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Cover photo: Yellow-bellied toad *Bombina variegata,* see p. 27,
photo: Milan Vogrin

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Vsebina/Contents

Članki/Articles

Distribution of the Pool frog *Pelophylax (Rana) Lessonae*, in North-Western Romania

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Abstract

We identified the pool frog in 29 localities in the north-western part of Romania. This is the first time in Romania that a continuous segment of the species' area has been identified (in Bihor and Satu-Mare Counties). Besides the northern populations, a small enclave exists in Arad County. *Pelophylax lessonae* is distributed in the wetlands on the plain, preferring areas with forested swamps.

Key words: *Pelophylax lessonae*, distribution, north-western Romania

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INTRODUCTION

Pelophylax lessonae is a European species encountered in Romania at the South – Western limit of its range (Günther 1997). The distribution of the species in our country is far from well known; in the most recent monograph on these amphibians (Cogălniceanu et al. 2000) it was cited in only 11 localities. *Pelophylax lessonae* has just recently been accepted as a valid species (Berger 1973); at the time of editing of the Fauna R. P. R. on amphibians, it did not even have a taxonomical statute (Fuhn 1960). Identifications of the species are missing from old Romanian studies, and a similar situation exists in other countries (Zavadil 1994). The first documentation of the species in our country occurred in 1975 (Fuhn 1975), and it was later identified in other locations (Tesio & Marinescu 1982, Vancea et al. 1989). In Romania, the records indicate only isolated specimens, not populations, until 1993. The first population, and until now the only one in the country, was reported in Reci (Cogalniceanu & Tesio 1993). The species was not found anywhere in Western Romania until 2002. Since then, the pool frog has been found in several localities in parts of the country (Ghira et al. 2002, Covaciu-Marcov et al. 2004, 2006). The aim of our study was to establish the distribution of the pool frog in North-Western Romania, to identify the biotopes that it inhabits, and to ascertain the species' status in this region.

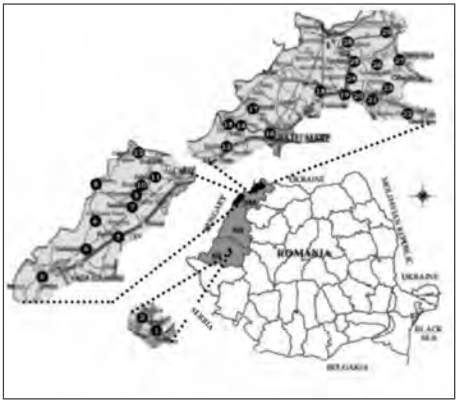
MATERIAL AND METHODS

The study took place between 2000 and 2006. We surveyed the north-western part of Romania, a territory consisting of three counties (Table 1, Figure 1). The investigations used the "transects" and

Table 1. Locality records for *Pelophylax lessonae* in North-Western Romania (AR – Arad county, BH – Bihor county, SM – Satu-Mare county).

Locality number	Locality name	County	Coordinates	UTM 10x10 km
LOC 1	Igneşti	AR	46°24′0″ N, 22°10′0″ E	ES 84
LOC 2	Prunişor	AR	46°25′0″ N, 22°7′0″ E	ES 84
LOC 3	Şimian	BH	47°29′0″ N, 22°6′0″ E	ET 85 / 86
LOC 4	Curtuiuşeni	BH	47°33′0″ N, 22°12′0″ E	ET 86 / 96
LOC 5	Pişcolţ	SM	47°35′0″ N, 22°18′0″ E	ET 96 / 97
LOC 6	Scărişoara Nouă	SM	47°37′0″ N, 22°14′0″ E	ET 97
LOC 7	Sanislău	SM	47°38′0″ N, 22°20′0″ E	ET 97 / FT 07
LOC 8	Horea	SM	47°41′0″ N, 22°14′0″ E	ET 98
LOC 9	Ciumeşti	SM	47°39′0″ N, 22°20′0″ E	FT 07
LOC 10	Berea	SM	47°41′0″ N, 22°21′0″ E	FT 08
LOC 11	Foieni	SM	47°42′0″ N, 22°23′0″ E	FT 08
LOC 12	Urziceni de Pădure	SM	47°44′0″ N, 22°24′0″ E	FT 08
LOC 13	Decebal	SM	47°48′0″ N, 22°46′0″ E	FT 39
LOC 14	Vetiş	SM	47°48′0″ N, 22°46′0″ E	FT 39
LOC 15	Dara	SM	47°49′0″ N, 22°45′0″ E	FT 39
LOC 16	Satu-Mare	SM	47°45′0″ N, 23°0′0″ E	FT 39 / 49
LOC 17	Dorolţ	SM	47°51′0″ N, 22°49′0″ E	FU 30
LOC 18	Ciuperceni	SM	47°51′0″ N, 23°4′0″ E	FU 50
LOC 19	Agrij	SM	47°4′0″ N, 23°8′0″ E	FU 50
LOC 20	Livada Mică	SM	47°52′0″ N, 23°7′0″ E	FU 50
LOC 21	Livada	SM	47°52′0″ N, 23°8′0″ E	FU 50 / 60
LOC 22	Medieş-Vii	SM	47°47′0″ N, 23°8′0″ E	FT 69
LOC 23	Păşunea Mare	SM	47°54′0″ N, 23°18′0″ E	FU 60
LOC 24	Drăguşeni	SM	47°55′0″ N, 23°5′0″ E	FU 50
LOC 25	Turulung	SM	47°56′0″ N, 23°5′0″ E	FU 51
LOC 26	Turulung Vii	SM	47°56′0″ N, 23°5′0″ E	FU 61
LOC 27	Gherţa Mică	SM	47°56′0″ N, 23°14′0″ E	FU 61
LOC 28	Băbăşeşti	SM	47°58′0″ N, 23°5′0″ E	FU 51
LOC 29	Turţ	SM	47°59′0″ N, 23°13′0″ E	FU 61

Figure 1. The investigated region in Romania and the position of the recorded *Pelophylax lessonae* populations in north-western Romania (for the name of localities see table 1).



direct observation methods (Brown 1997, Cogălniceanu 1997). Frogs were captured by hand or with different kinds of nets, photographed and then set free in their original habitat. Identifying the species in the *Pelophylax esculentus* complex is rather difficult; many times identification can lead to errors unless multiple characteristics are examined (e.g. Gubányi 1988, Joly et al. 1995). The samples were categorized according to their morphological, chromatic and biometrical attributes (in preparation, Sas et al.), using the methods and data indicated in the literature (Berger 1966, 1973, Wijnands & van Galder 1976, Ebendal & Uzzel 1982, Cogălniceanu & Tesio 1993, Csata 1998, and Cogălniceanu et al. 2000). In all, we inventoried 805 localities in North-Western Romania, and counted over 15,000 green frogs.

RESULTS AND DISCUSSION

Most of the green frogs found belonged to the *Pelophylax ridibundus* species, a smaller number to the *Pelophylax* kl. *esculentus* hybrid, and the smallest number to *Pelophylax lessonae*. In the north-western part of Romania we managed to identify the pool frog in 29 localities. Most of these are situated in the northern part of the region, in Satu-Mare County. These locations are quite close to one another, so that the frog populations come into contact. This is the first time in Romania that a continuous segment of the species' range has been identified, all of the previous points being dispersed, without any link between them (Cogălniceanu et al. 2000). Another first for our country is the fact that this segment of the area comes in contact with the species' range from Ukraine (Günther 1997), and Hungary (Puky et al. 2005) and implicitly with its entire European range.

Figure 2. *Pelophylax lessonae* male from Igneşti (LOC 1 – see table 1).

However, in the investigated region, *Pelophylax lessonae* presents a disjunctive range; besides the northern population, a small enclave exists in Arad County, near Ignesti (Covaciu-Marcov et al. 2006).

In North–West Romania, *Pelophylax lessonae* (Figure 2) inhabits lowlands exclusively, although in other parts of its range it can be found at high altitudes (Günther 1997). We encountered the pool frog no higher than 200 m. In the north of the region it is present in the plains sectors of the Somes, Crasna and Ier hydrographic basins, while in the south, in a micro depression situated along the upper course of the Teuz River.

Pelophylax lessonae can be found in habitats with a high level of humidity (Figure

Figure 3. Habitat of *Pelophylax lessonae* near Igneşti (LOC 1 – see table 1).

3). It inhabits biotopes similar to those inhabited by *Rana arvalis*, alongside which it is encountered in numerous locations. The most favorable habitats for the pool frog, judging by the number of specimens found, are the forest marshes and other forested wetlands (Rybacki & Berger 1994). In the absence of these biotopes, it can also inhabit clear wetlands, and generally vast areas of swamps. In areas with significant human interference, a few samples are present in the drains and ditches alongside roads or between agricultural fields. Both swamps and drains provide very rich grassy vegetation, including reeds and bulrushes, and some individual aquatic vegetation. In the southern part of the Ignesti area, the frogs can be found in large, swampy wetlands situated near forests.

The three forms of the green frog complex appear in different combinations, with more than one system being described (Tunner & Heppich-Tunner 1991). In the north-western part of Romania, *Pelophylax lessonae* can be found close to *Pelophylax ridibundus* and *Pelophylax* kl. *esculentus*, completing the R-E-L system (Covaciu-Marcov 2004). In the studied region though, *Pelophylax ridibundus* is usually found alone, or in some few cases together with *Pelophylax* kl. *esculentus*. In North-West Romania, *Pelophylax lessonae* is the least represented species of the water frog complex, both from the number of localities in which it has been documented and from the number of observer samples (Covaciu-Marcov 2004). Generally speaking, the populations of this species are small in number (Günther 1997). When the three forms of the complex congregate, *Pelophylax* kl. *esculentus* is usually best represented, while *Pelophylax ridibundus* and *Pelophylax lessonae* are present in smaller numbers. The only exceptions to this case are the humid forests of the northern part of Satu-Mare County, at Livada, where *Pelophylax lessonae* and *Pelophylax* kl. *esculentus* are represented by an almost equal number of individuals, while *Pelophylax ridibundus* is much rarer (5%) (from a mean of 110 frogs/day). Up to 50 individuals of *Pelophylax lessonae* could be counted each day here.

Pelophylax lessonae has a disjunctive range in the studied area. The absence of the species in the central part of the region is probably caused by the Western Hills and their proximity to Oradea. In this sector, the hills stretch to about 15 km from the Romanian – Hungarian border. The plains areas here are strongly affected by human activities; the swamps have been drained, greatly reducing possible habitats. The climate of the northern sectors and of the micro depression in Ignesti is slightly colder and more humid than that of the rest of the region (Stoenescu et al. l966), permitting the existence of the wet habitats necessary for this species.

Pelophylax lessonae is rare in the north–western part of Romania. Most populations are located in areas less affected by human activities. As a consequence, the species is not immediately threatened, but it is vulnerable because of the small number of identified samples. However, we have observed that the pool frog can survive in strongly degraded areas.

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Acariphagy in amphibian and reptile diet studies: what are the probabilities?

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Abstract

Mites (Arachnida: Acari) are regularly reported as prey-items in amphibian diet studies and occasionally in reptilian studies, with the identification of mites rarely being taken to below Subclass (Acari) level. Furthermore, many studies draw inferences solely from the presence of mites in gastrointestinal tracts and ignore other considerations such as the accumulation of hard-bodied prey, the digestibility of chitin, and bowel elimination in the predator. Size, movement, cryptic colouration and prey order are other factors that are often ignored when considering mites as prey. Often inferences are made regarding aspects such as seasonal and ontogenetic diet shifts, as well as foraging modes of the predator, all without any consideration for the size and life history of the mite species. It is suggested that a more specific identification and examination of mite life histories might reveal that the majority of mites in dietary studies are not primary prey, but rather secondary prey items that have inadvertently been ingested by either the primary prey, or by the predator itself. It is therefore proposed that mites are not the intentional prey of amphibians, reptiles, or other vertebrates, and that a distinction should be drawn between the occurrence of mites in the digestive tract and the possibility of them being prey items. On the other hand, there is clear evidence that a variety of arthropods actually prey on oribatid mites. This discussion intends to create a greater awareness of interpreting acariphagy in amphibian and reptile diet studies, while emphasising the importance of examining alternative explanations to primary predation.

Key words: mites, acariphagy; dietary studies, amphibians; reptiles, predatory arthropods

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INTRODUCTION

Occurrences of mites (Arachnida: Subclass Acari) in the gastrointestinal tracts of amphibians and reptiles are common, although they are more frequently reported in amphibian dietary studies than in reptilian dietary studies. Of 27 anuran species examined by Simon & Toft (1991), and a further 99 species diets reviewed from the literature, 55% and 33% respectively contained mites. Norton & MacNamara (1976) recorded 1914 individual mites from 276 *Notopthalmus viridescens*, while Schoener (1968) and Schoener & Gorman (1968) recorded mites in the digestive tracts of six out of the seven *Anolis* spp. examined. In a microscopic examination of the gastrointestinal tracts of the snake *Psammophylax rhombeatus*, Douglas (1992a) recorded mites in 20% of specimens. Many papers contain speculative inferences relating acariphagy to predation, and this prompted a closer look at possible alternatives for the occurrence of mites in the gastrointestinal tracts of amphibians and reptiles.

The level of mite identification in amphibian and reptilian dietary studies is often inadequate for the inferences being made by the authors. Terms such as Arachnida and mite (Blackith & Speight 1974), Acari (=Acarina) (Campbell 1970) and Acarina (Durant & Dole 1974, Labanick 1976), provide no specific information on the mite species encountered. Use of the terms Acari and mite could be seen as justifiable if the authors were simply listing mites as occurring in the gastrointestinal tracts (Durant & Dole 1974; Houston 1973). When, on the other hand, it is stated that mites were consumed by, or formed part of the amphibians' or reptiles' diet (Norton & MacNamara 1976, Schoener & Gorman 1968, Simon & Toft 1991), then the use of these general terms seems inappropriate. A problem with many inferences is that they are often further expanded on, and once an aspect such as the presence of mites has been established, other assumptions such as predation, seasonal and ontogenetic diet shifts, as well as foraging modes of the predator, may follow. For example, Van Dijk (1997) speculated that mites in the gastrointestinal tracts of the frog *Xenopus l. laevis* may have originated through the frogs ingesting their own moulted skin. This presumption was based on the occurrence of ostracods in the gastrointestinal tract of *Xenopus l. laevis*, with no mites being present. Douglas (2000) pointed out that, for many of the reasons given in this paper, the ostracods could just as well have been ingested unintentionally. It is therefore proposed that a more specific identification of mites and an examination of aspects of their life histories would contribute significantly in avoiding incorrect assumptions and inferences being made, particularly if the mites were to be considered as part of the diet. This would assist in determining whether certain mites were actually likely to be prey items, or not. Such an assessment would also allow for more educated and discerning inferences to be made on aspects such as predation, acariphagy, and seasonal and ontogenetic diet shifts.

Following Evans (1992), the Subclass Acari (=Acarina) comprises two Superorders: Anactinotrichida, represented by four Orders: Notostigmata (=Opilioacarida), Holothyrida (=Holothyroidea; Tetrastigmata), Ixodida (=Metastigmata, Ixodoidea) and Mesostigmata (=Gamasida); and Actinotrichida, represented by three Orders: Prostigmata (=Actinedida + Tarsonemida), Astigmata (=Acaridida) and Oribatida (=Cryptostigmata; Oribatei). Approximately 30,000 species of Acari had been described by 1950 (Radford 1950), with the number of undescribed species possibly exceeding this total by up to twenty fold (Evans 1992). In the Order Oribatida, for example, some 6,000 species had been described by 1992 (Balogh & Balogh 1992) with this number increasing to 9,356 valid species in 2001 (Schatz 2002). The number of species, combined with their wide habitat diversities and life histories, gives some indication of the magnitude that the terms Acari and mite encompass.

Considering the life histories and diets of mites may assist in redefining some of our other terminology more clearly. For example, the Subclass Acari was described by Simon & Toft (1991) as being soil and leaf-litter mites, which could lead to the conclusion that all Acari are soil and leaf-litter mites. This, of course, is an incorrect assumption. Without proper definition, soil and leaf-litter refers to habitat, while Acari, although including soil and leaf-litter mites, ranges from ticks to water mites, to a host of parasitic mites, most of which would not be classed as soil and leaf-litter mites. The feeding habits of Acari can be grouped into four broad categories 1) Zoophagy - consuming parts of living animals (carnivory, predation and parasitism); 2) Phytophagy - feeding on living plant material including fungi and algae; 3) Omnivory - utilizing both plants and animals as food sources; 4) Saprophagy - ingesting decaying plant or animal matter (Evans 1992). Many soil and leaf-litter mites are free-living and may eat live or decaying plant material, or decaying animal material, or be predatory, but this group largely excludes parasitism. Most free-living mites belong to the Orders Oribatida and Mesostigmata, although free-living mites also occur to a lesser extent in other orders. Therefore, although many Acari are in fact soil and leaf-litter mites, not all are necessarily free-living mites, as are the majority of oribatid and mesostigmatid mites commonly found in amphibian and reptile diet studies.

Oribatid mites have a hard and often thick cuticle, which is either smooth or intensively structured, with the latter developing specialized integumental foldings, or tecta, which may act as a defence against predation (Schmidt 1988). Soil and leaf-litter mites contain a relatively high proportion of chitin based on their surface: volume ratio, and this would then reduce their "profitability" as prey (Simon & Toft 1991) in predators. Based on their low numbers in many gastrointestinal tracts, their indigestibility and small size would be particularly pertinent to hard-bodied oribatid and mesostigmatid mites, tending to make them unlikely primary prey items from both a nutritional and energetics point of view.

DISCUSSION

Digestibility of mites

Many factors and variables thereof may influence the presence, passage, and accumulation of mites in the gastrointestinal tracts of amphibians and reptiles. The digestibility of Acari chitin has largely been ignored in amphibian and reptilian dietary studies and may have a considerable influence on the numbers of mites found in gastrointestinal tracts. The hard sclerotized chitin of oribatid and mesostigmatid mites appears to be largely indigestible (Douglas 1992b). This is compounded by evidence of calcium carbonate and calcium oxalate acting as additional hardening agents (Norton & Behan-Pelletier, 1991). It has been shown by Douglas (1992b) that chitin can remain relatively undamaged even after passing through three digestive systems, namely, those of earthworms, which were eaten by shrews (*Suncus varilla*), which were eaten by the snake *P. rhombeatus*. Forty-three percent of shrews contained mites and these were found only in association with earthworms (Douglas 1992b). An analysis of Churchfield's (1984) diet of the shrew, *Suncus araneus*, showed a 53% correlation between the occurrence of mites and earthworms (Douglas 1992b). However, this in no way implies that the shrews or the earthworms were acariphagous. Cochran (1988) recorded oribatid mites in the pellets of *Notophthalmus viridescens louisianus*, indicating that the mites had passed through the digestive tract and were indigestible. Intact oribatid mite exoskeletons have also been recorded in the rectum of the salamander, *Batrachoseps attenuatus* (Maiorana 1978).

The suggestion that mites may be eaten as a source of calcium (Norton & MacNamara 1976) appears unlikely when considering that 99% of the *Notopthalmus viridescens* stomachs examined by Norton & MacNamara (1976) contained, on average, less than three mites per stomach. Although Gist & Crossley (1975) suggested that oribatid mites processed a considerable portion of the calcium pool in some ecosystems, Seastedt (1984) felt that they did not have much influence on calcium cycling, as their standing crop biomass was usually too low. This would tend to support the proposed theory that the quantity of calcium available for sequestration by larger predators, particularly in the small quantities consumed, would be very low, if not insignificant. Simon & Toft (1991) found that in 85% of cases, mites made up less than 1% of the diet of the frogs examined. Weakly sclerotized mites, on the other hand, may be more easily digested, but this would have little influence on the results of diet study compilations, as they would not be detectable due to digestion.

Occurrence and distribution of mites in digestive tracts

Reports of acariphagy in amphibians and reptiles are based primarily on the occurrence of mites in the stomach contents, and rarely on the intestinal contents. Large numbers of mites in gastrointestinal tracts are extremely rare (Norton & MacNamara 1976, Simon & Toft 1991), probably due to the lower gastrointestinal tract seldom being examined. Occasional large occurrences of mites in the gastrointestinal tracts of amphibians and reptiles could be attributable to the accumulation of indigestible exoskeletons in the lower gastrointestinal tract of primary prey items, as would apply to any arthropod remains with a hard chitinous exoskeleton. In turn, this could be further compounded by the accumulation and concentration of exoskeletons in the gastrointestinal tracts of secondary, and even tertiary prey items, making the occurrence of mites by any means of ingestion appear considerably greater than it actually is. From the *P. rhombeatus* study, where the entire digestive tract was opened and the contents examined microscopically, these accumulations were found to be largely a result of mites becoming lodged within the folds of the intestinal walls (Douglas 1992a, b). In this instance, 85% of mites occurred in the large intestine, 7% in the small intestine, and 8% in the stomach (Douglas 1992a, b). This provides a clear indication that stomach contents alone do not provide a true reflection of indigestible remains in the digestive tract, just as the presence of mites does not necessarily mean that they constitute prey items.

This accumulation and distribution of mites can be seen as being analogous to, and supported by, the accumulation of other indigestible remains in *P. rhombeatus*. Indigestible arthropod remains in the gastrointestinal tract of *P. rhombeatus* accounted for the second highest percentage occurrence of items at 20%, while other indigestible items (excluding hair 30.8%) included the species' own teeth (23.6%) and Acari (7.2%) (Douglas 1992a). In the case of the species' own teeth, distribution was similar to that of the mites, with 86% occurring in the large intestine and 12.6% in the small intestine (Douglas 1992a). Arthropod remains could all have originated solely from insectivorous prey items such as shrews, lizards, and frogs.

Whether or not hindgut contents should be included in dietary studies is a somewhat contentious and debatable issue. Schoener (1967) examined the entire digestive tract of *Anolis* spp. because it was felt that larger items might be over-represented if only stomachs were examined because larger items take longer to break up in the stomach and enter the intestines, as opposed to smaller items. Floyd & Jenssen (1984) recorded a 32% decrease in the diversity of prey taxa between the stomach and hindgut in *Anolis opalinus*, with a corresponding decrease in the frequency of soft-bodied prey in the stomach of from 22% to 4% in the hindgut. It was concluded by Floyd & Jenssen (1984) that, "through food item removal, digestion may create a larger bias if the entire gut content is reported than any bias created by a differential rate of food passage from the stomach if only foregut contents are reported." These results contradict the results of the *P. rhombeatus* diet study by Douglas (1992a), where 30 % of prey items occurred in the foregut, and 70% in the hindgut, with soft-bodied prey decreasing from 12% in the foregut to 0% in the hindgut. A primary factor in the outcome of any diet compilation will be the level at which prey items are recovered and identified. In the *P. rhombeatus* study there was a 56% increase in taxa between the foregut and hindgut, with this increase caused by the greater accumulation of hair and lizard scales in the hindgut, and the microscopic identification of these items.

When Schoener (1989) determined prey diversity values by taxa for *Anolis aeneus*, all three size classes had higher stomach diversity values, as opposed to hindgut values, while in *A. richardi* one of the three size classes had a higher stomach value. When Schoener (1989) compared the percentage frequency of hard- and soft-bodied prey in the stomachs and hindgut of the three *A. richardi* size classes, all three size classes had a higher frequency of hard-bodied prey in the hindgut, compared to the stomach. This was the same for all three *A. aeneus* size classes. Despite only two out of six of Schoener's (1989) groups having a higher percentage of taxa in the hindgut, six out of six groups had a higher frequency of hard-bodied prey in the hindgut, indicating the importance of hard-bodied prey in both the stomach and hindgut. The previously mentioned hair, scales, and teeth of the *P. rhombeatus* specimen were also found to be indigestible, and behaved in the same manner as chitinous arthropod remains within the gut. The distribution and accumulation of arthropod remains will depend on the feeding frequency of a particular animal, as well as a number of other factors and variables such as taxa, seasonal and ontogenetic diet shifts, foraging modes, sexual dimorphism, habitat and habitat partitioning, and the individual utilization of available food resources. The effect of these factors and variables in diet studies may be considerably compounded by the fact that they may not only be applicable to the predator, but equally so to primary, secondary, and even tertiary prey.

Rate of passage through the digestive tract

Related to this accumulation factor, the frequency of bowel elimination will also play a role. Bowel elimination in snakes is, for example, dependent on many factors such as size of prey, nature of prey, and temperature (Neil & Allen 1956). Due to these factors, defecation may well be delayed for over two months, and then still not be complete (Neil & Allen 1956), while inactivity over colder winter periods, particularly in more temperate regions, may prolong this time frame considerably. This is equally applicable to amphibians and lizards. In specimens where infrequent bowel elimination had occurred prior to collection, many more mites might have accumulated in the digestive tract. Hard parts of customary prey may also remain in a snake's, and presumably an amphibian's, gastrointestinal tract long after softer parts have been digested. The probability of digestive enzymes not being adapted to digesting hard, or soft, parts of secondary prey which are foreign to these enzymes (Neil & Allen 1956) is yet another consideration.

Although Simon & Toft (1991) noted that acariphagous frogs would require specialized enzymes and a slow rate of passage for the digestion of mites, the hindgut did not appear to have been examined in order to determine whether the mites were actually being digested or not. Maiorana (1978) noted that because of their low metabolic rate, salamanders digested food at a far slower rate than either frogs or lizards, and yet, intact oribatid mite exoskeletons were found in the rectums of *Batrachoseps attenuatus*, as well as in the faecal pellets of *Notophtalmus viridescens louisianensis* by Cochran (1988).

Detectability of mites by predators

Within the subclass Acari, size variation is considerable and may well be another factor in determining whether mites could be profitably consumed as prey. Most Acari are less than 1 mm in length and very slow moving (Douglas, 1992b; Simon & Toft, 1991). Length may vary from 1.7 to 12.7 mm in Ixodida, from 100 to 1400 µm in Oribatida, with Prostigmata possibly having the greatest size range of 100 µm to 16 mm (Evans 1992). Field observations clearly indicate that frogs and lizards will take actively moving prey over sedentary prey. Maiorana (1978) felt that the fewer mites in large salamander diets could possibly be a result of them not perceiving small prey. This is most probably equally applicable to the larger quantities of mites in the smaller salamanders, where in both instances the occurrence of mites was most probably derived from secondary prey. The cryptic colouration of mites could also play an important role in deciding whether a mite species could be seen as potential prey by a predator. When in their natural habitat, or even amongst the sand and debris with which they have been collected, most oribatid mites are not visible to the human eye and can only be seen with the aid of a microscope. It must therefore be asked, what are the probabilities that an amphibian, or reptile, would be able to detect, let alone eat, such small, slow moving, cryptically coloured and indigestible prey, which would possibly provide virtually no nutritional value? A summary of probabilities for the non-predation of oribatid mites by vertebrates is given in Table 1.

Acariphagous frogs were placed in an ant specialist guild by Toft (1981, 1985) and Simon & Toft (1991). Ant specialists were defined as frogs specializing in eating ants, but also eating other chitinous, slow moving prey, such as mites. That frogs, salamanders and lizards eat ants is not questioned; however, that frogs eat mites, based purely on observations that they occur in the gastrointestinal tract along with ants, is. Most ant specialist frogs are small and consume small ants (Simon & Toft 1991), which occupy the same habitat as the even smaller mites. It is postulated that when these frogs prey on ants, which move at a relatively fast pace in relation to oribatid mites, the frogs inadvertently tend to pick up quantities of sand, organic matter, and mites along with the ants. This may well be applicable to foraging salamanders as well. Toft (1985) stated that, like frogs, salamanders and lizards can also be grouped as ant specialists. For many of the reasons presented here, it is doubtful whether ant specialist amphibians and reptiles deliberately take mites as prey, particularly oribatid mites, as part of their regular diet. For the same reasons, it is postulated that primary invertebrate prey ingest mites inadvertently, rather than preying on them as a food source.

Assumed ontogenetic and seasonal shifts in diet

It has also been suggested that ontogenetic shifts occur in the diet of acariphagous frogs, and that because mites are small, they are taken in greater proportions by smaller, rather than by larger frogs (Simon & Toft 1991), contrary to evidence present-

Table 1. Summary of probabilities for non-predation of oribated mites by vertebrates

Consideration	Effect	Consequence
Size	100 to 1400 μm	Not easily visible or detectable by larger predators
Colour	Cryptic	Not easily visible or detectable by larger predators
Movement	Extremely slow	Not easily visible or detectable by larger predators
Digestibility	Indigestible	Shown to pass through the digestive tracts of some species, remain undigested in the large intestine of others, and remain undigested even as a tertiary prey item
Nutritional value	Nil	No nutritional value due to indigestibility and size
Source of calcium	Nil	Calcium contribution possibly nil in the small quantities of mites usually found in digestive tracts. Could this form of calcium be utilized by the predator?
Feeding energetics	Not profitable	Energy expended on selectively predating on mites would be too great, particularly in light of the other considerations given here
Probable prey item	Nil	No direct evidence of either amphibians, reptiles, or other vertebrates actually preying on, or deliberately consuming oribatid mite

ed by Schoener (1989) for lizards. However, although smaller frogs consume smaller primary prey items (Ovaska 1991), smaller prey items would in turn ingest smaller mites. Conversely, larger frogs are reported to take fewer and larger primary prey items (Ovaska 1991), but this primary prey may not actually ingest many mites because of either food preferences, foraging strategy, larger size, or differing habitat. The difference in the size of mites, compared to the size of the frog, may therefore be solely attributable to the type and size of the frogs' primary prey, and not be ontogenetic at all. While it has been proposed that the high proportion of mites in some frog diets is associated with microhabitat (Simon & Toft 1991), this may simply be related to a higher incidence of the frogs' primary prey also occupying these mite rich microhabitats. Similar reasoning may be applied to conjecture on the seasonality of acariphagy in anurans, as mentioned by Simon & Toft, (1991). Maiorana (1978) pointed out that the availability of salamander prey, including mites, was more abundant when the habitat was wet. In this instance, a higher incidence of mites in an amphibian's diet at a particular time of the year may simply coincide with a higher availability of mites in the habitat of the frog's primary prey at a time when the frogs are actively foraging. Therefore, the seasonality of mites in gastrointestinal tracts may simply be a reflection of the seasonality of primary and secondary prey, and mites.

In possibly one of the most detailed diet studies regarding mites, Norton & MacNamara (1976) identified nearly all the mites found in the stomachs of *N. viridescens* to genus and species level. A breakdown of these results indicated that oribatid mites accounted for 59% of species, and mesostigmatid mites, which are largely a free-living group with some parasitic suborders, 30%. Prostigmatid mites, which have a larger feeding diversity than other orders and also attain larger sizes, accounted for 9%, and astigmatid mites (=Acaridei), where the only genera identified was saprophagous/fungivorous, with some species being zoophagous, 1%. Based on their life histories, size and other factors, most of these mites (89%) could well be discounted as being primary prey. In agreement with the findings of Norton & MacNamara (1976), Douglas (1992b) found that all mites in the *P. rhombeatus* gastrointestinal tracts were either oribatid or mesostigmatid mites, while Maiorana (1978) also found that the majority of mites in *B. attenuatus* stomachs were oribatid mites. This indicates that in all probability the mites were accidentally ingested in a leaf litter environment by primary or secondary prey. Based on numbers, Norton & MacNamara (1976) went so far as to assume that *N. viridescens* was acariphagous to the extent that it may cause population mortality in some mite species. A closer look at the diet of *N. viridescens* diet may well have revealed that these mites were related to either primary or secondary prey, or could have been incidentally ingested with other prey.

The interpretation of results

The possibility of the Acari originating in primary and secondary prey, as opposed to being part of the predator's diet, appears to have been ignored by many authors such as Norton & MacNamara (1976), Schoener & Gorman (1968) and Simon & Toft (1991), who referred to mites as part of the diet. This can be illustrated by the following examples, noting that in many instances care needs to be taken when appropriating gastrointestinal remains to diet. When Neil & Allen (1956) recorded only beetle remains in the gastrointestinal tracts of the water snake *Natrix erythrogaster*, further investigation revealed that the primary prey was a *Bufo* spp. which had been completely digested, leaving behind only beetle remains. However, when Haagner (1991) found whole termites (*Hodothermes mossambicus*) in the stomachs of two Shield-nosed snakes *Aspidelaps sutatus*, it could safely be assumed that these were in fact primary prey items. This was because the bodies of the termites were in a completely undigested state, without any evidence of other primary prey. Termites (*Trinervitermes* (cf. *trinervoides*) found in a *P. rhombeatus* gastrointestinal tract were identified as secondary prey because entire termites were found in the stomach of the partially digested remains of a frog, *Cacosternum boetgeri* (Douglas 1990). A mass of termite heads (*H. mossambicus*) in the faeces of a Vine snake (*Thelotornis capensis*) led Broadley (1982) to list these as part of the snake's diet. However, with the snake's diet comprising mainly frogs and lizards, it is more likely that these termites heads were consumed by the primary prey which had already been digested, and not the snake. These examples indicate that it is possible for the primary prey item to be completely digested, leaving behind secondary prey items, which may well be identified as primary.

While Behan-Pelletie & Bisset (1994) stated that oribatid mites had been recorded as primary and incidental prey for a limited range of vertebrates and invertebrates, this study found that mites were more often recorded in vertebrate studies, and very seldom in invertebrate studies. This appears to be largely because of the occurrence of mites in digestive tract being interpreted as prey items in vertebrate studies.

Behan-Pelletie & Bisset (1994) examined the gut of five species of odonate larvae for mites. The guts of 22% (range 10-63%) of larvae (n = 494) contained oribatid mites, with the mean occurrence of mites within a gut being 2.5 (range 1-23), which was similar to the average of less than three mites per stomach in

Table 2. Some Arthropod predators of oribatid mite

Predator Order	Family/Species	Common name	Reference
Coleoptera	Ptiliidae	Feather-winged beetle	Riha, 1951
	Pselaphidae	Short-winged mole beetle	Park 1954
	Scydmaenidae	Ant-like stone beetle	Schuster1966a,b, Schmidt 1988
	Staphylinidae	Rove beetle	Lebrun 1970, Coedo & DeLoach, 1976
Hymenoptera	Formicidae *Myrmecina* spp.	Ant	Masuko 1994
	Adelomyrmex sp	Ant	Masuko 1994
	Pheidole	Ant	Wilson 2005
Diptera	Cecidomyiidae	Gall gnat larvae	Walter & O'Dowd 1995
Neuroptera	Coniopterygidae	Dusty wings larvae	Walter & O'Dowd 1995
Odonata	Various	Dragon fly larvae	Behan-Pelletier & Bissett 1994
Hemiptera	Enicocephalidae	Gnat bug	Molleman & Walter 2001
Opilioacarida		Mite	Grandjean 1936, Walter & Proctor 1998
Prostigmata	Labidostommatidae	Mite	Vistorin 1989
	Bdellidae	Mite	Wallace 1967, Wallace & Mahon 1972, Alberti 1973, Wallwork 1980, Stamou & Askidis 1992
Mesostigmata	Various	Mite	Hartenstein 1962, Woodring & Cook 1962, Luxton 1964, Lebrun 1970, Stamou 1989
Symphyla	*Symphylella* sp	Symphylan	Walter et al.1989
Chilopda		Centipede	Lebrun 1970

the *Notopthalmus viridescens* examined by Norton & MacNamara (1976). Thirteen percent of odonate guts contained intact dipteran larvae, which were considered the potential primary prey of the oribatid mite. The question remains as to whether the consumed dipteran larvae were not digested, leaving behind the indigestible oribatid mites? Therefore, even at this lower level of the food chain, secondary prey oribatid mites might well be mistaken for primary prey, with the dipteran larvae having ingested the mite inadvertently. It may be asked that, if oribatid mites are not digestible by a host of vertebrates, some of which are capable of digesting bone, then what are the chances of these mites being preyed on, and digested, by an arthropod? Further to this, it may also be asked what possible benefit could the dipteran larvae derive from the mites, if the mites could not be digested? It should be borne in mind that many invertebrates, such as earthworms, dipteran and other larvae, snails, and other arthropods utilize the same food sources as oribatid mites, as they share and utilize the same habitats. These invertebrates may therefore inadvertently ingest oribatid mites along with the decaying vegetation on which they themselves feed.

It appears that the only evidence of actual predation on oribatid mites has been recorded within the arthropods (Table 2). Park (1947) noted predation of oribatid mites in the beetle family Pselaphidae, Riha (1951) in the beetle family Ptiliidae, Schuster (1966a) and Schmidt (1988) in the beetle family Scydmaenidae, Masuko (1994) in the ant genus *Myrmecina*, and Wilson (2005) in the ant genus *Pheidoli*. Predation by these arthropods largely involves the predator boring into the oribatid mite and sucking out the contents. Beetles of the family Scydmaenidae have developed special mouth parts for catching and opening the mite Schmidt (1988). A number of other arthropod predation citations were found, but none with references. These included the Black ground beetle *Pterostichus meanarus*, and the jumping spider *Phidippus audax*. It appears logical that arthropods would prey on mites because the mites are closer to their size, as opposed to the much larger amphibians and reptiles.

It is evident that the accuracy and interpretation of results will be largely dependant on the level and methods of retrieval and identification. Part of the problem in identifying secondary prey is that gastrointestinal tract contents are not viewed in situ, but are simply emptied into a pan for identification (Neil & Allen 1956), or palpated from the specimen. Because of the possibility of rearranging prey material in this manner, the flushing of stomachs also results in skewed perspectives on secondary prey. Had the stomach contents of *P. rhombeatus* simply been emptied or flushed out for examination, much of the available information would have been lost. Also, as previously mentioned, had the intestines not been examined vast amounts of information would have been lost. The *P. rhombeatus* mites may have been completely overlooked as even flushing may not have removed them from the folds of the stomach and intestine. In studies where food items are palpated from the stomachs of specimens, only complete, or near complete, prey items are retrieved. This means that although a basic diet may be established, a wealth of other dietary information may be lost. Therefore, a decision must be taken as to whether we are interested in the actual diet of the specimen, or simply want to record the occurrence of items in the gastrointestinal tracts. If the former is applicable, then we must step up the level of investigation and identification to make sure that the results are less suspect and more creditable.

Sampling as a control measure

Norton & MacNamara (1976) and Simon & Toft (1991) have noted that Acari are a potentially abundant prey. However, comparisons between stomach contents and available prey, as sampled by means of Berlese extractions, for example, may not be reliable (Maiorana 1978), and any correlations do not necessarily provide proof that the occurrence of mites in a habitat is directly related to acariphagy. This is largely as a result of the sampling method only being accurate when it "sees" prey in the same manner as the animal being investigated, and adequately samples all prey types consumed (Maiorana 1978). Furthermore, the sampling of available prey does not differentiate between the possible prey of the predator and secondary prey. Large numbers of mites in the gastrointestinal tracts of certain *Anolis* species groupings prompted Schoener & Gorman (1968) to assume that the mites must have been attached to other foods, and not ingested individually. This is, of course, a most logical deduction and may offers a sound explanation for the large numbers of mites in some gastrointestinal tracts. Schoener & Gorman (1968) also noted that small prey often tend to be clustered, making it profitable for large predators to feed on them. Whether mites, particularly oribatid and mesostigmatid mites, would cluster to the extent of being seen as prey is doubtful. Schoener (1989) felt that the presence of mites represented an anti-parasite motivation, rather than a prey item, because they were the only major-sized group more numerous in larger lizards, as opposed to smaller lizards. Again, this must be doubted. Similar to the opinions expressed here regarding amphibian and reptile diet studies, Evans (1992) felt that statements in the literature regarding mite diet studies are all too often based on speculation rather than on direct observations of feeding behaviour. Sampling therefore cannot take into account the multitude of variables that may be present in predator/prey relationships under natural conditions.

Mites as vectors in the transmission of parasites

An aspect of mites in the gastrointestinal tracts of amphibians and reptiles that is often overlooked is their potential as vectors in the transmission of parasites and possibly diseases. Although many Acari are basically macrophytophagous, microphytophagous or panphytophagous, many are parasitic and found on amphibians and reptiles. That many genera of ticks, such as *Amblyomma*, *Aponomma*, *Babesia* and *Ixodes*, parasitize reptiles is well documented (Apperson et al. 1993, Evans, 1992), and they may well be involved in the transmission of some diseases. The genus *Ornithodoros*, for example, is known to transmit larval filariae to Pythons (Evans 1992). The relationship of oribatid mites as vectors for anoplocephaline cestodes (tapeworm) in a variety of mammals including sheep, cattle, rabbits, rats, monkeys and equines is also well documented (Wallwork & Rodrigues 1961, Balogh et al. 1964, Sengbusch 1977), with the hosts ingesting the mites inadvertently. At least 47 oribatid mite species are known to act as vectors for at least 12 species of cestode (Sengbusch 1977). The mite genus *Scheloribates*, recorded in the gastrointestinal tract of *P. rhombeatus* (Douglas, 1992b), is known to act as a vector for at least 10 anoplocephaline cestodes (Balogh et al. 1964). Cysticercoids of the genus *Diplopylidium* develop in coprophagous insects which are then eaten by vertebrates including amphibians and reptiles (Prudhoe & Bray 1982). *Mesocestoides lineatus* cestodes occur naturally in some species of oribatid mites, which may then use other paratenic hosts, such as amphibians and reptiles, at a later stage in their life cycle (Prudhoe & Bray 1982). Whether mites ingested by amphibians and reptiles play any sort of role in the transmission of tapeworm does not appear to have been examined.

Conclusions

From the discussion, it is clear that all Arachnida are not mites and that all Acari are not soil and leaf-litter mites, or free-living mites, of which the latter appear to be best represented in gastrointestinal tracts. With the probability of there being up to 600,000 mite species, the identification of mites is obviously a highly specialised field and therefore the level of identification and investigation will ultimately reflect on the interpretation of acariphagy in reptilian and amphibian dietary studies. As is evident from the literature, herpetologists, for example, are unlikely to be able to identify mites to below Subclass and many will not have access to facilities for more detailed identification. This raises three basic questions as whether to include mites in amphibian and reptile dietary studies.

Firstly, is it necessary to identify mites to below Subclass? On the one hand, it will be found that in most dietary studies, the specific identification of mites to below Subclass is neither necessary nor worth the time and effort involved. As has been illustrated here, the identification of mites may not clarify issues of predation on its own, even when brought to below Subclass. On the other hand, where inferences are being made to aspects such as predation and seasonal and ontogenetic diet shifts in the predator, then identification to as close as possible to species level, as well as an examination of the mites' life histories, should be a priority. Perhaps as a rule of thumb it can be said that if mites were to be included in dietary studies as "other items occurring in the digestive tract," then identification to Subclass would be appropriate. However, if mites are to be included as part of the diet, and therefore as prey items with all the associated implications, then the researcher should be able to show that the mites were in fact ingested by the prey, and an attempt should be made to bring identification as close to species level as possible.

Secondly, owning to inherent difficulties in identifying mites, it may also be asked whether there is a need to develop more sophisticated, or detailed, method for obtaining information on the occurrence of mites in the gastrointestinal tract of a suspected predator? Further examination of life histories and a more detailed identification may well be justified if the study is intended to go further than simply stating that mites occur in the digestive tracts, but would not be warranted if the occurrence of mites was as far as the results intended to go. For example, trials could be carried out to obtain further detail on the stages of digestibility of different groups of mites through the gastrointestinal tracts of the organisms that ingested them. The simple occurrence of mites in gastrointestinal tracts may not be appropriate for this type of information unless it can be established, through the life history of the predator, that mites were primary prey. Proper trials would be important because if the mites were secondary, or even tertiary prey, a certain amount of digestion may have already taken place in previous gastrointestinal tracts.

The final, and most probably the most pertinent question to arise from this discussion is, whether mites should be included in diet compilations and the data relating to such compilations. Firstly, mites usually only form a very small proportion of a sample, and in most instances, have little influence on data derived from such compilations. Secondly, there is usually not enough evidence in dietary studies to categorically state that mites are actual prey items. It is the accuracy of the data, however, and not the possible influence of the data on results, which is important. Although mites in snake diet studies are rare at present, the example of *P. rhombeatus* does show what information can be obtained from a more detailed examination of the data, and this is applicable to most amphibian and reptilian dietary studies. It is therefore suggested that, in most instances, mites should not be included in dietary compilations and should be excluded from data relating directly to the diet, unless it can be proved otherwise. Such data should rather be listed as "other items occurring in the gastrointestinal tract."

It is apparent that the majority of mites, in amphibian and reptilian diet studies, as well as other vertebrate studies, are not primary prey. In conclusion, it can be stated that amphibian and reptile diet studies reflect the accumulation of indigestible, hard bodied, oribatid mites derived from inadvertent ingestion, and from the digestive tracts of primary, secondary, and even tertiary prey items. In order to ensure that speculative shortcomings in future diet studies are avoided, the necessity of identifying mites more specifically, examining their life histories, and most importantly, examining them in relation to prey items should always be born in mind. This supplementary information will not only optimise results, it should also help to make terms such as "Acari" and "mite" obsolete in dietary study compilations. Perhaps of even more importance is that by using a more holistic approach to the identification and occurrence of mites in dietary studies, it will be possible to rule out mites as being part of the primary diet of amphibians and reptiles.

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An experimental study on density effects on tadpole growth, mortality and metamorphosis in Yellow-bellied toad *Bombina variegata*

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Abstract

Crowding is a common situation in temporary ponds and it is determined by reduction of water volume through drying. In this study I experimentally evaluate the impact of larval density on the time to metamorphosis, body size at metamorphosis, and mortality rate in *Bombina variegata*. This experiment shows that density has a strong impact on the larval period and the body weight of the larvae, metamorphs, and mortality. The presence of an older tadpole negatively affected the age of metamorphosis of the younger ones, and caused mortality among them.

Key words: crowding, metamorphosis, *Bombina variegata*

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INTRODUCTION

Amphibian larvae can undergo considerable variations in size and developmental time until metamorphosis when exposed to a variety of biotic and abiotic environmental conditions (Newman 1992). Amphibians adapted to successful reproduction in temporary ponds are selected for rapid colonization of the available ponds, rapid larval growth rates and flexible larval development (Wilbur & Collins 1973, Morin et al. 1990, Wilbur 1997). In temporary ponds, where the predation risk is generally low, intra- and interspecific larval competition, in combination with other abiotic and biotic conditions, strongly influences growth rate, larval period, body size at metamorphosis, and survival (Wilbur 1997). Crowding is a common situation in temporary ponds and it is determined by the reduction of water volume through drying. Crowding may affect tadpoles through a combination of a series of factors such as increased amount of waste elements, increased CO_2 and decreased O_2 concentrations, food depletion, thermal effects, reduced swimming volume, increased physical interaction among larvae, and intraspecific competition (Semlitsch & Caldwell 1982, Denver et al. 1998, Smith 1998, Loman 1999).

In this study I experimentally evaluate the impact of larval density on the time to metamorphosis, mortality, and body size at metamorphosis in *Bombina variegata*. This species is common in Romania (Cogălniceanu 1996), and breeds in small, temporary ponds (Brandun & Reyer 1997a, b, Gollmann et al. 1998). *Bombina variegata* prefers temporary ponds for reproduction and shows a wide range of adaptations to enhance its reproductive success in these habitats (Barandun 1992, Barandun & Reyer 1997a, b, Hartel et al. 2007 *in press*). Since this toad also inhabits ponds with very short hydroperiods for reproduction, its larvae are frequently exposed to the threat of desiccation.

In this study I evaluate the effect of crowding on:

(i) the days until forelimb emergence and metamorphic climax.
(ii) the body size (mm) of tadpoles and the wet weight (g) of tadpoles at forelimb emergence and the wet weight after the metamorphosis is completed.
(iii) the mortality of tadpoles.

MATERIAL AND METHODS

The population from which the eggs were collected inhabit a number of temporary ponds in a mixed forest at about 500m altitude in the middle section of the Tarnava Mare valley (Hartel et al. 2007). The eggs were randomly collected from four ponds. We estimated that 2-3 egg clutches were collected from every pond. The eggs were placed in a 50 l holding tank at room temperature, and the tadpoles were kept here until they reached stage 25 (Gosner 1960). After this, randomly selected tadpoles were placed in transparent plastic vessels on 26th May 2004 (day one of the experiment), in four density groups: single individual (= group *SI*), low density (= group *LD*) with three individuals, high

Table 1. The experimental design. *SI* = single individual, *LD* = low density, *HD* = high density, *0* = low density group with an older tadpole. For abbreviations see the materials and methods section.

Density group	*SI*	*LD*	*HD*	*O*
Replicate	8	6	6	6
No. tadpoles / vessel	1	3	8	2 (younger) + 1 (older)
Total larvae	8	18	48	18

Table 2. The SVL and the total body length of the tadpoles at the two measurements. SD = Standard Deviation. For abbreviations see the materials and methods section.

1st Measurement	Total body length	SD	SVL	SD
SI	28.55	3.65	10.70	1.40
LD	22.87	3.00	9.00	0.84
HD	19.99	3.04	7.91	1.09
O	21.11	3.06	8.35	0.73
2nd measurement	Total body length	SD	SVL	SD
SI	36.56	2.20	13.30	0.26
LD	32.41	3.00	11.70	0.84
HD	29.19	4.21	10.15	1.58
O	30.72	3.99	11.23	1.38

density (= group *HD*), with eight individuals. The fourth group (= group *O*), was a low density group (three individuals) but one of the larvae was older (around stages 27 – 28, Gossner 1960) than the other two (around stage 25, Gosner 1960). The oldest larvae were removed after their forelimbs appeared. The individuals were raised in 1000 ml of water in all four groups. The vessels were placed in a sunny place of the room. Every vessel received 10 hours of sunlight daily. The water temperature was measured three times each day at the bottom of the vessels. The overall average water temperature was 20.66˚C (range 18.7 – 23.2, SD = 1.86). I used aged tap water, allowed to stand for two days. More than 80% of the water was changed in each vessel every second day. No substrate was used.

The experimental design with the number of replicates is presented in Table 1. The tadpoles were fed with Tetra Min fish flake. In the first 10 days the larvae from the group *SI* received 0.006 g, the groups *LD* and *O* received 0.02 g, and the *HD* group received 0.05 g nutrient per vessel in every second day. After this period (10 days), the larvae were fed daily with 0.01 (group *SI*), 0.03 (groups *LD-O*) and 0.08 (group *HD*) g food until each individual entered metamorphosis (stage 42). In all groups, the food quantity was slightly overrated, because a small amount of unconsumed food remained when the next food dose was added, or the water was changed. The food rate was adjusted if tadpole mortality occurred.

I measured the SVL (snout-vent length) and the total length of the body (from the snout to the end of the tail) of the larvae with 0.1mm precision, using a caliper. These measurements were made on days 10 and 20 respectively. The body weight was measured with a Kern balance with 0.01 g precision at the forelimb emergence (stage 42, Gosner 1960) and at the metamorphic climax. Before the weight measurement, the tadpoles and toadlets were first briefly placed on a paper towel to remove excess water. The larval period was determined as days from the start of the experiment (26th May as day one).

Since no differences in the homogeneity of variances were detected (Levenee test, $P > 0.05$) I compared the body size (g and SVL) of the different groups using the Analysis of Variance (ANOVA). The groups (i.e. *SI, LD, HD* and *0*) were used as grouping variables in the ANOVA. A post hoc test (Tukey HSD) was used to detect those groups that showed significant differences. The significance level was set at 0.05.

RESULTS

Days until forelimb emergence and metamorphic climax

There were significant differences in the average number of days spent until fore-

Figure 1. Days until the forelimb emergence and the end of metamorphic climax. The average values and standard deviations for each group are presented.

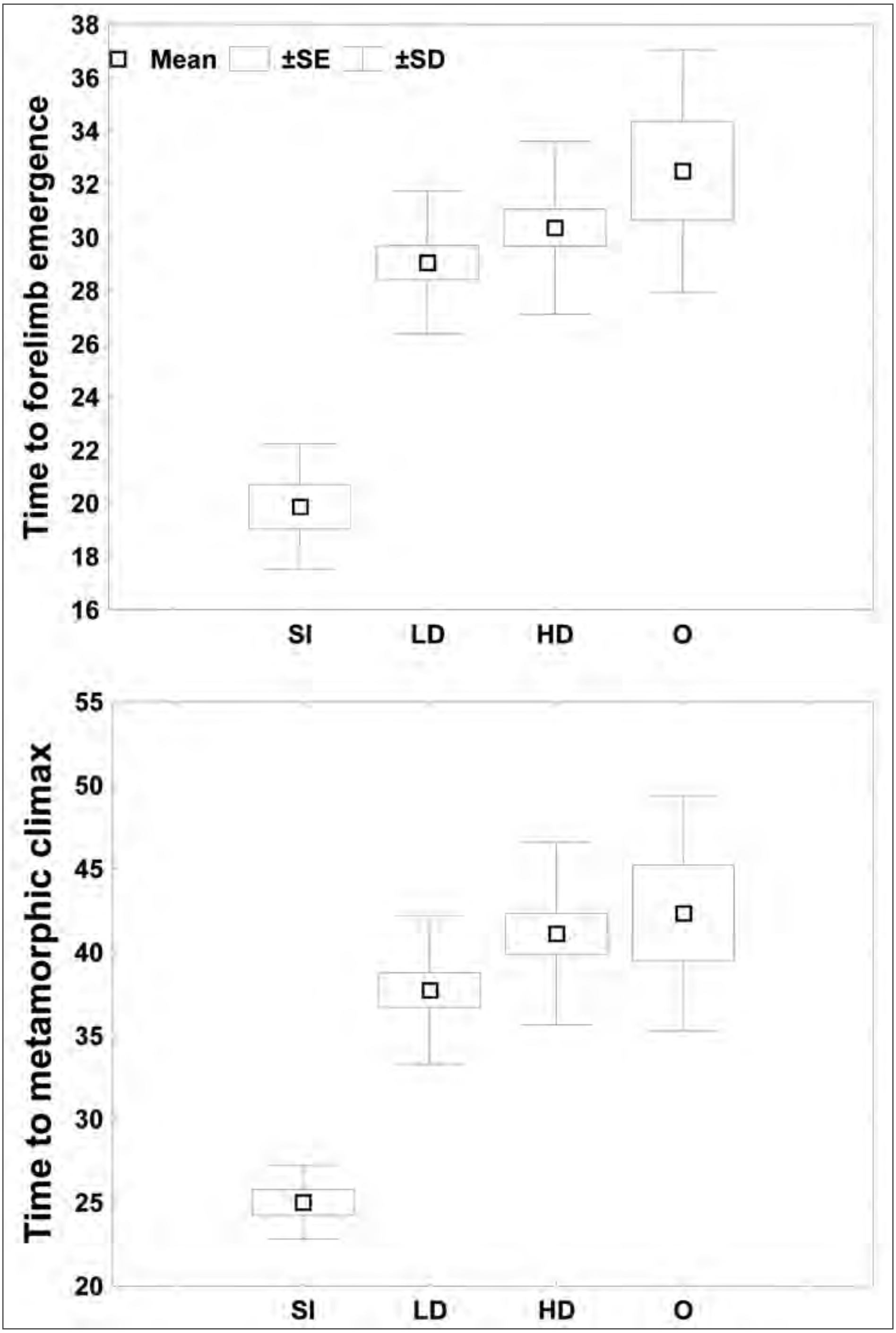
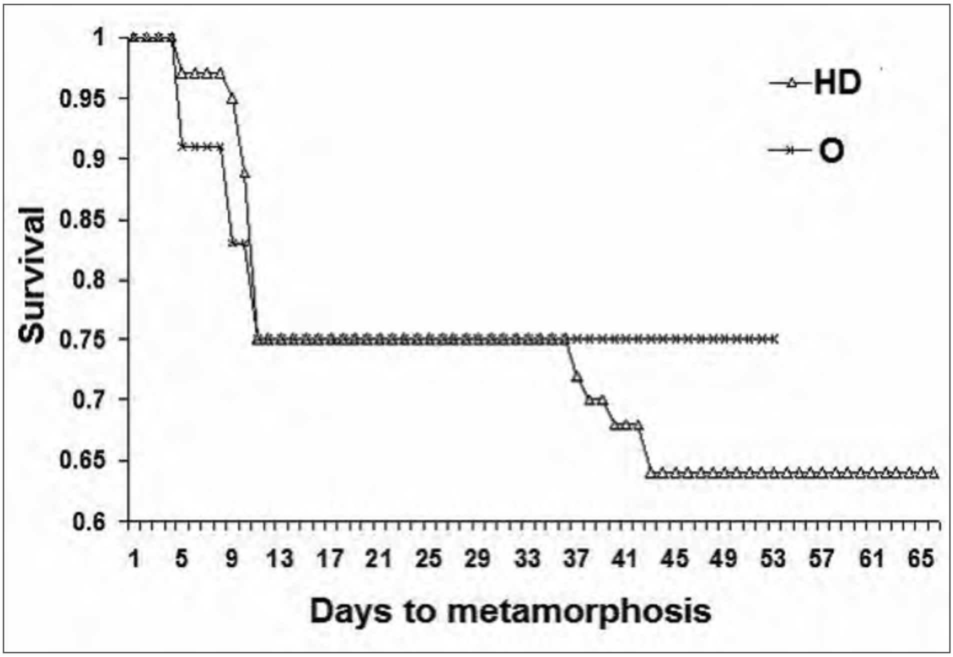


Figure 2. The rate of tadpole survival in the *HD* and *O* groups. Note that no mortality was found in the *SI* and *LD* groups.



limb emergence in the different density categories (ANOVA, $F_{(3, 51)} = 26.46$, $P < 0.001$) (Figure 1). The forelimb appeared significantly faster in the *SI* group (average 19.87 days, SD = 2.35) than in the other three groups (*LD*: 29.05 days, SD = 2.68; *HD*: 30.35, SD = 3.24 and *O*: 32.5, SD = 4.54) (Tukey HSD, P = 0.0001 in all cases). Although there was a tendency for an increase in time period until metamorphosis in the *LD, HD* and *O* groups, the differences were not statistically significant ($P > 0.1$ in all cases). The same pattern was found in the case of time spent until the end of metamorphic climax (ANOVA, $F_{(3, 49)} = 22.24$ $P < 0.0001$): the *SI* group completed metamorphosis faster (25.55 days, SD = 0.95) than the other three groups (Tukey HSD; $P < 0.0001$), whereas there was no significant difference between the other three groups (*LD*: 37.72, SD = 4.42, *HD* = 41.1, SD = 5.47, *O*: 42.33, SD = 7.06) (Tukey HSD; $P > 0.17$ in all cases) (Figure 1).

The effect of crowding on the body size of tadpoles

The descriptive statistics of the SVL and the total length of the body are presented in Table 2. The total body length of the larvae in the first measurement (10 day old larvae) differed significantly among the four groups (ANOVA $F_{(3, 69)} = 17.74$, $P < 0.0001$). The total body length of the *SI* group was the largest (Tukey HSD; $P < 0.01$) whereas no significant difference was found between the other three groups ($P > 0.5$ in all cases). The SVL was also significantly different in the four groups (ANOVA $F_{(3, 69)} = 17.31$, $P < 0.0001$). The SVL was significantly larger in the *SI* group than in the other three (Tukey HSD; $P < 0.0001$). The average SVL of *LD* was larger than that of *HD* (Tukey HSD, $P < 0.01$).

Almost the same pattern was found in the total body length and SVL of the larvae in the second measurement (20 day old larvae) as in the first one: the body length and SVL was largest in the *SI* group larvae and no significant differences were found in the other three groups (ANOVA and the post hoc test, $P < 0.01$ for the significant differences and $P > 0.2$ for the nonsignificant ones).

The effect of crowding on the body weight of tadpoles

There was significant difference in the body weight at forelimb emergence between groups (ANOVA $F_{(3, 51)} = 4.7$, $P < 0.01$). Significant differences occurred only between the *SI* (average 0.48g, SD = 0.05) and *HD* (0.44g, SD = 0.04) groups ($P < 0.001$). The body weight of the metamorphs was largest in the *SI* group (0.23g, SD = 0.02) (Tukey HSD; $P < 0.01$ all cases) and smallest in the *HD* (0.14, SD = 0.02) group (Tukey HSD; $P < 0.01$ in all cases). The average weight of the *O* group was greater than those of the *HD* group (0.19, SD = 0.03 *vs* 0.14, SD = 0.02) ($P < 0.01$).

The effect of crowding on survival and the end of metamorphosis

The survival of tadpoles until metamorphosis decreased with density and time spent growing to reach the stage of metamorphic climax. The highest mortality among the larvae was in the *HD* group, that is, the group with the highest abundance (overall 17 individuals = 35.4%); then in the "young" larvae from the *O* group (25%). In both groups, a high rate of mortality was observed in early larval development (first ten days) (Fig. 3). No mortality was observed in the group *SI* and *LD* (Figure 2).

DISCUSSION

This experiment shows that density has a strong impact on the larval period and the body weight of the larvae and metamorphs and also on mortality. The results of this study are in line with several other studies that document the negative effect of crowding on tadpole growth and development (Licht 1967, Wilbur 1977, Semlitsch & Caldwell 1982, Scott 1990, Smith 1998). Smith (1998) mentioned as possible mechanisms of the density effect the decrease of the per capita food ration, exploitative competition, and water borne growth inhibitor agents. It is possible that in high density conditions, an intraspecific inhibitory mechanism slows the growth and development of some tadpoles whereas others are at an advantage. As found by Wong et al. (2000), tadpoles of both *Rana temporaria* and *Bufo calamita* produced inhibitory cells in their faeces and the number of cells was related to the intensity of competition and tadpole size. The inhibitory cells affect the food consumption of the tadpoles of other amphibians by shifting them toward low quality food (Griffiths et al. 1991, Wong et al. 2000). The existence of such an inhibitory system in *B. variegata* is probable as it breeds in temporary ponds when the larvae from different cohorts are often crowded (especially in dry years). Jasienski (1988) compared the growth and development of sibling and nonsibling *B. variegata* larvae under high density conditions and found a negative effect caused by the larger nonsibling tadpoles. The observed density effect could, moreover, be an effect of increasing waste elements in the containers. This effect may be of little relevance in the field, where bacteria in the substrate perhaps process these wastes quickly. The variance of the body length and the SVL were the highest in the *HD* groups compared to other groups. This also suggests the possible competitive priority of some larvae in the high density environment. As was shown in the low density, presence of older tadpole (*O*) experiment (see below), an older tadpole indeed slows the growth and development rate of younger ones. This can be expected since the tadpoles of *B. variegata* are often exposed to crowding in the highly ephemeral water bodies where the eggs are often deposited (Hartel et al. 2007 *in press*).

The presence of an older tadpole tends

to negatively affect the age of metamorphosis of the younger ones, and increases the mortality rate among younger ones. The negative impact of old tadpoles on younger ones was demonstrated in *B. variegata* (Jasienski 1988) and *Hyla andersonii* by Morin et al. (1990). Our investigations in this area show that the yellow bellied toad reproduces two three times during the year and tends to occupy newly created and available ponds (including those of which the hydroperiod is increased due to precipitation) (Hartel et al. 2007). We don't know if this preference for newly created ponds (or to what extent) is the result of active avoidance by females of ponds already containing tadpoles (Hartel *personal observations*). Further field studies will elucidate this aspect of the reproductive biology of this species in this area.

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The birds of Rotes Luch fen (E Brandenburg, Germany): the effect of mowing frequency on bird species composition and density

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Abstract

This study aimed to determine the relationship between land-use and species richness and population density of birds on a fenland 50 km east of Berlin. Bird density was determined by mapping in the area of 52 ha divided into four plots with differentiated intensity of mowing and, as a result, with different structure of vegetation cover. The total density of breeding birds was determined to be 1.7 - 6.6 pairs/ha and species number from 5 to 31. The lowest density was recorded on plot B, mowed every three to four years, and highest on plot D, which had not been mowed for the last several years. The most intensively mowed plot (two times per year) was characterized by the highest density (two pairs/ha) and number of species (four) typical of grasslands. The density and species number of grassland birds was positively correlated with the intensity of mowing. On plots C and D (not mowed during the last several years, and partially covered by trees and shrubs) the density of grassland birds was very low and accounted for only several per cent of the whole community. Grassland plant species diversity did not reflect grassland bird diversity. From our observations, we conclude that conservation measures should be carefully designed to fit local demands.

Key words: breeding bird community, land-use, grassland, habitat structure, agricultural practices.

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INTRODUCTION

Grassland birds belong to a group of organisms which are strongly affected by farming intensification. Most grasslands in Europe exist under strong farming pressure. During the last 30 years, large areas of grasslands in many countries have been changed to arable land (e.g. Pain et al. 1997). In addition, remaining natural grasslands are being replaced by pastures or mowed meadows. Both crop fields and agriculturally used grasslands have been recognized as habitats inhabited by several species which have strongly declined during the last 30 to 40 years. However, knowledge about mechanisms involved in these changes differs markedly between these two habitats. The relationships between bird ecology and management of crop fields seem to be better recognized than linkage between bird ecology and grassland management (Atkinson et al. 2005). There is more and more evidence to link agricultural intensification to the decline of many species living on farmland (Fuller et al. 1995, Siriwardena et al. 1998) but the relevant studies deal mainly with arable land (Aebischer et al. 2000, Fox 2004). However, Atkinson et al. (2005) indicate that different studies show that intensification of grassland management has a negative impact on birds (Chamberlain & Fuller 2000, Siriwardena et al. 2000). There are several ways in which modern intensive agricultural practices influence grassland birds. Earlier mowing than in the past can destroy nests or render them more available to predators; earlier or more intensive mowing decreases the amount of prey for young bird feeding; and denser grass cover and reduced plant species diversity negatively affect the arthropod community (Sotherton & Self 2000, Di Giulio et al. 2001, Vickery et al. 2001). As a result, there has been a significant decrease in bird density, leading even to the disappearance of some species (Pain et al. 1997, Moller 1983, Lewartowski & Piotrowska 1987, Winiecki 1992). The survival of many of these species, e.g. Quail *Coturnix coturnix,* Corncrake *Crex crex,* and some Charadriiformes and Meadow Pipit *Anthus pratensis,* depends on the persistence of extensively used grasslands.

For the protection of animal and plant species whose survival depends on high quality grassland ecosystems, some of these areas are protected by law. However, grasslands are in an early stage of natural development and their vegetation structure changes relatively quickly. Natural development of grasslands leads to changes in fauna and flora up to the disappearance of typical grassland species. Therefore, effective protection of avifauna on grasslands needs careful determination of the proper ways of managing the habitats in these areas. Relationships between plant species, composition of grasslands, and bird species richness and abundance seem to be unclear. For example, coincidence between high plant diversity and high bird species richness was not proved by research in Sweden (Pärt & Söderström 1999).

Our study aimed to determine the influence of intensity of farming on bird communities on grasslands. The main goal of the study was to recognize the relationships between mowing frequency - the main driving force influencing the vegetation structure of grassland - and bird species richness and density, with special attention given to grasslands species.

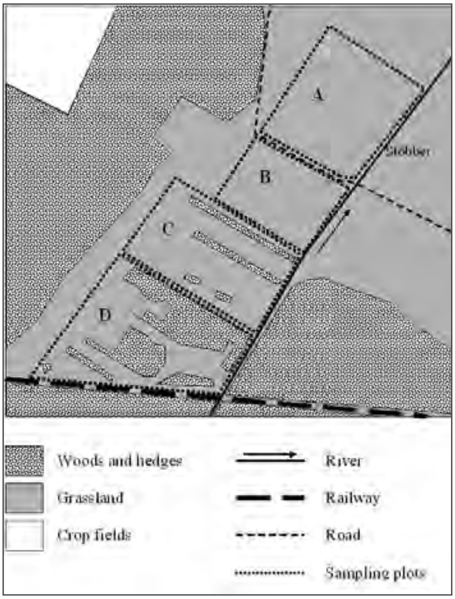
STUDY AREA

The study was carried out in 1994 in a complex of fresh grasslands named "Rotes Luch" located along the small regulated river Stöbber, five km east of Müncheberg (in the eastern part of Germany). The width of the complex is about 1 km, and the total area approximately 800 ha. The study covered an area of 52 ha, which was divided into four plots, A, B, C, and D (Figure 1), with different intensities of habitat use and, as a result, with different structures of vegetation. All the plots have rich flora. As many as 68-92 species of vascular plant per plot were recorded.

Plot A (12 ha) was mowed twice per year during the several previous years. The plant species occurring here are dispersed and do not create any clusters, with the exceptions of a few poorly developed patches of Lesser Pond-sedge *Carex acutiformis* and Slender Tussock-sedge *C. gracilis,* as well as Common Nettle *Urtica dioica*, with a total share of several per cent. Only the meliorating rows are composed of tall unmowed perennials dominated by Cabbage Thistle *Cirsium oleraceum*, Hemp-agrimony *Eupatorium cannabinum,* and Purple Loosestrife *Lythrum salicaria*.

Plot B (9 ha) was less intensively used than plot A. It was mowed every three to four years. Its vegetation is characterised by the occurrence of tall, compact patches of expansive perennial species: *Urtica dioica*, Cow Parsley *Anthriscus silvestris* and Creeping Thistle *Cirsium arvense*. These patches cover 50% of the plot. Other species (with species composition very similar to that observed on plot A) grow dispersed without any distinguished patches.

Figure 1. Study area



On plot C (13.2 ha) the composition and structure of vegetation cover are almost the same as on the previously described plot B, but some trees and bushes grow here in small strips and clumps. These tree and bush communities cover 10 per cent of the plot. They are composed of Elder *Sambucus nigra*, Grey Willow *Salix cinerea*, Bird Cherry *Padus avium,* Downy Birch *Betula pubescens*, Silver Birch *B. pendula*, oaks *Quercus* sp., Aspen *Populus tremula* and Hawthorn *Crategus* sp.

Plot D (18.5), in general similar to plot C, is characterized by the biggest share of tree and/or bush community covering 25% of the plot.

METHODS

Bird density was estimated with the aid of a combined version of mapping methods (Tomiałojć 1980). Good orientation in the field was possible thanks to a regular system of meliorating rows on plots A and B and the presence of tree and bush communities on plots C and D. On each plot six early morning counts were performed. A relatively low number of counts was compensated for by slow speed of censusing amounting to 8 ha/h, i.e. 2.5 times slower than recommended for farmland by Bibby et al. (1993). An area was regarded as breeding territory if birds with breeding or territorial behaviour were recorded at least three times. In the case of lately arriving *Acrocephalus palustris,* 50% of the territory was appointed on the basis of three records, and others, four records. For other species, most of the territory (84%) was appointed on the basis of at least four records.

Similarity of species composition between plots was determined by Sörensen's index: J = 2c x 100/(a+b) , where a and b represent the number of species in compared communities, and c the number of species common to both communities. Dominance similarity (*Re*) was estimated with the aid of Renkonen's formula: Σw, where *w* is the common or lower value of dominance (in %) for the species occurring in both communities.

RESULTS AND DISCUSSION

On the most intensively used plot A, six breeding species were recorded with a total density of 2.8 p/ha (Table 1). Among them, four species (*A. arvensis*, *A. pratensis*, *S. rubetra* and *C. crex*) can be regarded as species typical of grasslands. Total density of these species amounted to two p/ha. Species not linked with grasslands - *A. palustris* and *E. schoeniclus* - occurred relatively often (0.8 p/ha) due to the presence of meliorating rows of dense, tall perennials.

Plot B, less intensively used, was characterised by similar species composition to that described in plot A (J=90%), but significantly lower density (Table 2). Comparison of two open habitat plots (A and B) without trees and shrubs shows the significant effect of mowing frequency on dominance structure (Figure 2). Plots C and D were excluded from this analysis because of the presence of numerous trees and shrubs, which usually negatively influence grassland species independently of the structure of herb and grass layers. Dominance similarity index Re amounted to 46%. This value seems to be very low if we take into account the high similarity of species composition. Low density was recorded within the group of grassland species: the density of *A. arvensis* and *A. trivialis* was markedly lower (12 and 4 times respectively) than on plot A. Total density of grassland species amounted to 0.6 p/ha. On the other hand, the density of species not linked with grassland was higher (1.1 p/ha) than on plot B. For instance, the density of *A. palustris* was two times higher.

These differences are presumably related to different intensity of farming on the described plots and to the differences in the structure of plant cover mentioned above. Plot A, regularly mowed each year, was characterised by homogenous distribution of plant species and by the lack of patches of particular species. It seems that it is this kind of vegetation structure which is preferred by the most common grassland species - *A. arvensis* and *A. pratensis*. On the other hand, on plot B numerous tall (1.5 m) and compact patches of several perennial species were developing and these created very convenient nesting places for some species such as *A. palustris* and *S. rubetra*. These two species constituted over 80% of all pairs on that plot. Other species typical of grasslands bred sparsely on that plot, around 0.1 p/ha.

As far as plot C is concerned, a significantly larger number of species was recorded in comparison to A and B (Table 3). 22 species were found to nest there with a density of 3.7 p/ha. Among them there were only four grassland species (*C. crex*, *A. arvensis*, *A. pratensis*, *S. rubetra*) with very low density as well as low dominance (total - 10.5%). Therefore, even with less then 10% of hedges, the community of birds in a grassland habitat rapidly changed. Though grasses constitute 90% of the area, the dominance of birds typical of that habitat is low and the share of species linked with tree or shrub layer is significant (e.g. *C. chloris* - 12.2%, *S. borin* - 7.2%).

Plot D, with the highest share of hedges, was characterized by the largest number of species (32) as well as density (6.6 p/ha). Grassland species were absent (Table 4) though their habitat covered 75% of the plot. Thus, occurrence of hedges covering 25% of the area plays a most important role for the bird community and as a result, 75% of the area covered by grasses is invisible in the bird species list. Among the dominant species are typical forest species such as *Sylvia atricapilla*, *Turdus merula*, *Phylloscopus trochilus*, *Phylloscopus collybita*, *Parus major* and *Parus caeruleus*.

Table 1. Breeding bird community on plot A.

Species	N	Density (pairs/ha)	Dominance (%)
Alauda arvensis	15	1.2	42.9
Acrocephalus palustris	6.5	0.5	17.9
Anthus pratensis	5.5	0.4	14.3
Emberiza schoeniclus	4	0.3	10.7
Saxicola rubetra	4	0.3	10.7
Crex crex	1	0.1	3.4
Total	36	2.8	99.9

Table 2. Breeding bird community on plot B.

Species	N	Density (pairs/ha)	Dominance (%)
Acrocephalus palustris	8.5	1.0	60.7
Saxicola rubetra	3	0.4	21.4
Emberiza schoeniclus	1	0.1	7.1
Alauda arvensis	1	0.1	7.1
Anthus pratensis	0.5	0.1	3.6
Total	14	1.7	99.9

Table 3. Breeding bird community on plot C.

Species	N	Density (pairs/ha)	Dominance (%)
Acrocephalus palustris	16	1.2	33.0
Carduelis chloris	6	0.4	12.2
Sylvia borin	3.5	0.3	7.2
Emberiza schoeniclus	3.5	0.3	7.2
Crex crex	2	0.1	4.1
Cuculus canorus	2	0.1	4.1
Turdus merula	1.5	0.1	3.1
Sylvia atricapilla	1.5	0.1	3.1
Turus philomelos	1	0.1	2.1
Prunella modularis	1	0.1	2.1
Fringilla coelebs	1	0.1	2.1
Parus caeruleus	1	0.1	2.1
Alauda arvensis	1	0.1	2.1
Locustella naevia	1	0.1	2.1
Anthus pratensis	1	0.1	2.1
Hippolais icterina	1	0.1	2.1
Saxicola rubetra	1	0.1	2.1
Carduelis carduelis	1	0.1	2.1
Lanius collurio	1	0.1	2.1
Emberiza citrinella	1	0.1	2.1
Sylvia communis	0.5	+	1.0
Motacilla alba	+	+	
Total	48.5	3.7	100.2

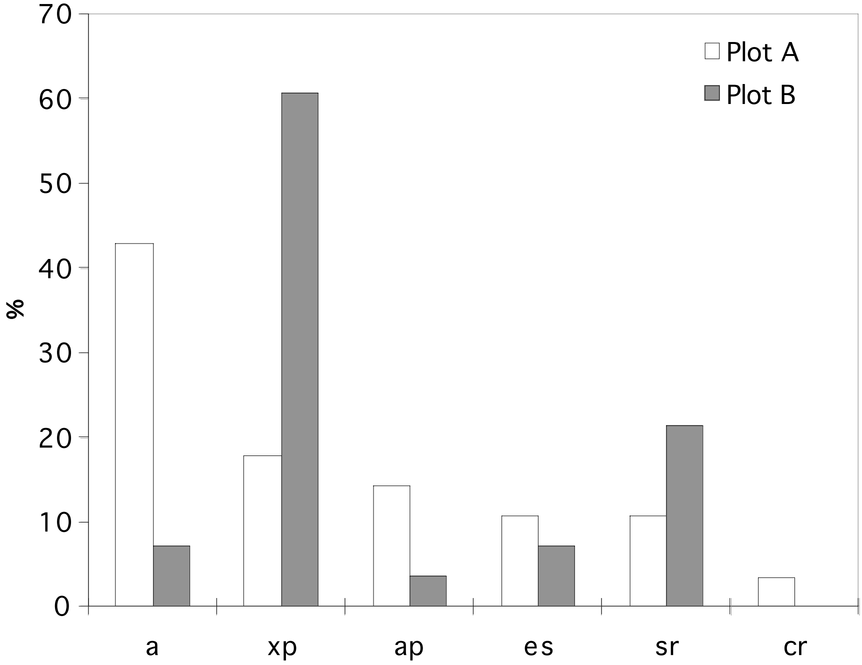
Table 4. Breeding bird community on plot D.

Species	N	Density (pairs/ha)	Dominance (%)
Acrocephalus palustris	15	0.81	12.8
Sylvia borin	11	0.59	9.4
Sylvia atricapilla	9	0.49	7.7
Turdus merula	8	0.43	6.8
Phylloscopus trochilus	7	0.38	6.0
Phylloscopus collybita	7	0.38	6.0
Parus major	7	0.38	6.0
Fringilla coelebs	6	0.32	5.1
Parus caeruleus	6	0.32	5.1
Sylvia communis	6	0.32	5.1
Turus philomelos	4	0.22	3.4
Carduelis chloris	3	0.16	2.5
Prunella modularis	3	0.16	2.5
Emberiza schoeniclus	2.5	0.14	2.1
Emberiza citrinella	2.5	0.14	2.1
Cuculus canorus	2	0.11	1.7
Streptopelia turtur	2	0.11	1.7
Luscinia megarhynchos	2	0.11	1.7
Erithacus rubecula	2	0.11	1.7
Parus montanus	2	0.11	1.7
Coccothraustes coccothraustes	2	0.11	1.7
Locustella fluviatilis	2	0.11	1.7
Dendrocopos major	1	0.05	0.8
Columba palumbus	1	0.05	0.8
Garrulus glandarius	1	0.05	0.8
Oriolus oriolus	1	0.05	0.8
Sylvia nisoria	1	0.05	0.8
Sitta europaea	0.5	0.03	0.4
Hippolais icterina	0.5	0.03	0.4
Muscicapa striata	0.5	0.03	0.4
Parus palustris	+		
Total	117.5	6.6	99.7

It should be taken into account that larger plot size can have also a positive influence for the number of breeding species. However, the most important factor enhancing bird species richness was the relatively high proportion of tree and shrub community on the plot, which was not related to plot size.

Although plot size does not fit recommendations for mapping methods applied to farmland (Bibby et al. 1993), pronounced differences in bird species composition and density observed between plots strongly suggest that the frequency of mowing strongly influences the bird community. The best environment for grassland species was found on plot A, the one with the most intensive mowing. With more extensive management on plot B, a significant decrease in grassland species density was recorded. Similar results have been reported from Japan, where *Alauda arvensis* increased slightly when grassland started to be used as pasture (Fujimaki & Takami 1986), and in Poland where the density of the species was much higher on mowed grasslands when compared to non-utilised areas (Lewartowski & Piotrowska 1987). The structure of plant cover on plot B has changed so much (as patches of perennials developed), that it did not match the habitat requirements of most grassland

Figure 2. Dominance (%) of species in plots A and B. Abbreviations: a - *Alauda arvensis*, xp – *Acrocephalus palustris*, ap – *Anthus pratensis*, es – *Emberiza schoeniclus*, sr – *Saxicola rubetra*, cr – *Crex crex*.



species. On the other hand, natural succession lasted for too short a time for the development of hedges, shrubs etc.; thus the density of species linked with that type of vegetation was very low. If natural growth lasts a sufficient time, and tree and/or bush communities start to develop (plot C and D), the bird community will begin to change rapidly until there is a total loss of grassland species (at 25% of tree/bush community). At the same time the proportion of common species increases, which leads to "homogenization" of the community as described by Devictors et al. (in press) with respect to the urbanization effect on bird communities. As a result of such "homogenization," the bird community tends to consist of more species, but most of the species are common to many habitats, and the conservation value of the grasslands becomes lower than in the past when plants were regularly mowed. Our study confirms that using vascular plants as indicators of overall biodiversity is unreliable (Pärt & Söderström 1999). Conservation measures should be precisely fitted to recognized local conservation demands.

Conclusions

The protection of breeding avifauna on grasslands needs special and careful management of the habitats. Conservation of the chosen area (in terms of the termination of farming) is surely insufficient. Only several years after mowing ends can a significant decrease of density of grassland species be expected. Reasonable protection of grassland bird communities should include mowing grasses, fitting their terms to breeding phenology to minimize brood losses.

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Aspects of the passage of waterfowl at the fish ponds in Brădeni, Romania

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Abstract

We studied the autumn and spring migration of water birds in autumn of 2003 and spring of 2004 at the Brădeni fishponds, situated in central Romania. We identified 24 passage bird species during autumn (seven species) and spring (23 species). The average number of passage bird species is significantly larger in spring than in autumn. The difference between the average number of individuals from each *Anatine* and *Aythyne* species is significant in autumn but not in spring.

Key words: water birds, fishponds, migration, Romania

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INTRODUCTION

The recent climate change is likely to influence the quality of wetlands as far as both breeding and passage avifauna are concerned, and thus to affect bird migration routes (UNEP/CMS 2002). The identification of new wetlands, useful for passage birds as well as for collecting data on the ecology of aquatic birds, is a necessary step in understanding the climate-related changes occurring in their distribution (Boere & Taylor 2004). The identification of new wet areas of interest for aquatic fauna, which should be protected in the future, also presents a compensatory measure for the depreciation of the quality of currently-protected ones (Delany 1999, Blanco & Carbonell 2001, Jackson et al. 2004, Rehfisch & Crick 2003); identification must be followed by the establishment of an ecological network for this bird group (Boere & Taylor 2004). Catry et al. (2004) have demonstrated that aquatic birds (waterfowl and waders) are faithful to their stopover sites. Therefore, the identification and preservation of the quality of wet areas used for the passage of aquatic avifauna are vital elements for the conservation of this group, and for determining its reproductive success (Newton 2004).

Previous Romanian references on aquatic avifauna passage were based mainly on faunistic studies (Weber 1993, Mitruly 1997, Bălescu 2002, Mesteacănu, Gava and Conete 2004). A few contain an analysis of aquatic avifauna passage (Fântână & Szabó 2004), but from a different perspective compared to the one we used. In this part of Europe, in general, there is little published data especially dedicated to the passage of aquatic birds, most of the references focusing on only one or two species (Vogrin 1998, 1999) but see, for example, Kralj et al. (1998).

The main objectives of the paper are to determine:

(i) are there differences in species richness between the two passage periods (autumn and spring) and within periods?

(ii) are there differences between the passage during the autumn and spring evidenced by the number of individuals of different species?

STUDY AREA

The fish ponds at Brădeni (N. 46.07017, E. 24.81736, 470 m above sea level) formed on a previously natural wet area along Hârtibaciului Valley, a tributary of the Olt River. They have a total surface of 171 ha, of which 99.5 ha is open water, and 71.5 ha paludal vegetation. The four pools, between 1.10 – 1.90 m deep, are separated by dams which are about 5 m high.

The paludal vegetation consists mainly of *Typha latifolia* (50.5 ha), and *Phragmites australis* (21 ha). The submerged macrophyte vegetation consists of *Ceratophylum* sp., *Myriophyllum* sp., and *Potamogeton* sp., covering about 50 % of the pond (Figure 1). As part of the local piscicultural technology regime, some of the ponds are emptied periodically; consequently, extended muddy areas containing small water puddles develop on which the typical vegetation described above starts to grow. An area of around two ha is covered by the habitat mentioned above.

MATERIALS AND METHODS

The studies were carried out during the autumn of 2003 (from September 21st until December 1st, when the ponds froze) and the spring of 2004 (from March 18th until June 26th). We made 11 observations in both autumn and spring.

In the field we used the linear transect method along the ponds, and the point counts method (Bibby et al. 2002). Field observations were made using a 9-27x50 zoom binocular and a 20x60 field glass.

We compared species richness in autumn and spring and the effectiveness of the three most common species, *Anas platyrhynchos*, *Aythya ferina* and *A. niroca*.

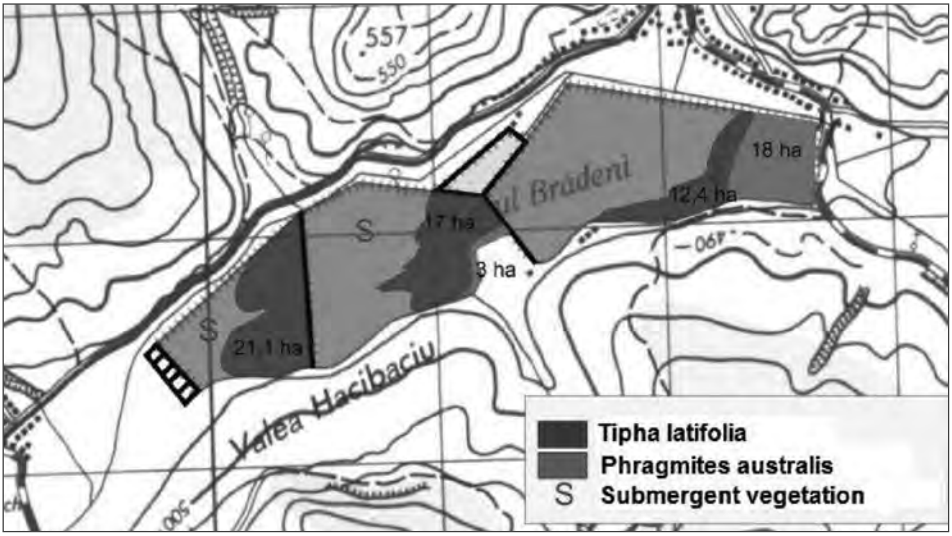
Before data analysis we tested the differences between the homogeneity of variances using the Hartley F max test. If significant differences were found ($P < 0.05$) a nonparametric test was used (Mann-Whitney U test, Median test); otherwise, ($P > 0.05$) a parametric test (ANOVA, t test) was applied to compare averages.

RESULTS AND DISCUSSIONS

Species richness

We identified 24 passage bird species during autumn and spring. The average number of passage bird species is significantly larger in spring (average 6.27, SD = 2.57) than in autumn (2.54, SD = 1.43) (ANOVA F = 17.58, $P < 0.001$). In both seasons, the number of species shows a decreasing trend toward the end of the passage period (Figure 2). The average number of *Anatine* species is larger in spring (average 2.81, SD: 1.53) than in autumn (being represented only by *A. platyrhynchos*), whereas there are no significant differences between the average number of species of *Aythyne* in the two periods ($t = -0.89$, df = 20, $P = 0.37$). The species richness of *Anseriformes* (*Anatynae* and *Aytinae*) shows fluctuations during the passage, being greater in the first days of both seasons (Figure 3). The evenness is greater during the spring passage than in the autumn (Figure 3). There is no significant difference between the average number of species belonging to *Anatyne* and *Aytinae* groups during the autumn passage (Mann-Whitney U test, Z=-0.36, $P = 0.71$), whereas the differences between the number of species belonging to *Anatyne* and *Aytinae* in spring is close to a statistical significance (Mann-Whitney U test, Z = 1.7, $P = 0.08$).

Figure 1. The Brădeni fishpond and the distribution of aquatic and paludal vegetation.



Weber (2003) mentioned a smaller number of species for the autumn passage as compared to the spring one, similar to what we noticed during our study. Fântână and Szabó (2004) in Sibiu county (around 100 km distant from our site in SV) evaluated the passage of aquatic birds at a similar reservoir lake with a late freezing date; between 1993 and 1996 they recorded 32 species, while between 1999 and 2004, 26 species. Moga (2003) recorded 17 aquatic bird species at the ponds at Câmpeneşti (160 km N from Brădeni) in the spring

Figure 2. The fluctuation of the number of bird species during spring and autumn passage.

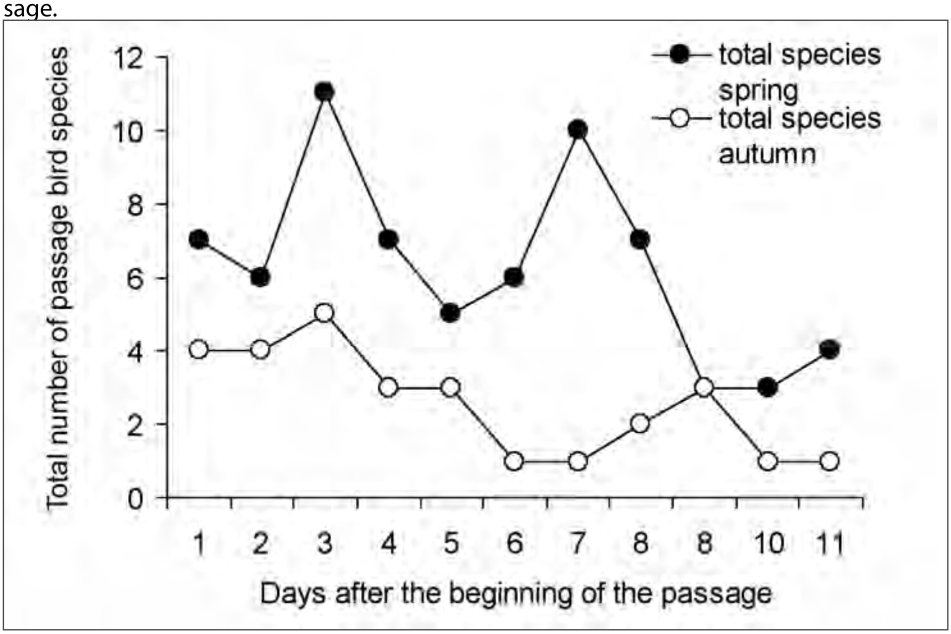


Figure 3. The species diversity of *Anatynae* and *Aytinae* (together) in the two passage seasons.

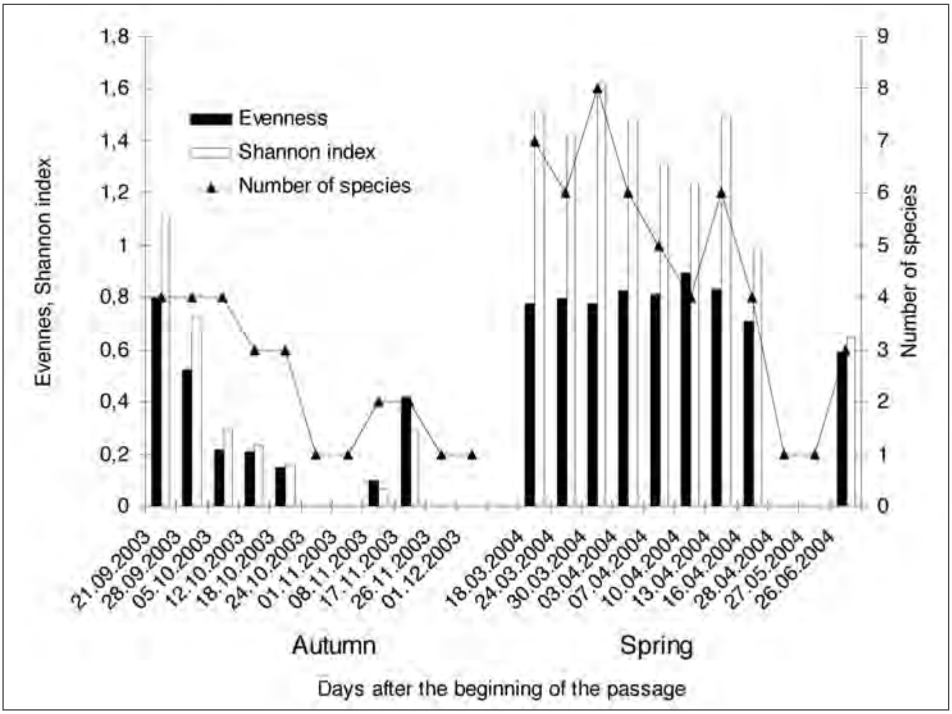
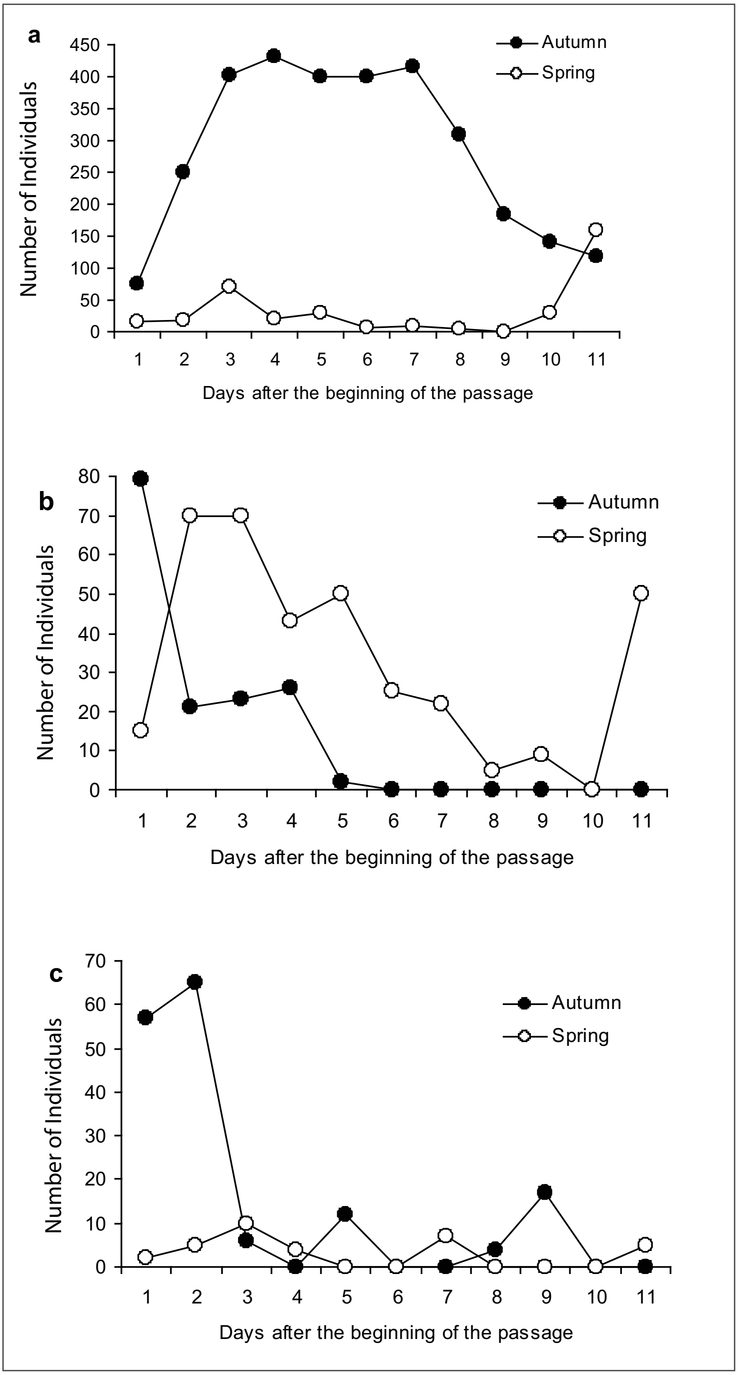


Figure 4. The fluctuation of the number of migrating individuals in *A. platyrhynchos* (a), *A. ferina* (b) and *A. nyroca* (c).



passage. The characteristics of the ponds at Câmpeneşti are very similar to those at Brădeni. Weber (1993), based on six years of observations of the passage birds at the reservoir lake behind the Ighiş hydroelectric dam (40 km west of our study area), registered a maximum of 28 passage bird species. The reason may be the longer study period compared to ours. The size of Ighiş lake is 93 ha but it is much deeper (max 20m) and is the last one that freezes in this area.

Population size comparisons

Anas platyrhynchos, A. querquedula, Aythya ferina and *A. niroca* all have breeding populations in the studied area: The number of females with young was ten in the case of *A. platyrhynchos*, seven in the case of *A. querquedulea*, seven in the case of *A. ferina,* and five in the case of *A. niroca*, all in 2003 (observations made by C.I. Moga).

The number of migrating individuals of *A. platyrhynchos* is significantly larger in autumn than in spring (Mann-Whitney U test, Z = 3.77, P < 0.001) (Figure 4a), which is in line with data provided by Kralj et all (1998) for fishponds in NW Croatia. The difference between the average number of individuals closely approaches a statistical significance in *A. ferina* (t = -1.79, df = 20, P = 0.08) (Figure 4b), and is not significant in the case of *A. niroca* (Mann-Whitney U test, Z = 0.79, P > 0.05) (Figure 4c).

The largest number of migrating individuals for the species *Anas platyrhynchos* was recorded during the autumn passage on October 12th (431 individuals). An early to mid-October peak was also noticed by Kralj et al. (1998) in NW Croatia. In spring, the largest number of migrating individuals was recorded on March 30th (70 individuals) and on June 26th (160 individuals). The species *Aythya ferina* registered the largest number of individuals (79), on September 21st. In spring, the largest number of individuals (70), was recorded on March 24th, and March 30th. These peaks are similar to those found by Vogrin (1998) on ponds in NE Slovenia. The species *Aythya nyroca* accounted for the largest number of individuals (65) in autumn on September 28th, while in spring, on March 30th the largest population consisted of 10 individuals.

The difference between the average number of individuals representing each *Anatine* and *Aythyne* species is significant in autumn (Chi-Square = 17.71, df = 2, P < 0.01), but not in spring (Chi-Square = 0.24, df = 3, P > 0.5).

Moga (2003) registered on April 10th, at the ponds at Câmpeneşti, the passage peak of the species *Anas platyrhynchos* (80 individuals). *Aythya ferina* recorded the maximum population (10 individuals) on April 2nd, while the species *Aythya nyroca* recorded a very small passage population (2 individuals).

Recently, the Bradeni fishponds have received the accept of the Romanian Academy and are legally protected as Natural Reserve. This aspect confirms their natural value. Moreover, the whole area was proposed to be part of the Natura 2000 network, as SPA.

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Comparing indicators of intensive agriculture from different statistical source

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Abstract

The aim of this paper is to compare spatial patterns of two indicators (called INAG and INT), both describing in rural land use intensification processes at different geographical and time scales. We have demonstrated that the spatial pattern of the simplified indicator (INT) is very similar to that of the more complex one (INAG), suggesting that INT can be used as a *proxy* indicator for land use by agriculture intensification. The indicator INT is positively correlated with the indicator INAG on the NUT-2 level and on all chosen altimetric zones in two different years of study, 1990 and 2000. A comparison between the INT indicator and other economic indicators describing agriculture intensification processes shows that INT significantly increases if cultivated area, mechanisation and irrigation levels, as well as population density, increase. Monitoring intensification processes by INT has the advantage of frequent updating, allowing time series analysis, as well as large availability through statistical sources at both regional and local scales.

Key words: Agriculture intensity, indicators, Corine Land Cover, agriculture census.

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INTRODUCTION

In the Mediterranean basin, agricultural systems have been evolving in the direction of intensification of production in many areas, most visible on plains (EEA 2001, OECD 2001, Brandt et al. 2003, Trisorio 2005). The concept of agriculture intensity in the traditional economic view refers to the input of capital, labour, and skills against constant land (Turner & Doolittle 1978). The intensification of agriculture usually means an increase in crop surface, larger yearly frequency of cultivation, and greater technical skills. Intensification of agriculture is a major cause of soil and habitat degradation (e.g. Brouwer et al. 1991). Intensive farming practices, such as deep water drainage, large-scale irrigation, heavy pesticide use, and multiple cropping, are causing degradation of agricultural and semi-natural habitats across huge areas (European Commission 2000).

Intensive farming is also depleting wildlife species. As an example, the numbers of many farmland birds are declining across the temperate zone. Many of these species inhabit agricultural areas and cannot be conserved solely within nature protection areas. Monitoring agricultural intensification by statistical indicators may provide information on species-habitat relationships, especially considering farm birds like thrushes, larks, and buntings (O'Connor & Shrubb 1986).

Indicators are especially useful when they successfully link to improve knowledge of a complex phenomenon like agricultural intensification. Here we analyse and compare two indicators of agriculture intensification, respectively called INAG and INT, computable from different statistical sources. The INAG indicator is derived from land cover maps (CORINE inventories) at the national level (Ceccarelli et al. 2006). Data for calculation of the INAG indicator are available at different spatial scales (regional, local), and can be obtained by GIS-based techniques of reclassification of the land cover types. Each land cover type is scored according to an agricultural intensification level it represents. For the computation of the INAG indicator, an accurate land cover inventory is needed, one which is generally difficult to update each year at the national level. Furthermore, analyses of environmental processes need statistical information with high updating rate and good spatial accuracy to be able to describe local (communal level) phenomena. Therefore, we suggest the INT indicator (see also APAT 2001) as a *proxy* of agriculture intensification. The computation of the INT indicator on the communal level is easy, since a national census of agriculture is available at a local scale and is frequently updated at regional or sub-regional scales (through farm structure surveys).

Our comparison of spatial patterns of the two indicators is based on commune data measured in the years 1990 and 2000. The aims of comparison are (i) to verify that INT is positively correlated to INAG for different spatial levels, thus producing a valuable estimation of intensification processes, and (ii) to propose the most efficient geographical scale to be used (regional, sub-regional, local) for an assessment of agricultural intensification over time. Moreover, INT was compared to other economic indicators generally correlated with intensification processes to confirm that INT may represent a *proxy* indicator for agricultural intensification. Finally, an estimation of INT for the years 1970 and 2000 is carried out for a case study to show an intensification trend over the last thirty years on a regional basis.

METHODS

Study area

This study regards estimates of agriculture intensification carried out in Italy. This country has the greatest percentage of cultivated land (44%) in the European Union, of which 45% is in the mountains, 23% in the hills and 32% in the plains. From the early 1930s, there has been a progressive reduction of cultivated land which is presently half that at the beginning of the 20th century (Venezian-Scarascia et al. 2006). From 1982 to 2000, the process of intensification slowed, with a reduction of 14% in cultivated area devoted to intensive crops. Figures higher than the national average were recorded in the north-east, in the south, and in islands. For the regions, the greatest rates of reduction occurred in Liguria, Tuscany, and Sardinia, whereas the largest areas of intensive farming were actually in Campania and Sicily (Trisorio 2005).

Indicators and data sources

Indicators should be: (i) easily computed at high spatial resolution, (ii) covering the whole national territory, and (iii) frequently updatable (from national sampling surveys or administrative sources). The indicator of agricultural intensification called INAG (see Salvati et al. 2005 for a description) can be used to monitor development of an agrarian landscape in connection to intensive agriculture, farm management with high inputs per land unit, and farming practices that may cause negative environmental effects (Ceccarelli et al. 2006). Based on a re-aggregration of CORINE land cover classes, INAG takes into account land cover in terms of (i) crop type, (ii) density, and (iii) the occurrence of irrigation schemes. INAG refers to a score system (table 1) of four land types with a different degree of intensification: higher scores identify areas prone to intensification processes. According to this weighting system, each CORINE map unit can be reclassified on an ordinal scale ranging between 0 and 1 (see also Ceccarelli et al. 2006). INAG was computed at the commune level based on a "zonal statistics" GIS procedure, as a weighted score based on the different land cover classes occurred in each municipality considered.

A simplified indicator of agricultural intensification was originally proposed as a *proxy* of intensification levels in the rural landscape (APAT 2001, Trisorio 2005). This index, called INT, was calculated as the percentage share of cultivated area used for intensive crops in a total cultivated area. Intensive crops were classified both as annual crops (i.e. potatoes, vegetables, other erbacean crops), as well as perennial crops (i.e. fruit, grapevines, olives). Surfaces of different crops were provided at the commune level by the National Census of Agriculture, carried out each decade, and at the regional or sub-regional levels by the Farm Structure Survey and by other administrative sources, with a frequent updating scheme.

Statistical tests

Both INAG and INT indicators were computed at the commune level (about 8,100 administrative units) separately for the two years of study, 1990 and 2000. Computation was based on the use of CORINE Land Cover maps (provided by the Italian Agency for the Protection of the Environment, APAT), datasets from the Census of Agriculture (provided by the National Italian Institute of Statistics, ISTAT), as well as maps of the administrative boundaries in both 1991 and 2001. INAG and INT indicators were made comparable by a standardisation process followed by a normalisation into the interval 0 – 1. In both cases, the value 0 indicates the absence of intensive crops whereas the value 1 indicates that the whole commune area is composed by intensive land types. Based on commune data, comparisons among indicators were carried out at different spatial scales aggregating municipalities into six functional areas as follows: (i) National sectors (Northern, Central, and Southern Italy); (ii) Altimetric zones (i.e., lowlands: communes with mean elevation less than 100 m on the sea level, hilly areas: communes with mean elevation ranging between 100 m and 600 m, and mountain areas: communes with mean elevation more than 600 m, see ISTAT 1958 and Figure 1); (iii) The intersection of the two precedent aggregations (national sectors and altimetric zones), giving nine zones (northern lowlands, northern hilly areas, northern mountain zone, central lowlands, central hilly areas, central mountain zone, southern lowlands, southern hilly areas, and southern mountain zone); (iv) Regions (i.e. NUT-2 level): twenty regions in both 1990 and 2000; (v) The intersection of regions and altimetric zones, giving 51 zones; (vi) Provinces (i.e. NUT-3 level): 95 and 103 zones in 1990 and 2000, respectively.

For each spatial scale, the figures of the two indicators were compared by a non parametric rank procedure, the Spearman correlation test. This test was chosen in order to highlight both linear and more complex relationships between data and to avoid bias caused by the lack of normality in some data aggregations. Two probability levels were fixed in order to detect significance in the correlation between INAG and INT ($P < 0.05$, considered as a weak correlation, and $P < 0.001$, considered as a strong correlation). Results of rank correlations between INAG and INT indicators were based on the ratio of significant correlations out of the total number of correlations in each spatial scale.

To verify that INT may correctly represent a *proxy* of agriculture intensification, a non parametric correlation analysis between this indicator and other economic indicators linked to intensification processes was carried out at the regional level. The Latium region, where the intensification level was high in the last several decades with a differential spatial pattern according to the altimetric zones (Salvati et al. 2005), was chosen as a case study (Salvati & Zitti 2005). Nine indicators were selected (see Table 2 for a list and a brief description) and calculated at the commune scale (n = 377 municipalities) for the year 2000. They explore demographic aspects (both in terms of population density and ageing processes), economic performance (gross domestic product, density of factories), and agriculture characteristics (mechanisation, landscape diversification, property and farm size). Original datasets and a detailed description of the indicators are presented in Salvati & Zitti (2005).

RESULTS AND DISCUSSION

At the national level INAG and INT showed a similar pattern in both years of study, clearly increasing in more dense agriculture zones such as the river Po plain in the north and the Apulia region in the south. Note that regions with lower intensification processes included mountain areas both in the Alps and in the Appennines as well as marginal hilly zones in southern Italy where traditional farming systems maintains their importance in the local economy (Figure 2).

Results of rank correlations between INAG and INT indicators at the six different spa-

Figure 1. Altimetric zones of Italy (see methods for definitions).

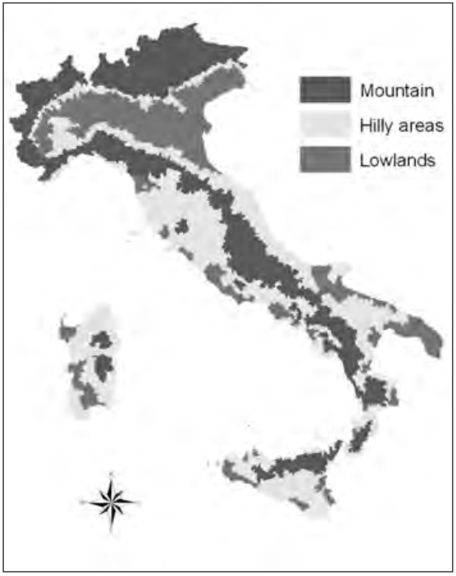


Table 1. CORINE land cover types reclassified according to INAG scores.

CORINE cover class	Type of land cover	Level of intensification	INAG weight
2.1.2, 2.2.1, 2.2.2, 2.4.2	Permanently irrigated land, vineyards, fruit trees and berry plantations, complex cultivation patterns	High	1
2.1.1, 2.2.3, 2.3.1, 2.4.1, 2.4.3	Non-irrigated arable land, olive groves, pastures, annual crops associated to permanent crops, land principally occupied by agriculture	Medium	0.5
3.2.4, 3.3.4	Transitional woodland scrub, burnt areas	Low	0.2
All the other codes	Forests, wetlands, urban areas	Absent	0

Table 2. Economic indicators computed to explore possible relationship with INT index.

Name	Year	Source
Population Density	2001	National Census of Households (ISTAT)
Elderly index	2001	
Density of industrial activities (factories km^{-2})	2001	National Census of Industry and Services (ISTAT)
Agricultural surface in affittance (%)	2000	National Census of Agriculture (ISTAT)
Density of tractors (no. tractors/farm)	2000	
Farms using agriculture machine (%)	2000	
Agricultural utilised area/Total farm area	2000	
Total farm area/Commune surface	2000	
Gross Domestic Product (per-capita)	2003	National Accounting Data (see Salvati & Zitti 2005)

Table 3. Significant comparisons between INAG and INT at different spatial aggregations (percentage variation between 1990 and 2000).

Zone	$p < 0.05$	$p < 0.001$
National sectors (n = 3)	0	0
Altimetric zones (n = 3)	0	0
National sectors & altimetric zones (n = 9)	0	11
NUT-2 regions (n = 20)	0	5
NUT-2 regions & altimetric zones (n = 51)	14	24
NUT-3 provinces (n = 95 [1990] or 103 [2000])	14	11

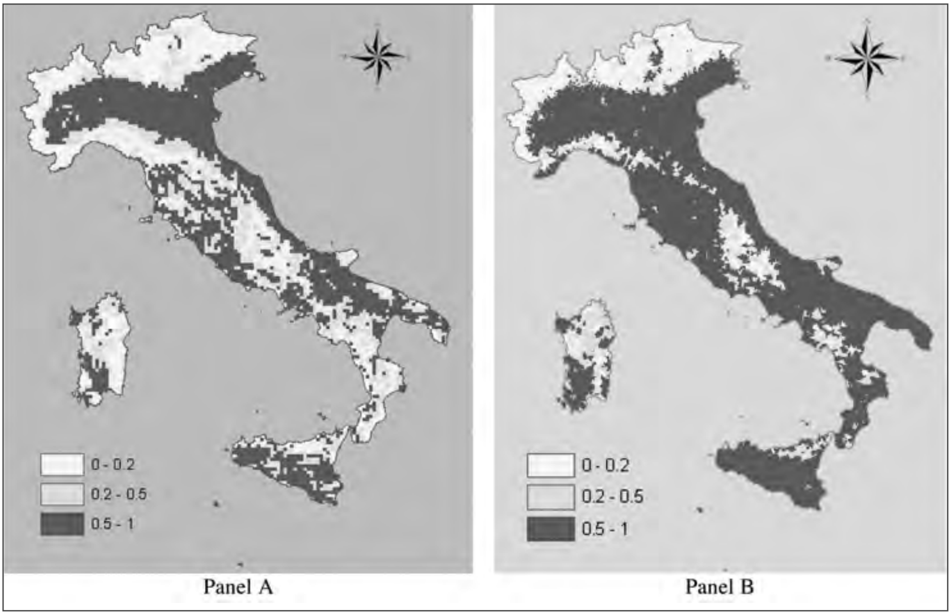
Table 4. Spearman rank correlations between INT and nine economic indicators in Latium, central Italy (significant level fixed at $p < 0.001$, n = 377 municipalities).

Variable	Spearman	p-level
Population density	0.29	< 0.001
Elderly index	-0.15	n.s.
Density of industrial activities	0.02	n.s.
Agricultural surface in affittance	0.10	n.s.
Tractors per farm	0.25	< 0.001
Farms using agricultural machines	0.42	< 0.0001
Agricultural utilised area/total farm area	0.42	< 0.0001
Total farm area/commune surface	0.42	< 0.0001
Pro-capita gross domestic product	0.10	n.s.

Table 5. Spatial and temporal trends of INT index between 1970 and 2000 in Latium region.

Year	Altimetric zones			Latium
	Lowland	Hilly areas	Mountain areas	
1970	0.85	0.77	0.42	**0.66**
1982	0.89	0.78	0.41	**0.67**
1990	0.87	0.77	0.36	**0.64**
2000	0.90	0.74	0.33	**0.62**

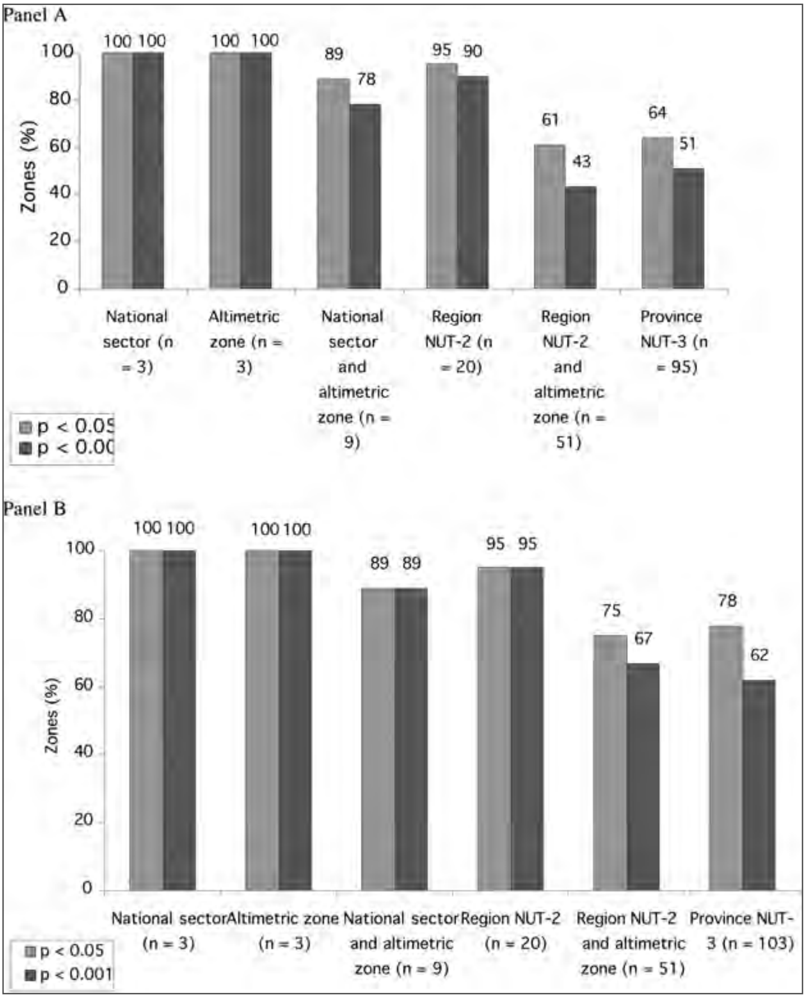
Figure 2. Geographical pattern of INAG e INT indexes (2000) at the Italian level (panel A: INAG, panel B: INT).



Panel A

Panel B

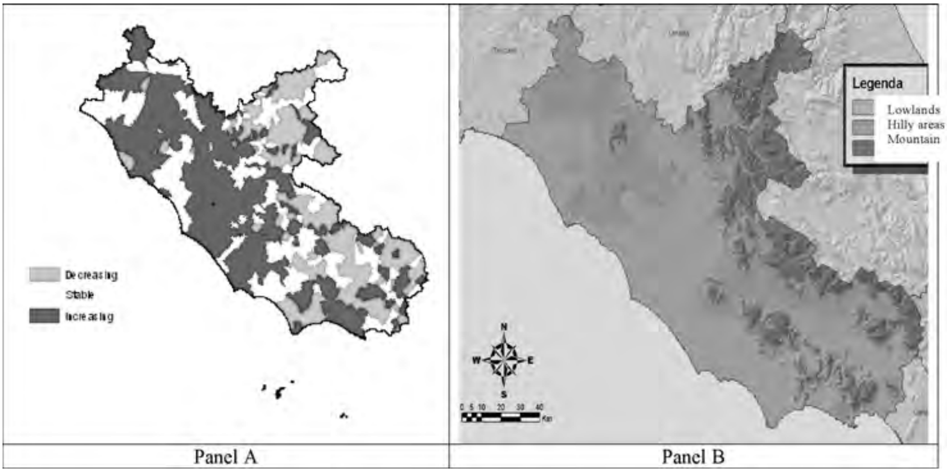
Figure 3. Results of the correlation tests between INAG and INT performed at six different spatial scales (Spearman rank correlation test with significance levels fixed at P < 0.05 and P < 0.001; panel A: 1990, panel B: 2000).



tial scales chosen are given in Figure 3. In both national sectors and altimetric zones all the correlations between INAG and INT were significant at $p < 0.001$ level in both years. At the regional level, the comparison was highly significant 19 times out of 20 in 2000 and 18 times out of 20 in 1990. At the province level, 51% and 62% of comparisons were highly significant in 1990 and 2000, respectively. Notably, significant correlations increased between 1990 and 2000 at both the regional and provincial levels (Table 3).

Comparing the spatial pattern of INT measured in 2000 with nine indicators regarded as *proxy* of agriculture intensification in terms of both mechanisation, irrigation, land, and demographic processes, collected in the same year at the regional level, highly significant pair-wise correlations

Figure 4. Variation in INT index between 1970 and 2000 (panel A) and altimetric zones (panel B) in Latium.



were shown between INT and such indicators (Table 4). In fact, INT directly increases with both the spreading of agricultural machines and tractor density, as well as with increases in cultivated area, total agricultural surface, and population density. On the other hand, INT showed no correlations with other economic indicators such as gross domestic products, industrial structure, and the demographic features of the population.

INT may provide multi-temporal estimates of agriculture intensification levels. Therefore, the trend of this index between 1970 and 2000 was calculated at the regional level (i.e. Latium) according to the altimetric zone (Table 5). Over thirty years, INT increases from 0.85 to 0.90 in the lowlands, stays quite stable in hilly areas, and decreases from 0.42 to 0.33 in mountain areas. As expected, lowlands in Latium, featuring a high urbanisation rate, tourist pressure, and intensive crop management mainly based on irrigation schemes, showed a clear increase in the index over time. On the other hand, mountain areas with traditional farming systems featuring small-sized farms containing pastures, woods, and low-surface perennial crops showed a general decrease in intensification. Finally, the geographical distribution of INT increase/decrease over time (Figure 4, panel A) confirms that a different pattern exists according to the altimetric zones (Figure 4, panel B) and suggests that such indexes correctly classify more dense agricultural areas and may be used as a *proxy* of agriculture intensification.

Conclusions

Agriculture intensification has environmental consequences which need to be controlled to ensure the sustainability of agriculture (Trisorio 2005). One of the objectives of the agri-environmental measures recently introduced is to stop the decline of areas with grassland and pastures which are generally farmed less intensively than croplands and produce less nutrient surplus. The final goal of the environmental policy is to reduce the pressure of intensive agriculture on the rural landscape (European Commission 2000).

To estimate intensification phenomena based on national agricultural statistics, INT may provide detailed spatial information on agricultural intensity for each Member State and for the European Community as a whole. Coupled with other statistical indicators, INT may also describe differences in the intensification process according to certain characteristics of the primary sector (e.g. farm size and type, economic size, volume of work, and landscape).

Finally, an integrated evaluation of the different aspects of intensification in order to assess environmental vulnerability should be carried out (Brouwer et al. 1991). One aspect is to calculate structural changes which have occurred in the primary sector during the last fifty years. Using suitable indicators collected from long time series, like the INT indicator, a multi-temporal approach may better indicate the spatial and temporal direction of degradation phenomena in southern Europe (Thornes & Brandt 1995). Giving precise spatial information on the rate of change of agriculture intensification may provide a useful tool for political actions to mitigate environmental degradation (Ceccarelli et al. 2006).

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Long-term demographic dynamics along an urban-rural gradient: implications for land degradation

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Abstract

The aim of this paper is to review recent findings in term of land degradation (LD) processes and population dynamics. A simplified model in which demographic variables may accelerate LD is illustrated. Based on this framework, population dynamics for a 130 year period (1871-2001) were analysed in Latium, central Italy, on a detailed spatial resolution (i.e. municipality level) through a multivariate approach including principal component and cluster analyses. The results of such analyses highlight the importance of migration movements along both elevation (mountain areas *versus* lowlands) and urban-rural gradients (Rome *versus* countryside), creating marked environmental impacts along coastal areas as well as on more intensified agricultural zones. Moreover, it has been proved that LD process have been more severe in recent years in those areas where demographic dynamics, leading to higher population density, were more evident.

Key words: Demographic dynamics, long-term trends, multivariate analysis, urban-rural gradient, land degradation, Latium, Italy.

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INTRODUCTION

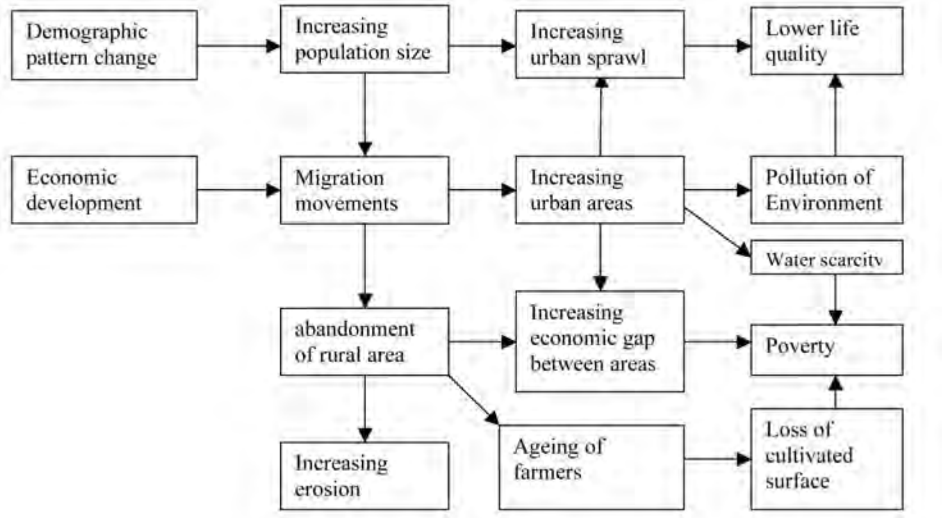
Land degradation (LD) is perceived as a major threat worldwide since it implies long-term decline in soil productivity and environmental unsustainability (Steer 1998, Arshad & Martin 2002). LD in arid and semi-arid zones has been recurrent in human history (United Nations 1977). In the distant past it tended to be sporadic and limited to certain areas in response to particular combinations of natural and social factors. Since the present system of production, finance, trade, and consumption began its rapid expansion from western Europe in the 16th century, LD has spread throughout dryland regions nearly everywhere (Garcia Latorre et al. 2001). This cannot be convincingly explained by recent evidence of climatic changes (Goria 2000). It suggests that global socio-economic processes as well as local ones are driving forces for LD (Herrmann & Hutchinson 2005). In fact, since 1990, a period during which the natural environment and ecological aspects of the phenomenon have been of great interest, the relationship between LD and population growth has alarmed politicians and scientists alike (Glenn et al. 1998).

Taken as a leading factor of environmental degradation, human pressure has intensified enormously during the last 50 years (Blaikie & Brookfield 1987). A current hypothesis concerning the relationship between LD and demographic dynamics suggests that population movements lead to a discrepancy between economic carrying capacity and population density in regions affected by LD. The carrying capacity is an ability of an economy to sustain a certain population (Knerr 1998, Goria 2000). From an ecological point of view, the term carrying capacity denominates the maximum number of persons able to live in a certain region on the basis of the resources necessary for life while maintaining their living standards and their quality of life in the long term (Blaikie & Brookfield 1987). Therefore, the carrying capacity of a certain region is determined by its available physical capital, as well as the human resources, the technologies used in the region, the institutional arrangements, and the possibilities to exchange goods and services with the outside (Goria 2000). Where population density grows, society tends to increase carrying capacity too (Cuffaro 2001). If not, people might react by emigration. Such movements might contribute to a permanently unstable situation, implying a threat to the natural environment and to the people living in it (Chopra & Gulati 1997).

A simplified model to show that changes in population may accelerate LD was presented here (Figure 1), according to the main findings gathered in recent studies on this topic (Rubio & Bochet 1998, Knerr 1998, Goria 2000, Cuffaro 2001, Garcia Latorre et al. 2001, Tanrivermis 2003, Salvati & Zitti 2005). Demographic change and economic development in coastal areas influence urban growth and sprawl, internal migration, and concentration of population in coastal areas, associated with unsuitable exploitation of natural resources. On the other hand, depopulation and ageing of farmers create crisis condition in traditional/marginal rural systems. The consequent land abandonment produces soil and water erosion, especially in steeper areas.

Based on this framework, population dynamics for a 130 year period (1871-2001) were analysed in Latium, central Italy, on a detailed spatial resolution (i.e. municipality level) through a multivariate approach. The aims of this analysis are to assess the importance of migration movements along both elevation (mountain areas *versus* lowlands) and urban-rural gradients (Rome *versus* countryside). Our hypothesis is that such movements create marked environmental impact along coastal areas as well as on more intensified agricultural zones. Therefore we intend to highlight

Figure 1. Demographic factors affecting environmental degradation and possible social consequences.



that LD processes have been more severe in recent years in those areas where demographic dynamics, leading to higher population density, were more evident.

MATERIALS AND METHODS

This study was performed in Latium, central Italy, a region characterised by a complex environmental configuration able to provoke LD, especially because of the dichotomy between the highly populated metropolitan area of Rome and the low-density rural countryside. For further details, see Salvati et al. (2005) and Salvati & Zitti (2005).

Environmental consequences of human pressure were primarily related to population density and demographic variation over time (Salvati et al. 2005). Such data are available each decade at the municipality level from national household censuses (ISTAT 1994). In order to depict human pressure dynamics we obtain for each decade in the period from 1871 to 2001 population density, expressed as inhabitants per square kilometers, and calculated differences of population densities in each decade in the period from 1881 to 2001 (expressed as a percentage). Population data were analysed using four altimetric zones (lowlands, coastal hilly areas, internal hilly areas, mountain) according to ISTAT (1958). Lowland municipalities are characterised by mean elevation ranging from 0 to 100 metres at sea level (a.s.l.), with maximum elevation lower than 300 m. Coastal hilly areas feature a mean elevation ranging between 100 m and 600 m a.s.l. and are close to the sea. Internal hilly areas are characterised by a mean elevation generally ranging between 100 m and 600 m a.s.l. and a distance from the sea higher than 10 km. Mountain municipalities include those with a mean elevation more than 600 m a.s.l.

To obtain a more detailed outlook on population dynamics at a low resolution scale, we subjected population density data to a Principal Component Analysis (PCA). The number of significant axes was chosen

Table 1. Demographic variation (differences in population densities between subsequent decades) in the Latium area municipalities according to altimetric zones (average values).

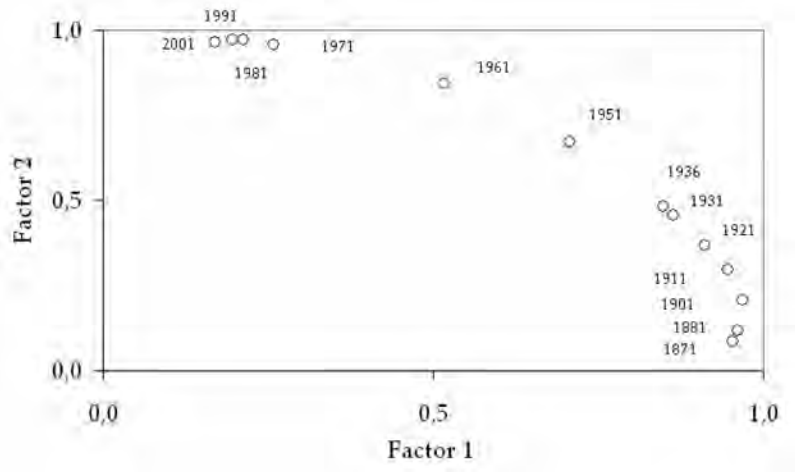
Year	Lowlands	Coastal hilly areas	Internal hilly areas	Mountain areas	Latium
1871-1881	0.24	0.10	0.03	0.01	**0.04**
1881-1901	0.55	0.29	0.23	0.11	**0.21**
1901-1911	0.16	0.10	0.09	0.10	**0.10**
1911-1921	0.17	0.17	0.05	0.03	**0.06**
1921-1931	0.32	0.13	0.05	-0.04	**0.04**
1931-1936	1.78	0.05	0.05	-0.03	**0.10**
1936-1951	0.68	0.21	0.09	-0.01	**0.09**
1951-1961	0.38	0.16	-0.04	-0.15	**-0.04**
1961-1971	0.38	0.12	-0.05	-0.18	**-0.06**
1971-1981	0.21	0.17	0.07	-0.07	**0.04**
1981-1991	0.14	0.16	0.07	-0.01	**0.06**
1991-2001	0.09	0.08	0.04	-0.02	**0.03**
Mean	*0.43*	*0.15*	*0.06*	*-0.02*	***0.06***

based on the scree-plot. Moreover, a non hierarchical cluster analysis (using k-means computation strategy) was performed on population density changes between 1881 and 2001 in regard to spatial patterns, defined by elevation, closeness to the sea, and urban-rural gradient expressed by population density. The results from PCA and cluster analysis are used to produce a spatial evaluation of the municipalities classified in terms of human pressure which may provoke higher vulnerability to LD. Finally, cluster results are compared to a synthetic index of rural land quality measured in the last several years at the same spatial resolution. The Agri-environmental Pressure Index (API) presents a system of agri-environmental indicators especially useful to improve a simplified model of agriculture-environmental sustainability, focusing on human capital, landscape characteristics, farm management, and the impact of agriculture practices on the rural environment (Salvati et al. 2005). Thirty-two indicators were recognised and included in an Environmental Sensitive Area (ESA) procedure able to define the contribution of the agricultural sector to land sensitivity. ESA procedure aggregates the indicators based on a standard weighting system depending on their frequency distribution and the causal link with LD phenomena. A score for each indicator at each municipality studied is obtained. The final index is calculated for each municipality as the geometric mean of the scores of all the indicators collected. Municipalities were classified in different groups according to different land quality based on API figures (for further details, see Salvati et al. 2005).

RESULTS

Demographic dynamics were consistent in the Latium area over the entire study period (Table 1). Population grew from 1,173,065 inhabitants censused in 1871 to 5,112,413 inhabitants censused in 2001, with a mean density increasing from 79.8 inhabitants/km^2 in 1871 to 172.0 inhabitants/km^2 in 2001. On average, population increased more rapidly during 1881-1951. The maximum population increase, averaging 21%,

Figure 2. Factor loading plot of population density in Latium municipalities from 1871 to 2001.



was observed in 1881-1901. Notably, the marked increase observed during 1931-36, especially in the lowlands, was due to consistent internal migration from northern Italy (e.g. the Veneto region) driven by Fascist policy. After a slight decrease observed from 1951 to 1971, population increased again, especially because of high fertility rates and consistent internal migration from southern Italy.

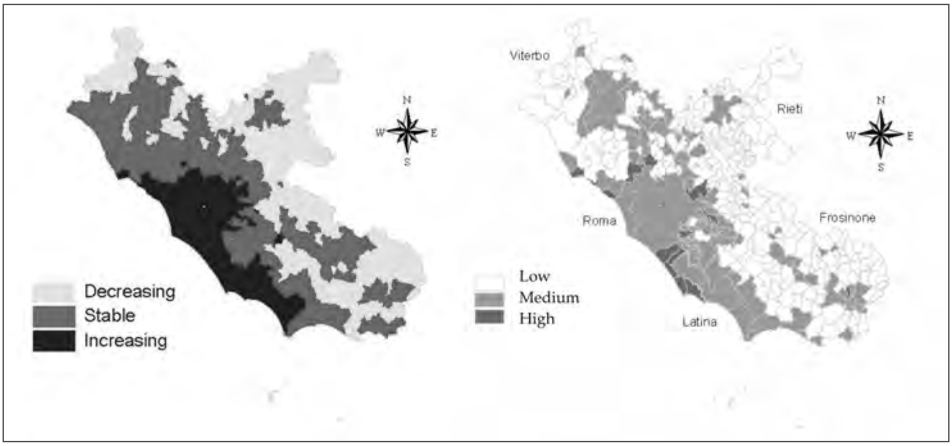
Population increase was observed throughout the entire period both in the lowlands (with an increase averaging 43%) and in hilly areas close to the sea (with an increase averaging 15%). A marked decrease was observed, especially during recent years, both in internal hilly areas and in mountain zones (with a mean decrease averaging 2% during the entire period), suggesting that consistent population movements exist along the elevation gradient.

Preliminary analysis on population density matrix suggested that a multivariate factor analysis could be appropriately applied to such a data-set. In fact, both the Kaiser-Meyer-Olkin measure of sampling adequacy, which tests whether the partial correlations among variables are small (0.85), and Bartlett's test of sphericity, which tests whether the correlation matrix is an identity matrix ($\chi^2 = 2344$, df = 66, $P < 0.0001$), indicate that the factor model is appropriate to analyse these data. We therefore subjected the data-set to PCA, extracting the first two axes which explain 97% of the total variance. The first and second axes accounted respectively for 76% and 21% of the total variance.

The plot of factor loadings on the first two axes (Figure 2) indicated a temporal path running from the late 19th century (positively associated with the first axis and negatively with the second) to the late 20th century (positively associated with the second axis and negatively with the first). Factor loadings on the first two axes therefore illustrate the population increase during the period 1871-2001. Based on the inspections of factor loadings and scores, the first axis was regarded as an urban-rural gradient, whereas the second axis may account for population movements along an elevation gradient running from lowlands to internal mountain zones.

K-means cluster analysis classified the municipalities of Latium into three homogeneous groups, characterised by different demographic dynamics over time (Figure

Figure 3. Maps of the municipalities of Latium classified according to cluster membership (left) and to the Agri-environmental Pressure Index (API) (right).



3, left panel). The first group (labelled as "increasing" communes) includes all the coastal municipalities close to Rome, featuring high population pressure, urban sprawl, and a consistent demographic increase in recent decades (1971-2001). The second group (labelled as "stable") includes many communes both in internal lowland zones and in rural hilly areas, featuring medium population density, demographic increase during the period 1871-1951, and a more stable pattern during the period 1951-2001, low urban sprawl, and a higher rate of agriculture intensification. The third group includes low-density mountain municipalities in the Apennines featuring a demographic increase during the period 1881-1921 and a subsequent, marked decrease since 1931.

The membership of each municipality in k-means cluster groups was associated with the Agri-environmental Pressure Index (API), regarded as a key descriptor of sensitivity to LD (Figure 3, right panel), thus suggesting a strong spatial relationship between population dynamics and land quality at the local scale (Salvati & Zitti 2005). In order to allow a better spatial comparison with the results of cluster analysis, the Latium municipalities were classified into three groups of different sensitivity to rural LD based on API figures.

DISCUSSION

Since the 1990s the relationship between LD and population growth has attracted increasing attention, and has alarmed politicians and scientists alike. High rates of population growth in arid and dry regions whose limits of ecological carrying capacity are obvious suggest the out-migration of part of the population would be a positive solution for the problem (Cuffaro 2001). Population movements which take place in reaction to increasing human impact on a given resource basis might well contribute to a permanently unstable situation, signifying a threat to the natural environment and to the people living in it (Garcia Latorre et al. 2001). The outcome of the interactions depends on the social, political, and economic framework which is set on the international, national, and local level (Goria 2000).

Migration movements which take place in reaction to increasing discrepancies between carrying capacity and population density in regions affected by LD tend to support the way to an equilibrium between both (Knerr 1998). It is essential for policy makers to gain deeper insights into the causes and consequences of migratory movements and about their interrelationship with the process of LD. Without specific knowledge about these issues, serious development policies in regions which are significantly affected by LD are not possible (Garcia Latorre et al. 2001). As these reactions have impact on the social, political, economic, and ecological conditions, their implications must be predicted in order to shape preventive policy measures against undesired consequences, as far as this is possible (Herrmann & Hutchinson 2005). To join in the effort to bring ecological and demographic developments in threatened regions on a path towards a socially accepted equilibrium is the most important element in the policy strategy to combact LD in the Mediterranean basin (e.g. Glenn et al. 1998).

The growth of population density in coastal municipalities, coupled with seasonal tourism concentration and intensification of agriculture, leads to high seasonal water use, land consumption, fire risks, and soil salinisation, all of which accelerate LD. In Latium, the population grew thoughout the entire study period and consistent movements occurred between rural/internal hilly areas and coastal municipalities close to the metropolitan district of Rome (Salvati & Zitti 2005). Multivariate analysis confirms that population movements were based on both an urban-rural gradient and an elevation gradient. Population decreased both in the rural countryside as well as on internal hilly and mountain areas, considered to be marginal zones from an economic point of view (Salvati et al. 2005).

The abandonment of marginal agricultural lands is the consequence of unbalanced population dynamics between internal and coastal areas which had been brought by man to an unstable equilibrium. In many cases, these are lands on sloping terrain which were protected by erosion control structures and practices (Tanrivermis 2003). In Latium, protection ceases and erosion accelerates when they are abandoned (Salvati et al. 2005). Land abandonment started during the 1950s because of industrialisation, increases in the cost of cultivation, decrease in profits, and changes in trade regulation between countries (Thornes & Brandt 1995). On the other hand, population increase in coastal areas has a direct consequence on soil sealing by human expansion into productive lands, which has reached high rates in recent years (Brouwer et al. 1991). Loss of agricultural land, degradation of high-quality soils, increase of fire risk, loss of semi-natural vegetation, as well as local salinisation of groundwater are documented in Latium with a marked relationship between urbanisation and densification phenomena (see Salvati et al. 2005 for a review). For example, unplanned urban expansion has resulted in the lack of even basic services such as water supply in central and southern Italy (Venezian Scarascia et al. 2006).

An integrated evaluation of ecological, demographic, economic, and social aspects of land configuration in order to assess LD should be carried out using a temporal approach, taking into account the structural changes which have occurred during the last century in southern Europe. Using suitable indicators, multivariate approaches like those applied in this study may better reveal the spatial and temporal direction of LD and may delineate the contribution of different factors acting on the environment (Rubio & Bochet 1998). Giving precise spatial information on the level of sensitivity to LD and on variation in its anthropic causes will, we hope, be a sufficient tool to drive political actions able to effectively mitigate degradation processes on a local scale.

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Food habits of a Pool frog *Pelophylax lessonae* – Edible frog *Pelophylax* kl. *esculentus* population from North-Western Romania

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Abstract:

From April to July 2004 we analysed, with the stomach flushing method, the trophic spectrum of 114 adult green frogs (74 *Pelophylax* kl. *esculentus*, 40 *Pelophylax lessonae*) from a habitat near Livada in the north-western part of Romania. We extracted 693 prey items (386 from *Pelophylax* kl. *esculentus* and 307 from *Pelophylax lessone*). Besides invertebrate prey, plant material and the remains of molted skin were identified in the stomach contents. Among the most important prey items consumed by the two green frogs studied are Araneidae, Coleoptera, and Lepidoptera larvae and Hymenoptera Formicidae. The results of our study reveal that there are no significant differences in the feeding habits of the two green frogs, *Pelophylax lessonae* and *Pelophylax* kl. *esculentus,* which share the same habitat.

Key words: feeding, *Pelophylax* kl. *esculentus*, *Pelophylax lessonae,* Romania

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INTRODUCTION

Two species from the green frog group, *Pelophylax lessonae* (Camerano 1978) and *Pelophylax ridibundus* (Pallas 1771), and the hybrid form between them, *Pelophylax* kl. *esculentus* (Linnaeus 1758), inhabit Romania. The validity of the species *Pelophylax lessonae* and the hybridogenic status of the *Pelophylax* kl. *esculentus* form were proven only during the 1970s (Berger 1973, Tunner 1973, Uzzell & Berger 1975). Most recent studies make no distinction between the three forms, treating them together under the *Pelophylax esculentus* complex (*Rana esculenta* complex) designation.

Data about the trophic spectrum of green frogs in the *Pelophylax esculentus* complex were collected both by foreign researchers and researchers from Romania. Studies which refer to the feeding of one of the three forms of the green frog complex were performed on the species *Pelophylax ridibundus* (Cicek & Mermer 2006, and in Romania by Covaciu-Marcov et al. 2000). Concerning studies of mixed populations of green frogs, in most research on feeding spectrum there is no distinction between the three forms, and they are treated altogether as *Pelophylax esculentus* complex (Török & Csörgő 1992, Lőw & Török 1998; and in Romania: Cogălniceanu et al. 2000a, Ghiurcă & Zaharia 2006). Only a single paper can be found in the specialty literature that refers to the feeding of the species *Pelophylax lessonae*, a study performed in the Reci region (Romania) which compares the feeding habits of the pool frog and the moor frog (Sas et al. 2005).

Our study was done on a mixed population of green frogs from the north-western part of Romania in order to discover if there are differences between the feeding habits of the *Pelophylax lessonae* species and the hybrid *Pelophylax* kl. *esculentus,* which share the same habitat.

MATERIALS AND METHODS

Samples were taken from a habitat near Livada (47°52′0″ N, 23°8′0″ E, a.s.l. 146 m) in the north-western part of Romania. Populations of *Pelophylax lessonae* and *Pelophylax* kl. *esculentus* were recently identified in this region (Covaciu-Marcov et al. 2004). The habitat studied is comprised of a swamp lying in a damp area of an oak forest; throughout much of the year it has a high water level but it dries up during summer (in the current study, June). Rich grassy vegetation, shrubs, and bushes surround the swamp.

A total of 114 adult green frogs were collected and analyzed from April to July, 2004. Although the R-E-L system can be found in the area studied (Covaciu-Marcov 2004), we captured only a small number of *Pelophylax ridibundus*, so this species was not included in the study. From the total number of adult frogs, 74 were *Pelophylax* kl. *esculentus* and the remaining 40 were *Pelophylax lessonae*. Because we collected only a small number of males of both green frogs, we did not treat the sexes separately. The studied samples were measured according to their morphological, chromatic and biometrical attributes, using the methods and data indicated in the literature (Berger 1973, Wijnands & van Galder 1976, Cogălniceanu & Tesio 1993, Cogălniceanu et al. 2000b).

Stomach contents were collected using the stomach flushing method (Joly 1987) and kept in separate airtight test tubes containing a 4% solution of formaldehyde. Prey were subsequently identified in the laboratory under a binocular microscope. Food composition was evaluated by percentage abundance (%A) and frequency of occurrence (%f). The Chi-square test was used in order to determine month-by-month differences in the frequency of occurrence of certain prey types among samples of the same species. The Kruskal-Wallis test was applied for comparison of the data sets, particularly for *Pelophylax* kl.

Table 1. The number of prey items and the prey percentage (%A) of the most important prey categories (esc – *P.* kl. *esculentus*, less – *P. lessonae,* l - larvae). Number of frogs sampled is shown in parentheses.

	IV.	V.		VI.		VII.
	esc	*esc*	*less*	*esc*	*less*	*less*
	(21)	(31)	(10)	(22)	(14)	(16)
No of prey	196	127	54	63	72	181
Mean	9.33	4.29	5.5	3.86	5.21	11.68
Range	1 - 19	1 - 17	1 - 11	1 - 9	1 - 15	1 - 92
Prey percentage (%A):						
Gastropoda	4.5	6.3	1.8	3.1	-	0.5
Araneida	29.1	16.5	16.6	17.5	8.3	6.6
Isopoda	5.1	3.1	-	1.5	1.3	1.6
Miryapoda	2.5	0.7	-	7.9	-	1.1
Heteroptera	2.0	3.1	1.8	-	-	5.5
Coleoptera [l]	5.1	7.8	3.7	6.3	1.3	0.5
Coleoptera	25.0	25.2	40.7	23.8	25.0	11.6
Lepidoptera [l]	2.5	11.0	12.9	14.3	4.1	3.3
Nematocera [l]	-	-	-	-	5.5	49.7
Nematocera	1.0	3.9	-	11.1	5.5	0.5
Brahycera [l]	-	1.5	5.5	-	-	-
Brahycera	1.5	5.5	-	-	27.7	-
Hymenoptera	12.8	10.2	11.1	6.3	9.7	17.1
Others	8.6	4.7	5.5	7.9	11.1	1.6

esculentus and for *Pelophylax lessonae* (Zar 1999). The Mann-Whitney U-test was used to compare *esculentus* - *lessonae* feeding differences in certain sampling events. All analyses were made and evaluated with a 95% confidence interval (Zar 1999). The temporal dependent diet diversity was estimated with the Shannon-Wiener (1949) diversity index (*H*).

RESULTS

In April-July, 2004, we analysed the trophic spectrum of 114 green frogs (74 *Pelophylax* kl. *esculentus*, 40 *Pelophylax lessonae*). The samples of *Pelophylax lessonae* and *Pelophylax* kl. *esculentus* were captured in three periods, with two differences: in April we found only *Pelophylax* kl. *Esculentus,* and in July after the swamp dried up, only *Pelophylax lessonae*. We extracted a total of 693 prey items (386 from *Pelophylax* kl. *esculentus* and 307 from *Pelophylax lessonae*) (Table 1). Besides invertebrate prey, plant material and the remains of molted skin were identified in the stomach contents (tab. 2). Regarding feeding intensity, we did not find any *Pelophylax lessonae* samples with empty stomachs, and only 3 samples of *Pelophylax* kl. *esculentus* had empty stomachs during this study ($\chi^2_2 = 15.6$, $P > 0.05$). Remains of molted skin were identified only in the samples of *Pelophylax* kl. *esculentus* ($\chi^2_2 = 2.65$, $P > 0.05$). There were significant differences ($P < 0.01$) in the occurrence of plant materials for both green frogs.

The prey items were determined as belonging to 39 categories, from which 34 were present in the stomachs of *Pelophylax* kl. *esculentus* and 27 in those of the *Pelophylax lessonae*. Tables 1 and 2 show only the most important ones. Categories with very small proportions are labelled as "Others". Most of the consumed prey are found in the terrestrial environment. An important fact is that *Pelophylax lessonae*, in the last sampling event, consumed a high amount of aquatic prey (July % A = 48.12);

Table 2. The frequency of occurrence (%f) of empty stomachs, stomachs with vegetal debris, shed-skin and animal content (esc – *P.* kl. *esculentus*, less – *P. lessonae*, l - larvae; chi^2: n.s.-difference not significant, $P > 0.05$; Significant differences:* - $P < 0.05$, ** - $P < 0.01$). Number of frog sampled is shown in parentheses.

	IV.	V.		VI.		VII.	x^2 (d.f.=3)	
	esc (21)	*esc* (31)	*less* (10)	*esc* (22)	*less* (14)	*less* (16)	*esc*	*less*
Occurrence of empty stomachs:	-	3.2	-	9.0	-	-	15.6$^{n.s}$	-
Occurrence: vegetation	85.7	58.0	90.0	81.8	100	68.7	1.64**	0.89**
Occurrence: shed-skin	4.76	-	-	9.0	-	-	2.65$^{n.s.}$	
Occurrence of animal contents:								
Gastropoda	28.5	16.1	10	9.0	-	6.2	2.38*	1.25$^{n.s.}$
Araneida	90.4	32.2	50	45.4	35.7	56.2	8.36*	0.68**
Isopoda	38.1	9.6	-	4.5	7.1	12.5	8.86$^{n.s.}$	1.28$^{n.s.}$
Miryapoda	14.2	3.2	-	9.0	-	6.2	1.92$^{n.s.}$	1.5$^{n.s.}$
Heteroptera	19.0	9.6	10	-	-	31.2	4.12$^{n.s.}$	5.08$^{n.s.}$
Coleoptera [l]	23.8	25.8	20	9.09	7.1	6.2	1.95*	1.33$^{n.s.}$
Coleoptera	80.9	45.1	60	40.9	71.4	68.7	3.96*	0.11**
Lepidoptera [l]	23.8	29.0	20	22.7	14.2	18.7	0.23**	0.13**
Nematocera [l]	-	-	-	0	7.1	6.2		0.67$^{n.s.}$
Nematocera	9.5	12.9	-	22.7	21.4	6.2	1.39*	3.05$^{n.s.}$
Brahycera [l]	-	3.2	20	-	-	-	1.38$^{n.s.}$	6$^{n.s.}$
Brahycera	14.2	19.3	-	-	21.4	-	4.07$^{n.s.}$	5.57$^{n.s.}$
Hymenoptera	52.3	29.0	30	18.1	28.5	56.2	4.06*	1.76*
Others	57.1	19.3	30	13.6	42.8	18.7	8.69$^{n.s.}$	1.44*

thus there were significant differences in the consumption of aquatic prey items between the two green frogs (*F-ratio variances*, $P < 0.05$). We identified among the aquatic prey Gastropoda, Isopoda, larvae and adults of Coleoptera (belonging to the Dityscidae family), Nematocera larvae, and tadpoles of green frogs.

Among the most important prey items consumed by the two green frogs studied by us are Araneida, Coleoptera, Lepidoptera larvae, and Hymenoptera (all belonging to the Formicidae family) (Table 1, 2). Beetles belonging to 5 families were identified: Carabidae, Cantaridae, Stafilinidae, Elateridae, and the most important, Curculionidae. All the Hymenoptera were members of the Formicidae family. Besides these, certain prey items are more important in some of the collecting periods. Thus, in the case of *Pelophylax lessonae*, there was significant variation in the following prey categories (Table 2): Araneida, Coleoptera adults, Lepidoptera larvae (with $P < 0.05$), and Hymenoptera Formicidae (with $P < 0.01$). For *Pelophylax* kl. *esculentus,* the p rey items with significant variations during the study are Gasteropoda, Araneida, Coleoptera larvae and Coleoptera adults, Nematocera and Hymenoptera Formicidae (with $P < 0.05$), and Lepidoptera larvae (with $P < 0.01$). However, the global changes in the consumption of prey types during the study are not significant for *Pelophylax lessonae* (Kruskal-Wallis-test $H = 0.03$, $P > 0.05$) nor for *Pelophylax* kl. *esculentus* (Kruskal-Wallis-test $H = 4.68$, $P > 0.05$). As for the differences in a certain month between the two green frogs, we found them not significant (May: U-test, $P > 0.05$, June: U-test, $P > 0.05$). The fact that we did not obtain significant global variations in seasonal level changes of the two green frogs or at the level of the differences between the two forms in the same period (May and June) indicates the use of similar feeding resources by the two green frogs.

The recorded feeding diversity (Shannon-Wiener *H*) was high for both of the studied green frogs (Figure 1). Only in July did *Pelophylax lessonae* present a low diet diversity (H=1.73). Seasonal changes in the diet diversity of *Pelophylax lessonae* ($H_{mean} = 2.12$, SD = 0.36, SE = 0.21) and *Pelophylax* kl. *esculentus* ($H_{mean} = 2.54$, SD = 0.06, SE = 0.03) did not show significant variations ($t = -1.31$, $P > 0.05$).

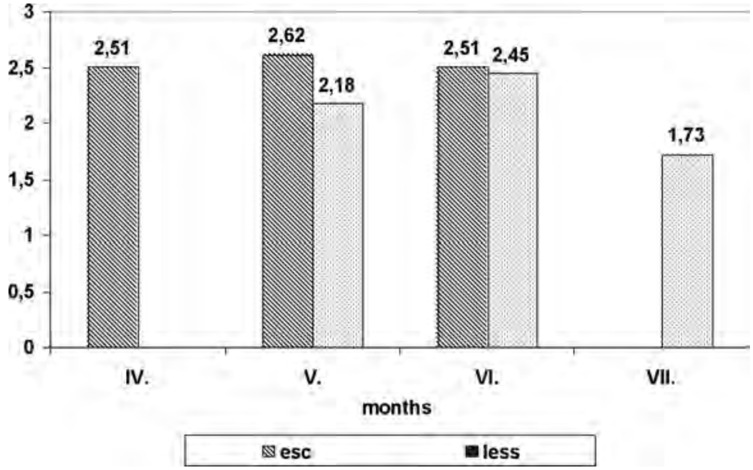
DISCUSSION

The results of our study reveal that there are no significant differences in the feeding of the two green frogs, *Pelophylax lessonae* and *Pelophylax* kl. *esculentus,* which share the same habitat. On the other hand, seasonal changes in feeding can be observed in both forms of green frogs. In the stomach contents of *Pelophylax lessonae* and *Pelophylax* kl. *esculentus*, we identified plant materials with a relatively high occurrence. The presence of fragments of vegetation in the stomachs may be considered to be caused by accidental intake together with animal prey. Shed skins were found only in the stomach contents of *Pelophylax* kl. *esculentus*. The low number of empty stomachs, considering the whole period studied, shows that there were optimal feeding conditions for the frogs' survival.

The differences observed during the study are caused by some ecological variations between the two green frogs *Pelophylax lessonae* and *Pelophylax* kl. *esculentus*. In the first instance, the fact that in April we captured *Pelophylax* kl. *esculentus* exclusively is a result of differences in the time when the two green frogs come out of hibernation. The *Pelophylax lessonae* species hibernates overland and leaves its winter shelter in late spring (Rybacki & Berger 1994). On the other hand, it is believed that the *Pelophylax* kl. *esculentus* hybrid, being able to hibernate both on land and in water, prefers hibernation in the aquatic environment (Lutschinger 1988) and leaves it earlier (Holenweg & Reyer 2000). These aspects concerning the return to activity of the green frogs after hibernation fit with our observations in the field, respecting the first sampling event for both forms (April – *Pelophylax* kl. *esculentus*, May – *Pelophylax lessonae*). This situation also seems to be influenced by the sexual activity of these forms, an activity that begins earlier in *Pelophylax* kl. *esculentus* than in *Pelophylax lessonae* (Heym 1974). Pairs of *Pelophylax* kl. *esculentus* in amplexus can be observed from April on, while the breeding period of the *Pelophylax lessonae* species in the north-western part of Romania begins in May (Covaciu-Marcov 2004). The fact that in July we encountered only samples of *Pelophylax lessonae* is caused by the drying up of the swamp studied (the very small number of *Pelophylax* kl. *esculentus* captured in this month was not included in the study). According to the specialty literature, *Pelophylax* kl. *esculentus* is much more attached to the aquatic environment than *Pelophylax lessonae* (Cogalniceanu et al. 2000b). The significant differences ($P < 0.05$ and $P < 0.01$) concerning the consumption of some prey items during the study are caused by seasonal changes of the prey type in question (see in: Lőw et al. 1990, Kovács & Török, 1995, Covaciu-Marcov et al. 2000).

Because *Pelophylax* kl. *esculentus* is a more aquatic form than *Pelophylax lessonae,* it is

Figure 1. Changes in diet diversity - Shannon-Wiener H (esc – *P. kl. esculentus*, less – *P. lessonae)*



reasonable to expect that the hybrid should forage mainly in the aquatic environment. Our data show a significant difference concerning the consumption of aquatic prey by *Pelophylax lessonae* and *Pelophylax* kl. *esculentus*. However, this significant variation is apparently determined by the consumption of a large number of Nematocera larvae by a single specimen of *Pelophylax lessonae* in July (92 samples, %A=49.72). Although the larvae of Nematocera seem to be numerically important, they are not significant according to their occurrence in this month (%f=6.25). A similar situation of the presence in high percentage of aquatic prey in the stomach contents of *Pelophylax lessonae* was observed by Sas and collaborators (2005) in a population from Reci (Romania), where the pool frog had fed on aquatic prey in %A=15.21. Similarly, in other amphibian species that are bound to the terrestrial environment, the consumption of some prey proceeding from the aquatic environment was noticeable (e.g. *Rana dalmatina* – Aszalós et al. 2005, *Bufo viridis* – Covaciu-Marcov et al. 2005). The fact that the *Pelophylax* kl. *esculentus* hybrid forages mainly on land was reported by other researchers as well (Lőw et al. 1990, Török & Csörgő 1992, Lőw & Török 1998). On the other hand, Cogălniceanu and collaborators (2000a) identified several aquatic prey, such as Crustacea (Amphipoda, Decapoda), Lamellibranchiata, Heteroptera and fish, in the stomach contents of *Pelophylax* kl. *esculentus*.

Similarly to our results, some Hungarian authors found a wide range of prey in the diet of *Pelophylax* kl. *esculentus* (Török & Csörgő 1992, Kovács & Török 1996). The species in the *Pelophylax esculentus* complex have a large range of body sizes, continuous activity, and use habitats of high diversity, and these factors lead to the large variety of the prey captured by them (Cogălniceanu et al., 2000a). The fact that *Pelophylax* kl. *esculentus* feeds on a larger variety of prey and presents a higher diet diversity (*H*) than *Pelophylax lessonae* might be caused by the plasticity and higher ecological adaptability of the hybrid form with respect to the parental species, showing no obvious ecological gradient (Berger 1973).

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A case of efficient long term sperm storage in Smooth snake *Coronella austriaca*

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The ability of females to perform sperm storage is present in all vertebrate groups with internal fertilization. Through sperm storage, females store sperm in their reproductive tracts following copulation but before using it to fertilize their eggs (reviewed by Birkhead & Mollar 1993). Evidence shows that females are able to store and efficiently use the sperm of different males to increase the genetic variability of their offspring (multiple paternity) through sperm competition (Schuett 1992, Birkhead & Mollar 1993, Gist & Fischer 1993). The risk of predation may also be reduced by sperm storage through reduction of the frequency of copulation (Conner & Crews 1980). When the species suffers from low population densities, or in the case of slow moving reptiles, it offers insurance against not finding a partner (Philip 1979, Conner & Crews 1980, Saint- Girons 1982, Birkhead & Mollar 1993).

Recent studies have indicated that parthenogenesis also appears sporadically in reptile species that normally reproduce sexually (Schuett et al 1997, 1998, Groot et al 2003, Watts et al 2006). In the cases described in these articles, the reptile offspring were either all male or all female.

The Smooth snake *Coronella austriaca* is an ovoviviparous species wide spread in Europe (Fuhn & Vancea 1961). Data regarding sperm storage in this species has been published in only two publications (Rollinat 1946; Birkhead & Mollar 1993); the latter, being a review, presents only the data contained in the first one. Here I report an unusually long period of sperm storage in *Coronella austriaca*.

On May 17th, 2005, an adult female *Coronella austriaca* (SVL = 50cm) was found near the city of Iasi (Iasi County, Romania) and taken into captivity. The snake was kept isolated in a 50 x 40 x 40 cm terrarium throughout its captive period. On August 26th, 2005, the female deposited four undeveloped or infertile eggs. During the following winter, the snake was not bromated, being kept at normal summer temperatures and fed small mice. During late spring and early summer, 2006, the specimen started to refuse food and started gaining weight. Then, on September 3rd, 2006, the female gave birth to six fully developed and perfectly healthy neonates, two males and four females.

The fact that parthenogenesis has never been reported in *Coronella austriaca* and the fact that both male and female offspring were delivered by this particular captive female exclude the possibility that the phenomena that took place was parthenogenesis and not a case of long term sperm storage.

According to the review published by Birkhead & Mollar (1993), the duration of sperm storage in different snake species varies from 90 (*Thamnophis sirtalis*; Rahn 1940, Halpert et al. 1982) to 2555 days (*Achrocordus javanicus*; Magnusson 1979). The same review (Birkhead & Mollar 1993) indicates the maximum reported period for sperm storage duration in *Coronella austriaca* as being 150 days. The data presented in the present note indicates a minimum temporal distance of 475 days between the earliest possible copulation (before May 17th, 2005) and the date on which the snake gave birth (September 3rd, 2006). To my knowledge, this is the longest recorded duration for sperm storage in *Coronella austriaca*.

The Smooth snake is a rare species in eastern Romania, represented by small and localized populations (Fuhn & Vancea 1961, Strugariu et al. 2006, Covaciu-Marcov et al. 2006). Therefore, it is safe to assume that sperm stored from a copulation that took place during a previous year could be used by females to fertilize their eggs in a season in which they do not encounter a partner. Energy reserves also are an important determinant of the reproductive potential of female Smooth Snakes (Reading 2004). Thus, if the female snake does not have the necessary energy reserves to sustain gestation immediately after copulation, sperm storage could offer the animal the possibility to fertilize its eggs after a longer period of time, when energy reserves are sufficient.

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Nove knjige / Book reviews

Jerzak, L., Kavanagh, B.P. & Tryjanowski, P. eds. 2005: **Ptaki krukowate Polski. Corvids of Poland**. Bogucki Wydawnictwo Naukowe. Poznan. ISBN 83-89290-92-8. 679 pages, Hard cover.

The book is a huge monograph of the corvids found in Poland. Eight species breed in Poland (*Garrulus glandarius, Pica pica, Nucifraga caryocatactes, Corvus monedula, Corvus frugilegus, Corvus cornix, Corvus corone* and *Corvus corax*) and two more are just visitors (*Perisoreus infaustus* and *Pyrrhocorax graculus*). The present book deal with seven breeding species (*C. corone* is not included, probably due previous status of subspecies).

The book consists of 52 articles which vary according to their length, topics and quality. The monograph starts, after the editors' introduction, with fossil corvids in Poland. Here we learn that bony corvid fossils are the most numerous among passerines in Poland and that *P. pyrrhocorax* also lived in the region where Poland is situated today. After this introduction to the history of corvids in Poland, there are seven papers with a general overview of species which breed in Poland. We found these articles very interesting and useful despite the fact that they are focused on only one country and mostly use just Polish references. The next five papers are much more specific, presenting parasitological problems and physiological and chemical studies done on corvids. In our opinion, these papers should be at the end of the book, perhaps even in a separate chapter, since they deal with very narrow and specific problems. Some other papers which follow deal with local problems of single species, such as Rook colonies and corvid communities in particular regions or towns during breeding or winter time. Among these we paid special attention to articles of corvid abundance and the breeding success of urban populations of *Turdus merula*, occurrence of Jays in managed forests, migration and wintering of the Rook, and those about Raven ecology. The last one especially deals with many details and new data not found elsewhere.

The articles in the monograph are mostly in Polish, but we found eleven articles in English. Those articles written in Polish all have English abstracts; also, all legends of Tables and Figures have English descriptions, which are easily understandable to non-Polish speaking people.

We recommend the book to everyone who is interested in birds, not just those who study corvids. The book contains a huge amount of data, very useful reviews, and many references which could help in further work.

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In memmoriam / V spomin

Jože Svetličič, 1942-2007

Meseca aprila nas je nenadoma zapustil Jože, med prijatelji poznan kot Svetilko. Novica je prišla povsem nepričakovano, saj Jože ni bil bolan. O tem pričajo tudi številne njegove ideje in projekti, ki jih je izvajal sam ali s prijatelji, za svojo dušo seveda. Pri marsikaterem sem sodeloval tudi sam zato vem s kakšno voljo in entuziazmom se jih je loteval. Nedokončani so ostali številni projekti, še več idej ter ponovna odprava v Skandinavijo, ki mu je postala tako rekoč drugi dom, čeprav sem prepričan, da mu je v duši bila na prvem mestu.

Svetilko se ni imel za ornitologa, prej za ekologa, kar je vedno tudi poudarjal, ko je kakšen pogovor nanesel v to smer. Čeprav bi lahko s svojim znanjem bil mirne duše ornitolog, saj je določene vrste poznal res do obisti. Njegove najljubše vrste so bile sove, predvsem gozdne vrste kot so kozača, mali skovik in koconogi čuk, triprsti detel, planinski orel, sokol selec in seveda gozdne kure z divjim petelinom na čelu. Vemo, da je raziskoval in o tem tudi poročal, recimo malega skovika in kozačo. Manj pa je poznano, da se je zelo intenzivno ukvarjal tudi s planinskim orlom, predvsem njegovim obnašanjem in ekologijo, podobno velja za sokola selca katerega je prvi odkril na gnezditvi v Savinjski dolini kar velja tudi za kozačo v Savinjskih Alpah ter da je proučeval divje peteline katere je znal med sabo ločiti tudi po vzorcu na repnih peresih. Veliko je pomagal tudi ostalim, bodisi s podatki, bodisi s konkretnim materialom, recimo nabranimi izbljuvki.

Že bežen pogled na zgornji spisek vrst pove, da je Svetilko bil gorski in gozdni človek. Ta njegov hobi je lepo sovpadal z gozdarsko službo, kjer je zagotovo naredil veliko koristi saj je poznal ključne vrste, na katere lahko vplivamo s primernim načrtovanjem posegov v gozd. Seveda vedno ni šlo tako kot bi si želel, kar je tudi jasno in glasno izražal. Njemu, poznavalcu, je seveda bilo vse jasno, le kako v to prepričati birokrate?

Jože ni bil pisec, na žalost. Na začetku najinega poznanstva ni bil niti marljiv pri terenskih zapiskih. Vse podatke je nosil v glavi. Odlično je poznal njemu tako ljube Kamniško Savinjske Alpe, kjer je vedel za vsak par kozače, rastišča ruševcev in divjih petelinov, poznal ovinek na katerem bo skoraj sigurno preplašil gozdnega jereba, vedel iz glave gostote belk na Raduhi po letih in še bi lahko našteval. Na moje prigovarjanje se je pričel spreminjati, vedno bolj vestno je opažanja tudi beležil ter se nekajkrat opogumil, ter nekaj svojih rezultatov tudi objavil, tudi v reviji Biota.

Svetilko je bil tudi fotograf. Kdo ve koliko metrov filmov je »pokuril« čepeč v snegu, vodi, blatu, ko je čakal ruševca, divjega petelina, planinskega orla, kozačo, triprstega detla, povodnega kosa… Njegova fotografija divjega petelina krasi tudi ovitek CD Gozdne ptice Slovenije, ki ga je izdal Prirodoslovni muzej Slovenije. Zadnje leto se je fotografsko povsem prebudil, razlog je bil prehod na digitalni aparat. Kolikor ur, ne, dni je preždel v naravi v zadnji sezoni je vedel samo on.

Tudi sicer je bil Jože terenski človek, ki ni maral formalnosti in zapetih gumbov. Najbolje se je počutil kje v gozdu, najraje sam ali v družbi katerega prijatelja.

Svetilko, upam, da tudi sedaj počivaš v svojem gozdu, bodisi Savinjskem ali Skandinavskem, oba sta ti bila domača.

Milan Vogrin

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Milan Vogrin

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Photo: Milan Vogrin

Smokulja *Coronella austriaca*
Smooth snake *Coronella austriaca* (see p. 79)

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Severni kovaček *Phylloscopus trochilus*
Willow warbler *Phylloscopus trochilus* (see p. 35)

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