**ARTEMIA BIODIVERSITY IN ALGERIAN SEBKHAS**

BY

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ABSTRACT

This paper summarizes the results of a study that comprised a survey along with a morphological characterization of *Artemia* populations from seven sebkhas, one chott, and an inland salt lake in Algeria. Sebkhas and chotts are two different types of closed inland basins. Morphological characters together with a multivariate discriminant analysis applied to morphometric data obtained from adult specimens cultured under standard conditions, were used to differentiate the species and strains. The bisexual species *A. salina* (L., 1758) is present in seven of these saltmarshes, but frequently co-occurs with diploid and tetraploid parthenogenetic strains. The biodiversity pattern of the populations of *Artemia* in Algeria appears to be similar to that found in the rest of the western Mediterranean region.

INTRODUCTION

The brine shrimp *Artemia* (Branchiopoda, Anostraca) is cosmopolitan and includes extreme halophilic species and strains. Brine shrimps live in several...
hundreds of locations (Van Stappen, 2002) on the five continents, where they thrive in coastal solar salterns as well as in inland salt lakes (Triantaphyllidis et al., 1998; Muñoz & Pacios, 2010). “Brine shrimp” comprises a complex of both bisexual species and parthenogenetic strains. There are six bisexual species and a variety of parthenogenetic strains of diverse ploidy, as follows:

Two of these bisexual species are autochthonous in the Americas, with *A. franciscana* Kellogg, 1906 spreading over the entire American continent (Hontoria & Amat, 1992; Triantaphyllidis et al., 1998; Abatzopoulos et al., 2002a), and *A. persimilis* Piccinelli & Proscocimi, 1968 present only in the American South Cone (Cohen et al., 1999; Gajardo et al., 2004). The bisexual species *A. salina* (Linnaeus, 1758) is present in the Mediterranean basin, being common on the African continent from the north to the south (Muñoz et al., 2008) where it is supposed to co-occur with parthenogenetic strains (diploid and tetraploid) (Amat, 1983). The rest of the bisexual species native to the Old World are distributed in Eurasia. *A. urmiana* Gunther, 1890 is present in Lake Urmia (Iran) and in Lake Koyashskoe (Crimea, Ukraine) (Abatzopoulos et al., 2009), *A. sinica* Cai, 1989 is mostly present in China (Van Stappen et al., 2002), and *A. tibetiana* Abatzopoulos, Zhang & Sorgeloos, 1998 is located in several salt lakes on the Tibetan plateau (Abatzopoulos et al., 2002b).

All *Artemia* species and strains can reproduce in two ways, ovoviviparously, producing live nauplii, and oviparously, producing encysted cryptobiotic embryos, this mode operating under unfavourable environmental conditions. The oviparous mode assures the continuity of the populations in the form of floating cysts, either in the brine or stranded along the banks of the hypersaline ecosystem. Later on, when the environment becomes appropriate again, the cysts resume embryonic development and a living population starts anew.

Algeria is endowed with a climate suited for the presence of plenty of biotopes fit for the development of *Artemia* populations (Vanhaecke et al., 1987). Among these biotopes, we must consider the sebkhas and chotts. According to the terminology accepted by North African geomorphologists a sebkha is a closed inland basin with impermeable bottom, which accumulates soluble and insoluble products provided by water inflows from surrounding, large hydrological areas. It can be filled up and flooded during short heavy rain periods, but becomes dry, slowly after because of evaporation. A chott usually does not become completely dry, because relies on underground water inflow. Their aquatic fauna is poorly known for a variety of reasons, usually the difficulty of access and drought.

Between the northern Algerian High Plains and the Mediterranean shore there is a vast complex of saltwater sebkhas. The Oran-Relizane complex in the west, and various sebkhas in the localities of Oum Bouagui, Batna, and Khenchela to the east, including Setif, Garaet et Tarf, and Ezzemoul, are the most important.
Going to the south, the Goléa Mnea salt lake, located in the “wilaya” (province) of Ghardaia deserves special attention.

Sebkhas sometimes are exploited for salt production. During the winter rainy season, mainly in November and December, rains usually cause some flooding due to their great hydrological catching area. The upper salt bed dissolves, producing brines that allow the development of \textit{Artemia} populations. These brines attain high salinities during the spring. In April salinities are higher than 190 gL$^{-1}$ and salt is harvested in several crystallizing ponds during the early summer period (May-June). From June to September, the sebkha shows a completely dry salt surface without water (ENASEL, Algerian National Salt Enterprise, pers. comm.). Living \textit{Artemia} populations are rarely found during this period, until the next rainy season when water provokes cyst hatching and a provision of brines, fit for the recruitment and growth of a new population.

Despite the abundant and wide distribution of these hypersaline areas, very little was known about the biodiversity of \textit{Artemia} populations inhabiting them. In their first biogeographical work on world-wide \textit{Artemia} localities, Vanhaecke et al. (1987) listed no more than four Algerian \textit{Artemia} sites. A first annotated check-list of large branchiopods of Algeria and an approach to the findings of \textit{A. salina} can be found in Samraoui et al. (2006), with personal references to its presence in the Bethioua saltworks, in the Ezzemoul sebkha, and in the chotts Merouane and Melghir in the Southern High Plains (Sahara). These authors also refer to previous records in Blanchard & Richard (1890), Gauthier (1928), Haddag (1991), Zemmouri (1991), and Beladjal et al. (1995). A limnological report composed by McCarracher (1972) also quotes the presence of \textit{A. salina} in two inland hypersaline Algerian sites. More recently, \textit{Artemia} was cited by Kara et al. (2004) and by Amarouayache et al. (2009a, b) in the chott of Merouane. All these reports are referring to the exclusive presence of \textit{A. salina}, probably due to a lack of information concerning the actual species biodiversity recently unveiled for the genus.

Morphometry has been chosen in this study as a tool to identify the different species and strains that are present at the sites sampled. This could be the easiest available methodology for Algerian researchers seeking to improve our knowledge of \textit{Artemia} biodiversity through an exhaustive prospection of the hypersaline ecosystems in Algeria. Several authors working on this topic in North African countries (Tunisia, Algeria, Morocco, Egypt, etc.) have already used similar morphological and morphometric methods. In our case, the results obtained with these methods have been confirmed by using Mediterranean reference species and populations that were taxonomically and systematically described and employed in multidisciplinary approaches, including molecular biological studies (Mura et al., 2005, 2006; Muñoz et al., 2008, 2010b). In addition, morphometry is a valid
first approach to survey the Artemia biogeography of an area; however, there is no
doubt that other, complementary methods should be applied in order to obtain a
complete picture of the distribution of the species and populations.

The objectives of this study focus on the biogeographical localization of hyper-
saline biotopes fit for the development of Artemia populations in northern Alge-
ria. The study also aims to update the actual biodiversity of Artemia populations
found. Thus, it tries to discern the real abundance of bisexual A. salina and/or
to unveil the previously mistakenly reported presence of parthenogenetic popu-
lations. The methods employed comprise species differentiation by morphological
(Amat, 1980; Mura & Brecciaroli, 2004) and morphometric criteria, supported by
the large morphometric data base on Mediterranean Artemia populations available
at the Instituto de Acuicultura de Torre de la Sal (Hontoria & Amat, 1992).

MATERIAL AND METHODS

Samples of mixed Artemia cysts and debris floating on brines, or accumulated
along the banks, were obtained during several surveys performed between 2005
and 2009 in the hypersaline ecosystems presented in table I. Samples of living
Artemia specimens, preserved in 70° ethanol, were also collected when present.
Debris and cysts were floated in brine in the laboratory, sieved through different
mesh sizes (1 mm, 0.5 mm, 0.3 mm, and 160 μm) and finally cysts were cleaned
with standardized methods (Vanhaecke & Sorgeloos, 1980), oven dried at 39°C,
and vacuum stored at 4°C.

Culture conditions

Cysts were hatched under standard conditions in 1 L glass tubes, filled with
filtered 35 gL⁻¹ seawater (pH 8), at 28°C with continuous illumination and

<table>
<thead>
<tr>
<th>Location</th>
<th>Province</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethioua sebkha and saltworks</td>
<td>Oran</td>
<td>35°42'31&quot;N 0°16'53&quot;W</td>
</tr>
<tr>
<td>Oran Grande sebkha</td>
<td>Oran</td>
<td>35°44'28&quot;N 0°23'13&quot;W</td>
</tr>
<tr>
<td>Relizane sebkha and saltworks</td>
<td>Sidi Bouziane</td>
<td>35°50'31&quot;N 0°39'10&quot;E</td>
</tr>
<tr>
<td>Setif sebkha</td>
<td>Ain Arnat</td>
<td>36°09'45&quot;N 5°17'28&quot;E</td>
</tr>
<tr>
<td>Ezzamoule sebkha and saltworks</td>
<td>Oum Bouaghi</td>
<td>35°52'54&quot;N 6°30'14&quot;E</td>
</tr>
<tr>
<td>Goléa Mnea salt lake</td>
<td>Ghardaia</td>
<td>30°28'39&quot;N 2°55'29&quot;E</td>
</tr>
<tr>
<td>Garaet et Tarf sebkha</td>
<td>Oum Bouaghi</td>
<td>35°40'33&quot;N 7°04'47&quot;E</td>
</tr>
<tr>
<td>Melghir chott</td>
<td>Biskra</td>
<td>34°10'46&quot;N 6°07'05&quot;E</td>
</tr>
</tbody>
</table>

TABLE I
Algerian hypersaline ecosystems surveyed: localization and geographical coordinates
aeration. Nauplii obtained were raised in transparent plastic cylindrical containers filled with 70-80 gL\(^{-1}\) filtered brine (seawater plus crude salt), on a mixed microalgal diet of \textit{Dunaliella salina} (Teodoresco, 1905) and \textit{Tetraselmis suecica} (Butcher, 1959) balanced to the same salinity. The temperature was maintained at 24 ± 1°C under a mild aeration from the bottom and a 12D : 12L light regime. The culture was monitored every 3-4 days to assess the size and developmental stage of the shrimps. When young and adult individuals became apparent, some of these were sampled randomly, and anaesthetized in a Petri dish with seawater under the addition of 5 mL chloroformed fresh water. They were observed under the microscope in order to verify the presence of males and females, and the presence of females belonging to one or more different species or strains (bisexual as well as parthenogenetic) according to the morphological traits defined by Amat (1980, 1985), and Mura & Brecciaroli (2004). This primary selection allowed a first approach to the specific composition of the \textit{Artemia} populations obtained from the hatched original cysts. On the basis of the abundance of enough adult specimens (30) to develop a morphometrical study, they were maintained in the same culture conditions until more than 50% of the females had attained full ovisac development and produced their first batch of offspring (living nauplii or cysts).

**Multivariate morphometry of large samples**

The hatching percentages for these samples ranged between 70 and 80%, and the survival to adulthood was over 50%.

Once adulthood was attained, random samples of 30 females were removed from each culture, anaesthetized and measured under a dissecting microscope provided with a micrometer eyepiece (Hontoria & Amat, 1992). The following 13 morphometric parameters were examined: total body length (TL), abdomen length (AL), width of the third abdominal somite (AW), head width (HW), maximal distance between the compound eyes (ED), eye diameter (ES), length of the first antenna (ANL), length of the furca (FL), number of setae on the right and on the left branch of the furca (LS, RS), abdomen length/total length ratio (ATL), and ovisac width (OW).

The discriminant analysis is a multivariate procedure that provides a series of variables, which are linear functions of the morphometric variables studied. These functions maximize the separation among different groups of observations defined a priori. In the analysis, the separation criterion is the origin of each population, and the presence of diverse populations for the same species or strains as references reinforces the discriminating capacity of the analysis. For this reason, a number of other \textit{A. salina} (4), diploid parthenogenetic (6) and tetraploid parthenogenetic (5) \textit{Artemia} strains native from several countries around the Mediterranean basin and
TABLE II

Species/strain designation, and origin and location of the populations retrieved from the IATS morphometrical database and used in the discriminant analysis

<table>
<thead>
<tr>
<th>Bisexual Artemia salina (L.)</th>
<th>Diploid parthenogenetic</th>
<th>Tetraploid parthenogenetic</th>
<th>Bisexual Artemia franciscana Kellogg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Souzama (Oualidia, Morocco)</td>
<td>32°44'N 9°01'W</td>
<td>Muñoz et al., 2008</td>
<td></td>
</tr>
<tr>
<td>Rocío (Cádiz, Spain)</td>
<td>36°52'N 6°19'W</td>
<td>Muñoz et al., 2008</td>
<td></td>
</tr>
<tr>
<td>Bonnati (Alicante, Spain)</td>
<td>38°10'N 0°37'W</td>
<td>Muñoz et al., 2008</td>
<td></td>
</tr>
<tr>
<td>Trapani (Sicilia, Italy)</td>
<td>37°59'N 12°32'E</td>
<td>Muñoz et al., 2008</td>
<td></td>
</tr>
<tr>
<td>Wadi Natron (El Cairo, Egypt)</td>
<td>30°23'N 30°19'E</td>
<td>Muñoz et al., 2010b</td>
<td></td>
</tr>
<tr>
<td>Odiel (Huelva, Spain)</td>
<td>37°15'N 6°59'W</td>
<td>Muñoz et al., 2010b</td>
<td></td>
</tr>
<tr>
<td>La Mata lagoon (Alicante, Spain)</td>
<td>38°02'N 0°42'W</td>
<td>Mura et al., 2005</td>
<td></td>
</tr>
<tr>
<td>Aigües Mortes (Languedoc, France)</td>
<td>43°32'N 4°10'E</td>
<td>Mura et al., 2005</td>
<td></td>
</tr>
<tr>
<td>Margherita di Savoia (Foggia, Italy)</td>
<td>41°22'N 16°05'E</td>
<td>Muñoz et al., 2010b</td>
<td></td>
</tr>
<tr>
<td>Torrecolimena (Apulia, Italy)</td>
<td>40°18'N 17°43'E</td>
<td>Mura et al., 2005</td>
<td></td>
</tr>
<tr>
<td>Odiel (Huelva, Spain)</td>
<td>37°15'N 6°59'W</td>
<td>Mura et al., 2006</td>
<td></td>
</tr>
<tr>
<td>Pinilla (Albacete, Spain)</td>
<td>38°45'N 1°40'W</td>
<td>Amat et al., 1995a</td>
<td></td>
</tr>
<tr>
<td>Delta del Ebro (Tarragona, Spain)</td>
<td>40°34'N 0°40'E</td>
<td>Mura et al., 2006</td>
<td></td>
</tr>
<tr>
<td>Larache (Tanger, Morocco)</td>
<td>35°11'N 6°06'W</td>
<td>Hontoria &amp; Amat, 1992</td>
<td></td>
</tr>
<tr>
<td>Margherita di Savoia (Foggia, Italy)</td>
<td>41°22'N 16°05'E</td>
<td>Mura et al., 2006</td>
<td></td>
</tr>
<tr>
<td>San Francisco Bay (California, U.S.A.)</td>
<td>37°30'N 122°12'W</td>
<td>Mura et al., 2006</td>
<td></td>
</tr>
<tr>
<td>Great Salt Lake (Utah, U.S.A.)</td>
<td>41°00'N 112°30'W</td>
<td>Mura et al., 2006</td>
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properly referenced, together with two A. franciscana populations (table II), were retrieved from the morphometric database of the Instituto de Acuicultura de Torre de la Sal (IATS-CSIC) and also included in the analysis. The morphometric data present in this database have been obtained from individuals chosen and cultured in the same way as described above in this study. The full data matrix was subjected to multivariate discriminant analysis using the statistical package SPSS for Windows version 17.0 (SPSS Inc. Chicago, Ill.) (Hontoria & Amat, 1992) in order to characterize the Algerian Artemia populations (bisexual and parthenogenetic), and to establish relationships with the other Mediterranean parthenogenetic and bisexual strains or species.

Morphology of small samples

Some very short cyst samples (less than 100 mg dry cysts after cleaning) from the Bethioua, Oran, and Setif sebkhas, most probably produced in late winter, showed hatching efficiencies of about 5% and the few nauplii obtained scarcely attained adulthood (30% survival approximately) under the standard culture conditions. Not enough adult specimens were obtained to apply a multivariate anal-
ysis. The few ones attaining adulthood, together with those sampled mainly in
winter in these biotopes and preserved in ethanol, were compared with the mor-
phological characters displayed by cultured adult specimens obtained from the
Relizane, Ezzamoule, and Garaet et Tarf sebkhas, according to the morphological
characterizations of Amat (1980), Mura (1990), Triantaphyllidis et al. (1997), and
Mura & Brecciaroli (2004). Therefore, instead utilizing of the discriminant anal-
ysis method, an approach based on visual identification (optical microscopy) fol-
lowing the morphological characters described by Amat (1980) and Mura & Brec-
ciaroli (2004) was used to identify the presence of A. salina winter populations in
those biotopes.

RESULTS AND DISCUSSION

Original samples monitored in the wild, as well as populations cultured in the
laboratory after hatching original cyst samples, showed the presence of different
Artemia populations, which, according to the morphological traits cited above
(Amat, 1980, 1985; Mura & Brecciaroli, 2004), agreed with the occurrence of
Artemia salina, and both diploid and tetraploid parthenogenetic Artemia strains.

Other zooplankters were present, especially during the periods characterized
by low salinities in winter after the rainy season and in the early spring, among
which rotifer Brachionus plicatilis (Müller, 1786), the harpacticoid copepod
Cletocamptus retrogressus (Schmankevitsch, 1875), or several cladocerans like
Chirocephalus salinus (Daday, 1910) and Ch. diaphanus (Desmarest, 1823) (cf.
Alonso, 1996; Samraoui et al., 2006). Sebkha samples showed a certain diversity
of aquatic invertebrate propagules together with Artemia cysts. It was possible
to distinguish cladoceran ephyppia, those from Ch. salinus and Ch. diaphanus,
as well as other large branchiopod cysts, likely Branchinecta spinosa (H. Milne
Edwards, 1840) (cf. Alonso, 1996; Ben Naceur et al., 2009). All populations
studied, either cultured under laboratory conditions after hatching original cysts,
or observed from preserved samples collected in the wild, showed more than
one species or strain. The only exceptions were the samples obtained from the
inland Goléa Mnea salt lake, and that from the Garaet et Tarf sebkha, which
always produced a tetraploid parthenogenetic Artemia and the bisexual A. salina,
respectively, as supported by the results of the discriminant analysis and completed
by the visual observations of the samples that could not be included in the
multivariate procedure.

The results obtained from the multivariate analysis applied to the female mor-
phology of the Algerian Artemia populations studied, together with those used as
references when the origin of the different populations was used as a separation
factor, are displayed in fig. 1. The multivariate analysis produced twelve discriminant functions. The first four of these give a cumulative variance explanation of 85.0%. The first 11 functions calculated were highly significant ($P < 0.001$). The analysis allows to correctly classify 86.9% of the observations in their original population groups. Moreover, when the species-parthenogenetic ploidy is used as a separation criterion in the discriminant analysis, the observations are classified correctly in the 98.7% of the cases. The females pertaining to *A. salina* were grouped properly in 98.8% of the cases studied, those being diploid parthenogenetic in 98.9%, the tetraploid parthenogenetic in 98.1%, and the reference observations from *A. franciscana* were all classified correctly.

The morphometric characters highly correlated with the first discriminant function were the length of the first antenna, the distance between the compound eyes, and total length, while those related to the second function were the length of the furca and the number of furca setae. Fig. 1 shows the centroids that can be considered as representative of each population according to the significance levels of the discriminant functions that are used to calculate them. The groupings
here unveiled correspond to the parthenogenetic diploid and tetraploid strains, to *A. salina*, and to *A. franciscana*, for the female individuals studied.

The females of the Algerian populations studied in this work are placed by the discriminant analysis among the centroids pertaining to the native bisexual *A. salina* or any of the parthenogenetic groups of different ploidy level. Then it is possible to accept that the biodiversity of the Algerian *Artemia* populations is congruent with the biodiversity found for the rest of the western Mediterranean countries (Amat et al., 1995a). On the Iberian Peninsula, there is a frequent co-occurrence of the bisexual *A. salina* and the diploid parthenogenetic strain in the seashore saltmarshes and saltworks, with a marked seasonality. While the bisexual species shows a preference for the low temperatures prevailing during the late winter and early spring period, the diploid parthenogenetic strains develop their populations during the spring and summer period (Amat, 1981). This is the same situation observed for the Algerian populations, at least in the northern area where sebkhas are found and where the mean thermal range varies between 10° and 12°C in winter and between 21° and 24°C in summer (ONM, Algerian National Office of Meteorology).

The morphological comparison of the small samples obtained from the Oran, Bethioua, and Setif sebkhas, not included in the morphometric study, verified the presence of *A. salina* at these sites during late winter and spring. Therefore, the visual identification described above satisfactorily established the presence of winter populations of *A. salina* in those biotopes.

In summary, *A. salina* and the diploid parthenogenetic populations are present in all sebkhas and in the chott Melghir, with the exception of Garaet et Tarf where only *A. salina* appeared. The tetraploid parthenogenetic population is absent in the Ezzamoule, Melghir, and Oran sebkhas, but is exclusive for the Goléa salt lake.

Until recently, and even today, biogeographical and biodiversity studies dealing with the distribution of *Artemia* species in North Africa have been limited to the identification of populations belonging to the bisexual *A. salina*, while the presence of parthenogenetic strains has been scarcely known (Amat, 1983; El Bermawi et al., 2004). Our results confirm that the biodiversity pattern of the populations of *Artemia* in Algeria is similar to that found in the rest of the western Mediterranean region.

The distribution of Algerian tetraploid parthenogenetic populations is quite astonishing. In the Iberian Peninsula, they are spread mainly in inland biotopes, while they are hardly present in the seashore saltworks. The inland hypersaline ecosystems are characterized by a quite extreme thermal regime, with cold winters and warm summers but showing plentiful populations in summer during the short period of salt production, at least in the case of inland solar saltworks (Amat et al., 1995a). The results for the Algerian populations likely do not match with this
scheme, with the exception of the population found in the inland Goléa Mnea salt lake. The mean thermal range for this area, in the northern Sahara, varies between 15° and 18°C in winter and 40° and 45°C in summer (ONM). The abundance and co-occurrence of the tetraploid parthenogenetic strain in the sebkha cyst samples could be explained by the high salinities and temperatures attained in these saltmarshes during the short period of brine availability in early summer, in the sebkha itself as well as in the exploited saltworks, especially in Bethioua and Relizane.

Crossbreeding experiments performed by Baratelli et al. (1990) suggested the conspecificity of the Mediterranean populations, from Italy as well as from the north of Africa, and SEM studies from Mura (1990) reinforced this conspecificity. Just recently it has been demonstrated that *A. salina* populations show substantial genetic diversity and a strong phylogeographical structure, with high regional endemism in the Mediterranean Basin, the Iberian Peninsula, the north of Africa, and on the Italian islands (Sardinia and Sicily) (Muñoz et al., 2008). An accurate knowledge of the biodiversity of bisexual *A. salina* populations in Africa is urgent, especially due to the lack of information from this continent. *A. salina* presence has been reported only in the Mediterranean area and in South Africa (Amat et al., 1995b), but the substantial genetic diversity and the presence of marked regional endemisms shown by Muñoz et al. (2008) for this species on the African continent allowed those authors to claim a specific status for the South African bisexual populations.

This lack of biodiversity information relies on the supposed exclusivity of the *A. salina* presence in the north of Africa. In fact, all the publications reporting the presence of *Artemia* populations in Algeria, cited in the introduction, are referring exclusively to *A. salina*. Even today, the efforts developed by several authors in the north of Africa are likely focused to establish the presence and distribution of the bisexual *A. salina*, without any mention of finding other strains. This is the case for Morocco (Sadkaoui et al., 2000) for Libya (El Magsodi et al., 2005) as well as for Tunisia (Ben Naceur et al., 2008). However, there are a few previous studies, rather apart in time, confirming the presence of some clonal or parthenogenetic (diploid) *Artemia* populations in this area. This is the case for the Larache salterns in Morocco (Amat, 1983) and also for the Egyptian salterns of El-Max and Borg El Arab, as well as the Qarun lake (El Bermawi et al., 2004) located at both (longitudinal) extreme ends of the North African Mediterranean coast. The great abundance of parthenogenetic *Artemia* populations in the northern Mediterranean countries (Amat et al., 1995a; Mura et al., 2005; Baxevanis et al., 2006) must have its congruent correspondence in the southern countries of the same geographical area or basin.
In the literature it is reported that parthenogenetic species or strains use to show widespread haplotypes (Law & Crespi, 2002), what suggests faster dispersal rates than their relatives or co-occurring bisexuals. For example, clonal lineages of parthenogenetic *Daphnia* are widely distributed (Weider et al., 1999). In addition, several studies suggest that asexuals are better and faster colonizers, and that they are usually spread over a greater niche breadth than co-occurring bisexuals (Browne & MacDonald, 1982; Browne et al., 1988; Triantaphyllidis et al., 1995; Muñoz et al., 2010). In the case of parthenogenetic *Artemia*, this colonizing capability is supported by their physiological and ecological tolerances, as well as their genetic structure (ploidy level: automixis or apomixis, types of reproduction: ovoviviparity or oviparity) (Zhang & Lefcort, 1991; Baxevanis et al., 2006). These arguments are sufficiently confirmed today, together with the demonstrated presence of parthenogenetic *Artemia* populations in the whole Old World, to explain the presence of these strains in northern Africa.

It is also worth mentioning that there is a generalized invasion of the western Mediterranean by the exotic species *A. franciscana* (cf. Amat et al., 2005, 2007; Mura et al., 2006). Its presence has also been reported from various African countries, in the Bou Areg sebkha (Morocco) (Amat et al., 2005), in the Fundisha salterns (Kenya) (Muñoz & Pacios, 2010), in the Ifaty salterns (Madagascar) (Kaiser et al., 2006; Muñoz & Pacios, 2010), and in the Cape Verde archipelago (Ballell, 2006; Muñoz & Pacios, 2010). Consistently with a man-mediated introduction or dispersion via shorebirds (Green et al., 2005) it is possible to expect that viable *A. franciscana* cysts could eventually reach the coastal sebkhas or salt-works in the North African Mediterranean region. For this reason, it is valuable to have developed a reliable overview of identification and geographical distribution of the native *Artemia* populations beforehand. This provides a basic knowledge useful to discern the presence of different species or strains, primarily based on morphological differentiation. This knowledge will allow assessing the presence of original populations, or the unexpected arrival of the invasive species, possibly preventing its expansion, or at least facilitate maximally effective measures for the conservation of the autochthonous species and strains.

**ACKNOWLEDGEMENTS**

This study was partially financed by the Spanish Ministry of Research and Innovation projects CGL2005-02306, CGL2008-03277, and by a Spanish Agency for International Cooperation and Development (AECID) project (A/017377/08). M. S. Ghomari was supported by a fellowship of the University of Mostaganem (Algeria) and by project A/017377/08.
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