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Distribution and bioacoustics of *Rana perezi* Seoane, 1885 (Amphibia, Anura, Ranidae) in Tunisia

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Abstract. Extensive bioacoustic studies have demonstrated the presence of *Rana perezi* in Tunisia. The call analyses were used to determine the distribution of this species in the various geographic zones of the country. The mating and territorial calls are described and compared with the corresponding calls of a population of *R. perezi* in Spain.

Key words. Amphibia, *Rana perezi*, bioacoustics, distribution, Tunisia.

Introduction

Over more than two decades, many investigations of western palaearctic water frogs have built up a considerable fund of information about their calls and reproductive behavior (Wahl 1969; Günther 1969; Schneider 1973; Schneider et al. 1979; Nevo & Schneider 1983; Kuhn & Schneider 1984; Schneider & Sofianidou 1985; Schneider & Joermann 1988; Radwan & Schneider 1988; Akef & Schneider 1989; Schneider & Egiasarjan 1989, in press). The mating calls proved to be extremely specific, so that they are useful indicators with respect to taxonomic questions. As a result of bioacoustic and morphometric analyses, the existence in western Greece of the new species *Rana epeirotica* and its hybrid with *R. ridibunda* was documented, after which the distribution of *R. epeirotica* was determined (Schneider et al. 1984; Schneider & Sofianidou 1987; Sofianidou et al. 1987; Sofianidou & Schneider 1989).

While many detailed bioacoustic findings were thus assembled for several water-frog species, the Spanish lake frog, *R. perezi*, had been neglected. Therefore, in 1990 Schneider & Steinwarz examined the structure of the calls of a population of *R. perezi* near the nature reserve Doñana, at Seville. The bioacoustic analyses showed that the mating call is distinct from those of other species and thus demonstrated the independence of the species *R. perezi*. This conclusion was corroborated by serological and enzymological studies (Tunner 1970; Hemmer 1973; Tunner & Uzzell 1974; Graf et al. 1977; Uzzell 1982).

The range of *R. perezi* covers the Iberian peninsula and extends into southern France and to the Balearics; the species has also been introduced to the Canary Islands and the Azores (Mertens & Wermuth 1960). Once the independence of *R. perezi* as a species had been demonstrated, the close relationship to *R. ridibunda* that had previously been assumed was no longer valid, and the systematic relations of *R. perezi* became an open question. On the whole, the systematics of the North African water frog is still quite uncertain (see Discussion). Therefore, further study in this region seemed a useful and promising endeavor. The results of our bioacoustic analyses document the presence of *R. perezi* in Tunisia and show how the species is distributed in this country.

Material and Methods

The herpetofaunistic investigation of *R. perezi* was carried out from the 18th to the 30th of March, 1990. An effort was made to include sites representative of all the various geographically and climatically distinct zones. The water frogs were identified primarily on the basis of bioacoustic characteristics, though morphological features were also considered.

The calls were recorded in the field with a portable tape recorder (Uher Report 4200) and a condenser microphone (Sennheiser K3 N with head ME 80). The air and water temperatures were measured with an electric rapid-response thermometer (technoterm 1500, Testoterm).

The oscillograms were produced by displaying the recorded calls on a Tektronix 502 A oscilloscope and photographing them (Toennies Recordine camera). For frequency analysis a sonagraph (Kay Electric 7029 A) and a frequency spectrograph (Nicolet UA 400 A) were used. The statistical calculations were carried out with an AT computer (Highscreen) and the software Statgraphics, from the Statistical Graphics Corp., Knoxville, USA.

The recordings so analyzed were obtained at Gafsa, Nefta, Bechri, El Hamma, Chenini and Medenine.

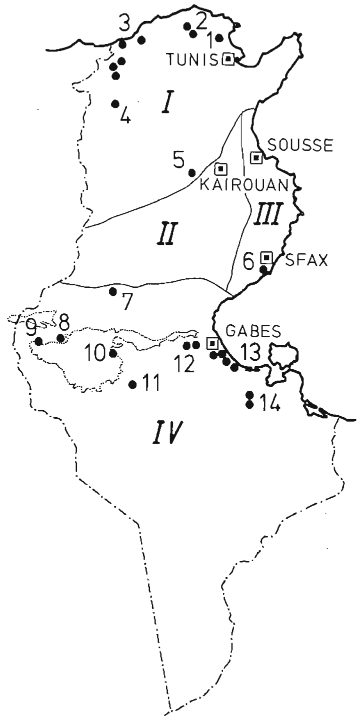


Fig. 1: Distribution of *R. perezi* in Tunisia. I: northern highland and basin of Tunis; II: central Tunisian steppe; III: Sahel; IV: southern Tunisia. The dots indicate the sites at which frogs were found. Arabic numerals: see text.

Results

Distribution of *R. perezi* within Tunisia

Tunisia comprises the eastern part of the Maghreb and can be subdivided into four zones (Fig. 1): I. the mountainous terrain in the north, including the basin of Tunis and Cap Bon; II. the central Tunisian steppe; III. the Sahel; IV. southern Tunisia (Köhler 1983).

I. Northern highland, basin of Tunis

The northwestern part of Tunisia is distinguished by three mountain chains that run from southwest to northeast (Kroumerie/Mogod; Monts de Medjerda/Monts de Teboursouk; Dorsale). Between these chains lie river valleys, basins and high plateaus. In the Kroumerie, especially, extensive forests of oaks (*Quercus suber* and *Q. sessiliflora*), thujas and Aleppo pines can still be found. The valleys, plateaus and coastal regions have been converted to settlements and cultivated fields. The highland descends to the basin of Tunis and Cap Bon.

The mean annual precipitation exceeds 800 mm at the north coast and is 400—600 mm in the middle and southern parts of the mountain region and in the basin of Tunis.

Sites at which *R. perezi* was found:
1. Basin of Tunis:
— Scattered calling frogs at the Qued Nabtour next to the road linking Bizerte and Tunis. No other find in the surroundings of Tunis and Bizerte.
— According to workers at the biological station of the Lac Ichkeul National Park, that area is inhabited by lake frogs.
2. Vicinity of Mateur:
— Medium-size population (50—100 animals) in the Qued Jourmine on the outskirts of Mateur.
— Occasional individuals in a small qued near the village of Ghezala.
3. Vicinity of Tabarka:
— Occasional frogs along the road between Mateur and Tabarka, near the village of Nefza in the Qued Melah.
— On the outskirts of Tabarka, occasional frogs were found in the extremely slowly flowing waters near the broad mouth of the Qued el Kebir.
— Ben Metir reservoir: in small ponds below the side of the dam away from the reservoir, occasional frogs.
— Occasional frogs found at two sites along the road between Tabarka and Jendouba, each in small, slowly flowing brooks near Fernaria.
4. Vicinity of El Kef:
— In the immediate surroundings of the city El Kef and along the road between El Kef and Sakiet Sidi Youssef, at the Algerian border, there are no habitats suitable for *R. perezi*.
— Barrage Mellegue (reservoir) near the village of Nebeur. In many ponds surrounding the reservoir walls, calling groups of *R. perezi* were found (a total of ca. 50—100 animals).
5. Haffouz:
— On the outskirts of this community in the southern Dorsale, along the road between Kairouan and El Kef, a large population (several hundred animals) was found in a large pool created as a watering place.

II. Central Tunisian steppe

Toward the south highlands are bounded by the central Tunisian steppe, a plain at an altitude of 600—800 m in the southwest and 100—200 m in the east. With a mean annual precipitation of only 200—400 mm (mostly in the lower part of this range), the region is extraordinarily short of rain. There are no natural bodies of water.

Neither in the surroundings of Kairouan nor along the Kairouan-Gafsa or Gafsa-Sfax roads were biotopes suitable for lake frogs found.

III. Sahel

The Sahel extends along the eastern coast of Tunisia, between the Gulf of Hammamet, the Gulf of Gabès and the central Tunisian steppe. It is a densely settled region, intensely cultivated, with centers of population around Sousse and Sfax. The mean annual precipitation in the Sahel is 200—400 mm (mostly in the upper part of range).

Neither in the southern vicinity of Sousse (the region including Monastir, Moknine, and Jemmel) nor to the north (Hammam Sousse, Akouda, Kalaa Kebira) was *R. perezi* to be found. The few water-filled streams, such as the Qued el Hammah, are severely polluted.

6. Small qued on the southern outskirts of Sfax: ca. 10 lake frogs.

IV. Southern Tunisia

About half of the southern part of Tunisia is desert steppe and the rest is true desert. It comprises several regions with different characteristics, as follows:
a. Highland region near Gafsa, with desert steppe to the south;
b. Salt-lake depressing including the Chott el Djerid, Chott el Fedjadj and Chott el Rharsa, flanked by the extended oasis regions Bled el Djerid and Nefzaoua;
c. The Arad plain at the Gulf of Gabès;
d. The coastal plain Djeffara and Djerba Island;
e. Southern Tunisian mountain region (Dahar);
f. Sand-dune desert Grand Erg Oriental (Sahara) south of the chotts.

The climate is characterized by severe aridity. In the coastal areas and in the north of the zone the mean annual precipitation is 200 mm, but south of the chotts it is less than 100 mm.

In southern Tunisia essentially no natural bodies of water are present all the year round.

Finds of *R. perezi*:
7. Gafsa: city in an extensive oasis.
— Ca. 20 animals in a large water reservoir in the oasis, ca. 4 km south of the city center.
8/9. Bled el Djerid: Oasis region at the northwest boundary of the Chott el Djerid. This area is irrigated from artesian and drilled wells (groundwater 60—100 m deep), by way of an intricate network of above-ground canals.
— Touzeur (8): Occasional frogs in irrigation canals around the oasis garden "Paradise".
— Nefta (9): Several scattered frogs in irrigation canals and occasional individuals in a distribution basin.
10/11. Nefzaoua: Oasis region at the southeastern boundary of the Chott el Djerid. Irrigation from artesian wells, by way of subterranean conduits (foggaras).
— Bechri (10): Community in a spit of land that projects far into the Chott el Djerid. On its outskirts, in a man-made watering place up to 15 m deep, ca. 50—100 frogs were found. It is highly probable that water is supplied to this pond all year round, since many fish were present.
— Douz (11): Community in the southern Nefzaoua, surrounded by sandy semidesert and sand-dune desert. Occasional frogs in a watering place made for domestic animals.
12/13. Arad plain: A steppe landscape with numerous oases, along the Gulf of Gabès.
El Hamma (12): Oasis at the Qued el Hamma, with six sulfurous thermal springs.
— A few frogs in a distribution basin;
— Several hundred frogs at the Qued el Hamma, which empties into a swampy region with many small pools after it has passed under the Kebili-Gabès road.
Gabès and surroundings (13): A medium-size city in the middle of an oasis that covers 2000 hectares. The oasis receives its water supply from the Qued Gabès and artesian wells.

— The Qued Gabès is dammed near the small settlement Chenini (Barrage Romaine). A large frog population (several hundred animals) lives in the reservoir and in nearby river meanders and small pools.
— Kettana: Oasis south of Gabès. The Qued el Ferch backs up before the underpass below the Gabès-Medenine road, providing the habitat of a small frog population (10—20 animals).
— Teboulbou: Another oasis to the south of Gabès. Habitats like those in Kettana at two small queds, each with a small population (10—20 aminals).
Mountains of southern Tunisia (Dahar),
The Dahar extends to the south of the Arad plain, seperating the Djeffara plain from the Grand Erg Oriental. It consists of dry, bare hills. Along the Gabès-Matmata and Matmata-Medenine roads no habitats suitable for lake frogs were found. The people living there also say that there are no frogs in the Dahar.
14. Djeffara plain: Desert steppe along the Tunisian coast, bounded on the south by the Arad plain.
— Medenine: In the city center the Qued Smar passes under the Medenine-Foum Tatahouine road, and near the underpass the qued backs up to form a swampy region. This is the habitat of a frog population comprising ca. 50—100 animals. Two km to the south a smaller qued forms a similar biotope, also inhabited by many frogs.

Morphology

The *R. perezi* in Tunisia are small animals, with a snout-vent length of at most 7—8 cm. Their coloration is variable; green hues predominate, but some animals are mainly brown. Often there are sharply outlined dark-brown spots on the upper surface. There is usually a light mid-dorsal line, but it may be absent. The tympanic membranes are light brown, and the paired vocal sacs are light gray to almost white.

Calling behavior

Because of the differences in climate between northern and southern Tunisia, the frogs in these regions exhibit clear phenological differences. During the time in which their distribution was being mapped, the temperature in the mountainous northern region was low. In the vicinity of El Kef the air temperature on March 28, 1990 was 6.4 °C at 0845 h, 16 °C at 1300 h, and 13.5 °C at 2030 h. The water temperature reached only 12 °C in large bodies of water (pond at the Barrage Mellegue) and 15.1 °C in small pools (ditches). Accordingly, the *R. perezi* populations were still in the prespawning phase. Scattered territorial and mating calls could be heard at a water temperature as low as 12 °C. In the south, by contrast, the air temperature rose to a daily maximum of over 25 °C in the shade, though it fell sharply after sundown. For example, measurements on March 20, 1990, in Gafsa showed air temperatures between 12.5 °C at 0800 h and 25.2 °C at 1300 h. At the same times, the water temperatures in a reservoir were 15.3 and 20.1 °C. In the south, therefore, the *R. perezi* populations were already in the main spawning season. The males were giving mating calls as well as numerous territorial calls.

During the observations in Tunisia, the *R. perezi* called during the day and in the evening twilight. At night, calling was interrupted by the rapid decrease in water temperature.

While calling, many males lie at the water surface with the forelegs hanging down and the hindlegs spread out. After emitting a series of calls the animals swim about for a while but usually change their calling sites only slightly. Other animals call from stones in the water or from the vegetation on the shore. These do not change their position after calling. The distances between calling males depend on the density of the frogs in the spawning habitat, ranging from ca. 50 cm to 2 m. The males exhibit territorial behavior. When another male approaches too closely, they give territorial calls and swim toward the intruder, whereupon the latter usually goes away.

Calls

During the spawning period, the male *R. perezi* in Tunisia give calls of various types. The mating call, three different territorial calls, transitional calls and a short high-frequency call can be distinguished.

1. Mating call

The mating call is composed of pulse groups (Fig. 2). At a water temperature of 19.0 °C the call parameters have the following avarage values. The call duration is 514.83 ms, the call consists of 10.64 pulse groups with 7.35 pulses per group, the pulse-group duration is 34.45 ms, and the interval between the pulse groups is 16.62 ms. The mating calls are emitted either singly or in series. Analysis of 50 such series, with a total of 197 calls, gave an average of 3.93 ± 2.52 calls per series.

During the field observations calls were recorded at water temperatures between 17.0 and 23.6 °C. Several call parameters are correlated with water temperature; the statistical calculations are shown in Table 1. The pulse-group duration, the interval between the pulse groups and the sum of these two parameters, the pulse-group period, decrease with rising water temperature (Fig. 3a, b, c). In contrast, the number of pulse groups per call and the pulse-group rate (pulse groups per second) (Fig. 3d, e) are positively correlated with the water temperature. No significant correlation was found for the parameters pulses/pulse group, call duration, intercall interval and call period.

The sonagrams of the mating call (Fig. 4) reveal a frequency range between about 350 and 3000 Hz, within which two particular concentrations of energy stand out. The upper, domi-

Table 1: Results of the statistical calculations. Regression equations: x = independent variable (water temperature); y = dependent variable. Significance (F-test) for the correlation with water temperature (coefficient r): $P < 0.05^*$; $P < 0.01^{**}$; $P < 0.001^{***}$; $P > 0.05^-$ (not significant).

Dependent variable	N	r	Regression equation	F-test
Mating call				
Duration of calls (ms)	88	—0.10⁻	—	0.97⁻
Intervals between calls (ms)	88	—0.23*	y = 2171.47—81.54x	3.00⁻
Period of calls (ms)	88	—0.21⁻	—	2.50⁻
Pulse groups/call (n)	88	0.55***	y = —8.55 + 1.01x	38.40***
Duration of pulse groups (ms)	88	—0.48***	y = 70.55— 1.90x	25.43***
Interval between groups (ms)	88	—0.21⁻	—	3.99*
Period of pulse groups (ms)	88	—0.81***	y = 106.17— 2.90x	162.76***
Pulse group rate (Hz)	88	0.85***	y = —6.06 + 1.40x	226.68***
Pulses/group (n)	88	—0.20⁻	—	3.74⁻
Territorial call 1				
Duration of calls (ms)	84	—0.51***	y = 266.78— 7.49x	29.73***
Pulses/call (n)	84	—0.30*	y = 63.92— 1.38x	8.30**
Territorial call 3				
Duration of calls (ms)	48	—0.59***	y = 1222.66—39.33x	25.40***
Pulses/call (n)	48	—0.30*	y = 32.02— 0.74x	4.72*

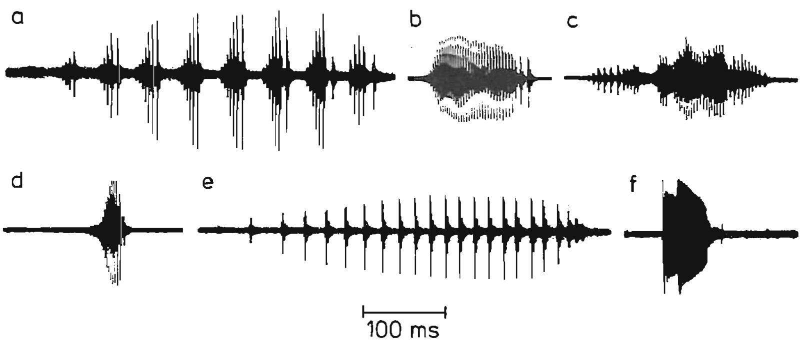


Fig. 2: Oscillograms of the calls of *R. perezi*. a: mating call; b: territorial call 1; c: transitional call; d: territorial call 2; e: territorial call 3; f: short high-frequency call (water temperature 19.5 ° C in each case).

nant frequency band is about 500 Hz wide and lies at 1991 ± 317 Hz (n = 110). It can be modulated in various ways; usually there is an upward modulation in the first call of a series. The lower, usually somewhat weaker band lies at 617 ± 115 Hz (n = 98) and may be unmodulated or may change in either the same direction as the upper band or the opposite direction. There is a significant positive correlation between the level of the upper frequency band and the water temperature (Table 2). The lower band also appears to be positively correlated to some degree, but the correlation cannot be confirmed statistically with the available data (Table 2).

2. Territorial call 1
Territorial call 1 is the most common territorial call (Fig. 2). Its duration averages 124.55 ms at 19 ° C and decreases significantly as the water temperature rises (Table 1). At 19 ° C this call is composed of an average of 37.7 pulses. The number of pulses decreases with increasing temperature (Table 1). Many territorial calls show some sign of subdivision into 2—6 pulse groups. However, unlike the mating call, these calls have no distinct intervals between the groups. Often a soft sound precedes the actual call.

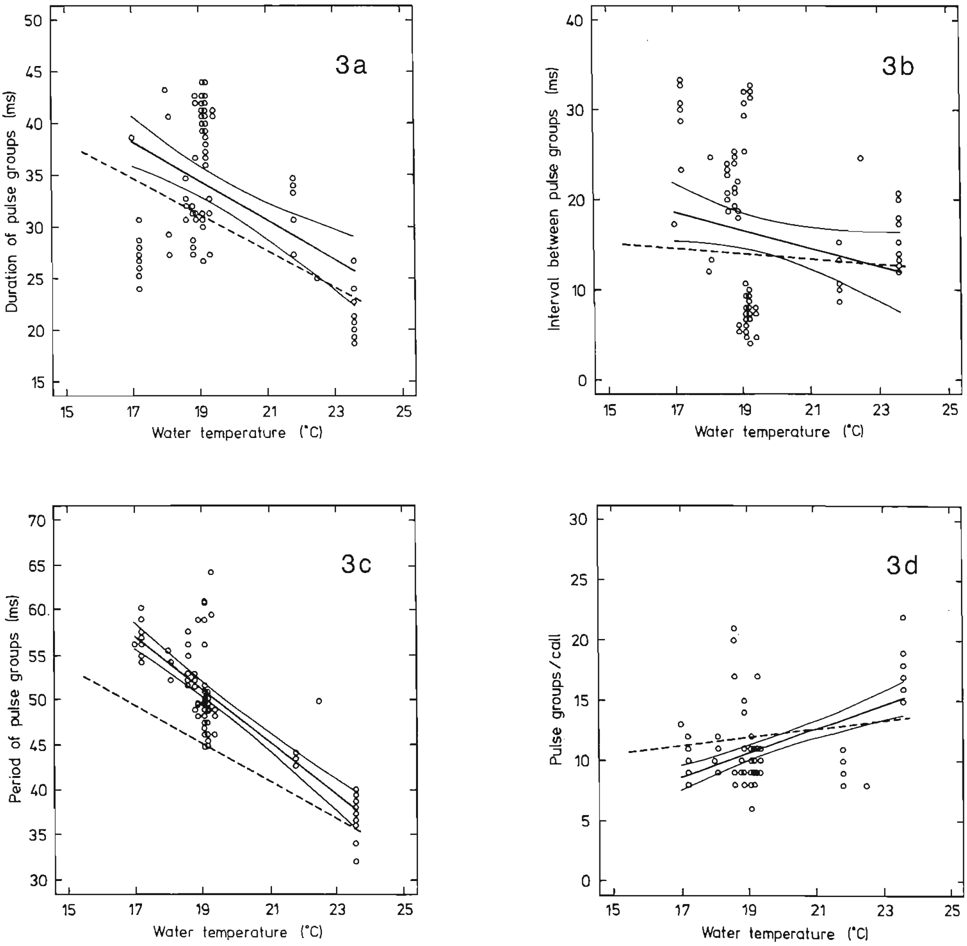
A sonagram of a territorial call 1 is shown in Fig. 4. Again there are two high-energy frequency bands, the upper and dominant one of which (1568 ± 306 Hz; n = 13) reaches significantly higher levels as the water temperature rises (Table 2). The lower frequency band is also positively correlated with the water temperature (Table 2).

3. Territorial call 2
Of the three types of territorial calls, this is the least often produced. It is a brief call, within which the individual pulses are often indistinguishable, at least in the middle of the call.

The sonagram has 3—8 energy-rich bands (Fig. 4), at harmonically related frequencies. The call, therefore, has a tonal character.

4. Territorial call 3
This call is often to be heard, usually at the end of a series of territorial calls. At 19 ° C the duration of the call averages 475.43 ms, and it comprises an average of 18.0 individual pulses. With rising water temperature, both call duration and number of pulses decrease significantly (Table 1).

The sonagram of a territorial call 3 is shown in Fig. 4. The call usually has a very low-pitched sound. Its dominant frequency, averaging 517 Hz at 19 ° C, is positively correlated with the water temperature (Table 2). A higher-frequency band is often also present, though it is usually fairly weak.



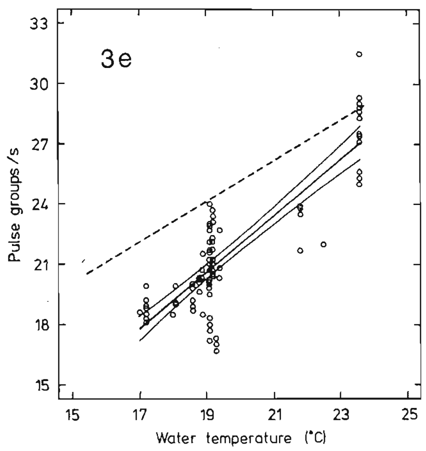


Fig. 3: Various parameters of the mating call as a function of water temperature. a: pulse-group duration, b: pulse-group interval; c: pulse-group period; d: pulse groups per call; e: pulse groups per second. Each diagram includes the regression line and the 95 % confidence interval for the slope of the regression line. The corresponding regression line for a Spanish population of *R. perezi* (Schneider & Steinwarz 1990) is also shown (dashed).

5. Short, high-frequency call
A very brief call at high frequency is also produced, usually singly but sometimes as part of a series of territorial calls (Fig. 2). Its duration is 57.5 ± 13.07 ms (n = 16) and its dominant frequency is 2203 ± 429 Hz (n = 16). Sometimes a second, distinctly weaker band is present at 1690 ± 543 Hz (n = 5). There is a marked downward modulation in the course of this call. The individual pulses of which it is composed are usually not separated one from another.

6. Transitional call
This call is intermediate in structure between territorial call 1 and the mating call (Fig. 2). A pronounced amplitude modulation divides it into 3–8 pulse groups. This subdivision is more distinct than that of territorial call 1, but there are no clear intervals between the pulse groups as in the mating call.

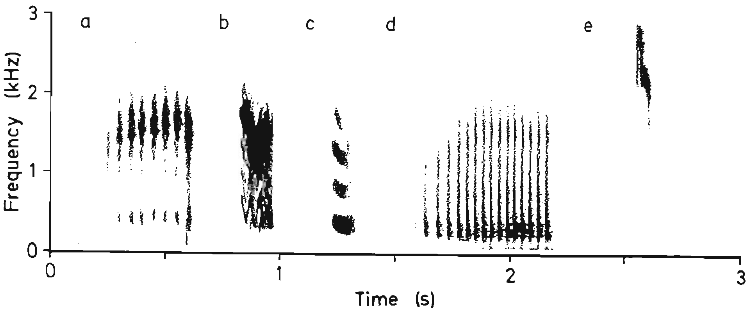


Fig. 4: Sonagrams of the calls of *R. perezi*. a: mating call; b: territorial call; c: territorial call 2; d: territorial call 3; e: short high-frequency call (water temperature between 18.6 and 18.9 °C in each case).

Table 2: Results of the statistical calculations: frequency analysis. Regression equations: x = independent variable (water temperature); y = dependent variable. Significance (F-test) for the correlation with water temperature (coefficient r): P <0.05*; P <0.01**; P <0.001***; P >0.05⁻ (not significant).

Dependent variable	N	r	Regression equation	F-test
Mating call				
Upper frequency maximum	109	0.63***	y = 320.73 + 86.32x—	73.00***
Lower frequency maximum	97	0.20*	—	3.91⁻
Territorial call 1				
Upper frequency maximum	112	0.64***	y = 70.94 + 79.09x	78.00***
Lower frequency maximum	105	0.49***	y = —1.37 + 32.34x	33.30***
Territorial call 3				
Upper frequency maximum	52	0.17⁻	—	1.50⁻
Lower frequency maximum	79	0.48***	y = 31.59 + 28.88x	23.70***
Short high-frequency call				
Frequency maximum	16	0.25⁻	—	1.00⁻

Discussion

Bioacoustics: According to the results of our bioacoustic investigations, there can be no doubt that *R. perezi* is common in Tunisia. The mating call of the many lake-frog populations there has a structure remarkably similar to that of a population of *R. perezi* in Spain that was analyzed by Schneider & Steinwarz (1990). There is a good match in the average number of calls per series and in the average call duration, and the regression lines of most of the call parameters that depend on the water temperature lie close together (Fig. 3a—d). The calls differ somewhat more with respect to the parameter pulse-group rate (Fig. 3e). The greatest difference lies in the number of pulses per pulse group. Higher values are found for this parameter in the calls of the lake frogs in Tunisia than in those of the frogs in Spain.

To express the relationship more precisely, a discriminant analysis was carried out for the mating calls of the two populations, taking into account the parameters pulses/pulse group, pulse groups/call, call duration, call interval and call period. The results are shown in Fig. 5 and Table 3. Although a statistically significant discriminant function can be calculated, in the discriminant classification of the mating calls from Tunisia and Spain 27 % and 19 % of the call parameters, respectively, are incorrectly classified. The result of the analysis, therefore, is that whereas on one hand there are discernible differences between the call parameters of the lake frogs in Tunisia and Spain, on the other hand the extensive overlap of the bioacoustic data indicates that the two populations are closely related. On the basis of the discriminatory ability found in behavioral tests of the tree frogs *Hyla savigny* and *H. meridionalis* (Brzoska et al. 1982; Schneider 1982; Schneider et al. 1984), the slight differences between the mating calls of the lake frogs in Tunisia and Spain would not be expected to suffice for auditory discrimination.

The territorial calls 1, 2 and 3 described for *R. perezi* in Spain (Schneider & Steinwarz 1990) are also given, in a very similar form, by the lake frogs in Tunisia. Slight quantitative differences can be discerned for territorial call 1, in that the amplitude has reached its maximum by the second to fourth pulse in the calls of the population in Spain, whereas in those of the frogs in Tunisia the maximum is generally shifted

Table 3A, B: Discriminant analysis of the mating call of *R, perezi* in Tunisia and Spain.
A. Significance levels (5 degrees of freedom)

Eigen-value	Canonical Correlation	Wilks Lamda	Chi-Squared	P
0.5745	0.6041	0.6351	115.98	$\ll 0.001$

B. Success rate (%) of discrimination classification

Actual group	Predicted group (count, percentage) Tunisia		Spain	
Tunisia	43	72.88	16	27.12
Spain	38	18.91	163	81.09

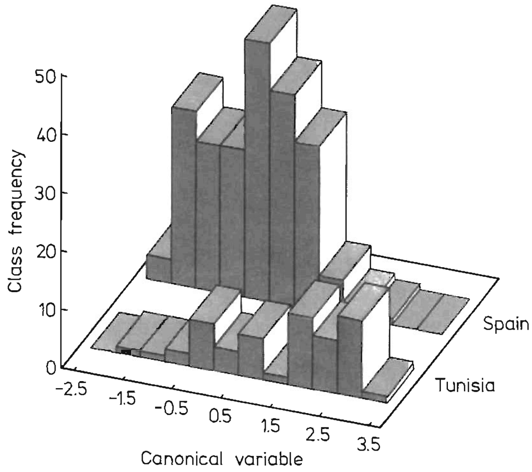


Fig. 5: Discriminant analysis of the mating calls of the lake frogs in Tunisia and Spain. The group centroid values are 1.3936 for the calls from Tunisia and —0.4091 for those from Spain.

toward the middle of the call. The short high-frequency call often given by the frogs in Tunisia was not documented for the populations in Los Palacios (southern Spain), but it can be heard in tape recordings from other parts of Spain (Lenné unpublished).

Distribution: *R. perezi* is widely distributed and common in Tunisia. During the observation period *R. perezi* was the only species of water frogs that was calling. A total of 24 habitats were mapped.

The range within the country is disjunct. The northern Tunisian mountains and the basin of Tunis provide *R. perezi* with many natural habitats. The annual precipitation is high enough that rivers, brooks and ponds contain water all year. In addition, anthropogenic biotopes offer suitable habitats such as man-made watering places and ponds in the vicinity of reservoirs or ditches along roads. In the central Tunisian steppe and in the Sahel there are no natural habitats, because the balance between precipitation and evaporation is not such as to sustain perennial bodies of water. In the agricultural regions crops such as halfa grass and olive trees are grown, which do not ordinarily require a constant supply of water by way of irrigation ditches and reservoirs. The few bodies of water found in the vicinity of Sousse and Sfax (small queds, watering places, ditches) were almost always severely eutrophic or polluted. In the middle part of Tunisia, therefore, *R. perezi* was documented at only one site. Southern Tunisia is characterized by very low precipitation, and hence by a nearly complete absence of perennial bodies of water. However, the oases provide many anthropogenic habitats for lake frogs. As a consequence, the distribution of *R. perezi* in southern Tunisia is largely synanthropic. Here the species occupies irrigation ditches, water reservoirs and distribution channels, and ponds constructed as watering places. In the surroundings of Gabès and Medenine *R. perezi* also lives in the few water-containing queds. There is no habitat for lake frogs in the barren highlands of the Dahar, in the extensive saline lakes or in the sanddune desert of the

Grand Erg Oriental (Sahara). It remains to be determined whether *R. perezi* also occupies oases further out in the Sahara. It seems possible that they do, in view of the severely isolated habitats in which *R. perezi* can be found even in Tunisia.

Taxonomy: A large amount of data is available for the water frogs in North Africa, and some are inconsistent. From finds in the oases El Golea, Igosten and In-Salah in Algeria, Boulenger (1913) described *Rana esculenta* var. *saharica*. The snout-vent length of the males is between 71 and 80 mm, less than the values found for *R. ridibunda*, and the tibiae are also shorter. The coloration is olive, and dark spots and a light line along the back may be present or absent. According to Boulenger, there is a strong similarity between *R. esculenta* var. *saharica* and an Iranian variety of *R. ridibunda*, the varietas *susana* (Boulenger 1905). On the basis of morphometric studies of water frogs, Terentjev (1927) assigned all *R. ridibunda*-like forms with short tibiae — including the var. *susana* — to *R. ridibunda saharica*. Cherbak (1960) adopted this view and reported a range of distribution for *R. ridibunda saharica* that extends from Lybia across Egypt, Iraq, Iran and Afghanistan to the Indus, bounded in the north by Azerbaijan and the Caspian Sea. Eiselt & Schmidtler (1973) included in their comprehensive morphometric analyses the specimen of *R. ridibunda saharica* collected in Algeria by Boulenger. According to their results, the values for *R. ridibunda susana* lie within the range of variation of *R. ridibunda*. They drew the taxonomic conclusion that *R. r. susana* should be synonymized with *R. r. ridibunda*. They also regarded *R. ridibunda saharica* as an extreme expression of graded tendencies within *R. ridibunda*, but argued that it should be retained as a subspecies, not least because of the insularity of its occurrence.

From Nigeria (the Bilma oasis) Angel (1936) described the form *R. esculenta bilmaensis*. He characterized it by short hindlegs and by the absence of ankle processes and of dorsal glandular ridges. Böhme (1978) demonstrated the synonymy of this form with *Dicroglossus occipitalis*. He also casted doubt on the validity of the *R. ridibunda riodeoroi* described by Salvador & Peris (1975) from the Rio de Oro region. According to the description of this subspecies, based on only four specimens, its main difference from *R. perezi* lies in the absence of a light line along the back. A new species *R. zavattari* described by Scortecci (1936) in Libya was synonymized with *R. r. saharica* by Eiselt & Schmidtler (1973).

Uzzell (1982) carried out immunological comparisons of the western Palaearctic water frogs and came to the conclusion that *R. perezi* and "*R. 'saharica'*" are closely related immunologically. In an albumin phenogram he placed "*R. 'saharica'*" in closer kinship with *R. perezi* than with *R. ridibunda*, but he stated that the systematic status of "*R. 'saharica'*" was still uncertain.

Günther (1990, 1991) considered "*R. saharica*" a true species and indicated the northwestern part of Africa as the range of distribution, including Tunisia.

Given the finding that *R. perezi* inhabits Tunisia, it seems likely that the range of this species also extends to Algeria and Morocco and it might be identical to Boulenger's varietas *saharica*. However, the results of Hemmer et al. (1980) contradict this interpretation. Comparing the patterns of plasma proteins and the DNA content of the erythrocytes in water frogs from Algeria and Morocco, Hemmer et al. (1980) found differences from which they concluded that two forms of water frogs occur in these countries and that they hybridize with one another. This conclusion implies the possible existence of two species of water frogs in these regions. The animals tested by Hemmer et al. (1980) were obtained from several sites, but the total number was small. The situation can easily be examined by means of the bioacoustic method.

Now that *R. perezi* has been demonstrated to occur in Tunisia, the range of distribution of this species must be re-evaluated. The Iberian peninsula and southern France, previously considered the main region inhabited by this species, probably represent only the northern part of the range of *R. perezi*, while the northwestern region of Africa most likely constitutes the major part of its range. The situation is presumably like that found for *Hyla meridionalis*. That is, according to Schneider (1968), the Mediterranean tree frogs living on the Iberian peninsula and in France belong to a species complex native to Africa. Moreover, very recent bioacoustic analyses have shown that in northeastern Africa (Nile delta), in Israel and in western Turkey lake frogs occur that differ distinctly from the typical form of *R. ridibunda* and have a close systematic relationship to *R. perezi* (Schneider & Sinsch in press).

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Zusammenfassung

Nach den Ergebnissen umfangreicher bioakustischer Untersuchungen kommt in Tunesien *Rana perezi* vor. Mit Hilfe von Rufanalysen war es weiter möglich, die Verbreitung dieser Art in den verschiedenen Naturräumen des Landes zu ermitteln. Paarungsrufe und Revierrufe werden vorgestellt und mit den entsprechenden Rufen einer Population von *R. perezi* in Spanien verglichen.

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