy beaches of Morocco on the Atlantic and Mediterranean coasts are considered and a list of all insects recorded is compiled and discussed. Some factors contributing to the deterioration of sandy beaches in Morocco are considered.

Key words: Morocco, sandy beaches, entomological research review, coleoptera

Résumé. Rétrospective des recherches entomologiques sur les plages sableuses au Maroc, avec une attention particulière pour les Coléoptères. Les plages sableuses constituent une zone de transition entre la mer et la terre. Elles sont qualifiées aussi de milieux extrêmes à cause du forçage de certains facteurs écologiques qui exigent de la part des insectes une grande adaptation de telle sorte que certaines espèces sont devenues strictement liées à ces habitats. En dépit de la grande étendue des côtes au Maroc (3500 Km), les insectes des plages sableuses n'avaient connus que quelques notes fragmentaires suite à certains prélèvements occasionnels de cette faune avant les années quatre-vingt. Néanmoins quelques études suivies dans le temps avaient eu lieu ultérieurement sur les insectes des plages sableuses de l'Atlantique et de la Méditerranée. Pour établir cette rétrospective des recherches entomologiques sur les plages sableuses au Maroc, nous avons consulté la littérature entomologique marocaine (rétrospective de 1870 à 1975) et notre propre base de données actualisée relative aux publications sur l'entomologie marocaine. Les travaux sur les plages sableuses marocaines atlantiques et méditerranéennes sont pris en considération et une liste générale de tous les insectes prélevés a été établie et discutée. Les facteurs de dégradation des plages sont également mentionnés.

Mots clés : Maroc, plages sableuses, rétrospective des recherches entomologiques, coléoptères

INTRODUCTION

Sandy beaches provide contact between terrestrial and marine environments. Factors such as flooding, erosion of the coast, deposition of sediments by water and wind cause spatial and temporal changes in sandy beaches. These are considered an extreme environment because some factors operating in these habitats are harsh and promote considerable adaptation in organisms that inhabit them, including insects. Although they are characterised by a high degree of dryness, sandy beaches provide favourable conditions for a rich entomofauna. Many of these invertebrates spend all or a part of their life cycle in or on the sand.

Despite the vast extension of coastline in Morocco (3500 km), the insects of sandy beaches are only discussed in disparate publications based on occasional sampling. Although some publications from the 19th Century treat species typical of sandy beaches (e.g., Champion 1891, 1898), data presented in these are vague and do not specify

precise localities or habitats in which these species were found. The first study dealing exclusively with insects of sandy beaches was published in the early 20th century (Bedel 1905). More comprehensive studies on these insects were carried out since the early 1980s. These considered the sandy beaches of the Atlantic (Idrissi 1984, Colombini *et al.* 2006) and Mediterranean coasts (Maachi & Radouani 1993, Bouraada *et al.* 1999, Colombini *et al.* 2005, 2006 & 2008). Mouna *et al.* (2007) studied some areas that are less disturbed by human activity, between the town of Martil and the touristic village of “Cabo Negro” (region of Tetouan) on the Mediterranean coast.

Sandy beaches are under pressure globally due to excessive urbanization and use by humans, especially holidaymakers. Morocco is not exempt from the destruction of coastal dunes for socio-economic development. This results in the loss of an environment that is rich in biodiversity and supports many organisms that are adapted to its conditions.

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We provide an overview of entomological research carried out on sandy beaches in Morocco. A list* of the insects collected on the Atlantic and Mediterranean coasts is presented, with a brief discussion of the ecological characteristics of some species. The fauna of both coasts are compared, causes of degradation of coastal dunes are discussed and the preservation and formal protection of some areas of coastal dunes is proposed

MATERIAL AND METHODS

In order to carry out our review of entomological research on sandy beaches in Morocco, we consulted the Moroccan bibliography (Choumara 1977). We used our own updated database on Moroccan entomological publications (Mouna 2010), which was established for the Sixth Francophone International Conference of Entomology, for references after this date (1975).

Morocco has two main coastlines, the Atlantic coast in the west and the Mediterranean coast in the north (Fig. 1). We divided the results of our review according to the section of coastline sampled (i.e., Atlantic and Mediterranean).

RESULTS

A list of mainly psammophile insect species recorded from sandy beaches in Morocco is given (Table I). This is dominated by Coleoptera, reflecting in part that there has been a strong bias towards Coleoptera in these studies. According to some studies (Idrissi 1984, Ponel 1986) and our own observations, insects of sandy beaches in Morocco can be classified in the following categories:

- Predatory species such as the Coleoptera: Carabidae *Scarites (Scallophorites) cyclops*, which predate on other insects (particularly Coleoptera: Tenebrionidae), *Parallelomorphus laevigatus* and *Eurynebria complanata* which feed on amphipods (*Talitrus saltator*).
- Phytophagous species which inhabit dunes because of the presence of their food plants, such as *Coniatus (Coniatus) repandus* (Coleoptera: Curculionidae, which feeds on *Tamarix*), *Perapion (Perapion) hydrolapathi* (Coleoptera: Apionidae, on *Rumex*) or *Cassida (Odontionycha) viridis* (Coleoptera: Chrysomelidae, on Lamiaceae).
- True sand-loving species that forage on the surface, such as the genera *Tentyria* and *Pimelia* (Coleoptera: Tenebrionidae).
- True sand-loving species adapted to digging, with endogean habits. This group includes species such as: *Cephalocteus scarabaeoides* (Hemiptera: Cydnidae), *Odontoscelis (Odontoscelis) dorsalis* (Hemiptera: Scutelleridae), *Platytomus laevistriatus* (Coleoptera:

Aphodiidae), *Ammobius rufus* (Coleoptera Tenebrionidae) and *Xenonychus tridens* (Coleoptera: Histeridae). These species are only found on the surface of the sand exceptionally.

In addition, halobiont species that live below the tide line or in salty water are present, such as: *Aepopsis robini* and *Cillenus (Cillenus) lateralis* (Carabidae) and *Ochthebius (Ochthebius) subinteger* and *Ochthebius (Calobius) quadricollis* (Coleoptera: Hydraenidae).

Atlantic Coast

To our knowledge, the first publication that dealt exclusively with insects of sandy beaches in Morocco was carried out in Essaouira (Mazagan), from where Bedel (1905) described two species of beetle in the Tenebrionidae: *Crypticus vaucheri* and *Heliotaurus (Omophlus) splendidus*. Forty years later, Escalera (1943) described a new species of Tenebrionidae (*Eurycaulus pachecoi*) from the Oued Draa (South of Agadir: Fig. 1).

In what he referred to as the "sea" beetles of Morocco, Kocher (1966) reported two genera of Carabidae: *Aepopsis* and *Cillenus*. These are found on the seashore, within rock crevices or buried in pockets within sand. They often live below the tide line but emerge during low tide to feed on detritus. Two species were recorded from the Moroccan coast by Kocher (1956–1969): *Aepopsis robini* and *Cillenus (Cillenus) lateralis*. This author added that aquatic beetles that are tolerant of salt water can also live in these environments, including Hydraenidae: *Ochthebius (Ochthebius) subinteger* and *Ochthebius (Calobius) quadricollis*.

A more prolonged study was conducted in the early 1980s, in the beaches of Sidi Boughaba (Kenitra region) and Mohammedia (Casablanca region: Fig. 1) (Idrissi 1984). The author sampled a lot of beetles on both beaches, using sieving methods and transects.

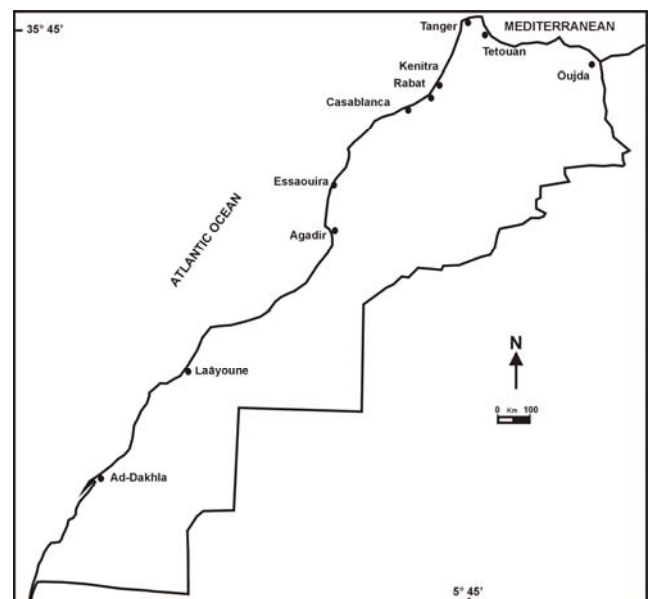


Figure 1: Map of Morocco and the location of the main cited regions

* Currently accepted taxonomy of species was verified using the Fauna Europaea database (<http://www.faunaeur.org>) or the Internet for the species that are not in this database.

Table I: Insects recorded from sandy beaches of the Atlantic and Mediterranean coasts in Morocco, with their authors.

Taxon	Authors	Atlantic	Mediterranean
Coleoptera			
Tenebrionidae			
<i>Alphitobius diaperinus</i> Panzer, 1797	Maachi & Radouani 1993		+
<i>Ammobius pardoii</i> Kolbe	Maachi & Radouani 1993; Bouraâda <i>et al.</i> 1999		+
<i>Ammobius rufus</i> Lucas 1849	Mouna <i>et al.</i> 2007		+
<i>Arthrodeis glomeratus</i> Fairmaire, 1871	Idrissi 1984	+	
<i>Arthrodeis occidentalis</i> Fairmaire, 1868	Idrissi 1984	+	
<i>Catomulus olcesii</i> Fairmaire, 1883	Idrissi 1984	+	
<i>Phthora crenata</i> Germar 1836	Español Coll 1949		+
<i>Pseudoseriscius adspersus</i> Kuster, 1851	Idrissi 1984	+	
<i>Pseudoseriscius pruinosis</i> Dufour, 1820	Español Coll 1949; Maachi & Radouani 1993		+
<i>Crypticus nebulosus</i> Fairmaire, 1870	Idrissi 1984; Mouna <i>et al.</i> 2007	+	+
<i>Crypticus pubens</i> Fairmaire, 1880	Maachi & Radouani 1993		+
<i>Crypticus vaucheri</i> Bedel 1905, 1906	Bedel 1905	+	
<i>Echporoma hemisphaerica</i> Solier, 1836	Idrissi 1984	+	
<i>Erodius carinatus</i> Solier, 1834	Mouna <i>et al.</i> 2007		+
<i>Erodius tibialis</i> Linnaeus, 1766	Mouna <i>et al.</i> 2007		+
<i>Erodius audouini</i> Solier, 1834	Bouraâda <i>et al.</i> 1999		+
<i>Erodius emondi</i> Solier, 1834	Maachi & Radouani 1993		+
<i>Erodius emondi laevis</i> Solier, 1834	Allaud 1925		+
<i>Erodius granipennis</i> Fairmaire, 1871	Idrissi 1984	+	
<i>Erodius granipennis reitteri</i> Kocher, 1951	Idrissi 1984	+	
<i>Erodius tangerianus</i> Solier, 1834,	Idrissi 1984	+	
<i>Eurycaulus pachecoi</i> Escalera, 1943	Escalera 1943	+	
<i>Gonocephalum perplexum</i> Lucas, 1849	Maachi & Radouani 1993		+
<i>Heliotaurus plenifrons</i> Fairmaire, 1866	Bouraâda <i>et al.</i> 1999		+
<i>Heliotaurus splendidus</i> Bedel, 1905	Bedel 1905	+	
<i>Isocerus ferrugineus</i> Reitter, 1866	Mouna <i>et al.</i> 2007		+
<i>Leichenium pulchellum</i> Lucas, 1849	Mouna <i>et al.</i> 2007		+
<i>Lyphia angusta</i> Lucas, 1849	Español Coll 1944		+
<i>Opatrum sabulosum</i> Linnaeus, 1761	Colombini <i>et al.</i> 2008		+
<i>Pachychila germari</i> Solier, 1835	Español Coll 1944; Bouraâda <i>et al.</i> 1999		+
<i>Pachychila intermedia</i> Haag-Rutenberg, 1875	Idrissi 1984	+	
<i>Pachychila plasoni</i> Haag-Rutenberg, 1875	Idrissi 1984	+	
<i>Pachychila breviscula</i> Haag-Rutenberg, 1875	Idrissi 1984	+	
<i>Pachychila punctata</i> Fabricius, 1798	Español Coll 1944; Idrissi 1984	+	+
<i>Pachychila salzmanni</i> Solier, 1835	Español Coll 1944; Idrissi 1984	+	+
<i>Pachychila tumidifrons</i> Kraatz, 1865	Allaud 1925; Pardo Alcaide 1955		+
<i>Pachychila (Pachychila) haroldi</i> Kraatz	Allaud 1925; Maachi & Radouani 1993		+
<i>Phaleria acuminata</i> Küster, 1852	Español Coll 1949; Pardo Alcaide 1955; Maachi & Radouani 1993; Colombini <i>et al.</i> 2005&2008		+
<i>Phaleria bimaculata</i> Linnaeus, 1767	Colombini <i>et al.</i> 2008		+
<i>Phaleria cadaverina</i> Fabricius, 1792	Idrissi 1984; Colombini <i>et al.</i> 2006	+	
<i>Pimelia ariasi</i> Escalera, 1914	Allaud 1925		+
<i>Pimelia duponti</i> Solier, 1836	Allaud 1925		+
<i>Pimelia mauritanica breiti</i> Koch, 1941	Maachi & Radouani 1993		+
<i>Pimelia rotundipennis</i> Kraatz, 1865	Idrissi 1984	+	
<i>Pimelia tristis</i> Haag-Rutenberg, 1875	Idrissi 1984	+	
<i>Pimelia servillei papulosa</i> Solier, 1836	Pardo Alcaide 1955; Bouraâda <i>et al.</i> 1999; Chavanon 2003		+
<i>Scaurus calcaratus</i> Fabricius, 1798	Mouna <i>et al.</i> 2007		+
<i>Scaurus uncinus</i> Forst, 1771	Pardo Alcaide 1955; Maachi & Radouani 1993; Bouraâda <i>et al.</i> 1999		+
<i>Tentyria maroccana</i> Solier, 1835	Allaud 1925; Pardo Alcaide 1955; Idrissi 1984; Bouraâda <i>et al.</i> 1999; Mouna <i>et al.</i> 2007	+	+
<i>Tentyria elongata sinuaticollis</i> Rosenhauer, 1856	Chavanon 2003		+
<i>Trachyscelis aphodioides</i> Latreille, 1809	Pardo Alcaide 1955; Idrissi 1984; Maachi & Radouani 1993	+	+
<i>Xanthomus pallidus</i> Curtis, 1830	Español Coll 1949; Idrissi 1984	+	+
<i>Zophosis errans</i> Solier, 1834	Idrissi 1984	+	
<i>Zophosis punctata</i> Brullé, 1832	Allaud 1925; Maachi & Radouani 1993		+
<i>Nesocaeidius pardoii</i> Español, 1956	Chavanon 2003		+
Carabidae			
<i>Parallelomorphus laevigatus</i> Fabricius, 1792	Allaud 1925; Idrissi 1984	+	+
<i>Scarites (Scallophorites) cyclops</i> Crotch, 1871	Idrissi 1984; Mouna <i>et al.</i> 2007	+	+

Taxon	Authors	Atlantic	Mediterranean
<i>Scarites (Scallophorites) buparius</i> Förster, 1771	Allaud 1925; Pardo Alcaide 1955; Bouraâda <i>et al.</i> 1999; Colombini <i>et al.</i> 2005		+
<i>Dyschirius numidicus</i> Putzeys, 1846	Maachi & Radouani 1993		+
<i>Dyschiriodes (Dyschiriodes) clypeatus</i> Putzeys, 1866	Maachi & Radouani 1993		+
<i>Carabus (Macrothorax) morbillosus marginatus</i> Lallemand	Chavanon 2003		+
<i>Carabus (Cathoplius) asperatus</i> Dejean, 1826	Idrissi 1984	+	
<i>Cephalota (Taenidia) litorea</i> Forskål, 1775	Maachi & Radouani 1993		+
<i>Lophyra (Lophyra) flexuosa</i> Fabricius, 1787	Allaud 1925; Pardo Alcaide 1955; Maachi & Radouani 1993; Mouna <i>et al.</i> 2007		+
<i>Calomera lunulata</i> Fabricius, 1781	Allaud 1925; Pardo Alcaide 1955		+
<i>Calomera lunulata rolphi</i> Kraatz, 1890	Allaud 1925		+
<i>Calomera littoralis</i> Fabricius, 1787	Maachi & Radouani 1993		+
<i>Calomera littoralis littoralis</i> (Fabricius 1787)	Chavanon 2003		+
<i>Cassolaia maura</i> Linnaeus, 1758	Allaud 1925		+
<i>Cylindera (Eugrapha) trisignata</i> Latreille & Dejean, 1822	Allaud 1925		+
<i>Cylindera (Eugrapha) trisignata trisignata</i> Latreille & Dejean 1822	Maachi & Radouani 1993		+
<i>Cymindis setifensis setifensis</i> Lucas, 1842	Pardo Alcaide 1955; Bouraâda <i>et al.</i> 1999		+
<i>Eurynebria complanata</i> Linnaeus, 1767	Allaud 1925; Colombini <i>et al.</i> 2006; Idrissi 1984	+	+
<i>Harpalus (Harpalus) hirtipes</i> Panzer, 1796	Colombini <i>et al.</i> 2008		+
<i>Microlestes abeillei brisouti</i> Holdhaus, 1912	Pardo Alcaide 1955; Bouraâda <i>et al.</i> 1999		+
<i>Pogonus (Pogonus) luridipennis</i> Germar, 1822	Maachi & Radouani 1993		+
<i>Aepopsis robini</i> Laboulbene, 1849	Kocher 1966	+	+
<i>Cillenus (Cillenus) lateralis</i> Samouelle, 1819	Kocher 1966	+	+
<i>Microlestes angusteforcipatus</i> Antoine, 1941	Idrissi 1984	+	
<i>Bradycellus (Bradycellus) distinctus</i> Dejean, 1829	Idrissi 1984	+	
<i>Amblystomus mauritanicus</i> Dejean, 1829	Idrissi 1984	+	
<i>Orthomus velocissimus kocheri</i> Mateu	Chavanon 2003		+
<i>Phyla rectangula</i> (Jacquelin du Val 1852)	Chavanon 2003		+
<i>Calodromius bifasciatus</i> (Dejean 1825)	Pardo Alcaide 1955; Chavanon 2003		+
<i>Sphodrus leucophthalmus</i> (Linnaeus 1758)	Chavanon 2003		+
Staphylinidae			
<i>Bledius (Euceratobledius) furcatus</i> Olivier, 1811	Maachi & Radouani 1993		+
<i>Bledius (Bledius) graellsii</i> Fauvel, 1865	Maachi & Radouani 1993		+
<i>Tachyporus nitidulus</i> Fabricius, 1781	Maachi & Radouani 1993		+
<i>Myrmecopora (Paraxenusia) laesa</i> Erichson, 1839	Maachi & Radouani 1993		+
<i>Aleochara bipustulata</i> Linnaeus, 1761	Maachi & Radouani 1993		+
<i>Luzea nigrifulva</i> Erichson, 1840	Bouraâda <i>et al.</i> 1999		+
<i>Phytosus nigriventris</i> (Chevrolat, 1843)	Colombini <i>et al.</i> 2005		+
Histeridae			
<i>Hypocaccus (Baeckmanniolus) dimidiatus</i> Illiger, 1807	Colombini <i>et al.</i> 2006	+	
<i>Saprinus (Saprinus) caeruleus</i> Hoffmann, 1803	Maachi & Radouani 1993		+
<i>Saprinus (Saprinus) chalcites</i> Illiger, 1807	Pardo Alcaide 1955; Maachi & Radouani 1993		+
<i>Saprinus (Saprinus) semistriatus</i> Scriba, 1790	Pardo Alcaide 1955; Maachi & Radouani 1993		+
<i>Saprinus (Saprinus) ornatus</i> Erichson, 1834	Bouraâda <i>et al.</i> 1999		+
<i>Xenonychus tridens</i> (Jacquelin du Val 1852)	Mouna <i>et al.</i> 2007		+
Scarabaeidae			
<i>Onthophagus (Trichonthophagus) maki</i> Illiger, 1803	Bouraâda <i>et al.</i> 1999		+
<i>Onitis alexis septentrionalis</i> Balthasar 1942	Chavanon 2003		+
<i>Scarabaeus (Scarabaeus) sacer</i> Linnaeus, 1758	Pardo Alcaide 1955; Idrissi 1984; Bouraâda <i>et al.</i> 1999	+	+
<i>Scarabaeus (Ateuchetus) semipunctatus</i> Fabricius, 1792	Pardo Alcaide 1955; Idrissi 1984; Bouraâda <i>et al.</i> 1999	+	+
<i>Scarabaeus (Ateuchetus) cicatricosus</i> Lucas, 1846	Idrissi 1984; Mouna <i>et al.</i> 2007	+	+
Aphodiidae			
<i>Platytomus tibialis</i> Fabricius, 1798	Maachi & Radouani 1993		+
<i>Platytomus laevistriatus</i> Perris, 1870	Mouna <i>et al.</i> 2007		+
<i>Brindalus porricollis</i> Illiger, 1803	Idrissi 1984; Maachi & Radouani 1993; Bouraâda <i>et al.</i> 1999	+	+

Taxon	Authors	Atlantic	Mediterranean
<i>Erytus cognatus</i> Fairmaire, 1860	Bouraâda <i>et al.</i> 1999		+
<i>Alocoderus hydrochaeris</i> Fabricius, 1798	Bouraâda <i>et al.</i> 1999		+
Chrysomelidae			
<i>Cassida (Odontionycha) viridis</i> Linnaeus, 1758	Colombini <i>et al.</i> 2006	+	
<i>Chaetocnema hortensis</i> Geoffroy, 1785	Colombini <i>et al.</i> 2006	+	
<i>Entomoscelis rumicis</i> Fabricius, 1787	Pardo Alcaide 1955; Maachi & Radouani 1993		+
<i>Galeruca barbara</i> Erichson, 1841	Maachi & Radouani 1993		+
<i>Psylliodes inflatus</i> Reiche, 1858	Bouraâda <i>et al.</i> 1999		+
<i>Cryptocephalus (Cryptocephalus) curvilinea</i> G. A. Olivier 1808	Pardo Alcaide 1955		+
Curculionidae			
<i>Coniatus (Coniatus) repandus</i> Fabricius, 1792	Pardo Alcaide 1955; Maachi & Radouani 1993		+
<i>Sitona (Charagmus) griseus</i> Fabricius, 1775	Mouna <i>et al.</i> 2007		+
<i>Cycloderes rolphi</i> Fairmaire, L., 1867	Mouna <i>et al.</i> 2007		+
<i>Pentatemnus arenarius</i> Wollaston, 1861	Idrissi 1984	+	
Apionidae			
<i>Perapion (Perapion) hydrolapathi</i> Marsham, 1802	Bouraâda <i>et al.</i> 1999		+
Hydraenidae			
<i>Ochthebius (Ochthebius) subinteger</i> Mulsant & Rey, 1861	Kocher 1966	+	
<i>Ochthebius (Calobius) quadricollis</i> Mulsant 1844	Kocher 1966	+	
Anthicidae			
<i>Cyclodinus constrictus</i> Curtis, 1838	Maachi & Radouani 1993		+
<i>Anthicus fenestratus</i> W.L.E. Schmidt, 1842	Maachi & Radouani 1993		+
Melolonthidae			
<i>Polyphylla sicardi</i> Bedel, 1917	Pardo Alcaide 1955; Chavanon 2003		+
<i>Pachydema hornbecki</i> Lucas, 1859	Chavanon 2003		+
Dermestidae			
<i>Dermestes (Dermestinus) frischi</i> Kugelann, 1792	Maachi & Radouani 1993		+
Geotrupidae			
<i>Thorectes distinctus</i> Marseul, 1878	Idrissi 1984	+	
Elateridae			
<i>Isidus moreli</i> Mulsant & Rey, 1874	Idrissi 1984	+	
Nitidullidae			
<i>Meligethes elongatus</i> Rosenhauer, 1856	Bouraâda <i>et al.</i> 1999		+
Cryptophagidae			
<i>Cryptophagus distinguendus</i> Sturm, 1845	Maachi & Radouani 1993		+
Dynastidae			
<i>Oryctes (Oryctes) nasicornis grypus</i> Illiger, 1803	Idrissi 1984	+	
Anobiidae			
<i>Dignomus lusitanus</i> Illiger, 1807	Bouraâda <i>et al.</i> 1999		+
Cetoniidae			
<i>Tropinota squalida pilosa</i> Brulle, 1832	Bouraâda <i>et al.</i> 1999		+
Dasytidae			
<i>Psilothrix viridicoerulea</i> Geoffroy, 1785	Pardo Alcaide 1955; Bouraâda <i>et al.</i> 1999		+
Trogidae			
<i>Trox (Trox) granulipennis</i> Fairmaire, 1852	Idrissi 1984	+	

Taxon	Authors	Atlantic	Mediterranean
Cerambycidae			
<i>Parmena pubescens algerica</i> (Laporte de Castelnau, 1840)	Chavanon 2003		+
Dermaptera			
Labiduridae			
<i>Labidura riparia</i> Pallas, 1773	Allaud 1925; Colombini <i>et al.</i> 2006		+
Hymenoptera			
Mutillidae			
<i>Dasylabris atrata</i> (Linnaeus, 1767)	Allaud 1925		+
<i>Stenomutilla argentata</i> Villers, 1789	Allaud 1925		+
Hemiptera			
Cydnidae			
<i>Cephalocteus scarabaeoides</i> Fabricius, 1803	Mouna <i>et al.</i> 2007		+
Scutelleridae			
<i>Odontoscelis (Odontoscelis) dorsalis</i> Fabricius, 1798	Mouna <i>et al.</i> 2007		+

In a study on the effects of freshwater discharge on terrestrial arthropods in the beach of Mehdiya (Kénitra region: Fig. 1), Colombini *et al.* (2006) presented an extensive list of orders and families of insects, which included some genera and species of beetle that are typical of sandy beaches such as *Phaleria cadaverina* (Tenebrionidae) and *Eurynebria complanata* (Carabidae). The use of transects and pitfall trap sampling techniques has also led to the frequent capture of other species: *Chaetocnema hortensis*, *Cassida (Odontionycha) viridis* (Chrysomelidae), *Hypocaccus (Baeckmanniolus) dimidiatus* (Histeridae) and the inevitable *Labidura riparia* (Dermaptera: Labiduridae), a species that is closely associated with coastal sands (Bigot 1983).

Mediterranean Coast

According to our records, the first publication on insects of sandy beaches on the Mediterranean coast of Morocco dates from when Allaud (1925) gave a detailed description of various areas on the beach of Saidia (Oujda region, Eastern Mediterranean: Fig. 1), with their associated faunas.

Two notes were published on the Tenebrionidae of the western Mediterranean coast of Morocco (Español Coll 1944, 1949). Species recorded in these were: *Pachychila punctata*, *Pachychila salzmanni*, *Pachychila germari*, *Lyphia angusta*, *Phaleria acuminata*, *Pseudoseriscius pruinosus*, *Xanthomus pallidus* and *Phtora crenata*.

A huge list of Coleoptera was published from the downstream valley of Oued Moulouya (eastern Mediterranean coast, East of Nador) (Pardo Alcaide 1955), which includes some species of sandy habitats (Table I).

Maachi & Radouani (1993) used sieving and direct sampling methods to collect many species of beetles on wet and dry sections of the sandy beach of Bou-Areg (Nador region, eastern Mediterranean coast: Fig. 1). The authors reported that the wet section of the beach is

relatively poor in beetles, hosting only species with a high tolerance of salt in the genera *Dyschirius* (Carabidae) and *Bledius* (Staphylinidae). These inhabit small galleries at the shoreline. In addition, this biotope is characterised by *Cylindera (Eugrapha) trisignata*, one of three tiger beetle (Carabidae: Cicindellinae) species restricted to beaches. The section of beach between the shore and dunes provides unfavourable conditions for most species. *Phaleria acuminata* (Tenebrionidae) is abundant on this beach and characterises this section.

The beetles of foredunes that are partly stabilised by *Ammophila arenaria* (Poaceae) were studied in Saidia (Oujda region, eastern Mediterranean coast) (Bouraada *et al.* 1999). The authors used three sampling methods (direct sampling, sieving and pitfall traps) and captured a large number of species (Table I).

Terrestrial invertebrates were studied along the eastern Mediterranean coast (Nador and Oujda regions) using mainly direct sampling (Chavanon 2003). The author collected some Coleoptera and proposed a management plan of the sand dunes in the study area.

The arthropods of sandy dunes between the Smir Lagoon and the Mediterranean (north of M'Diq, Tetouan region: Fig. 1) were studied using pitfall traps (Colombini *et al.* 2005). A large number of insect families were identified. Although results focussed mainly on insect orders, three species of beetles were recorded: *Phaleria acuminata*, *Scarites (Scallophorites) buparius* (Carabidae) and *Phytosus nigriventris* (Staphylinidae).

We conducted a study of insects in the sand dunes of Dar Skirej (between Martil and Cabo Negro: Tetouan region), using the sieving method. This area is less disturbed by human activity (Mouna *et al.* 2007). The richness and composition of the insects collected in Dar Skirej reflect the health of this habitat. Most elements of this fauna are Mediterranean in origin, such as *Isocerus ferrugineus*,

Erodius tibialis and *Erodius carinatus* (Coleoptera: Tenebrionidae). *Cephalocteus scarabaeoides* (Hemiptera: Cydnidae), which was recorded from Dar Skirej, had not been cited in any previous study on sandy beaches, despite its wide distribution in Europe and North Africa (Vidal 1949). In addition, *Xenonychus tridens* (Coleoptera: Histeridae) was new to the Mediterranean coast of Morocco.

The population structure of sand-loving arthropods has been studied at the sandy dunes at the mouth of the Oued Laou (Tetouan region, western Mediterranean coast), based on chemical and physical parameters related to the dumping of waste (Colombini *et al.* 2008). The results demonstrate the health of the habitat and the abundance of two sympatric Coleoptera Tenebrionidae: *Phaleria acuminata* and *Phaleria bimaculata*, among other species, especially in the spring (Table I).

Comparison between the Atlantic and Mediterranean Coasts

One hundred forty one species and subspecies of insects are listed from sandy beaches on the Atlantic and Mediterranean coasts of Morocco (Table I). Beetles of the Tenebrionidae dominate this list with 39% of species recorded, followed by Carabidae with 21%. Beetles dominate in sandy environments, both coastal and inland. Composition of families is similar in such habitats, but differs at the generic and species level (Ponel 1986). However, *Xenonychus tridens* (Histeridae), of which we collected a single specimen at Dar Skirej (Tetouan region, western Mediterranean), is found in sandy habitats on the coast and inland (Therond & Bigot 1964).

More species have been recorded on sandy beaches on the Mediterranean coast than on Atlantic ones, with 109 and 47 species recorded respectively (Table I). This is a similar finding to the study carried out on the Atlantic and the Mediterranean coasts of France (Bigot 1983). 15 species were common to both coasts (approx. 12% of species sampled and a Sorensen Similarity Index coefficient of 20.9). In terms of beetles, these were: *Crypticus nebulosus*, *Tentyria maroccana*, *Trachyscelis aphodioides* and *Xanthomus pallidus* (Tenebrionidae); *Parallelomorphus laevigatus* and *Eurynebria complanata* (Carabidae); *Scarabaeus (Scarabaeus) sacer* and *Scarabaeus (Ateuchetus) semipunctatus* (Scarabaeidae) and *Brindalus porcicollis* (Aphodiidae) (Kocher 1956–1969). Records of congeners differ between coasts, with some species recorded only on the Mediterranean coast and others on the Atlantic. The genera *Phaleria* and *Erodius* in the Tenebrionidae are examples of this.

Main causes of degradation of Sandy Beaches in Morocco

Many sandy beaches are subject to alteration and destruction, owing largely to the demands of tourism. This is due to anthropogenic pressures such as: compacting of sand due to a high density of humans and their vehicles (most serious close to the shoreline), excessive urbanization and development of seaside residences, resorts, marinas, and golf courses, creation of access routes

to the sea and littering and pollution. Illegal removal of sand from beaches is also a problem in Morocco.

DISCUSSION AND CONCLUSION

Our review summarises knowledge on insects of sandy beaches in Morocco. The list of insects recorded from sandy dunes is certainly not exhaustive and consists mainly of Coleoptera, but it does provide an indication of the richness and composition of this fauna.

The composition of species recorded on the Mediterranean and Atlantic coasts differs considerably. These apparent differences are perhaps accentuated by the apterous morphology of many sand-dwelling beetles, with congeners filling similar niches at sites that are only a small distance away from each other.

Recording of insects in sandy habitats is not easy. It is normal, for example, to collect individuals of the same species in abundance in some dm³ samples of sand only, and not in others at the same site. Methodology employed and timing of sampling probably influence the quality of results. The only record of *Cephalocteus scarabaeoides* (Hemiptera: Cydnidae) in the dunes of Dar Skirej (where it was recorded in abundance), despite its wide distribution in Europe and North Africa (Vidal 1949), could reflect this.

Eurynebria complanata (Coleoptera: Carabidae) has not been recorded from areas that are frequented by a high density of humans. Some species have very precise and sensitive habitat requirements and anthropogenic factors could compromise their conservation. Degradation of sandy beaches is in many cases irreversible. However, it would be beneficial to preserve relatively undisturbed areas as reservoirs of biodiversity and for the benefit of future generations. The role of the authorities is crucial to limit the impact of destructive practices on sandy beaches. They could do so by establishing management plans to achieve conservation goals and working with scientific and educational institutions and NGOs to involve them in conservation efforts and establishing educational programmes and interpretation. The recent proposed measures for the eastern Mediterranean coast (Nador and Oujda regions) by Chavanon (2003) could be used as a model. It is also desirable to conduct more research on the biodiversity of these fragile habitats, particularly on the less explored southern Atlantic coast of Morocco.

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