Morphometrics, distribution and ecology of the amphibians in Jordan

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> Abstract

One urodele amphibian species *(Ommatotriton vittatus)* and four anuran species *(Pseudepidalea viridis, Pelophylax bedriagae, Hyla savignyi* and *Pelobates syriacus)* were recorded from Jordan. Alcohol-preserved specimens (n = 340) were examined. Seventeen measurements were taken and are compared between the sexes. The distribution and habitat for each species are discussed. The current status of the amphibians of Jordan is discussed.

> Kurzfassung

Eine Schwanzlurch-Art *(Ommatotriton vittatus)* und vier Froschlurch-Arten *(Pseudepidalea viridis, Pelophylax bedriagae, Hyla savignyi* und *Pelobates syriacus)* wurden nachgewiesen für Jordanien. Alkoholfixierte Exemplare (n = 340) wurden untersucht. Siebzehn morphometrische Maße wurden erhoben und geschlechtsabhängig verglichen. Die Verbreitung und das Habitat für jede Art werden diskutiert. Der gegenwärtige Status der Amphibien in Jordanien wird diskutiert.

> Key words

Amphibians, Jordan, ecology, morphometrics.

Introduction

The earliest reports on the amphibians of Jordan were made by Tristram (1884) and Hart (1891). Other reports were made by Barbour (1914) and Balletto *et al*. (1985). Barbour (1914) erroneously reported the presence of *Bufo regularis* from Petra, but Werner (1987) re-examined the material originally collected by J. C. Phillips and W. Mann expedition, and found that all specimens are in fact *Bufo viridis*.

Within the Middle East, Turkey harbors the highest number of amphibians reaching about 22 species in the Asiatic part (Cox *et al*., 2006). Balletto *et al*. (1985) gave the first comprehensive study on the amphibians of Arabia. They listed nine species, six of which are endemic to the Arabian Peninsula. In Syria, "Israel/ Palestine" and Lebanon, 7 species of amphibians have been recorded (Cox *et al*., 2006).

Jordan is considered to be a semi-arid area where as much as 87 % of its total area is dry. Water bodies are limited and mainly found along the Jordan Valley, Wadi Araba, Amman-Zarqa Basin, the Mediterranean biotope and the Azraq Desert Oasis. Jordan remains with the lowest number of amphibians in the region with only five confirmed species.

Schneider & Sinsch (1999) compared calls of Middle Eastern water frogs with those of *Rana ridibunda* in Kazakhstan, Armenia and Greece. They concluded that the Middle Eastern populations are in fact *R. bedriagae*. This taxon is the oldest available name for water frogs of our regions and was given priority over *R. r. caralitana* and *R. levantina*.

Recent molecular investigations on the amphibians of the Palaearctic region yielded new insights into the taxonomic status of the amphibians of the Middle East and Jordan in particular. For example, Plötner *et al*. (2001) showed that the water frog, *R. bedriagae*, in Jordan and Syria is distinct from the European

Water Frog, *Rana ridibunda*, and that the Anatolian *R. bedriagae* differs from the Southern populations by 2.2–3.4 % of the analysed sites.

Recent molecular studied revealed the taxonomic status of the amphibians worldwide, and resulted in the replacement of new generic names (Frost *et al*., 2006). Che *et al*. (2007) reconstructed phylogenetic trees for representative species of the subfamily Raninae using approximately 2000 base pairs of DNA sequences from two mitochondrial (12S rRNA, 16S rRNA) and two nuclear (tyrosinase, rhodopsin) genes. They elevated Raninae to familial status and recognized at least twelve genera, among them *Pelophylax*. In this paper we adopted the new proposed generic names.

This study is an attempt to define the taxonomy of the amphibian fauna of Jordan with emphasis on the recent nomenclature changes, their zoogeography, ecological preference, association, morphometrics as well as to define threats to their populations.

Materials and Methods

Three hundred and fourty two alcohol-preserved specimens at the deposition of the Jordan University Museum, Amman and at the Jordan Natural History Museum, Yarmouk University, Irbid, were examined. The collections were made since 1977 till present time and numerous observations were performed during many field excursions all over Jordan. Specimens were collected using nets and by hand. Also, many specimens were examined morphologically in the field and then released.

Seventeen measurements were taken according to Balletto *et al*. (1985) using a caliper with an accuracy of ±0.1 mm. All reported measurements are in cm.

1. Snout urostyle length (SV): the distance between the anterior tip of the snout and the posterior tip of the urostyle.
2. Eye-nasal distance (EN): the distance between the anterior margin of the eye and the posterior margin of the naris.
3. Head length (HL): the distance between the tip of the snout and the posterior margin of the tympanum including the tympanic annulus.
4. Head width (HW): the greatest width of the head, at the level of the tympanum.
5. Internasal distance (IN): the minimum distance separating the nares.
6. Eye diameter (E): the greatest distance between the anterior and posterior margins of the eye.
7. Tympanic diameter (T): the longitudinal distance between the outer margins of the tympanic annulus.
8. Interorbital distance (IO): the distance between the outer margins of the two eyelids at the middle points.
9. Hand length (HDL): the distance between the inner margin of the palmar metacarpal ? tubercle to the tip of the longest finger (third finger).
10. First finger length (FIL): the distance between the inner corner of the finger and the tip of the finger.
11. Fist finger width (FlW): the greatest width of the first finger (between the inner and the outer corners).
12. Thigh length (THL): length between the lateral tip of the urostyle and the convex surface of the condyle (the knee was held at the flexed position).
13. Tibial length (TL): the distance between the tibial head and the tibio-tarsal articulation.
14. Tarsal length (TSL): distance between the tibio-tarsal articulation and the joint between foot and tarsus.
15. First toe length (TI): the length between the outer margin of the inner metatarsal tubercle and the tip of the 1st toe.
16. Inner tubercle length (TBL): the longitudinal length of the inner metatarsal tubercle.
17. Foot length (FL): the distance between the posterior margin of the outer metatarsal tubercle and the tip of the fourth toe (longest toe).

Sex identification. For *Pseudepidalea viridis*, males are characterized by their extended single keratinisation on the mesial side of the first finger. This feature is prominent during the fertilization season. *Hyla savignyi* males have large obvious yellowish or brownish vocal sacs beneath the chin. *Pelophylax bedriagae* males are distinguished morphologically by their two external grey or black vocal sacs that opens externally through irregular slits behind the mouth corners, also males possess well developed callosity on the external and ventral parts of the first finger. Specimens whom their sex was not identified were excluded from the statistical treatment.

Field observations. Field trips were conducted routinely in many parts of the country by the authors. Field observations were recorded describing breeding seasons, abundance etc. Also, large number of specimens were identified in the field and subsequently released. Locality names spelling are according to the Gazetteer of Jordan (Anon., 1990).

Results

Salamandridae

Ommatotriton vittatus (Gray in Jenyns, 1835)

Filed observations. The presence of the Banded Newt in Jordan is based on a field observation made by Ahmad Disi during a field excursions accompanied by Friedhelm Krupp and Wolfgang Schneider in March 1981. The Banded Newt was spotted in a temporary pond near Amman, Princess Hayah Farm. This locality is within the Mediterranean biotope, characterized by high rainfall (400–500 ml annually) and *Terra Rosa* soil type, with ample temporary ponds. No other specimens were ever seen or collected from this site or any other region in Jordan despite the continuous visits to the same area and other sites during different seasons.

Morphological characteristics. Head distinguishably from body, gills, fore and hind limbs visible from an early stage throughout development, teeth present in both jaws; larvae lack the combination of rounded or obtuse caudal extremity and the distance between the two nostrils are greater than the distance from nostrils to the eye; adults with a strongly compressed tail and often with a keel or crest. Dorsal crest is well developed in males in the aquatic phase. A distinct white band usually bordered by black, on sides of body between fore- and hind limbs. Total length may reach 10–12 cm (Disi, 2002).

Habitat. Steinitz (1965) and Mendelssohn & Steinitz (1945) pointed out that *O. vittatus* has a restricted distribution associated with temporary ponds and its reproduction is strictly confined to ponds. *Ommatotriton vittatus* usually spawns during January and that coincides with the high rainfall. It may spawn in small swamp springs with dense vegetation or stagnant, muddy high water with poor vegetation but rich with fauna or slow running, clear water with rich vegetation and a poor content of fauna (Geffen *et al*., 1987).

Remarks. Since the only record from Jordan is based on a single field observation, and no other materials substantiate the presence of the Banded Newt in Jordan, it is suggested to drop this species from the list of amphibians of Jordan. This species was listed in Disi *et al*. (2001). This species occurs in rain pools in the upper Galilee and the coastal plains (Degani & Mendelssohn, 1983; Geffen *et al*., 1987; Degani & Kaplan, 1999; Pearlson& Degani, 2008). Perhaps Ajlune Mountains in northern Jordan may offer a suitable habitat for this species, however, no specimens were collected for the past 30 years.

Family Bufonidae

Pseudepidalea viridis (Laurenti, 1768)

Material examined. (n=137) **Jordan University Museum**: JUMA 1–2, 2 ♂♂, 13.10.1977, Wadi Beesan. JUMA 4, 3 ♀♀, 13.10.1977, Wadi Beesan. JUMA 28, 1 ♂, 26.10.1978, Amman (Ras el-Ein). JUMA 43, 2 ♀♀, 28.3.1978, Ghore As-Safi. JUMA 60, 19.3.1979, Azraq ash Shishsn. JUMA 64, 1 ♀, 19.4.1979, Petra. JUMA 65–68, 2 ♀♀, and 5 immature specimens, 13.4.1978, Ma'an, A1-Ghadeer. JUMA 77, 1 ♀, April 1980, Wadi Al-Arab. JUMA 79 and 81, 2 ♂♂, 28.5.1980, Wadi Dahal. JUMA 80, 1 ♂, 28.5.1980, Dayr Alla. JUMA 90, 1 ♂, 23.8.1980, Dayr Alla. JUMA 101, Februray1980, Ziqlab Dam. JUMA 104, 1 ♀, no date, Wadi Dahl. JUMA 105, 1 ♂, 23.8.1980, A1-Dhuliel. JUMA 126, 1 ♀, 21.8.1980, Wadi Al Haydan. JUMA 142, 21.8.1980, Wadi Al-Haydan. JUMA 145, 1 ♂, 4.3.1981, Wadi Al-Khafiah. JUMA 146, 24.4.1981, Wadi Amruk. JUMA 149, 17.2.1981, Wadi Shu'ayb. JUMA 152, 11.6.1981, Wadi Hisban. JUMA 166 and 167, 23.8.1980, A1-Dhuliel. JUMA 170, 1.5.1980, Wadi A1-Hasa. JUMA 172, 31.8.1983, Al-Jubayhah. JUMA 184, 1 ♂, 13.4.1978, Ma'an, A1 Ghadeer. JUMA 185, 1 ♀, 21.8.1980, Wadi Al-Haydan. JUMA 234, 2.9.1982, Wadi Fidan. JUMA 244, 1 ♀, 1982, Hartha. JUMA 245, 1 ♂, 10.4.1982, Amman. JUMA 246, 1 ♀, 9.9.1980, King Talal Dam. JUMA 299, (immature), February 1992, Jordan Valley. JUMA 301, 1 ♀ and 1 ♂, 1.2.1980, Ma'an, Al-Ghadeer. JUMA 302, 1.5.1980, Wadi Hisban. JUMA 303–304, 25.10.1980, Al-Qatranah. JUMA 305–306, 2 ♀♀, 27.4.1981, Wadi Amruk-Khinzirah, JUMA 312, 1 ♀, 4.9.1982, Ash Shawbak. JUMA 313, 10.9.1982, Ar-Ramtha. JUMA 314, 20.10.1982, Khaw. JUMA 315, 28.2.1983, Amman. JUMA 318, 1 ♂, 31.3.1983, Shuna esh Shamaliyah. JUMA 320, 2 ♂♂, 10.6.1983, Ash Shawmari. JUMA 321, 1 ♂ and 1 ♀, 3.8.1979, Azraq ash Shishsn. JUMA 323, 1 ♂, 3.8.1979, Azraq ash Shishsn. JUMA 325, 2 ♂♂, 10.11.1983, Qasr El Hallabat. JUMA 326, 31.8.1983, Al-Jubayhah. JUMA 327, 2 ♀♀, 10.9.1983, Ash Shawmari. JUMA 328, 2 ♀♀, 10.11.1983, Qasr El Hallabat. JUMA 333, 5 ♀♀, 17.8.1983, Um Al-Jamal. JUMA 334, 17.8.1983, Dayr Abu Said. JUMA 335, 3 ♀♀, 19.4.1983, Ibbin. JUMA 336, 2 ♂♂, 17.8.1983, Surra Range Reserve. JUMA 337, March 1988, El-Hemma. JUMA 338, 13.4.1988, Jarash. JUMA 340, 1 ♀, September 1992, Ar-Ramtha. JUMA 342, 1 ♂, 17.2.1983, Um Al-Jamal. JUMA 356–357, 8.5.1992, Qasr Burqu. JUMA 360, immature, 2.7.1987, Qasr Burqu. JUMA 361–363, 16.5.1989, Azraq ash Shishsn; JUMA 364, 1 ♀, 24.6.1992, Ash Shawmari. JUMA 365, 1 ♂, 24.6.1992, Ash Shawmari. JUMA 366, 1 ♀, 29.8.1992, Eshtafina. JUMA 367, 1 ♂, 29.8.1992, Eshtafina. JUMA 374, 23.2.1992, Qasr Burqu. JUMA 375, 1 ♀, 19.1.1995, Qasr Burqu. JUMA 376, 1 ♀, February 1992, Jordan Valley. JUMA 422, 1 ♀, April 1995, Baq'ah. JUMA 423–426, 2 ♀♀, April 1995, Dayr Alla. JUMA 427–428, 2 ♂♂ , April 1995, Dayr Alla. JUMA 429, 1 ♀,

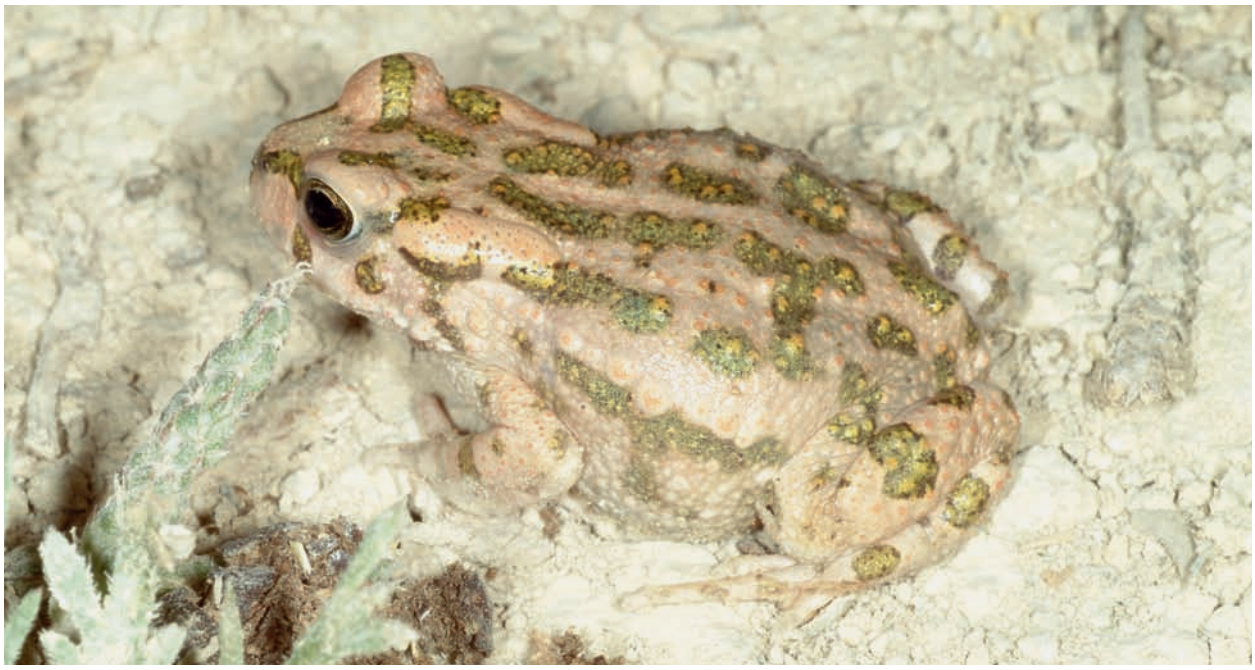

Fig. 1. Female *Pseudepidalea viridis* from Dibbin, Jordan with pale colouration.

14.9.1995, Al-Hishah Al-Byieda. JUMA 435, 1 ♀, 14.9.1995, Al-Hishah Al-Byieda. JUMA 436, 1 ♂, 14.9.1995, Al-Hishah Al-Byieda. JUMA 441, 1 ♂, 14.9.1995, Al-Hishah Al-Byieda. JUMA 442, 1 ♀, 15.9.1995, Ash Shawbak. JUMA 445, 1 ♀, 15.9.1995, Ash Shawbak. JUMA 446–448, 2 ♂♂, 15.9.1995, Ash Shawbak. JUMA 449–454 (immature), 15.9.1995, Ash Shawbak. JUMA 504, 1 ♀, 15.9.1995, Junienha, Ash-Shawbak. JUMA 509, 1 ♀, 27.4.1995, Petra. JUMA 510, (immature), 4.5.1995, Kurayyimah. JUMA 511, (three immature specimens), 29.8.1992, Eshtafina. JUMA 515, seven immature specimens, 14.6.1998, Bugayawiyah. **Yarmouk University Museum**: YUM 13, Al karamah, 6.2.1993. YUM 73, Irbid, 19.5.1982. YUM 77, Irbid, 28.4.1982. YUM 112, Al karamah, 6.2.1993. YUM 145, 26.11.1982, NE Al Ghadeer. YUM 151, 8.3.1987, Irbid. YUM 152, June 1987, NE Al Ghadeer. YUM 159, 15.8.1987, NE Al Ghadeer. YUM 160, 13.12.1989, Wadi Abu Mohamad.

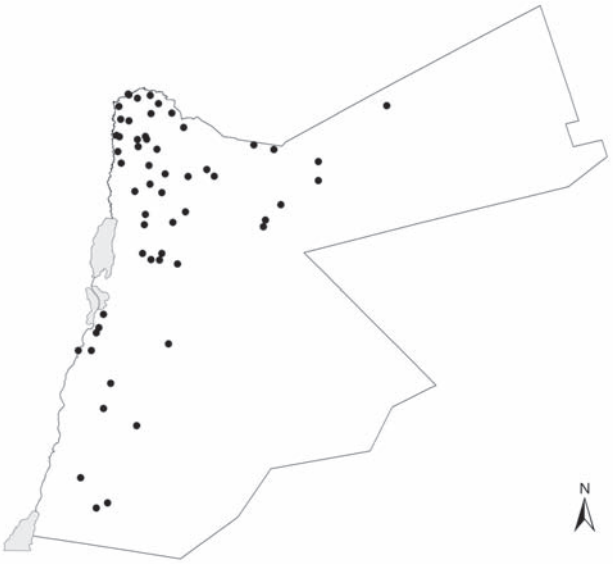

Fig. 2. Distribution of *Pseudepidalea viridis* in Jordan.

Previous records. Shores of the Dead Sea (Tristam, 1884); Wadi Ghuweir (Hart, 1891), Petra (Barbour, 1914); Petra (Disi & Hatough-Boran, 1999); Azraq, Burqu, Buqayawiyah (Disi *et al*., 1999); Er Ramman, Qasr al Mushatta, Wadi Al Walla, Al Jubayhah, Ramaah, Ash Shawbak, Petra, near Azraq, Dayr Alla (Disi *et al*., 2004); Ras Munif, Al Mukhaybeh, Wadi Shaib, Ramtha, Ghore Al Balawneh, Madaba, Berein, Wadi Al Yabis, Al Karamah and Al kerymeh (Al Sorakhy, 2000); Dibbeen (Damhoureyeh *et al*., 2009).

Besides the above mentioned locations, specimens were examined in the field and released in the following sites: Azraq ash Shishan, Safilt, Al-Muwaggar, Umm ar Rasas, Safawi, Al-Dhuleil, Ibilin, Wadi al Yabis, Suweilih. Wadi Dahl, Ghore Feifa, Wadi Faunan, Wadi al Fidan, Wadi Hasa, Wadi Al Mujib, Anjarah, Qasr Al Mushattah, Ayn ad Disah, Sawwan plain, Wadi Rum and Wadi Al'al.

Morphological characteristics. The pupil is rounded, color is both variable and changeable as well as blotch geometry; the dorsum varies from light gray to olive or green in color, with or without olive to black blotches, often associated with dark edges (Fig. 1). The blotches are of varying shapes, sizes, number and dispositions. Specimens collected from semiarid regions exhibit paler coloration with fewer or smaller blotches than those collected from the Mediterranean ecozone. Similar observations were reported by Werner (1988,

Tab. 1. Morphometric measurements for *Pseudepidalea viridis* (measurements in cm).

	Males (n = 38)				Females (n = 54)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
SV	6.45	0.92	4.12	8.21	6.52	1.12	4.40	9.27
EN	0.47	0.06	0.32	0.58	0.48	0.06	0.36	0.68
HL	1.84	0.22	1.24	2.15	1.84	0.29	1.20	2.50
HW	2.19	0.29	1.33	2.66	2.18	0.40	1.15	3.05
IN	0.38	0.06	0.15	0.50	0.41	0.07	0.27	0.57
E	0.76	0.08	0.57	0.91	0.79	0.11	0.57	1.10
T	0.33	0.06	0.16	0.50	0.32	0.07	0.20	0.46
IO	0.69	0.09	0.44	0.81	0.67	0.11	0.47	0.94
HDL	1.60	0.22	1.05	2.00	1.66	0.26	1.15	2.17
F1L	0.80	0.11	0.59	1.11	0.87	0.16	0.50	1.18
F1W	0.51	0.11	0.20	0.68	0.49	0.13	0.25	0.80
THL	2.67	0.38	1.61	3.22	2.56	0.43	1.70	3.36
TL	2.22	0.35	1.49	2.93	2.16	0.36	1.19	2.77
TSL	1.27	0.26	0.77	2.32	1.25	0.29	0.76	2.31
T1	0.55	0.09	0.36	0.77	0.55	0.11	0.36	0.79
TBL	0.40	0.07	0.26	0.62	1.25	0.29	0.76	2.31
FL	2.37	0.46	1.52	3.91	2.58	0.45	1.66	3.82

1998). A pair of green stripes extend from the eye to the nostril; a green spot on the upper lip under the eye; two green cross bars on the upper eyelids, running backwards along the medial edges of the parotid glands and this is a constant feature in the studied specimens. A faint vertebral stripe is occasionally present especially in specimens collected from arid zones. Also, series of cross bars on dorsal parts of the limbs. A pair of interrupted laterodorsal glandular ridges, running from the mouth corners to the groin. A well defined continuous ulnar ridge and a prominent sharp tarsal fold. Ventrally the color is whitish and sometimes with dusky spots. The tympanic membrane is fairly large and distinct and almost equal in both sexes. The flat parotid glands are prominent, elongate and kidney-shape, and almost parallel, posterior to the tympanum on the lateral side. Dorsum has numerous warts of varying sizes and tipped with a black brown hard spine. The largest warts are amid similar smaller tubercles. It is characterized by short web in the foot. Tips of fingers and toes are brown.

Head is moderate, 85 ± 9 % as long as broad, and about 28 ± 3 % as long as snout-urostyle length. The internarial distance is about 84 ± 12 % of the distance between the nostril and the eye, also it is around 18 ± 2 % of the head width. Tympanum is vertically elliptical and is less than half of the horizontal diameter of the eye. The interorbital distance is almost 87 % of the horizontal eye diameter. Posterior limbs are rather thick and short in comparison with both *Pseudepidalea bedriagae* and *Hyla savignyi*. Perhaps this due to the terrestrial mode of life for *Pseudepidalea* compare to the more aquatic Rana and Hyla. Fingers are thick. The greatest width of the first finger at its base is almost 60 % of its length, and its length is 51 % of the hand length. Tarsal width is almost 48 % of the foot length and 48 % of the thigh length. Tibial length is almost 84 % of the thigh length; 173 % of the tarsal length; 83 % of the foot length; and 34 % of the snout-urostyle length. Outer tubercle length is almost 74 % of the inner tubercle length, and the latter is 14 % of the foot length. The first toe length is around 53 % of the fourth toe length. Thigh length is 40 ±4% of the snout-urostyle length, 119 % of the tibia and more than twice of the tarsal length. Foot length is 209 % of the tarsal length. The first toe length is around 53 % of the fourth toe length; almost 44 % of the tarsal length; and 21 % of the foot length, while the fourth toe length is around 82 % of the tarsal length and almost 39 % of the foot length (see Table 1) for comparison between males and females.

Sexual dimorphism is obvious; an internal resonator is found underneath the skin of the throat of males, and surrounded by black pigmented muscles. Those sacs are not distinguished externally. Also, males are characterized by their extended single keratinisation on mesial side of the first finger. This feature is prominent during the fertilization season. Males have slender and smaller bodies than females. Females measure 4.4–9.27 cm with a mean 6.52 (± 1.12). Males (n = 38) measure 4.12–8.21 cm with a mean 6.45 (±0.92).

Habitat. The Green Toad was collected from a variety of water bodies including rivers, creeks, springs, irrigation canals, aquifers and ponds. *Pseudepidalea viridis* is a highly adaptable species with a wide range

of distribution. As shown by the distribution pattern in Jordan, *P. viridis* inhabits various ecozones representing all biogeographical regions (Fig. 2). Irrespective of isohyetal line or altitude, *P. viridis* was reported at elevation –400 m bsl and from heights more than 1200 m asl**.**

Our field observations showed that the breeding season in the Irano-Turanian biotope is quite short and affected by abundance of water that depends on rainfall which varies from year to year. In permanent water bodies, however, commencing of the breeding season is affected by temperature. In the Jordan Valley, breeding commences as early as late January while in other regions (i.e. Ajlun, Kufranja, Amman, Heidan) it starts in March and sometimes extends to May. In the Badia region and Tafila mountains *P. viridis* was observed after the first heavy rains in great numbers. This shows that the breeding season in arid areas follows the first heavy rain whenever it occurs. We observed large numbers of metamorphosed larvae few weeks after the rainy season in Jawa area in the eastern desert. The Green Toad spawns in all kinds of natural water bodies, stagnant or running. Moreover, within the Mediterranean biotope, *P. viridis* has a wide distribution and is found under rocks and on dry hillsides. During spring and early summer *P. viridis* was seen in gardens in the proximity of human habitations with irrigation. The Green Toad makes use of the temporary ponds formed, but the size, formation time and duration of water availability vary from year to year depending on rainfall and water quantity stored in the surrounding depressions. Ponds contain a rich fauna of crustaceans, turbellarians and insects, in addition to unicellular algae. Courtship and spawning take place in temporary ponds. The survival rate of these tadpoles varies, and depends on the amount of water in the pond and for how long it remains wet before it dries. It is here suggested that *P. viridis* eggs or larvae are transported along with water tanks used by the locals to transport water for drinking purposes in the Jordanian desert, thus expanding the distribution range of this toad. For example, after construction of a new water well near Safawi in the eastern desert, we encountered tadpoles and immature toads in this newly established pools. Water tanks regularly visit this site, and perhaps they introduced eggs or tadpoles to new areas with water pools.

The Green Toad was collected from both the deserted and active burrows of rodents. In Khaldiyya, Halabat, Muwaqar, Umm-Arassas, Qatrana, Hasa and Ma'an area, *P. viridis* was recovered from the Fat Sand Jird, *Psammomys obesus,* burrows after flooding their burrow with water. It takes 2–10 minutes for *P. viridis* to leave the burrows after flooding. The depth of these burrows ranged from 25 to 35 cm below the surface.

Anthropogenic impacts are also detrimental, many individuals of the Green Toad were seen killed by cars on roads. In the last two decades Jordan has witnessed agricultural expansions in the Badia and Wadi Araba. This expansion has been positively reflected on populations of *P. viridis* and it is the only amphibian species to flourish due to such changes. Currently it is abundant in the Badia (Safawi, Burqu and Bqeuaiah) as well as in the Irano-Turanian ecozone that extends from Al-Khaldiyya in the north to Ma'an in the south. These new localities are close to artificial wells or ancient large pools which were used in the past to collect rain water.

Remarks. Morphometric measurements of *P. viridis* obtained in this study were compared with those reported in literature. Minton (1966) studied *P. viridis* from Pakistan, and reported that tympanum is about half the diameter of eye and this is similar to those from Jordan and their greatest width is approximately equal to their length. The shape of parotid glands differs from those described from Pakistan, where as Pakistani specimens have parotid glands oval to triangular in shape. Minton (1966) stated that the West Pakistani specimens examined differ from the Middle East and European specimens chiefly toward dwarfism. Pakistani specimens were collected at an altitude between 1.524–2.133 m. However, Minton (1966) did not specify any subspecific taxon from this population. Mertens (1969) assigned the populations from West Pakistan to *P. v. arabicus* and stated that the length of this taxon ranges 65–68 mm. *P. viridis* males from Arabia measure 53–78 mm (Balletto *et al.,* 1985).

Flindt & Hemmer (1968) studied *P. viridis* from the Near East and compared it with those from central Europe. Body length of males from Turkey ranged 60–76 mm with an average of 67.9 mm (SD ± 5.7), while for males from middle Europe ranged from 49–83 mm with an average of 64.9 (SD ± 8.7).

Stöck *et al*. (2006) stated that the status of green toads in the Middle East, Sinai and other populations of the isolated, relict population in the southern Hadramaut in south-western Saudi Arabia is currently unclear, and it is possible that these populations should be included within either *Pseudepidalea variabilis* or *Pseudepidalea boulengeri* pending further review. Flindt & Hemmer (1968), Mertens (1971), Hoogmoed (1972), and Eiselt & Schmidtler (1973) reported that the distribution of *P. v. arabicus* extends from Pakistan in the east to Turkey in the west and to Sinai and extend in North Africa to central Libya. Hoogmoed (1972) presented measurements and indices of *P. viridis* from Morocco, with a body length for males and females as 65–87 and 68–81 mm respectively.

Eiselt & Schmidtler (1973) reported that *P. v. arabicus* is smaller than *P. v. viridis*. Also, the former subspecies has a more pointed snout and the interorbital distance is broader than in the latter species. Moreover, *P. v. arabicus* collected from mountainous region exhibited more detailed decoration than those from dry regions. Anderson & Leviton (1969) stated that the SV length of the largest female and male collected from Iran reached 78 mm and 68 mm respectively. Shine (1979) stated that in 90% of anuran species females grow larger than males. Also, he attributed that to female fecundity and to the high male mortality.

Nevo (1972) stated that the size of *P. viridis* is partly a function of humidity and increase as a measure of adaptation to arid climates. Also, larger toads are selectively superior in arid habitats and have a relatively smaller evaporative body surface area, so they are capable of withstanding longer periods of desiccation. Balletto *et al*. (1985) stated that *P. viridis* in Saudi Arabia was found in different habitats and at different altitudes with different annual rainfall and extreme ranges of annual temperature from near zero to 38 °C. Also, *P. viridis* is nocturnal, sheltering under rocks and in burrows by day. In Hail and Hulaifa Saudi Arabia, *P. viridis* inhabits the perennial waters found in association with gardens and date palms, in a much more desert surrounding. Newman & Dunhan (1994) stated that smaller desert anuran amphibians may be able to absorb water from moist substrate at a higher rate than larger amphibians can. *P. viridis* in Jordan can survive through long droughts and at high temperatures in burrows of rodents. We observe toads in deserted rodent burrows in many parts of the country. Also, it is encountered on dry steppes and in damp localities.

Warburg (1971) studied the water economy of amphibians in Israel, and indicated that the burrowing frogs in arid lands were capable of surviving long periods of drought; absorbing water at a high rate when available, and storing it in the bladder for use during drought. Also, Degani *et al*. (1984) showed that *P. viridis* is adapted to drought by having high concentrations of blood plasma and blood urea.

Dessauer *et al*. (1975) showed that populations of *P. viridis* have a high genetic variability which may be a selective response to a fluctuating environment. Nevo (1972) and Nevo & Beiles (1991) reported that *P. viridis* shows high genetic variability that may act as a selective response to environmental fluctuations and is possibly the basis for the toad's effectiveness as a colonizer of diverse habitats. In Jordan snakes form the major predators of the Green Toad, mainly *Walterinesia aegyptia* and *Natrix tessellata* (Amr & Disi, 1998).

Family Hylidae

Hyla savignyi (Audouin, 1828)

Material examined. (n = 33) **Jordan University Museum:** JUMA 14 – 15, 2 ♀♀, 1.2.1978, Ghore es Safi. JUMA 20 and 26, 13.10.1978, Wadi Feinan. JUMA 42, 28.3.1978, Ghore es Safi. JUMA 93 – 94, 14.9.1980, Jarash, Al-Berkatain. JUMA 124, 28.9.1980, As Salihi. JUMA 151, 27.4.1981, Tafila, Al-Laban. JUMA 154, 27.4.1981, Tafila, Al-Laban. JUMA 158, 2 ♂♂, 27.4.1981, Tafila, Al-Laban. JUMA 155, 27.4.1981, Tafila, Al-Laban. JUMA 159, 2 ♀♀, 27.4.1981, Tafila, Al-Laban. JUMA 252, 11.3.1983, Ghore Abu-Ubaydah. JUMA 310, five specimens, 25.3.1982, Barashta-Harta. JUMA 316, 2 ♀♀, 11.3.1983, Ghore Abu-Ubaydah. JUMA 350 – 353, 4 ♂♂, 22.10.1988, As Suknah. JUMA 508, immature, 8.6.1998, Birket Al-Araies. JUMA 510, March 1998, As Salihi. JUMA 511 – 514, 30.4.1996, As Salihi.

Previous records. Jordan Valley (Tristram, 1884); Wadi el-Karak (Barbour, 1914); Wadi Al Yabis, Al Karamah and Al kerymeh (Al Sorakhy, 2000),
Besides the above mentioned locations, many specimens were examined in the field and released in the following sites: Quwaylibah Dam, Al'al, between Jarash and Fara'h, Wadi Amra, Braashta ('Ayn al Ghazal), Ziglab Dam, At Tafila, El- Hema, Ibbin, Dibbin, Ar Ramtha, King Talal Dam, Dayr Alla, As Salt, Iraq Al-Amir, Siel Az Zarqa, Ar Rusayfah. As Sukhnah, Ghore Abu Ubayda, Wadi Amruk, Quraygira and Finan, Wadi Al Mujib, Wadi Zara, Ghore As-Safi, At Tafila, Wadi Al Hasa, Wadi Wala.

Morphological characteristics. The head length is about 111 ± 5.9 % of its width, and about 31 ± 4 % as long as the snout-urostyle length. The internarial distance is about 80 ± 2 % of the distance between the nostrils and the eye, also it is around 27 ± 1.9 % of the head width. The internarial distance is about 61 % of the horizontal eye diameter (Fig. 3 & 4). Tympanum is fairly distinct, and its horizontal diameter is half the eye diameter; interorbital space about as broad as upper eyelid; internarial space is slightly narrower.

Tips of fingers and toes have adhesive disks allowing it to climb vertical surfaces. Fingers are slightly webbed at their base, while toes are almost half to two thirds webbed. Metatarsal tubercle is distinct; terminal phalanx hooked; digital pads two third size of tympanum. First finger length equals 0.43 + 0.05 of the hand length; measures 40 % of the third finger; and almost 43 % of the hand length. The tibia length is 47 ± 6 % of the snout-urostyle length; 92 ± 10 % of the thigh length; 174 % of the tarasal length; 112 % of the foot length. Tarsal length is almost 53 % of the thigh; 64 % of the foot length; 124 % of the fourth toe length. Thigh length is 51 ± 5 % of the snout-urostyle

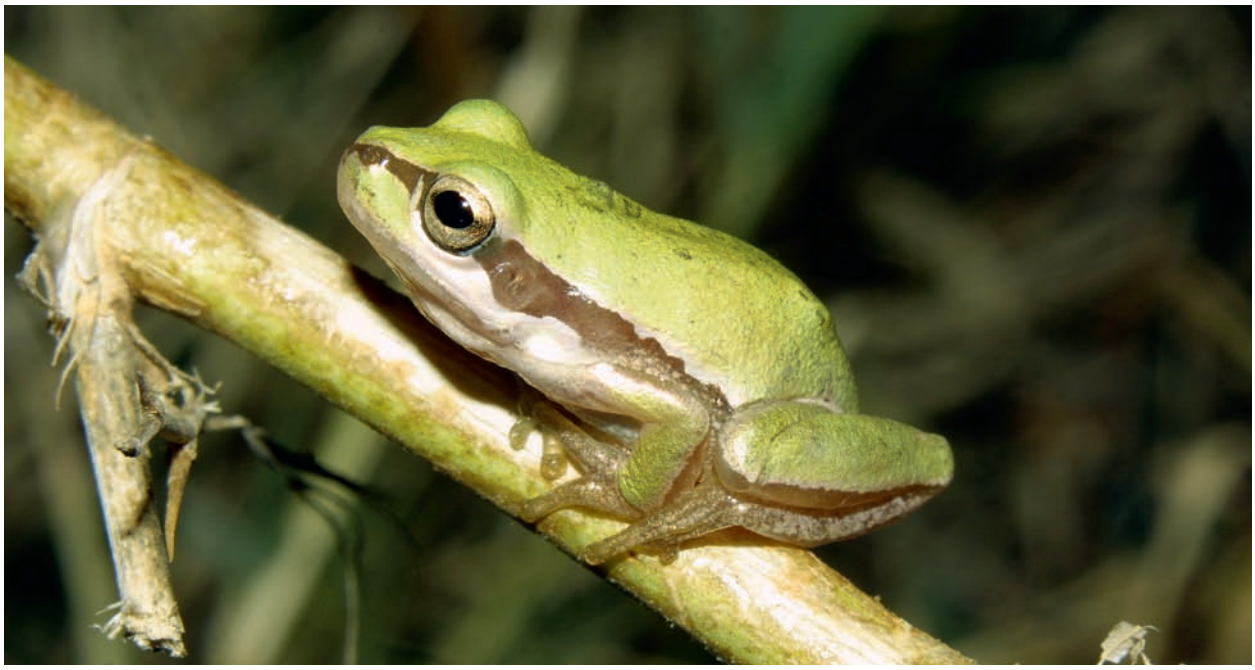

Fig. 3. *Hyla savignyi* female from the Jordan Valley, Jordan.

Fig. 4. *Hyla savignyi* male with gray color from Birkat Al Arayes, Jordan.

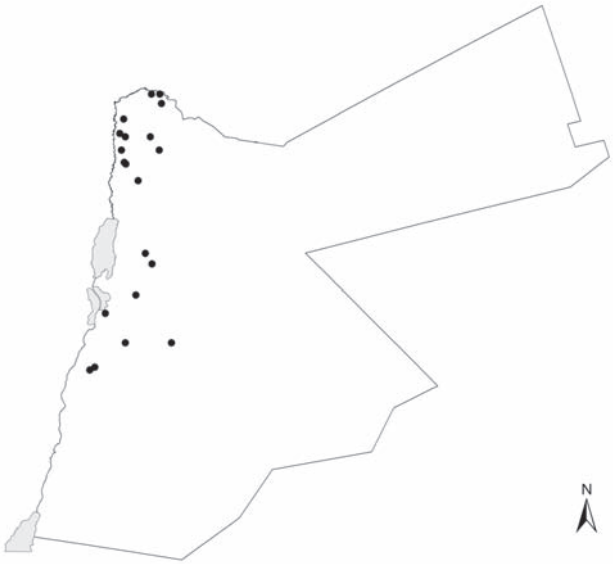

Fig. 5. Distribution of *Hyla savignyi* in Jordan.

length; 108 % of the tibia; and almost 174 % of the tarsal length; and 121 % of the foot length. The inner tubercle length is around 12 % of the foot length; and 18 % of the tarsal length. The first toe length is around 52 % of the fourth toe length; and 27 % of the foot length, while the fourth toe is 80 % of the tarsal length and almost 52 % of the foot length.

Males have large brown external subgular vocal sacs. In addition the gular skin of the female is on the average more granulose than in males. The females are normally larger than the mature males with average length of 4.15 cm (SD ± 0.52), while the males' average length reaches 3.54 cm (SD ± 0.3). The largest female and male measured 4.87 and 4.02 cm respectively (Table 2).

Color is physiologically changeable, uniformly bright green, yellowish to light brown. A dark brownish band is running from the eye through the tympanum down the side of the body to the groin, edged above and below by light yellowish line. Another whitish line runs on the lips from the snout tip to the shoulder. Dorsally the skin is smooth to finely granular, while it is more granulose on the belly, and this granulation decreases on the throat.

Tab. 2. Morphometric measurements for *Hyla savignyi* (measurements in cm).

	Males (n = 20)				Females (n = 13)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
SV	3.54	0.30	3.03	4.02	4.15	0.52	3.18	4.87
EN	0.34	0.06	0.25	0.04	0.37	0.04	0.30	0.45
HL	1.14	0.15	0.91	1.50	1.25	0.18	0.87	1.46
HW	1.08	0.23	0.27	1.40	1.26	0.17	0.88	1.48
IN	0.27	0.05	0.20	0.37	0.30	0.07	0.20	0.45
E	0.45	0.08	0.20	0.54	0.48	0.04	0.43	0.56
T	0.42	0.07	0.27	0.61	0.42	0.08	0.25	0.72
IO	0.47	0.07	0.30	0.67	0.50	0.09	0.30	0.73
HDL	1.55	0.21	1.14	2.29	1.61	0.26	1.03	2.30
F1L	0.86	0.15	0.57	1.35	0.92	0.18	0.59	1.42
F1W	0.44	0.08	0.26	0.66	0.42	0.09	0.25	0.61
THL	2.94	0.49	1.90	4.93	3.15	0.59	1.98	4.83
TL	2.64	0.40	1.91	4.30	2.78	0.54	1.63	4.05
TSL	1.28	0.21	0.94	2.00	1.35	0.24	1.00	2.00
T1	0.41	0.07	0.33	0.57	0.47	0.07	0.33	0.59
TBL	0.32	0.05	0.18	0.43	0.32	0.06	0.22	0.47
FL	1.52	0.22	1.23	1.38	0.73	0.23	1.38	2.07

Habitat. *Hyla savignyi* usually hides most of the daytime on trees or bushes. It is nocturnal and hibernates in the bottom sediments of water bodies. It inhabits permanent water bodies associated with thick vegetation of *Phragmites* and *Typha*. In water bodies where the three species; *P. viridis, P bedriagae* and *H. savignyi* coexist, partitioning of habitats was observed; *P. viridis* occupies the periphery of the water body as well as the humid surrounding areas, while *P. bedriagae* remains in water or on objects submerged in water. The tree frog on the other hand, occupies mainly vegetation stands in the water body or its proximity.

It was found that the larvae of the three anuran species in most cases live together in one water body. In Wadi Fidan and in all pools along the eastern shores of the Dead Sea, *Hyla* tadpoles are dispersed around the pool and remain near by water plants or rocks; while the tadpoles of *P. viridis* and *P. bedriagae* stay close to the bottom.

Remarks. *H. savignyi* is restricted to north east Sinai (Werner, 1982; Baha El Din, 2006). Balletto *et al*. (1985) reported that the distribution of *H. savignyi* in the Arabian Peninsula is seemingly restricted by altitude, i.e. rainfall and temperature. It inhabits the areas above 1400 m asl or the 400 mm isohyetal line, being more common at 2000 m asl and higher at the maximum isohyetal level where there is perennial or semi-perennial water, lower temperature and relatively good vegetation. In Jordan, the distribution of the Tree Frog seems to be affected by the perennial or semi-perennial water bodies and the suitable vegetation irrespective of the temperature, altitude or amount of rainfall. It was collected from areas 400 m bsl up to 1200 m asl.

Hyla heinzsteinitzi was described from Jerusalem and its vicinity (Grach *et al*., 2007). It differs from the sympatric common *H. savignyi* of the Middle East in head shape, as the head is relatively wider and the snout more truncate; in call structure and in colouration, as its dark lateral band is highly disrupted. This species seems to be endemic within the range of distribution of *H. savignyi*; where as the two are sympatric and at least sometimes apparently syntopic (Grach *et al*., 2007).

Recently, Grach *et al*. (2007) reviewed the nomenclature of *H. savignyi* Audouin, 1827, described from ‘‘Egypt” and considered this taxon to be widespread from ‘‘Turkey, Transcaucasia and northwestern Iran over Syria and Lebanon to central Jordan and Israel and the southwestern Arabian Peninsula**.** Based on molecular results from both mtDNA and nuDNA, the nominal species *H. savignyi* forms a monophyletic group composed of two subclades. Tree frogs from southwestern Syria and a disjunctive range in southern Arabia form a clade. The second clade occurs on Cyprus, southern Turkey, north-eastern Syria, Iraq and Western Iran, and is considered as *H. savignyi* (Stöck *et al*., 2008). Gvoždik *et al*. (2010) described *H. felixarabica*, for the southern populations of *Hyla savignyi* from Yemen, Jordan, southern Syria and extreme north-eastern Israel based on molecular findings. They pointed out that the importance of the Dead Sea Rift as a historical geographical barrier separating the new species from *H. savignyi* and the biogeographic connection of the south-western Arabian Peninsula and southern Levant.

Fig. 6. **A**: Adult *Pelobates syriacus* collected from Ibbin. **B**: Toes of *Pelobates syriacus*. **C**: Immature *Pelobates syriacus* collected from Ibbin.

Family Pelobatidae

Pelobates syriacus Boettger 1889

Material Examined. (n=4) **Jordan University Museum**: JUM 82–83, 5.8.1980, Ibbin. JUM 341, 19.4.1983, Ibbin.

Morphological characteristics. Body robust, hind legs short, head large. Tympanic membrane absent. Pupil of the eye is vertical. Frontal area between eyes flat. Inner internal metatarsal tubercles large and yellowish in colour, metatarsal tubercle of the hind foot quite large and spade-shaped (Fig. 6). Webs between the toes well-developed and with large cuts. No male resonators. Dorsum with black spots on gray or yellowish background. Ventral surface white-grayish, without pattern.

Habitats. *Pelobates syriacus* was collected from a temporary pond formed on red light *terra rosa* at an altitude of 1000 m and with 500 mm annual rainfall in northern Jordan during 1980–1983. It is not easy to find this toad since it hides in the mud, presumably digging down into the humid subsoil for most of the year. They are adapted to this behavior by possessing a special tubercle on their hind feet that helps them burrow backwards and hide rapidly in the mud. Adults were seen after the first heavy rains of the winter season (January-February). At this time adults come to the surface and courtship and spawning starts. Tadpoles are omnivorous. They usually reach more than 100 mm in total length. After metamorphosis, the length of immature specimens at the beginning is around 30 mm**.** The breeding sites lack all vegetation.

Remarks. *P. syriacus* is an Eastern Mediterranean species and thought to be a relic of the early Euro-Siberian fauna (Bodenheimer, 1944). In Jordan it has been collected from one locality in the Mediterranean ecozone. *P. syriacus* in Jordan is a relict species, separated by considerable distance from the nearby populations. Expansion of human population and agricultural projects adversely affected the region in terms of availability of permanent water bodies. Further conservation efforts are required to protect the remaining populations of this species.

Family Ranidae

Pelophylax bedriagae (Camerano, 1882)

Material examined. (n=166) **Jordan University Museum**: JUMA 23, 1 ♂ and 2 ♀♀, 11.9.1978, Jarash, Al Birkatain. JUMA 27, 13.10.1978, Wadi Fidan. JUMA 29–30, 32, 34–39, 26.10.1978, Azraq ash Shishan. JUMA 45–52, 19.3.1979, Azraq ash Shishan. JUMA 56–58, 19.3.1979, Azraq ash Shishan. JUMA 61–63, 19.3.1979, Azraq ash Shishan. JUMA 69, 85–86, 88–89, 21.8.1980, W. Al-Hidan. JUMA 70–74, 10.5.1980, Azraq ash Shishan. JUMA 76, 30.3.1981, Wadi Shu'ayb. JUMA 91–92, 2 ♀♀, 25.8.1980, Dayr Alla. JUMA 95, 14.9.1988, Jarash, Al Birkatain. JUMA 96, 15.9.1980, King Talal Dam. JUMA 99, 1 ♂, 1.9.1980, King Talal Dam. JUMA 102 , 1 ♀, 21.5.1980, Suweilih. JUMA 103, 23.8.1980, Ziglab Dam. JUMA 106–107, 21.8.1980, W. Al-Hidan. JUMA 108–116, 21.8.1980, W. Al-Hidan. JUMA 117–118, 2 ♂♂, 1.9.1980, King Talal Dam. JUMA 119–122, 9.9.1980, King Talal Dam. JUMA 123, 125, 28.9.1980, Suliehi. JUMA 127–134, 3.8.1983, Azraq ash Shishan. JUMA 135–136,

Fig. 7. Adult male *Pelophylax bedriagae* from the Jordan Valley, showing the vertebral stripe.

27.9.1981, Ghore. JUMA 137, 139–140, 2 ♀♀, 11.2.1981, Wadi Shu'ayb. JUMA 143–144, 199–204, 21.8.1980, W. Al-Hidan. JUMA 147–148, 2 ♀♀, 4.3.1981, W. Al-Khafia. JUMA 186–198, May 1988, Wadi Shu'ayb Dam. JUMA 156, 1 ♂, 23.8.1980, Ziglab Dam. JUMA 160, 23.8.1980, Ziglab Dam. JUMA 162–163, 2 ♂♂, 4.3.1981, W. Al-Khafia. JUMA 171, 1.5.1980, Wadi Al Hasa. JUMA 217, 8.9.1980, Siel Al-Khuriast, Zarqa. JUMA 219, 1 ♂, 2.9.1980, King Talal Dam. JUMA 222, 9.9.1980, King Talal Dam. JUMA 223–227, 9.9.1980, King Talal Dam. JUMA 228, 9.9.1980, King Talal Dam. JUMA 229, 1 ♀, April 1981, Wadi Shu'ayb. JUMA 231, 1 ♂, 21.8.1980, W. Al-Hidan. JUMA 235, 2.9.1982, Wadi Fidan. JUMA 236, 1 ♂, 2.9.1982, Wadi Fidan. JUMA 239–242, June 1981, Dayr Alla. JUMA 254–281, May, 1988, Wadi Shu'ayb Dam. JUMA 282–298, 13.4.1988, Dayr Alla. JUMA 308, 1 ♂, 27.4.1981, Wadi Amruk. JUMA 309, 25.3.1982, Barashta-Harta. JUMA 322, 3.8.1983, Azraq ash Shishan. JUMA 330, 19.4.1985, Dayr Alla. JUMA 333, 19.4.1985, Dayr Alla. JUMA 339, March 1988, El Hemah. JUMA 348–349, 20.10.1986, Ghore Az-Zer'ah. JUMA 354–355, 22.10.1988, As Sukhnah, Zarqa. JUMA 419–421, March, 1995, Kuriemha. JUMA 424, 3.8.1983, Azraq ash Shishan. JUMA 455–456, 2 ♀♀, April 1995, Shuna ash Shimaliya. JUMA 477–478, 2 ♂♂, April 1995, Shuna ash Shimaliya. JUMA 488–494, 2 ♀♀, June, 1994, Birien. JUMA 495–503, June, 1994, Birien. JUMA 506, 3.9.1997, Birket al Araies.

Previous records. Ghor (Hart, 1891), Wadi Karak and east of the Dead Sea (Barbour, 1914); Wadi Shu'ayb, Swaymeh, Wadi Al Yabis, Mukhaybeh, Ghore Al Balawneh, Kharja, Al Kerymeh, Zuweia (Al Shorakhy, 2000).

Specimens examined in the field and released (N = 35): Wadi Az Zarra'ah, Wadi al Yabis, Ar Rusayfah, Kurrayyimah, Al Karamah, Wadi Hisban, Sell Az Zraqa, Iraq al-Amir, Wadi Al Karak, Maqarin Dam, Shuna al Janubiyah, Shunat Nimrin, Zarqa Main, Wadi Al Hasa, and Wadi Al Mujib, Abu el Lauqus, Wadi Fa'al, Masharia Dam, Wadi Al-Arab, Wadi Zarqa, Barashta (Ayn-Al-Ghazal), Dayr Alla, Wadi Al Al, and Ayn Abdeh..

Morphological characteristics: Color is very variable and changeable. Dorsum is usually green to olive and dark brown with black or dark green spots of different sizes and also highly variables among individuals. A light vertebral stripe and small pointed warts may be seen in certain specimens. The back of the thigh is lighter than the body with dark and light marbling**.** In most cases the back is covered, with small warts (Fig. 7 & 8). The belly is dirty whitish. Head is slightly longer than wide (Length/width 1.06 ± 0.07), in dorsal view triangular in general shape, and about 36 ± 3 % as long as the snout-urostyle length. The internarial distance is about 83 ± 12 % of the distance between the nostril and the eye, also around 19 ± 2 % of the head width. Tympanum is distinct, mostly circular and may be slightly pear-shaped, and is about 56 % of the horizontal diameter of the eye. The interorbital distance is almost 64 % of the horizontal eye diameter. Fingers are pointed, well developed, distal ends of terminal phalanges with simple prominent subarticular tubercles. Hind limb is well developed. Feet webbed to about of the third phalanges of fingers I-III-V and to the base of the third phalange on the IV toe. There is a single flattened inner metatarsal tubercle scarcely prominent in lateral view. First finger length is slightly more than twice of its greatest width; and 57 +6 % of hand length. Tarsal length is 45 % of foot length and 43 % of thigh length. Tibial length is almost

Tab. 3. Morphometric measurements for *Pelophylax bedriagae* (measurements in cm).

	Males (n = 68)				Females (n = 88)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
SV	5.88	0.83	4.25	8.95	6.17	1.13	4.30	9.52
EN	0.46	0.08	0.30	0.75	0.48	0.08	0.33	0.71
HL	2.12	0.31	1.50	3.58	2.23	0.35	1.62	3.22
HW	2.01	0.37	1.46	3.63	2.12	0.39	1.50	3.35
IN	0.37	0.07	0.20	0.52	0.40	0.07	0.25	0.60
E	0.74	0.10	0.55	1.20	0.76	0.10	0.53	1.10
T	0.42	0.07	0.27	0.61	0.42	0.08	0.25	0.72
IO	0.47	0.07	0.30	0.67	0.50	0.09	0.30	0.73
HDL	1.55	0.21	1.14	2.29	1.61	0.26	1.03	2.30
F1L	0.86	0.15	0.57	1.35	0.72	0.18	0.59	1.42
F1W	0.44	0.08	0.26	0.66	0.42	0.09	0.25	0.61
THL	2.94	0.49	1.90	4.93	3.15	0.59	1.98	4.83
TL	2.64	0.40	1.91	4.30	2.78	0.54	1.63	4.05
TSL	1.28	0.21	0.94	2.00	1.35	0.24	1.00	2.00
T1	0.76	0.11	0.47	1.00	0.84	0.15	0.44	1.28
TBL	0.32	0.05	0.18	0.43	0.32	0.06	0.22	0.47
FL	2.86	0.43	2.06	4.18	2.99	0.51	1.63	4.30

89 ± 8 % of thigh length; slightly more than twice the tarsal length; 93 % of the foot length and 15 % of snout-urostyle length. Thigh length is 51 ± 5 % of snout-urostyle length; 113 % of tibial length; 239 % of tarsal length. The inner tubercle length is almost 11 % of the foot length, and the latter is 222 % of the tarsal length. The first toe length is around 68 % of the fourth toe length; 61 % of the tarsal length; and 27 % of the foot length, while the fourth toe length is 89 % of the tarsal length and almost 40 % of the foot length in both sexes (Table 3).

Males are distinguished morphologically from females by exhibiting two external gray or black vocal sacs which open externally through irregular slits behind the mouth corners. Also, they have well developed callosity on the external and the ventral parts of the first finger during mating season. The ear-drum of males are always gray or blackish-brown, while lighter in females. Table 3 shows that the mean length in males is 5.88 cm (SD ± 0.83) and the largest male is 8.95 cm; while the mean length in females is 6.17 (± 1.13), and the largest female is 9.52 cm.

Habitat. *Pelophylax bedriagae* was collected from most permanent water bodies in Jordan including rivers, streams, ponds, dams, pools and mineral springs (Fig. 9). Moreover, the marsh frog was the only amphibian found in tributary canals originating from hot mineral springs around the Dead Sea area, El Hemma and Azraq mineral springs. Along the Jordan Valley *P. bedriagae* lives in association with *Mauremys rivulata*. In one occasion, at Birket Al-Araies, *M. rivulata* was observed feeding on the Marsh Frog.

P. bedriagae starts mating in late January and February in the Jordan, while in the northern highlands occurs in March to April. In the southern highlands of Jordan, mating takes place during later April to May. *Pelophylax* breeding is not dependent on rain, since it inhabits permanent water bodies. These findings are in agreement with Duellman & Trueb (1994) who reported that temperature acts as an important factor at higher elevations and higher latitudes in initiating breeding activity and determining the time and duration of breeding season.

Remarks. Sinsch & Schneider (1999) in their studies on taxonomic reassessment of the Middle East water frogs found that all populations represent the same species, *Pelophylax bedriagae*. On the basis of morphology and morphometry there are good similarities of the examined specimens and those reported by Balletto *et al*. (1985) from the Arabian Peninsula. But the question is still open if the populations of *Pelophylax* in Arabia belong to the same species or not (Disi, 2002).

Variations of the coloration were observed within the same populations as in the presence or absence of the mid vertebral line, number and size of blotches and color of the abdomen. The distribution is restricted to availability of permanent water bodies, mostly in the Jordan Valley and the eastern side of the Dead Sea and Wadi Araba and upper reaches of springs, ponds or creeks within the Mediterranean ecozone and Azraq Desert Oasis.

Fig. 8. Adult female *Pelophylax bedriagae* from Birkat Al Arayes, Jordan.

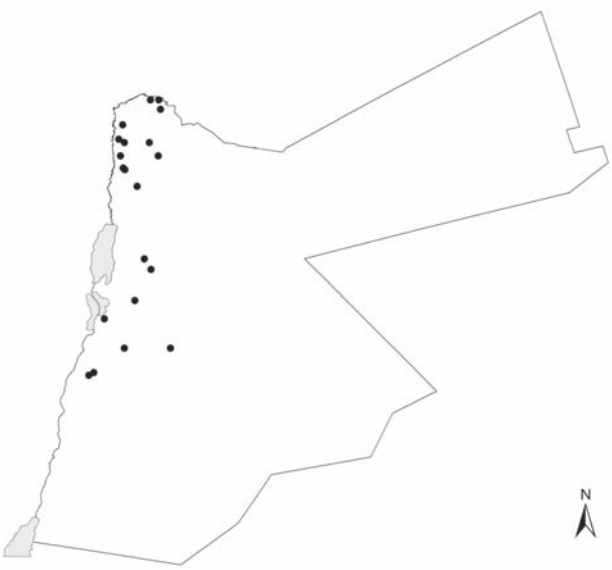

Fig. 9. Distribution of *Pelophylax bedriagae* in Jordan.

General discussion

Jordan is a crossroad of four zoogeographical realms and southern Jordan represents part of the Levantine land bridge (Disi, 1996). This strategic location allows comprehensive studies on the zoogeography of amphibians in Jordan and the Levant. Moreover, a small area such as Jordan that comprises a great variety of geomorphological as well as climatic conditions, acts as a natural laboratory and allows better understanding of the effect of abiotic factors on the distribution and reproductive behavior of amphibians.

The amphibian fauna of Jordan is comparatively poor compared with the northerly surrounding countries (e.g. Turkey) due to the aridity of the region. Obviously, *B. viridis* has a wide range of distribution in Jordan, extending to arid regions in eastern Jordan (see Fig. 2) as compared to *H. savignyi* and *P. bedriagae*. The later species requires permanent water bodies that are mostly confined to the western part of the country.

Jordan is suffering a serious problem of water shortage. Irrigation water consumes about three-fourths of the available freshwater resources in Jordan (Al-Weshah, 2000). This caused severe changes in water courses all over the country. These changes include alteration of water flow, construction of dams, direct pumping of water for municipal use from the main springs (Fig. 10). The disappearance of the last locality for *P. syriacus* from Jordan is believed to be an example of man-made changes that cause extinction of vulnerable populations. In Lebanon they are very localized and in small populations (Hraoui-Bloquet *et al.*, 2001). It is a threatened species in Israel (Degani & Kaplan, 1999).

Some endemic amphibians in the Middle East, such as the Hula Painted Frog *Discoglossus nigriventer*, became extinct around the 1950s due to drainage of their habitat (Cuttelod *et al.*, 2008). This species was recorded from localities on the eastern shore of Lake Huleh and northwest of the Jordan Valley (Mendelssohn & Steinitz, 1943; Steinitz, 1965).

Further studies should address threats of these changes to amphibian populations in Jordan, and conserve the amphibians of Jordan.

Fig. 10. Wadi Zara Ma'ain after diverting water from the wadi system. This wadi used to harbor populations of *H. savignyi* and *P. bedriagae*

Fig. 11. Qasr Burqu'a pond in the middle of the Eastern Desert of Jordan. This pond hosts the most eastern population of the Green Toad. *P. viridis*.

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Fig. 12. Birket Al-Araies in the extreme northwestern Jordan. This pond hosts three species of frogs, *H. savignyi*, *P. viridis* and *P. bedriagae*.

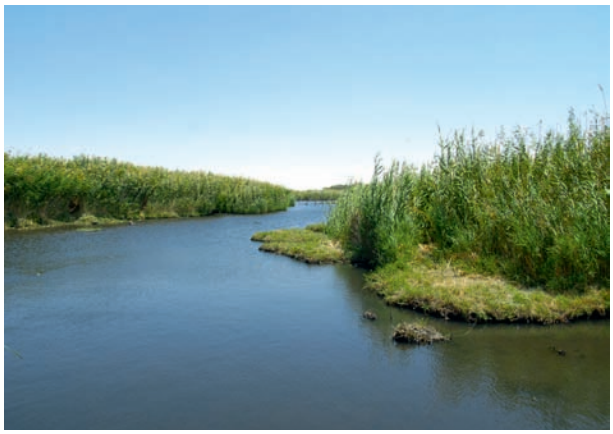

Fig. 13. Open marshes of Azraq Desert Oasis. In these marshes, two amphibians, *P. viridis* and *P. bedriagae* occur.

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