Recent shrinkage of the range of the Eastern Spadefoot Toad, *Pelobates syriacus* (Amphibia: Anura): archaeological evidence from the Bronze Age in Israel

by Massimo Delfino, Guy Bar-Oz, and Lior Weissbrod

Abstract. The analysis of the remains collected in the Ara Burial Cave in Lower Galilee, Israel (Late Bronze Age II, c. 1300-1200 BCE), permitted the identification of 725 anuran remains belonging mostly to *Bufo viridis* but also to *Pelobates* cf. *syriacus*. The origin of the anuran assemblage in Ara cave appears to be intrusive, probably related to the need to find aestivation shelter during the dry and hot summer season. Despite the relative rarity of *Pelobates* remains (attributable to a single individual), their presence in the Ara cave testifies to a wider range of the taxon in the recent past, since the cave is located outside its present range. *Pelobates* remains are also found in several Israeli Late Pleistocene archaeological sites that lie outside the present fragmented range of the species and completely fill its main gap in this country. This suggests recent environmental modifications, which may be due to climatic fluctuations as well as anthropogenic impact. An accurate analysis of the range contraction evidenced by the zooarchaeological record, and of the environmental changes that recently occurred in the region, should be taken into consideration in the preparation of soundly based conservation or reintroduction plans in Israel.

Kuzfassung. Die Bearbeitung der Funde der Ara Burial-Höhle in Unter-Galiläa, Israel (Späte Bronzezeit II, c. 1300-1200 BCE), ergab 725 *Anura*-Reste, welche hauptsächlich *Bufo viridis*, aber auch *Pelobates* cf. *syriacus* zugehören. Der Ursprung der Anuren-Vergesellschaftung in der Ara-Höhle scheint intrusiv, vermutlich durch die Suche nach einem Unterschlupf während der trockenen und heißen Sommermonate verursacht. Trotz der relativ geringen Häufigkeit an *Pelobates*-Resten (einem einzigen Individuum zugehörig) deutet dieses Vorkommen auf eine größere Verbreitung in der unmittelbaren Vergangenheit hin, da sich die Höhle außerhalb des heutigen Verbreitungsgebietes befindet. *Pelobates*-Reste kommen weiters an verschiedenen anderen israelischen spät-pleistozänen bis holozänen archäologischen Fundstellen vor, welche allesamt außerhalb der heutigen Verbreitung liegen. Das dürfte mit heute veränderten Umweltbedingungen zusammenhängen, welche durch Klimaschwankungen und menschlichen Einfluss verursacht sein können. Eine umfassende Analyse dieser heutigen eingeschränkten Verbreitung, untermauert durch zooarchäologisches Vorkommen und die Umweltveränderungen, welche in dieser Region in der nahen Vergangenheit stattgefunden haben, sollten für jedwede Schutz- und Wiedereinführungspläne Israels unbedingt in Betracht gezogen werden.

Key words. *Bufo viridis*, range fragmentation, biogeography, Holocene, conservation.

Introduction

Archaeological evidence can provide an important insight into understanding current zoogeographical patterns of extant species and recent biodiversity changes. In particular, the comparison of the ranges of modern species with the geographic distribution of their Late Pleistocene and Holocene occurrences is essential for accurately assessing the respective impact of climate change and human actions and their environmental consequences on the structure of contemporary animal communities (LYMAN 1996, LYMAN & CANNON 2004, HAYASHIDA 2005). Amphibians are especially suitable for the application of this approach

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because they are regarded as good proxies of environmental conditions in both terrestrial and aquatic habitats, are spatially stable in representing local environmental conditions, and exhibit slow rates of evolutionary change (PECHMANN et al. 1991, HOULAHAN et al. 2000, STUART et al. 2004, DELFINO 2005, POUNDS et al. 2006). In addition, the ecological requirements of many extant amphibians are well known and are expected to apply equally to their Quaternary representatives due to the ancient origin of many of these species. An understanding of the implications of such comparisons depends however on valid taxonomic identification of archaeofaunal material, accurate appreciation of the spatial scale of analysis, and consideration of the way such faunal assemblages have occurred in archaeological contexts.

The study of the anuran remains found during the recent excavation of the Ara burial cave, dated back to the Late Bronze Age II (c. 1300-1200 BCE; WEISSBROD & BAR-OZ 2004) and uncovered key evidence on the historic range of one of the two identified species, presenting the chance to summarise the zooarchaeological information on the contraction of its range. We present here a detailed taxonomic analysis of the anuran remains, and discuss the implications of the results, in order to understand the past chorology of the identified species and its bearing on conservation efforts for their still extant populations.

The site and its settings

Ara burial cave is located adjacent to Tel Ara and the modern village of Kfar Ara in the Yiron valley in Lower Galilee, Israel (Fig. 1). Excavation uncovered two adjoining multi-chambered burial caves forming part of the Tel Ara cemetery. The faunal material from tomb one only was made available to WEISSBROD & BAR-OZ (2004) for analysis.

According to the excavators, the burial cave was quarried in a narrow outcrop of soft Senonian chalk and was sealed when discovered. It consists of a large central chamber, and five subsidiary rooms. The context of the tomb as a whole clearly demonstrates its burial function. Inside the tomb, an unusually dense concentration of finds was recovered comprising mainly a large variety of local and imported ceramic vessels, bronze artefacts, and several scarab seals. The human osteological material from the cave represents a minimum of 26 individuals, including male and female adults and adolescents. The dead were apparently laid to rest with various burial offerings placed beside the bodies. Based on the artifact typology, the chronology of the tomb's use spans the periods of the Intermediate Bronze Age when the cave was quarried, the Middle Bronze Age I, and the Late Bronze Age II to which the majority of the finds present here are attributed (YUVAL GADOT, pers. comm. 2006).

The number of studied and published burial faunal assemblages from the near-eastern biblical periods is rather limited. Similar to other such assemblages, the Ara large-size faunal material is dominated by domestic livestock species, in particular juvenile sheep and goats that were ritually offered to the dead (reviewed in WEISSBROD & BAR-OZ 2004; see also HORWITZ 1987, 2001). The small fauna is comprised predominantly of anuran remains.

Material and methods

Anuran remains were retrieved mainly from 18 intact ceramic vessels from the Ara burial cave (VS 16, 003, 024, 057, 064, 084, 076, 090, 093, 111, 112, 119, 137, 165, 188, 280, 617, 885). They are currently stored in the collections of the Laboratory of Archaeozoology, Zinman Institute of Archaeology (University of Haifa, Israel). The anatomical nomenclature applied here follows ROCEK (1981) for maxillae and squamosal, SANCHIZ (1998) for the rest of the described skeletal elements.

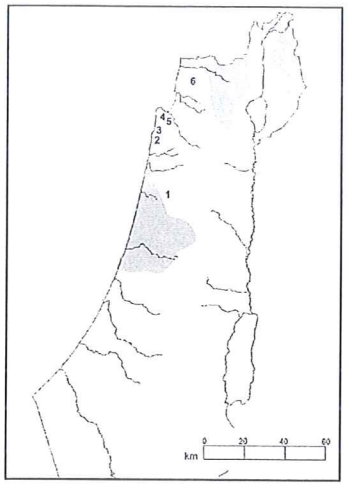

Fig. 1. Present range of *Pelobates syriacus* in the area discussed in the text (according to DOLEV & PREVOLOTSKY 2005) and archaeological sites that yielded remains of this taxon. 1) Ara cave; 2) el-Wad Terrace; 3) Abu Usba; 4) Iraq e Zigan; 5) Geula cave; 6) Hayonim Cave. See text for chronological allocation and pertinent literature.

The following remains from the Ara Tomb have been attributed to amphibians:

- *Pelobates* cf. *syriacus* [3 remains]: maxilla: 1; sphenethmoid: 1; squamosal: 1.
- *Bufo viridis* [578 remains]: maxilla: 3; frontoparietal+exoccipital+prootic: 4; frontoparietal+prootic: 1; exoccipital: 1; mandible: 2; clavicle: 1; coracoid: 2; scapula: 1; humerus: 133; radioulna: 55; ilium: 71; ischium: 2; femur: 146; tibiofibula: 126; atlas: 1; sacral vertebra: 3; vertebra: 11; urostyle: 15.
- Anura indet. [144 remains]: mandible: 1; humerus: 18; radioulna: 4; ilium: 9; femur: 13; tibiofibula: 63; vertebra: 2; indet.: 34.

A detailed list of skeletal remains found in each vessel is available from the authors on request. Almost all of the 144 undetermined anuran remains most probably belong to *B. viridis* but the absence of diagnostic traits or the poor preservation do not allow them to be identified with confidence. The minimum number of individuals (MNI, based on the humeri) indicates that the ceramic vessels contained at least 75 Green Toads and a single individual of an Eastern Spadefoot Toad. The sex ratio of the Green Toads, as borne out by the dimorphic humeri, indicates that the assemblage is markedly prejudiced toward females (26 males and 49 females). This bias most probably resulted from the presence of small subadult males that still lacked a well-developed *crista medialis* and were consequently identified as females.

Few reptilian remains are associated with the anurans; they belong to an undetermined chelonian (a fragmentary humerus and a possible fragmentary femur), an undetermined lizard (represented by a fragmentary caudal vertebra), a colubrid snake (one vertebra with haemal keel) and undetermined snakes (five vertebrae with hypapophysis, four caudal vertebrae and three vertebral fragments).

Results

Pelobates cf. *syriacus* Boettger, 1889 - Eastern Spadefoot Toad

Description. Maxilla (Fig. 2A, B): only the region posterior to the basis of the *processus palatinus* of the fragmentary right maxilla is preserved (the process itself is not preserved).

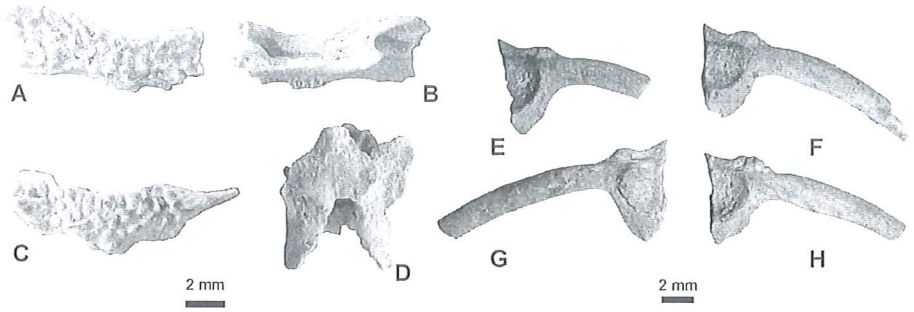

Fig. 2. *Pelobates* cf. *syriacus* (VS 885): A, B – right maxilla in lateral and medial view; C – right squamosal in lateral view; D – sphenethmoid in dorsal view. *Bufo viridis* (VS 280): E, F, H – right ilia in lateral view; G – left ilium in lateral view.

The region ventral to the *crista dentalis* is almost completely broken off and no teeth are preserved; but a faint trace of their pleurodont attachment can be seen. The *crista dentalis* terminates posteriorly with an evident *processus pterygoideus*, the dorsal sector of which conceals a tiny foramen when seen in medial view. The *margo orbitalis* is partly incomplete but the preserved posterior part indicates that the orbit margin was widely concave. The *processus frontalis* is partly broken while the *processus posterior* is broken off at its base. The *processus zygomatico-maxillaris* is high and posteriorly directed (its tip seems to be slightly eroded). A shallow groove is developed dorsally to the *crista dentalis* and posteriorly to the *processus palatinus*. The external wall is profusely ornate by irregular pustules.

Squamosal (Fig. 2C): the right squamosal is somewhat damaged and only the central part of the *lamella alaris* is preserved. The pointed, antero-medially directed *processus zygomaticus squamosi* is well-preserved, and its ventral surface shows the scars of the contact with the maxilla. The dorsal, posterior and ventral regions of the *lamella alaris* are broken off and therefore it is not possible to assess the development of their processes. The *processus posterolateralis* is represented by its root, corresponding to the preserved portion of the *lamella alaris*. As in the case of the maxilla, the external surface of the squamosal is markedly ornate.

Sphenethmoid (Fig. 2D): despite its incompleteness, it can be appreciated that this element was clearly much more elongated than high. The *trabeculum sinistrum* is broken off and the anterior region of the sphenethmoid is significantly eroded. In dorsal view, the *antrum pro lobo olfactorio* is elongated but not broad, the dorsal surface anterior to such *antrum* does not show any ornamentation with the exception of two anteriorly divergent ridges (the left less visible than the right) starting at the cranial end of the antrum; the lateral outline of the sphenethmoid does not show the presence of any process posterior to the *trabeculum*. In anterior view, the *antrum olfactorium* preserves the part of the ventral and the posterior walls; the small *foramen nutrititium* is quite close to the larger foramen of the first nerve.

Taxonomic remarks. The skull remains described in this section clearly belong to a member of the genus *Pelobates*, being characterised by a distinct ornamentation on their external surface (except on the sphenethmoid). With regard to specific allocation, the remains are tentatively attributed to the only species presently inhabiting southwest Asia, *P. syriacus*, to which all the fossil and subfossil remains of *Pelobates* from Israel have been attributed by

previous authors (see discussion). Moreover, some morphological traits linking the remains with *P. syriacus* can be highlighted. The *processus zygomatico-maxillaris* is high and posteriorly directed (although it is also slightly eroded in the only available maxilla from the Ara Tomb). This matches the morphology of *P. syriacus* maxilla determined by ROCEK (1981: Fig. 32a) and differs from that of *P. fuscus* (ROCEK 1981: Fig. 31a, b). BÖHME (1977: Fig. 6c) shows that the sphenethmoid of *P. syriacus* exhibits a comparatively narrow *antrum pro lobo olfactorio*, and also a small laterally pointed expansion located posteriorly to the *trabeculum*, but that it does not show a lateral process or thickening (compare BÖHME's fig. 6c with fig. 6d and 6e, showing the condition of *P. cultripes* and *P. fuscus* respectively). However, the fragmentary nature of the remains does not permit specific identification of *P. syriacus* on the basis of the osteology alone (see discussion in ROCEK 1981). The taxonomic particle "cf." is therefore introduced in order to indicate that identification at a specific level is based mainly on the chronological and geographic context of the remains. The three remains could belong to one single specimen with a snout-vent length of about 6-7 cm.

Bufo viridis Laurenti, 1768 – Green Toad

Description. This section describes only sufficient diagnostic elements required to support taxonomic identification. Due to their high numbers these elements are described collectively and synthetically. – Ilium (Fig. 1E-H): several ilia are characterised by a tubular *pars cylindriformis* (devoid of a laminar *crista dorsalis*), by a well-marked *tuber superius* usually showing an evident tubercle in the anterior area, and by an evident preacetabular pit. – Femur: these elements are rather stout and massive and exhibit an evident undivided *crista femoris*. – Vertebrae: all the vertebrae are procoelous and characterised by distinctly flattened and broad cotyles and condyles. The sacral vertebrae have relatively wide lateral processes (*processus transversus*) and a W-shaped *carina neuralis* laterally delimited by a marked pit.

Taxonomic remarks. All the above-mentioned characteristics are diagnostic of *B. viridis* (see BAILON 1999 for a list of diagnostic characters) but show some degree of variability among the specimens from the Ara burial cave. For example, the anterior tubercle of the tuber superior of the ilium can be variably expressed or flanked by other tubercular structures. Additionally, the *pars descendens ilii* hosts in some cases a "step" located on the lateral surface ventrally to the preacetabular pit. The ilium shown in Fig. 1H is characterised by a developed "*calamita* ridge" (sensu SANCHIZ 1977) that is rarely present in *B. viridis*. Such morphologies are here considered as falling within the intraspecific variability of *B. viridis*.

Discussion

WEISSBROD & BAR-OZ (2004) proposed several possible ways of accretion that may explain the origin of the Ara anuran remains. Of these, it seems that the most likely explanation is that the anurans are intrusive (mostly because of the absence of traces of digestion and limited fragmentation of the skeletal elements). Such origin could be related to the need to find suitable aestivation shelter during the dry and hot summers (or hibernation during particularly cold winters).

Remains referred to as *P. syriacus* or *P.* cf. *syriacus* are common in archaeological cave contexts in Israel from the Late Pleistocene (Fig. 1): Abu Usba (Late Pleistocene; HAAS 1951), Geula (Late Pleistocene; HAAS 1967), Hayonim (Late Pleistocene; BAR-YOSEF &

TCHERNOV 1966) and Iraq e Zigan (Late Pleistocene; HELLER 1978). A single *Pelobates* remain was also found in el-Wad Terrace (Late Pleistocene; VALLA et al. 1986). *Pelobates syriacus* has been reported with confidence from Late Miocene contexts in Greece and, questionably, also in sites from Poland, Slovakia and the Ukraine (see SANCHIZ 1998, and references therein). There are no data from other areas within the present range.

B. viridis, one of the most common anurans in Quaternary sites of the Mediterranean area, seems to be less frequent than *Pelobates* in the fossil record of Israel. According to SANCHIZ (1998), this taxon has been identified at Gilgal (Early Holocene; NOY et al. 1980) and in Abu Usba and Hayonim (see references above).

At present, *Bufo viridis* is widespread in Israel while *Pelobates syriacus* inhabits exclusively the north of the country where it is present in three isolated areas (see grey areas in Fig. 1). Such areas represent the southern edge of the *P. syriacus* range because the populations in Jordan are now considered to be probably extinct (no observations since 1984; DISI et al. 2001). The distribution of the six fossil localities in Northern Israel fills the gap between the southernmost isolated part of the present range and that at the border with Lebanon, furnishing evidence of a previous continuous range into Israel and its rather recent (starting at least in Late Pleistocene) and progressive shrinkage. This may be supported by the fact that the youngest locality (the Ara cave, the only Holocene locality) is also the closest to the modern range. However, it must be borne in mind that the fossil record is by far less spatially continuous when compared with data on the modern distribution of these species.

The Eastern Spadefoot Toad appears to be less selective than its relative *P. fuscus,* the Common Spadefoot Toad, in terms of soil preference because it inhabits not only soft soil suitable for a fossorial life, but also solid, rocky soils, in particular those with variably friable clay and pebbles. In the southern and eastern portion of its range at least, the Eastern Spadefoot Toad also inhabits plots of semi-desert and areas bordering steppes, or even salty areas periodically flooded with marine waters. For reproduction, the species prefers temporary or semi-permanent riverside or lakeside water bodies, as well as stagnant temporary water bodies in uncultivated areas adjacent to cultivated fields. According to some authors, temporary waters are avoided (the larval development is relatively long) but for others the preferred biotopes are those around temporary water bodies, and large permanent pools are selected only in drought years. The Eastern Spadefoot Toads can breed in waters relatively distant from the foraging or hibernation-aestivation quarters, and post breeding dispersion can exceed 7 km (for the ecology of these species, see: GASC et al. 1997, KUZMIN 1999, TARKHNISHVILI & GOKHELASHVILI 1999, DISI et al. 2001, DOLEV & PREVOLOTSKY 2005). Such ecological flexibility can partially explain why Eastern Spadefoot Toads were formerly widespread in a large area of southeast Europe and southwest Asia, stretching from the Balkans to the Caspian Sea at least. The present-day range is characterized by huge gaps and several isolated populations, clearly betraying a remarkable relictual nature that, at least for Israel, is confirmed by the fossil record. This shrinkage appears to be recent in origin and may have begun as early as the Late Pleistocene in Israel due to the progressive, late Quaternary, increase of aridity in the eastern Mediterranean (BRICE 1978, TSOAR 1995).

It is most likely, however, that more recent anthropogenic factors have also considerably affected the distribution of amphibians in the region, through drainage of breeding pools, the construction of embankments, and the alteration of the biotopes around the breeding sites by agricultural and urban activities, which pose a major threat for the long-term survival of amphibian populations in Israel (GAFNY & GASITH 1987, DEGANI & KAPLAN 1999). The Eastern Spadefoot Toad is currently ranked at the level of "Least Concern" in the IUCN Red

List categories, mostly because of its wide distribution and presumed large populations in at least a part of its range, but it is listed in Appendix II of the Berne Convention and in Annex IV of the EU Natural Habitats Directive, and is also included in the Red Data Books and Red Lists of several countries (Global Amphibian Assessment, www.globalamphibians.org) where it is locally rare and threatened by extinction (as in Israel; DOLEV & PREVOLOTSKY 2005).

An accurate analysis of the pattern of recent range contraction evidenced by the fossil record, and of the environmental changes that have recently occurred in the region, should be taken into consideration in the preparation of soundly based conservation or reintroduction plans in Israel.

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