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DISTRIBUTION OF AMPHIBIANS IN URBAN WATER BODIES (WARSAW AGGLOMERATION, POLAND)

ABSTRACT: The studies on batrachofauna of 76 mostly small water bodies of an area 0.01–16 ha were carried out in Warsaw in 1992–1994. Species composition, number and distribution of breeding sites, as well as specimen numbers of breeding populations were determined. Importance of the distance from the city centre and effects of breeding pond transformations (rush destruction, pool bracing, seasonal drainage) on occurrence and specimen numbers of amphibian species were analysed. Frequencies of the consecutive species were: "green" frogs (*Rana esculenta, Rana lessonae, Rana ridibunda*) – 56%, *Triturus vulgaris vulgaris* – 31%, *Bufo viridis viridis* – 30%, *Bufo bufo bufo* – 30%, *Rana arvalis arvalis* – 27%, *Rana temporaria temporaria* – 18%, *Bombina bombina* – 9%, *Pelobates fuscus fuscus* – 6%, *Triturus cristatus* – 1%. Amphibian species outgoing from the city (*Triturus cristatus, Bombina bombina*, and to a lesser degree *Rana temporaria, Rana arvalis*) and those which are clearly acclimatized (*Bufo viridis, Triturus vulgaris*) were distinguished. Amphibians occurred in 95% of the examined ponds, also those located in the central part of the town. In the central part, the number of species was lower than in the suburbs. Sex ratios (males : females) for selected species ranged from 1 : 1 (*Rana temporaria, Triturus vulgaris*) to 7 : 1 (*Bufo bufo*).

KEY WORDS: urbanization, amphibians, urban pools, sex ratio.

1. INTRODUCTION

Spatial development of cities influences animal populations. In case of birds, mammals and amphibians, number of species declines (especially in central parts of the cities), whereas some species increase in numbers (Luniak et al. 1964, Nuortewa 1971 after Andrzejewski et al. 1978, Luniak 1990, Luniak and Nowicki 1990, Vershinin 1990). Similar regularities are observed for invertebrates (Chudzicka and Cholewicka 1990, Pisarski 1990). Investigations on blackbird (*Turdus merula*) (Luniak et al. 1990), crow (*Corvus corone*) (Ilyichev et al. 1990) and field mouse (*Apodemus agrarius*) (Andrzejewski et al. 1978) have shown that breeding season is extended when compare

to the out-of-town populations of these species. This is explained by warmer microclimate of urban areas.

Other feature of animals inhabiting cities is their worse health condition and frequent pathological changes of individuals living in close vicinity to the centre (Andrzejewski et al 1978, Luniak et al. 1990, Vershinin 1990). It is also known that birds inhabiting cities differ from those living outwards with regard to mortality (Batten 1974 after Andrzejewski et al. 1978, Luniak et al. 1990) and fertility (Bożko 1971 after Andrzejewski et al. 1978, Luniak et al. 1990). Scientific works concerning ecology of amphibians inhabiting urban areas are scarce.

Urban areas in comparison to their surroundings are characterized by lower humidity and higher air temperatures, higher precipitation sums and lower wind speed (Stopa-Boryczka et al. 1990). Głowacka et al. (1990) pointed out that built-up areas diversify spatial conditions of the environment, affecting mainly shading and airing.

During breeding season amphibians are associated with aquatic environment. Factors important for selecting the pond include its surface area, depth, presence of anthropogenic pollutants, aquatic vegetation, seasonal drying up, presence of shallow waters, their depths and shading, water chemistry, as well as occurrence of competitive amphibian species (Strijbosch 1979, Aston et al. 1987, Juszczyk 1987, Loman 1988, Beattie and Tyler-Jones 1992). Terrestrial environment where majority of Polish amphibians remain after breeding plays also a significant role.

One of phenomena typical for city development is liquidation of water pools lying in the areas designed for intensive building-up, and partly also degradation of the remaining pools in the areas of town green. Destruction of a breeding pond is of different importance for different amphibians species. Majority of Polish amphibians are tied to the pond where their larval growth occurs. However, Reading and co-authors (1991) have revealed that 4–21% of individuals of common toad (*Bufo bufo*), regarded as a species strongly associated with the natal pond, do not return to the place of birth and find other ponds. It may thus be suggested that if a breeding site is destroyed, some individuals will ensure reproductive success for their population by breeding in another pond. On the other hand, toads: natterjack (*Bufo calamita*) and green toad (*Bufo viridis viridis*) are regarded as species not associated with the natal pond (Juszczyk 1987). Hence, it may be suggested that the pond destruction would be of lower importance for those species. It has been found that common toad may cover a distance up to 3 km on its way to the pond (Sinsch 1987), and edible frog (*Rana esculenta*) – up to 2.5 km in a straight line (Juszczyk and Michałowski 1959). Presumably, the distances determine the radius of the adjacent land area penetrated by these species.

Warsaw amphibians have not been investigated since 1921 (Sumiński and Tenenbaum 1921). At that time in Warsaw and its surroundings all

lowland species of Polish amphibians occurred: smooth newt (*Triturus vulgaris vulgaris*), warty newt (*Triturus cristatus*), common toad (*Bufo bufo bufo*), green toad (*Bufo viridis viridis*), natterjack (*Bufo calamita*), common spadefoot (*Pelobates fuscus fuscus*), fire-bellied toad (*Bombina bombina*), common tree frog (*Hyla arborea arborea*), common frog (*Rana temporaria temporaria*), moor frog (*Rana arvalis arvalis*), edible frog (*Rana esculenta*). In those days green frogs were believed to be one species. Therefore, we do not know whether the name comprises pool frog (*Rana lessonae*), marsh frog (*Rana ridibunda*), a hybrid of those species – edible frog (*Rana esculenta*), or eventually all those taxa.

The objective of this work was to evaluate the influence of the Warsaw agglomeration on individual populations of amphibian species and to recognize their preferences due to breeding sites. In this purpose:

– Number of amphibian species were compared between ponds located in the parts of the town being under the heaviest urbanization pressure and beyond that area. The area of the heaviest urbanization pressure was assumed to be the central part of the city densely built-up, with dense transport system, the highest traffic intensity and intensively penetrated by people. This area overlaps to some extent the boundaries of the oldest quarter of the city (Śródmieście), so that it has been affected by urban pressure for relatively longest time.

– Amphibian numbers were estimated in the water ponds and sex ratios for selected species were determined during a breeding season.

– Preferences of amphibian species for breeding sites were assessed with regard to such properties of the pond like: its surface area, periodical drainage, concrete bed of the pond.

3. STUDY SITES AND METHODS

Warsaw is large urban agglomeration and has ca. 1.6 mln of inhabitants. It comprises an area of 495 km^2. The studies were carried out on the left-bank part of Warsaw that constitutes approximately one half of the town area. Of the right-bank part, only one complex of park green was surveyed. Seventy six randomly chosen water bodies were taken under study (Fig. 1). The examined pools were highly differentiated with regard to the surface area: the largest one had ca. 16 ha, whereas the smallest one – from ten to twenty square meters. The pools included mostly clay-pits, and occasionally – old river beds or temporary water pools. Majority of the sites were shallow water bodies of small surface area qualified as ponds. Additionally, lakes (i.e. deep pools of an area over 2 ha with zonal aquatic vegetation), 5 canals and 2 temporary puddles were censused. Some pools form groups consisting of two to ten ponds. Sixteen such groups were taken under study.

The examined sites differ due to the vegetation types. The most frequent rush species was common reed (*Phragmites communis*) having very wide ecological range (M a t u s z k i e w i c z 1984). Other species frequently occurring were reed-

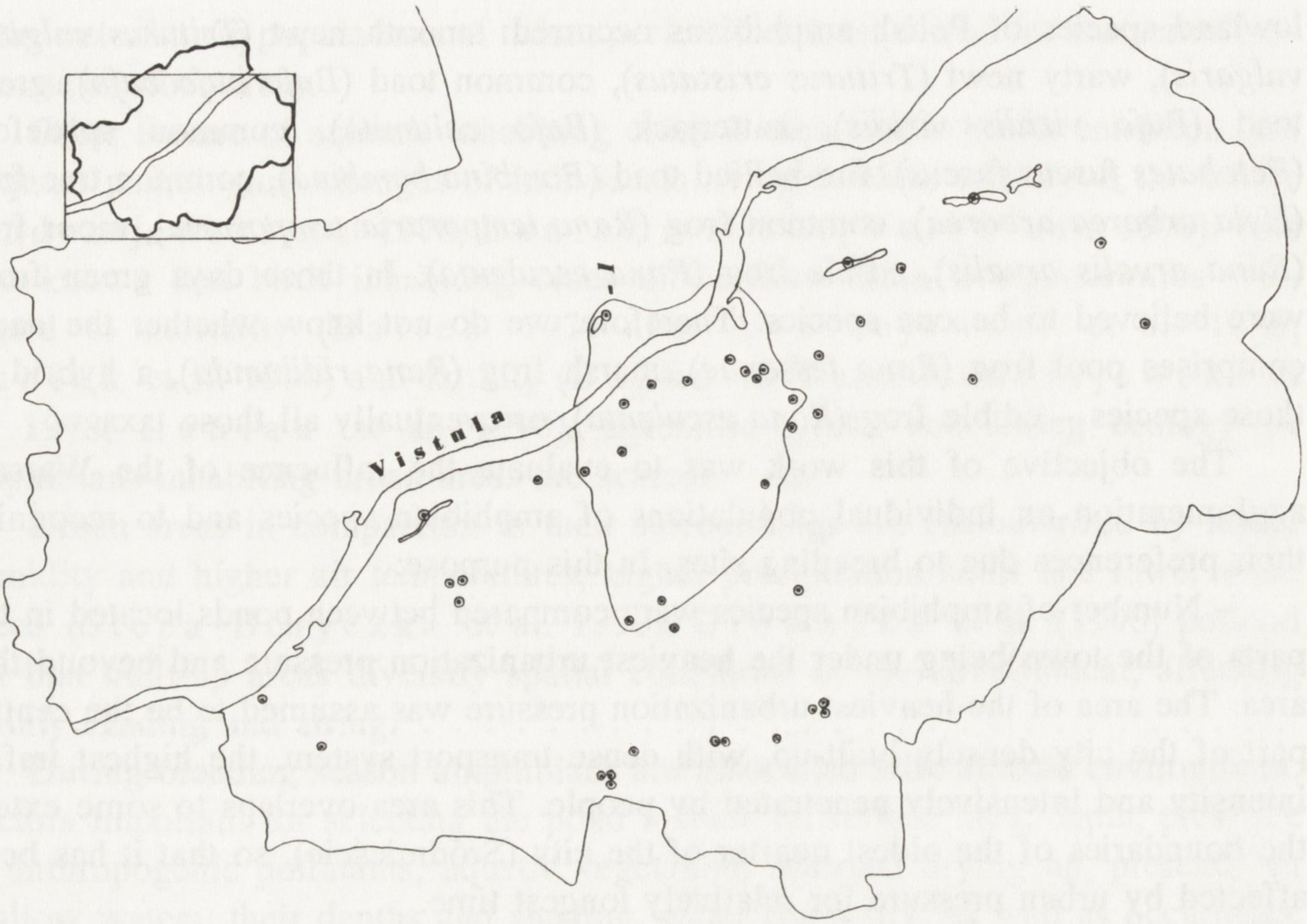

Fig. 1 Scetch of Warsaw agglomeration with marked locations of the ponds and boundaries of the central area
– location of a pond or group of adjoining ponds; **1** – boundaries of the central area scale 1 : 100 000

mace (*Typha latifolia*, found in 14.3% of all the ponds and *Typha angustifolia*, 10.4%), water-manna grass (*Glyceria aquatica*, 13%), and sporadically – sedges (*Carex sp.*). Approximately 40% of the examined pools were free from rush vegetation. Plant species with floating leaves were represented by yellow water-lily (*Nuphar lutea*), common white water-lily (*Nymphaea alba*) and pondweed (*Potamogeton sp.*). Relatively frequent were plant species submerged in water: water-thyme (*Elodea canadensis*), the stoneworts (*Charophyceae*), filamentous algae, and in suburbs – water-soldier (*Stratiotes aloides*).

The rush-free pools, with stabilized banks (e.g. stacked or concrete), had been of a natural character but modified by human activity afterwards. Out of 12 completely concrete pools, 8 is periodically water-free (mainly in spring) which makes plant growth (except algae) and fish occurrence impossible. At least in 46 pools (60% of all the sites) occur fishes, among other: pike (*Esox lucius*), perch (*Perca fluviatillis*), stickleback (*Gasterosteus aculeatus*), carp (*Cyprinus carpio*), crucian carp (*Carassius carassius*), rudd (*Scardinius erytrophalmus*) (author's own observations). In 46 pools (60% of all the sites examined) fen-duck (*Anas platyrhynchos*) was observed. Out of all the 76 pools, 31 were free from rush, 12 had concrete beds, and 8 were emptied in spring.

Observations were made during three spring-summer seasons, in 1992–1994. Each year the study started prior to pond thawing (March), and ended when breeding of all the amphibian species was over (June/July). Observations were made by moving along the shoreline of a pond and recording and counting up all living and dead amphibians found, their spawn and larvae. Number of calling males was also noted. Except edible and pool frog and newts (the latter ones not giving off any mating calls), all the remaining species were recognized by voice.

Observation time of a pool took from 15 minutes to 3 hours – depending on the area of the pool, water transparency and abundance of hiding places (rush, bushes with branches hanging down to the water, tufts of grass rooting in the pond), where amphibians could possibly hide themselves. Usually, observations were made in sunny and windless days. In case of shallower ponds, not only shore but also near-shore zone was penetrated and, in case of small ponds and puddles – their entire areas. Each pond was censused min. 5 and max. 13 times. In case of several pools with very long shorelines, selected parts of the shore were surveyed. Species or genus composition (if problems with species determination occurred) of floating and rush plants was recorded. Moreover, changes in water level, seasonal drying up, emptying and filling dates of some pools were noted.

With regard to the difficulties with species determination (B e r g e r 1957), "green" frogs (i.e. edible, marsh and pool frog) were regarded as one taxon.

A central area of ca. 30 km^2 was delimited. When assessing an influence of a pond location on amphibian diversity, a point lying in the middle of the central area was fixed (for statistical purposes) – the distance had to be expressed by a number. Significance of the influence of a pool or their group location (35 in total) in relation to "the centre" on number of breeding amphibian species was measured by Student t-test (for one-factor correlation coefficient). There were 21 water pools within the boundaries of the central area (Fig. 1).

In order to find a relationship between the distance from the central area and the number of amphibian species, taxa occurring in adjacent pools were summed up (a group of ponds was treated as one site).

The pools were grouped into three size classes: 1st class – smaller than 1 ha, 2nd class – from 1 to 2 ha, 3rd class – larger than 2 ha. The first class included 57 pools, 2nd class – 13, and 3rd class – 6 pools. In order to assess the specimen numbers of the amphibian species occurring in the given pool, the highest number of individuals found was considered (S t r i j b o s c h 1979). On that basis, three classes were distinguished: 1st class – from one to twenty individuals, 2nd class – several dozens of individuals, 3rd class – over one hundred individuals. Sex ratios were determined during breeding peak, when toads and frogs were in amplexus and least shy.

4. RESULTS

4.1. OCCURRENCE, DISTRIBUTION, NUMBER OF INDIVIDUALS AND SEX RATIOS OF AMPHIBIAN SPECIES

Amphibian occurrence was evidenced in 72 localities, i.e. 95% of all the examined pools. Usually, between 1 and 3 species were recorded per one pond (80% of ponds). Maximally 6 amphibian species were reported (3 such localities were found). The highest number of amphibian species in a group of ponds was 7. A relationship between a pool location in relation to the central area and number of breeding species was found. In the ponds lying in the central area, the species number was significantly lower than in the suburban localities (correlation coefficient $R = 0.538$; $t = 3.666$; $p < 0.05$; $n = 35$).

The most common were "green" frogs (56% of all the examined pools). The most rare species was warty newt (1 pond). Fire-bellied toad (*Bombina bombina*) and common spadefoot (*Pelobates fuscus*) were reported in few localities (Table 1). Green and common toad have never been found to breed in the same water pond.

Table 1. Frequency (%) of amphibian species occurring in 76 examined water ponds

Amphibian species	Frequency (%)
Green frogs*	56
Triturus vulgaris	31
Bufo viridis	30
Bufo bufo	30
Pana arvalis	27
Rana temporaria	18
Bombina bombina	9
Pelobates fuscus	6
Triturus cristatus	1

**Rana esculenta, Rana lessonae, Rana ridibunda*

Sex ratios for selected amphibian species ranged from 1 : 1 to 7 : 1 (Table 2).

Table 2. Sex ratios of selected amphibian species during the peak of breeding season species

Species	Number of ponds chosen for sex ratio determination	Male number	Female number	Sex ratio
Bufo bufo	8	133	19	7 : 1
Bufo viridis	5	61	21	3 : 1
Rana temporaria	2	64	61	~ 1 : 1
Triturus vulgaris	11	75	77	~ 1 : 1

4.2. OCCURRENCE OF AMPHIBIAN SPECIES WITH REGARD TO SOME PROPERTIES OF THE PONDS

Ponds free from hiding places comprised 74% of all the localities of green toad and 54% of those of smooth newt. Fire-bellied toad did not occur in such ponds (Table 3).

Table 3. Occurrence of amphibians in the ponds under different site conditions and locations in relation to the central area

Species	Number of localities	Site conditions			Location:***	
		Ponds free from hiding places**	Ponds with concrete beds	Ponds emptied in spring	out of the central area	in the central area
Rana temporaria	14	3	0	0	14	0
Rana arvalis	21	2	0	0	21	0
Green frogs*	43	6	0	0	38	5
Pelobates fuscus	5	1	0	0	5	0
Bombina bombina	7	0	0	0	7	0
Bufo bufo	23	6	0	0	20	3
Bufo viridis	23	17	9	7	12	11
Triturus vulgaris	24	13	5	4	5	9
Triturus cristatus	1	0	0	0	1	0

*See Table 1; **ponds free from hiding places (rush, bushes with branches hanging down to the water and tufts of grass rooting in the pond); ***See Fig. 1.

Table 4. Occurrence of amphibians during the breeding season: with regard to the surface area of the ponds and number of individuals

Species	Total number of localities	Surface area of the ponds			Number of individuals in the ponds		
		< 1 ha	1–2 ha	> 2 ha	1–20	20–100	> 100
Rana temporaria	14	8	3	3	8	3	3
Rana arvalis	21	19	0	2	12	8	1
Green frogs*	43	33	5	5	28	13	2
Pelobates fuscus	5	5	0	0	n.d.	n.d.	n.d.
Bombina bombina	7	7	0	0	2	4	2
Bufo bufo	23	14	5	4	8	11	4
Bufo viridis	23	19	4	0	15	8	0
Triturus vulgaris	24	23	1	0	23	0	1
Triturus cristatus	1	1	0	0	1	0	0

*See Table 1; n.d. – no data.

In pools with concrete beds and drained in spring, only smooth newt and green toad occurred, being at the same time the most abundant species in the central area where such pools are common. Those species were accompanied by common toad and "green" frogs, but only in two largest green areas in the central part of Warsaw (Table 3).

With the same number of localities, common toad occurred rarely in small ponds (1st class) visiting mainly large pools (3rd class), whereas green toad was not recorded in any pond larger than 2 ha (Table 3).

Common spadefoot and fire-bellied toad were recorded only in those ponds included in 1st size class whereas smooth newt and moor frog were reported mainly in the 1st class ponds (96% and 90% of those ponds, respectively).

At least six amphibian species were found to occur in masses in some ponds (breeding groups consisting of over hundred of individuals) – (Table 4). No one was such pond located in the central area.

5. DISCUSSION

It has been confirmed (Vershinin 1990) that usually one to three amphibian species occur in pools of big cities. In contrast to the results obtained by Vershinin in Swierdłowsk – the 1.5 mln city of Ural, amphibians of Warsaw occupy ponds located even in the central area of the town. This may result from geographical differences and, hence, different species inhabiting the cities. Unfortunately, the author did not give a complete list of amphibian species occurring in Swierdłowsk region.

In Poznań, fifth biggest city of Poland (ca. 260 ha of an area, ca. 590 thousand of inhabitants), amphibians also occurred in the central part of the town (Pawłowski 1993). There were the same species found in Warsaw as in Poznań. Natterjack and common tree frog were not reported in any of the two cities. However, Pawłowski (personal communication) found one locality of natterjack after finishing his study.

Warty newt, fire-bellied toad and common spadefoot are relatively rare species, also in the country-side (Juszczyk 1987). One should therefore be careful when interpreting few localities in Warsaw as resulting from the lack of adaptations of these species to urbanized biotopes. However, such a statement may be supported by the fact that neither species occurred in the ponds modified by man (without rush, with concrete shores or/and beds, drained in spring) and lying in the central area of the town.

Already Sumiński and Tenenbaum (1921) regretted warty newt disappearing which had commonly occurred years before that date. The fact of being attractive aquarium animal could contribute to the species extinction. It is also likely that the amphibian is susceptible to environmental changes. At present, it is threatened by extinction in Sweden (Hagstrom et al. 1988). As a reason, the authors point out on water acidification and farm modernization.

Sumiński and Tenenbaum (1921) reported common spadefoot in solely two localities in Warsaw. Pawłowski (1993) evidenced this species as occurring in the central part of Poznań.

Fire-bellied toad, in turn, is one of the most threatened amphibian species in Western and Northern Europe (Andren and Nilson 1988, Andren et al. 1988, Briggs et al. 1988, Andren et al. 1984 after Briggs et al. 1988). The reason of the species extinction is eutrophication, land drainage, road and factory

building (Andren et al. 1988, Briggs et al. 1988). In the Poznań agglomeration, fire-bellied toad is not very common but numerous in places (Pawłowski 1993). It has been confirmed (Juszczyk 1987) that both species fire-bellied toad and common spadefoot prefer small ponds. In the study area they were found to prefer ponds smaller than 1 ha.

The results obtained in Warsaw confirm opinions that "brown" frogs do not occur in central parts of cities (Vershinin 1990, Pawłowski 1993). Slightly higher number of localities of moor frog than common frog found in Warsaw may result from better tolerance for low air humidity characteristic of cities (Krasawcew 1939 after Juszczyk 1987). According to Kubicka (1976), moor frog selects drier sites than do common frog.

Common occurrence of green toad and common toad in the Warsaw agglomeration may also be explained by their exceptionally great resistance to drying out (Juszczyk 1987). Green toad tolerates water loss reaching 50% of its body weight, whereas common frog, for instance, dies at 15% water loss (Denisowa 1969 after Juszczyk 1987). It is very possible that green toad has extended its range in the course of Warsaw development and spread over the central part of the town meeting suitable growth conditions. According to Sumiński and Tenenbaum, in 1921 it was rather rare species at that area. Juszczyk (1987) claims that it is the species most strongly tied to built-up areas. Beside green toad, smooth newt is another species closely associated with central parts of cities (Pawłowski 1993). However, Vershinin (1990) recorded smooth newt only in localities lying beyond the central area of Swierdłowsk.

Another reason which may cause green toad to inhabit the central area is the lack of other amphibian species there (except smooth newt). This limits interspecific competition and predation (Banks and Beebee 1987, Griffiths et al. 1991, Griffithsand Denton 1992). Additionally, majority of the ponds in the central area are periodically drained and hence free from crucian carp and other fishes and predatory invertebrates feeding on spawn and tadpoles of the species considered (Amtkjaer 1988, Henrikson 1990).

Occurrence of green toad in the ponds drained in spring (after their refilling with water) may be explained by the fact that the species is thermofilous and breeds relatively late (Juszczyk 1987). Reproduction occurs even when the pond is filled in May. The results obtained indicate a clear difference in preferences for the area of breeding ponds between common and green toads. Common toad occurred less frequently in the ponds smaller than 1 ha but it was usually recorded in large pools (over 2 ha). Green toad avoids ponds larger than 2 ha. The results concerning occurrence of common toad in the pools larger than occupied by green toad are confirmed by Juszczyk' observations (1987).

Many scientists have noticed common toad to be the most frequent and numerous species of urban areas (Chruściel 1968 after Pawłowski 1993,

Kral et al. 1983, Sehnal and Tiedemann 1990 after Pawłowski 1993, Pawłowski 1993). Observations made in Warsaw have not confirm predominance of that species with regard to the numbers of localities although it has been found to occur in masses in the greatest number of ponds (four). This may result among other from the fact that in the examined area small ponds where the species rarely breed (Juszczyk 1987), are most numerous. Furthermore, common frog clearly avoids heavily urbanized biotops. Pawłowski (1993) has not recorded that species in the central part of Poznań, and in the central area of Warsaw it has been found only in the ponds surrounded by town green areas.

Sex ratio found for common toad (7 : 1) differs from that given by Juszczyk (1987) – 1.5 : 1. The author mentioned that Kowalski (1969) had obtained 10 : 1 ratio for that species. Davies and Halliday (after Verrell and Mc Cabe 1986) give the value of sex ratio closer to that obtained in this work, namely 5 : 1.

Sex ratio acquired for green toad (3 : 1) differs considerably from that noticed by Juszczyk (1987) – 1.3 : 1. On Utklippan island Stromberg and Schlyter (1988) found sex ratio reaching 1 : 7.

Sex ratios obtained for smooth newt and common frog are almost identical with those found by Juszczyk (1987).

Smooth newt is considered an early-spring species (Juszczyk 1987). Nevertheless, similarly to green toad it breeds in the area of Warsaw also in ponds periodically drained in spring. The results obtained in this work indicate that in spite of some author opinions that batrachofauna of surroundings of Polish big cities has been almost completely exterminated (Młynarski 1981), some amphibian species successfully persist in heavily urbanised biotops.

6. SUMMARY

In 1992-1994, batrachofauna of 76 water bodies of Warsaw agglomeration were investigated (Fig. 1). The objective of the studies was to assess ecological requirements of individual amphibian species with regard to the following properties: location of a pool in relation to the central part of the town, surface area of the pool, shore type (rush, concrete etc.), bed type (concrete, natural), periodical drainage of the pool. In this purpose, water ponds were censused (at least 5 surveys per one pond) during the breeding season. Observations were made along the shorelines, usually on sunny and windless days. Living and dead amphibians found were counted up. Mating calls, spawn and larvae of particular species were recognized and recorded. Sex ratios were determined for selected amphibian species. Specimen numbers of particular species in the given pond were grouped into three classes: from one to ten–twenty, several dozens and over one hundred of individuals. The central area covering ca. 30 km^2 was delimited (Fig. 1).

Nine following species of amphibians were evidenced in the study area (considering "green" frogs as one taxa): common frog, moor frog, green frogs, common toad, green toad, fire–bellied toad, common spadefoot, smooth newt and warty newt. Neither common tree frog nor natterjack were found in the examined ponds. Amphibians occurred in 95% of the surveyed pools, also those located in the central area.

The number of amphibian species was found to be dependent upon the location of a pond (or their groups) in relation to the central area and was lower in the central localities (1–3 species) than in suburban ones (up to 7 species).

Green toad and smooth newt are the most common amphibian species occurring in the central part of Warsaw (Table 3). They bred mainly in rather small, rush-free ponds, with concrete beds, periodically drained in spring (Table 3). In such ponds, green toad was more frequent than smooth newt.

The rarest species recorded in Warsaw was warty newt found in one locality (Table 1). Occurrence of common spadefoot and fire-bellied toad were documented in few ponds of suburbs. All the three taxa found in the study area occurred in small, shallow natural ponds with abundant rush plants (Table 3).

In few ponds concentrations of breeding amphibians were found consisting of one hundred individuals or more (Table 4). No such localities were evidenced for the town "centre". Sex ratios of selected species ranged from 1 : 1 to 7 : 1 (Table 2).

Green toad and common toad did not breed in the same ponds.

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7. POLISH SUMMARY

W latach 1992–1994 przeprowadzono badania batrachofauny 76 zbiorników wodnych położonych na terenie Warszawy (rys. 1). Miały one na celu określenie wymagań ekologicznych poszczególnych gatunków płazów odnośnie takich cech zbiorników rozrodczych jak: położenie zbiornika w stosunku do obszaru centralnego miasta, powierzchnia zbiornika, rodzaj brzegu (szuwary, beton itp.), rodzaj dna (betonowe, naturalne), okresowe osuszanie zbiornika.

W tym celu w okresie rozrodu płazów przeprowadzono kontrole zbiorników wodnych (co najmniej pięć na jeden zbiornik). Przejścia wokół linii brzegowej zbiornika odbywały się głównie w słoneczne, bezwietrzne dni. Liczono napotkane żywe i martwe płazy.

Rozpoznawano i notowano głosy godowe, skrzek i larwy poszczególnych gatunków. Dla wybranych gatunków płazów określono proporcje płci. Liczebność poszczególnych gatunków w danym zbiorniku pogrupowano w trzy klasy: od jednego do kilkunastu, kilkadziesiąt i ponad sto osobników. Wyznaczono obszar centralny miasta o powierzchni ok. 30 km^2 (rys. 1). Na terenie badań stwierdzono występowanie dziewięciu taksonów płazów (traktując "żaby zielone" łącznie): żabę trawną, żabę moczarową, żaby zielone, ropuchę szarą, ropuchę zieloną, kumaka nizinnego, grzebiuszkę ziemną, traszkę zwyczajną, traszkę grzebieniastą. W badanych zbiornikach nie stwierdzono: rzekotki drzewnej i ropuchy paskowki. Płazy wystepowały w 95% badanych zbiorników, w tym także położonych w obszarze centralnym.

Liczba gatunków płazów była istotnie statystycznie zależna od położenia zbiorników (lub ich grup) względem obszaru centralnego i była mniejsza w zbiornikach leżących w obszarze centralnym (1–3 gatunków), niż w zbiornikach leżących na peryferiach miasta (do 7 gatunków).

Ropucha zielona i traszka zwyczajna to gatunki płazów najpowszechniej występujące w obszarze centralnym Warszawy (tab. 3). Odbywały one gody głównie w niewielkich zbiornikach pozbawionych szuwaru, o zabetonowanym dnie,. okresowo spuszczanych na wiosnę (tab. 3). Ropucha zielona występowała w takich zbiornikach powszechniej niż traszka zwyczajna.

Najrzadszym gatunkiem stwierdzonym w Warszawie była traszka grzebieniasta – znaleziono jedno stanowisko tego gatunku (tab. 1). Grzebiuszkę ziemną i kumaka nizinnego stwierdzono zaledwie w kilku zbiornikach, położonych na terenach peryferyjnych miasta.

Wszystkie te trzy taksony na terenie badań występowały w małych, płytkich, naturalnych zbiornikach o obfitej roślinności szuwarowej (tab. 3).

W kilku zaledwie zbiornikach stwierdzono skupienia godowe płazów liczące sto i więcej osobników (tab. 4). Stanowisk takich nie znaleziono w "centrum" miasta. Proporcje płci dla wybranych gatunków wyniosły od 1 : 1 do 7 : 1 (tab. 2).

Ropucha zielona i ropucha szara nie rozmnażały się na terenie badań w tym samych zbiornikach wodnych.

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