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CONTENTS

A NEW *CHORIZOPES* O.P. – CAMBRIDGE, 1870 (ARANEAE: ARANEIDAE) FROM WEST BENGAL, INDIA

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Chorizopes quadrituberculata sp. nov. recorded both from tea estates and protected areas of Dooars, West Bengal, India is described and illustrated.

Key words: *Chorizopes quadrituberculata* sp. nov, Araneae, Araneidae, tea estates, protected areas, Dooars, West Bengal, India.

INTRODUCTION

Typical orb weavers (Araneidae) are globally represented by 3045 species with 169 genera (Platnick, 2014). These include 163 Indian species belonging to 28 genera (Keswani *et al*., 2012).

Nine out of the 24 species are known to comprise the genus *Chorizopes* O. P. – Cambridge, 1870 of India (O. P. – Cambridge, 1885; Simon, 1895; Tikader, 1965; Sadana & Kaur, 1974; Reddy & Patel, 1993; Gajbe & Gajbe, 2004; Siliwal *et al*., 2005).

During our sustained survey on spiders from the tea ecosystem and reserve forests of Dooars, West Bengal we found a *Chorizopes* species, collected from Nepuchapur tea estate, Dalgaon tea estate, Kurti tea estate, Mahananda Wildlife Sanctuary, and Gorumara National Park. After critical examination, this species is considered as new to science and accordingly described and illustrated.

MATERIAL AND METHODS

Materials were mainly collected by visual search and hand picking from the tea bushes of the referred tea estates and adjoining reserve forests of Dooars respectively. Collected samples were preserved following Tikader (1987) and Barrion & Litsinger (1995) and studied under Stereo Zoom Binocular Microscopes, model Olympus SZX-7 and Zeiss SV-11. The measurements indicated in the text are in millimeters (mm), made with an eye piece graticule. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus).

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Abbreviations: AL = abdominal length; ALE = anterior lateral eye; AME = anterior median eye; AW = abdominal width; CL = cephalothoracic length; CW = cephalothoracic width; PLE = posterior lateral eye; PME = posterior median eye; TL = total length; NTE = Nepuchapur tea estate; KUTE = Kurti tea estate; DTE = Dalgaon tea estate; MWLS = Mahananda Wildlife Sanctuary; GNP = Gorumara National Park.

TAXONOMY

Family Araneidae Clerck, 1757

Subfamily Araneinae

Genus *Chorizopes* O. P.-Cambridge, 1870

Chorizopes quadrituberculata sp. nov.

(Figs. 1–11 & 12–13)

Type Material

Holotype: 1♀, NTE, Dooars, 01.XI.2010, coll. T.K. Roy.
Allotype: 1♂, KUTE, Dooars, 23.VII.2008, coll. T.K. Roy.
Paratype: 2♀♀, Kalijhora, MWLS, 11.IX.2007, coll. D. Raychaudhuri; 2♀♀, Sevok, MWLS, 19.X.2008, coll. S. Saha; 4♀♀, Dhupjhora, GNP, 03.V.2008, coll. S. Sen; 1♀, Dhupjhora, GNP, 12.II.2009, coll. S. Sen; 1♂, KUTE, Dooars, 23.VII.2008, coll. T. K. Roy; 1♂, KUTE, Dooars, 27.VIII.2010, coll. T.K. Roy; 1♂, DTE, Dooars, 23.VIII.2010, coll. D. Raychaudhuri.

Description

Female (*Holotyp*e)

Cephalothorax (Fig. 1) brown, sub rectangular, cephalic region raised, anteriorly produced, parallel sided, medially with a longitudinal shallow depression from posteromedian eye up to the middle, cervical furrows well marked by brown; thoracic region round, much darker, posteriorly depressed gradually, fovea dark, V shaped, radii distinct.

Eyes 8, homogeneous, pearly white, basally ringed with black, arranged in 2 recurved rows as viewed dorsally, anterior row strongly so; ocular quad set on a black tubercle, weakly wider than long, anteriorly narrower than behind, postero-medians largest, anteromedians on the slope, laterals contiguous, eye diameter: PME > PLE > AME ≥ ALE; interocular distances: AME – AME = 0.17; ALE – AME = 0.23; ALE – ALE = 0.57; PME – PME = 0.19; PLE – PME = 0.21; PLE – PLE = 0.58; ALE – PLE = 0.08; AME – PME = 0.11.

Clypeus yellow brown, broad, clypeal angles obtusely produced, margins with few small, dark brown hairs.

Chelicerae (Fig. 2) pale brown, moderate, more or less parallel, promargin with 4 and retromargin with 2 teeth, fang dark brown, curve, sharp and stout.

Labium (Fig. 3) more than twice wider than long, basally dark brown, constricted sub basally, apically pale, broad, triangular and scopulate. Maxillae (Fig. 3) brown, distinctly longer than wide, basally constricted, apically weakly bulged, pale and scopulate.

Sternum (Fig. 3) cordate, reddish brown, margins darker, outer lateral margins with blunt, triangular projections at each coxae, apical margins concave, tip projected between coxae IV, bluntly round. Legs pale brown, long, stout, usually clothed with pale brown hairs, tarsal claw 3 with 2 superior and 1 inferior, claws not pectinated, leg measurements I 3.71 (1.21, 0.43, 1.00, 0.64, 0.43); II 3.22 (1.14, 0.29, 0.79, 0.71, 0.29); III 2.51 (0.86, 0.29, 0.50, 0.50, 0.36); IV 3.78 (1.21, 0.36, 1.00, 0.71, 0.50). Leg formula: 4123.

Abdomen (Fig. 1) brown, sub rectangular, coarsely punctate, finer at apex, each marked by small, brown hairs, anteriorly overhanging the cephalothorax, posteriorly abruptly slopped beyond the black, posterior paired lateral tubercles. Dorsum further with a pair of black lateral tubercles at the widest region, posterior pair distinctly higher, projected outwardly; a creamy white mid longitudinal patch extending up to the posterior humps, laterally flanked with 3 pairs of distinct, brown sigillae, apical 2 pairs larger. Venter brown, mid longitudinally with a broad, chocolate brown band with 3 pairs of brown sigillae: 1st below the epigastric furrow, 2nd little above the middle and the last little before the apex, extending from epigastric furrow to spinnerets; laterally with brownish black corrugations.

Epigynum – Internal genitalia (Figs. 4–5): Epigynum semi lunar, spermatheca kidney shaped.

Male (*Allotype*)

Cephalothorax (Fig. 6) blackish brown, cervical furrows well marked, but not brown; thoracic region round, posteriorly depressed abruptly, fovea indistinct. Ocular quad nearly square, set on a tubercle, posteriorly weakly narrower than front, medians subequal, eye diameter: AME ≥ PME> ALE≥ PLE; interocular distances: AME – AME = 0.13; ALE – AME = 0.30; ALE – ALE = 0.49; PME – PME = 0.11; PLE – PME = 0.26; PLE – PLE = 0.51; ALE – PLE = 0.06; AME – PME = 0.13.

Clypeus narrow.

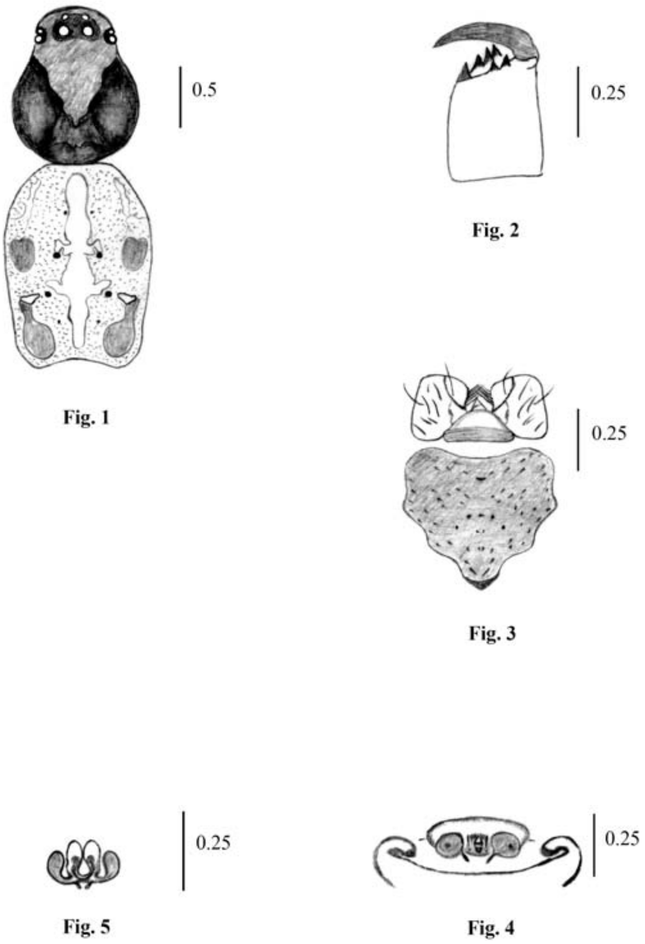
Chelicerae (Fig. 7) small, each margin with 3 teeth, fang pale brown.

Labium (Fig. 8) less than twice wider than long. Maxillae (Fig. 8) apically weakly bulged.

Sternum (Fig. 8) dark brown, outer lateral margins with pointed projections at each coxae, apical margins nearly straight, tip projected between coxae IV, blunt but not round. Leg measurements I 1.53 (0.45, 0.23, 0.38, 0.28, 0.19); II 1.42 (0.34, 0.25, 0.32, 0.28, 0.23); III 0.96 (0.36, 0.13, 0.15, 0.15, 0.17); IV 1.58 (0.60, 0.17, 0.26, 0.32, 0.23). Leg formula: 4123.

Abdomen (Fig. 6) pale brown with blackish brown tubercles. Each of anterior tubercles with 5 lateral, brown sigillae. Dorsum with a off white patch, postero-medially with 3 pairs of distinct, brown sigillae; both anterior and posterior margins truncate, the latter broader. Venter brown, coarsely punctate in front of spinnerets, laterally corrugated with punctations. Otherwise similar to the holotype.

Palp (Figs. 9–11) short, cymbium basally broad, apically prolonged, blunt, RTA short spiny, embolus sharply pointed.



Figs. 1–5. *Chorizopes quadrituberculata* sp. nov. (Female) 1. Dorsal habitus; 2. Chelicerae (ventral view); 3. Maxillae, labium and sternum (ventral view); 4. Epigynum (ventral view); 5. Internal genitalia (dorsal view).

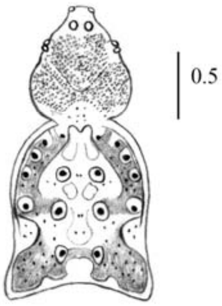


Fig. 6

Fig. 7

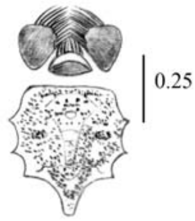


Fig. 8

Fig. 9

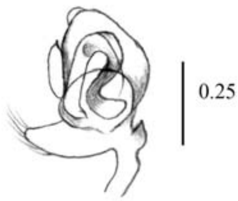


Fig. 10

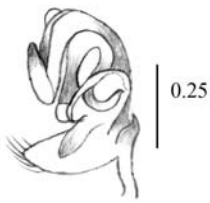


Fig. 11

Figs. 6–11. *Chorizopes quadrituberculata* sp. nov. (Male) 6. Dorsal habitus; 7. Chelicerae (ventral view); 8. Maxillae, labium and sternum (ventral view); 9. Male palp (prolateral view); 10. Male palp (ventral view); 11. Male palp (retrolateral view).

Figs. 12–13. *Chorizopes quadrituberculata* sp. nov.
12. General habitus of female; 13. General habitus of male.

Distribution. India: West Bengal. The species is so far known from the type locality.

Etymology. The specific epithet is derived from abdominal tubercles.

Type deposition. Entomology Laboratory, Department of Zoology, University of Calcutta, registration no. EZC 0032 - 14.

Remarks. The closest ally of the species is *Chorizopes anjanes* Tikader, but can be separated by: i) cephalothorax basally broad, apically narrowed (cephalothorax basally narrowed, anteromedially broadest and roundish anteriorly in *C. anjanes*); ii) ocular quad weakly wider behind than front, posteromedian eyes largest (ocular quad not wider behind, anteromedian eyes weakly larger than posteromedians in *C. anjanes*); iii) abdominal dorsum with 2 pairs of lateral tubercles, posterior pair distinctly higher, projected outwardly (abdominal dorsum with 1 pair of lateral tubercles anteromedially at the widest region and 1 pair of vertically arranged blunt caudal process projected outwardly at the posterior end in *C. anjanes*); iv) dorsum with 2–3 pairs of sigillae (dorsum with 5 pairs of sigillae in *C. anjanes*); v) epigyne semilunar (epigyne plate like in *C. anjanes*); vi) spermatheca kidney shaped (spermatheca circular in *C. anjanes*).

Based on such differences, the species is recognized as new to science.

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NEW DATA ON ICHNEUMONID HIBERNATION (HYMENOPTERA: ICHNEUMONIDAE) IN THE BÂRNOVA FOREST MASSIF (IAŞI COUNTY, ROMANIA)

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In this paper the authors present the results of their researches made in the period of 2006–2010 on the hibernation of some ichneumonid species in the Bârnova forest massif (Iaşi county). 30 species of ichneumonids (only females) belonging to 20 genera of the the subfamily Ichneumoninae were recorded. Five of these species are new as hibernating. During the studied period there were established 6 hibernating stations, but with a low abundance.

Keywords: Hymenoptera, Ichneumonidae, hibernation, Bârnova forest massif, Romania.

INTRODUCTION

The hibernation of ichneumonids was reported so far only from temperate zones. This group of entomophagous parasitoid insects hibernates as pupae or larvae and less as adults. From the literature and from our own researches, we found that only a relatively small number of fertilized ichneumonid female species hibernates in the adult stage, males dying in the autumn when the temperature decreases suddenly. Preferences for overwintering are slopes with northern exposition, at the base of the valleys less exposed to sunlight, with high humidity during all period of hibernation.

Worldwide there were published relatively few papers on ichneumonid hibernation: Jonson (1920), Townes (1938), Rasnitzin (1959), Dasch (1971) and more recent Kolarov (1992) and Šedivý & Dvorák (2002).

In Romania, Constantineanu (1928, 1959, 1965) reported the presence of 99 hibernating ichneumonid species, but the only papers on ichneumonid hibernation were published by Constantineanu (1969, 1970). For a period of 39 years there were no other studies related to this topic, so this paper establishes the current situation about the hibernating ichneumonid species in the Bârnova forest massif.

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MATERIAL AND METHODS

The researches were achieved between 2006–2010 in the Bârnova forest massif in mixed forests (oak, beech, lime, cherry tree, poplar, pine). During this period, annual collections were made, starting in mid-October to mid-April, twice a month. To compare the evolution of ecological hibernating conditions in Bârnova forest massif, the researches were achieved in the same stationaries that were studied during 1964–1967, next to the train station and spring (on the both sides of Nastia brook). Also observations were made in the Poieni stationary.

We established the following hibernating stations: 1. between the cracks of the bark of living trees covered with moss; 2. under the bark of fallen logs (pine, poplar, hornbeam), 3. into the xylophagous insect galleries of the fallen logs; 4. between shrubs of tufted hair-grass; 5. stones covered by moss; 6. the forest litter.

RESULTS AND DISCUSSION

Prior to 2006–2010, when our researches were achieved, there have been cuttings in the forest sector where was the stationary "spring", where there were old trees, especially oaks. Massive sanitation works were carried out, which extended, moreover, to the whole forest (excepting the deep valleys, less accessible), so the fallen logs and stumps disappeared almost entirely. The pollution has also been an important factor in limiting the abundance of bryophytes, which favors ichneumonid hibernation.

Thus, the presence of moss dense "carpets" was reported only in a few places in the Bârnova forest. During the whole research period, there were not reported anymore ichneumonid clumps composed of dozens of hibernating individuals, we had recorded only isolated hibernating individuals, or even just one.

During the research period, we had recorded 30 species of hibernating ichneumonids belonging to 20 genera of Ichneumoninae subfamily, as follows: *Apaeleticus mesostictus* Grav., *Centeterus nigricornis* Thoms., *Chasmias lugens* (Grav.), *Cinxaelotus erythrogaster* Holmgr., *Coelichneumon deliratorius* (L.) (syn. *Ichneumon deliratorius* L.), *Ctenichneumon devylderi* (Holmgr.), *Deloglyptus pictus* Schm., *Diadromus troglodites* (Grav.), *Herpestomus brunnicornis* (Grav.), *Ichneumon balteatus* Wesm., *Ichneumon bellipes* Wesm. (syn. *Ichneumon divergens* Holmgr.), *Ichneumon bucculentus* Wesm., *Ichneumon coniger* Tischb., *Ichneumon extensorius* L., *Ichneumon inquinatus* Wesm., *Ichneumon languidus* Wesm., *Ichneumon proletarius* Wesm., *Ichneumon simulans* Tischb. (syn. *I. subquadratus* Thoms.), *Ichneumon tempestivus* Holmgr., *Heterischnus truncator* (F.) (syn. *Ischnus truncator* (F.), *Herpestomus brunnicornis* (Grav.), *Hoplismenus pica* Wesm., *Lymantrichneumon disparis* (Poda), *Orthocentrus petiolaris* Thoms., *Phaeogenes invisor* (Thunb.). *Phaeogenes semivulpinus* (Grav.), *Proscus cephalotes* (Wesm.), *Rhadinodonta flaviger* (Wesm.), *Stenichneumon culpator* (Schrank) and *Tycherus nigridens* (Wesm.) (syn. *Phaeogenes nigridens* (Wesm.).

The following species were recorded for the first time as hibernating adult females: *Ichneumon bellipes*, *Ctenichneumon devylderi*, *Apaeleticus mesostictus*, *Proscus cephalotes* and *Phaeogenes semivulpinus*.

The ichneumonid species have been recorded in the following hibernating stations:

1. Between the cracks of the bark of living trees, covered by real moss carpets: *Anomodon viticulosus* Hook et Tayl., *A. attenuatus* (Schreb.), *Hypnum cupressiforme* L., *Platygyrium repens* (Brid.) B. e., *Porella platyphylla* (L.) Lindb., *Brachytecium salebrosum* (Hoffm.) Br. Eur. on old trees: oak (*Quercus* sp.), beech (*Fagus sylvatica* L.), hornbeam (*Carpinus betulus* L.), lime (*Tilia platyphylos* Mill.) etc. (Fig. 1). The ichneumonid species recorded in this station were: *Apaeleticus mesostictus*, *Deloglyptus pictus*, *Herpestomus brunnicornis*, *Ichneumon simulans*, *Rhadinodonta flaviger*, *Ichneumon balteatus*, *Heterischnus truncator*, *Herpestomus brunnicornis*, *Diadromus troglodites* and *Proscus cephalotes*;

2. Under the thick bark of fallen logs (lime, poplar, hornbeam) (Fig. 2) we recorded the following species: *Ctenichneumon devylderi*, *Chasmias lugens*, *Hoplismenus pica*, *Ichneumon bucculentus*, *Ichneumon coniger*, *Ichneumon extensorius*, *Ichneumon inquinatus*, *Ichneumon languidus*, *Ichneumon proletarius* (Fig. 3), *Ichneumon tempestivus*, *Lymantrichneumon disparis*, *Rhadinodonta flaviger, Coelichneumon deliratorius* and *Stenichneumon culpator* (Fig. 4). In this station we noticed the presence of other hibernating insects, as neighbors belonging to the order Coleoptera, with family Carabidae (*Carabus intricatus* L.), Histeridae, Cerambycidae (larvae), and order Hymenoptera, with family Vespidae (*Vespa crabro* L.). We mention that inside this station, the ichneumonids are protected from predators and from dehydration.

3. In the xylophagous insect galleries from fallen logs the species: *Ichneumon languidus*, *Ichneumon bucculentus*, *Ichneumon extensorius* and *Orthocentrus petiolaris* were found;

4. Between tufted hair-grass, *Deschampsia caespitosa* (L.) P. Beauv., species reported in this station were: *Ichneumon proletarius*, *Phaeogenes semivulpinus* and *Phaeogenes invisor*;

5. On rocks covered by moss (*Mnium stellare* Reich), the only species recorded was *Cinxaelotus erythrogaster*;

6. In the forest litter the species *Tycherus nigridens* and *Phaeogenes invisor* were found.

Fig. 1. Oak stalk (*Quercus* sp.) covered with moss on base *Hypnum cupressiforme* and *Anomodon* sp., up to 2 m height (orig.).

Fig. 2. Fallen log of lime (*Tilia platyphyllos*) covered with moss (orig.).

Fig. 3. *Ichneumon proletarius* (♀, adult) hibernating under *Tilia platyphyllos* bark (orig.).

Fig. 4. *Stenichneumon culpator* (♀, adult) hibernating under *Tilia platyphyllos* bark (orig.).

CONCLUSIONS

30 species of ichneumonids (only females) belonging to 20 genera of the subfamily Ichneumoninae were recorded in the Bârnova forest.

There were established 6 hibernating stations. The most species were recorded under the bark of the fallen logs (14 species) and between the cracks of the bark of living trees, covered by moss (10 species).

Due to excessive forest hygiene and pollution, a significant number of hibernating places disappeared, compared to the period 1964–1967. We did not record any more clusters of a few dozen individuals of hibernating ichneumonids, recording only a few individuals or a single one. In this regard we propose a rational forest sanitation in order to maintain the hibernation stations of ichneumonids and other entomophagous parasitoid and predatory insects that can limit the outbreak of pest insect populations therefore achieving an ecological equilibrium in the forest ecosystem.

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DIVERSITY OF ENTOMOFAUNA (HYMENOPTERA, DIPTERA, COLEOPTERA) IN THE COMANA NATURAL PARK (ROMANIA)

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This study presents data on the diversity of Hymenoptera, Diptera and Coleoptera in the Comana Natural Park (Romania), based on the material collected between 2000 and 2010. A total of 323 species belonging to 52 families were recorded, hymenopterans and coleopterans being dominant. The families Cynipidae, Chrysomelidae and Syrphidae were the best represented. The species richness was higher for parasitoid hymenopterans, phytophagous coleopterans and predator dipterans. Insect species richness and abundance are explained through the habitats diversity (protected natural and semi natural ecosystems, agrosystems and rural areas), and the ratio between the zoophagous (parasitoids and predators) and phytophagous species. Among hymenopterans, the species *Trichosteresis glabra* (Boheman, 1832), *Megaspilus dux* (Curtis, 1829), *Exallonyx microcerus* Kieffer, 1908 and *Exallonyx pallidistigma* Morley, 1911 are recorded for the first time in the Romanian fauna.

Key words: Hymenoptera, Diptera, Coleoptera, Comana Natural Park, Romania.

INTRODUCTION

The Comana Natural Park (Giurgiu County) is the largest protected area in Southern Romania. With a surface of about 250 km^2, this area includes many species of plants and animals protected by international conventions and national laws. The Comana Natural Park includes natural, semi natural ecosystems (forests, meadows, rivers, lakes, canals, and a micro-delta), agrosystems, and rural areas. The habitats types are represented by forests (80%), lakes and rivers (11%), marshes and peats (3%), agrosystems, mainly cereal crops (4%) and grasslands (2%). This area includes two types of protected areas: Special Protection Area (ROSPA0022), aiming to protect the wild birds and their habitats and Site of Community Interest (ROSCI0043), protecting the natural habitats and species of plants or animals (other than birds).

Data on the diversity of entomofauna from Comana area were published by Maican (2006), Serafim & Maican (2008), Stan (2008) – for Coleoptera; Iorgu *et al*. (2009) – for Orthoptera; Pârvu (2009), Fălcuță *et al*. (2011) – Diptera; Székely (2011) – Lepidoptera etc.

MATERIAL AND METHODS

The material was collected between 2000 and 2010 (May-September period) from forest, shrubs, around villages, in/or in the neighbourhood of different agrosystems, in the ecotone zones.

The collecting methods were correlated with insect's size, order and organs of host plants, using the entomological net, the examination of the aerial plant organs, inclusively observations with the naked eye. The galls were collected into plastic bags, together with parts from the attacked organs of the plant. An important number of species were obtained in laboratory, such as: *Helorus* species from *Chrysopa* larvae and *Telenomus acrobates* from *Chrysopa* eggs; *Psilus*, *Aneuropria*, *Trichopria* species from *Lucilia* and *Calliphora* puparies; *Telenomus laevusculus*, *T. phalaenarum, T. macroceps, T. tetratomus, Anastatus, Ooencyrtus* and *Azotus* species from *Lymantria* and *Malacosoma* egg-masses; *Leucopis* and many Syrphidae species from some Aphididae colonies.

RESULTS AND DISCUSSION

Coleoptera order was represented by 116 species from 23 families, Chrysomelidae and Coccinellidae being the best represented, with 31, and respectively, 13 species (Table 1). 73 species (62.93%) are phytophagous (phyllophagous, anthophagous, seminiphagous, rhyzophagous, xylophagous or polynivorous), especially polyphagous (Elateridae, Buprestidae, Chrysomelidae, Melolonthidae, Cetoniidae, Rutelidae, Curculionidae, Attelabidae, Rhynchitidae, Scolytidae, few Tenebrionidae, Silphidae and Coccinellidae) (Panin, 1951, 1955; Freude *et al*., 1983; Simionescu & Teodorescu, 1997; Teodorescu & Vădineanu, 2001; Stan, 2008; Serafim & Maican, 2008). A number of 27 species (23.27%) belonging to Dytiscidae, Melyridae, Anthicidae, Staphylinidae, Cantharidae, Histeridae, Coccinellidae and some Silphidae are predators, as adults and larvae. Few species are necrophagous (Silphidae), mycophagous (Coccinellidae), detritophagous (*Oryctes*), coprophagous (*Gnaptor*, Scarabaeidae) and omnivorous (Anthicidae).

We notice the presence of *Lucanus cervus*, a silvicolous, saproxylic species, included in the Annex II of the Habitats Directive. At national level, it is a protected species listed in the Government Emergency Ordinance no. 57/2007. According to Nieto & Alexander (2010), the species *Lucanus cervus* and *Dorcus parallelopipedus* are classified as Least Concern and, respectively, Near Threatened.

A total of 136 species belonging to 20 families, from Hymenoptera order, were identified (Krombein *et al*., 1979; Algarra *et al*., 1997; Alekseev & Radchenko, 2001; Attila, 2009) (Table 2). Out of them, 59 species (43.38%) are phytophagous, three of these being social insects, their workers foraging for nectar and pollen to brood. Over 88% of phytophagous species are gall maker insects (Tenthredinidae and Cynipidae), the most part being represented by cynipid wasps

(84.74%), predominant parthenogenetic. 82% of cynipid gall makers are produced on *Quercus* and some on *Rosa*, *Rubus*, *Potentilla* and *Glechoma*. Galls are found on the leaves (on the underside of leaves, on both leaf sides, on the leaf axils, or on the petiole), on the flowers, the fruit, the apex of the shoots, on the buds (lateral, apical or accessory) (Ionescu, 1957, 1973; Melika *et al*., 2000; Bellido & Pujade-Villar, 2001; Skrzypczyńska, 2001; Kiyak *et al*., 2008; Stănescu, 2009; Kollar, 2011).

Table 1

Coleptera species recorded in the Comana Natural Park

No.	Taxa	Trophic category
Dytiscidae		
1.	*Dytiscus marginalis* (Linnaeus, 1758)	predatory: as adults and larvae hunts a wide variety of prey, including insects, tadpoles and small fish
Melyridae		
2.	*Malachius bipustulatus* (Linnaeus, 1758)	predatory: adults feed with small insects found on flowers; larvae feed with the nymph of xylophagous insects
3.	*Malachius aeneus* (Linnaeus, 1758)	predatory: adults feed on other insects that visit the flowers; larvae feed on some insects under tree bark
Anthicidae		
4.	*Anthicus antherinus* (Linnaeus, 1761)	possibly omnivorous: feed mainly on dead beetles, though on a wide range of invertebrates
Meloidae		
5.	*Lytta vesicatoria* (Linnaeus, 1758)	phytophagous: the adults feed on leaves of *Fraxinus, Syringa vulgaris, Lygustrum vulgare, Salix alba*; larvae are parasitoid on the brood of ground nesting bees
Staphylinidae		
6.	*Aleochara erythroptera* Gravenhorst, 1806	predatory polyphagous: adults are predators of insects and other arthropods; larvae are parasitoids on Diptera pupae
7.	*Oxyporus rufus* (Linnaeus, 1758)	predatory polyphagous: both adults and larvae feed on range of arthropod preys
8.	*Tachyporus hypnorum* (Fabricius, 1775)	predatory polyphagous: both adults and larvae feed on range of arthropod preys
9.	*Staphylinus caesareus* Cederhjelm, 1798	predatory polyphagous: both adults and larvae are predators of insects and other invertebrates
Elateridae		
10.	*Ctenicera* (= *Corymbites) cuprea* (Fabricius, 1775)	phytophagous: the larvae feed principally on the roots and underground stems of plants (potatoes, wheat, oats, barley), but they can exist on decayed organic matter in the soil
11.	*Anostirus* (= *Corymbites*) *castaneus* (Linnaeus, 1758)	phytophagous: the larvae develop in soil and are considered pests of various species of grasses, young trees and food crops
12.	*Agriotes lineatus* (Linnaeus, 1767)	phytophagous: polyphagous larvae feed on the roots of many different plants (especially in grassland, pasture, cereal crops, nursery plants, etc.)
13.	*Agriotes obscurus* (Linnaeus, 1758)	phytophagous: the larvae are radicivorous and granivorous, preferring wild and cultivated grasses
14.	*Agriotes ustulatus* (Schaller, 1783)	phytophagous: the larvae prefer annual and perennial grasses, attack sunflower, carrot, potato, sugar beet, corn, lettuce, canola and seed onions, strawberries, germinating seeds or young seedlings
15.	*Hemicrepidius niger* (Linnaeus, 1758)	phytophagous
Buprestidae		
16.	*Agrilus viridis* (Linnaeus, 1758)	phytophagous wood-boring larvae (xylophagous): the favourite host plants are *Salix caprea*, *Fagus*, *Betula*

Cantharidae		
17.	*Cantharis fusca* Linnaeus, 1758	predatory: the adults hunt for small insects; the larvae feed on torpid or dead small arthropods, even on snow surface
18.	*Cantharis livida* Linnaeus, 1758	predatory: the adult hunts other insects, often waiting on flowers for potential prey to arrive; the larvae hunt snails and worms
19.	*Cantharis rustica* Fallen, 1807	predatory: adults hunt mainly on flowers; the larvae live on the ground, feeding on a variety of other small organism
Tenebrionidae		
20.	*Opatrum sabulosum* (Linnaeus, 1758)	phytophagous: the adults and larvae eat dead vegetation residues and live plants
21.	*Gnaptor spinimanus* (Pallas, 1781)	coprophagous
Silphidae		
22.	*Necrophorus vespilloides* Herbst, 1783	necrophagous
23.	*Necrophorus vespillo* (Linnaeus, 1758)	necrophagous
24.	*Necrophorus antennatus* (Reitter, 1884)	necrophagous
25.	*Necrophorus germanicus* Linnaeus, 1758	necrophagous
26.	*Necrophorus humator* Gleditsch, 1767	necrophagous
27.	*Thanatophilus rugosus* Linnaeus, 1758	necrophagous
28.	*Thanatophilus sinuatus* (Fabricius, 1775)	necrophagous
29.	*Aclypea opaca* Linnaeus, 1758	phytophagous: the adults feed initially on the young leaves of winter cereals; they then migrate to beet fields; the larvae attack beet
30.	*Aclypea undata* (Müller, 1776)	necrophagous
31.	*Silpha carinata* Herbst, 1783	predatory: feed on soil invertebrates (snails, caterpillars or slugs)
32.	*Silpha obscura* Linnaeus, 1758	predatory: feed on soil invertebrates (snails, caterpillars or slugs)
33.	*Dendroxena* (= *Xylodrepa*) *quadripunctata* Linnaeus, 1758	predatory: feed on soil invertebrates (snails, caterpillars or slugs)
Histeridae		
34.	*Pachylister inaequalis* (Olivier, 1789)	predatory: both larvae and adults feed on the eggs and larvae of flies colonizing the animal bodies in decomposition stages
35.	*Hister quadrimaculatus* Linnaeus, 1758	predatory: feed on the egg, larval and adult stages of insects
36.	*Hister quadrinotatus* Scriba, 1790	predatory: feed on the egg, larval and adult stages of insects
37.	*Hister cadaverinus* Hoffmann, 1803	predatory: feed on the egg, larval and adult stages of insects
38.	*Hister sepulchralis* Erichson, 1834	predatory: feed on the egg, larval and adult stages of insects
39.	*Hister uncinatus* Illiger, 1807	predatory: feed on the egg, larval and adult stages of insects
40.	*Hister bipustulatus* Schrank, 1781	predatory: feed on the egg, larval and adult stages of insects
Coccinellidae		
41.	*Coccinella septempunctata* Linnaeus, 1758	predatory: adults and larvae feed on 60 aphid species, thrips, psyllids, aleyrodids, leafhoppers, coccids, moths, beetles
42.	*Coccinella vigintiduopunctata* (Linnaeus, 1758)	predatory: both adults and larvae feed aphids, psyllids, aleyrodids
43.	*Adalia bipunctata* (Linnaeus, 1758)	predatory: both adults and larvae feed aphids
44.	*Hippodamia variegata* (Goeze, 1777)	predatory: both adults and larvae feed aphids, psyllids, aleyrodids
45.	*Propylaea quatuordecimpunctata* (Linnaeus, 1758)	predatory: both adults and larvae pray on at least 20 species of aphids, psyllids, aleyrodids
46.	*Tytthaspis sedecimpunctata* (Linnaeus, 1758)	feeds fungal spores, pollen and nectar
47.	*Coccinula quatuordecimpustulata* (Linnaeus, 1758)	predatory: both adults and larvae feed aphids, psyllids, aleyrodids
48.	*Oenopia conglobata* (Linnaeus, 1758)	predatory: both adults and larvae feed aphids, psyllids, aleyrodids and immature chrysomelids, pollen and nectar
49.	*Psyllobora vigintiduopunctata* (Linnaeus, 1758)	mycophagous: both adults and larvae feeding on mildew; found on Apiaceae and shrubs
50.	*Halyzia sedecimguttata* (Linnaeus, 1758)	mycophagous: both adults and larvae feed mainly on mildew and occasionally on small aphids

51.	*Hippodamia undecimnotata* (Schneider, 1792)	phytophagous: both adults and larvae feed on aphids
52.	*Subcoccinella vigintiquatuorpunctata* (Linnaeus, 1758)	phytophagous: both adults and larvae feed on grassy plants (*Medicago sativa, Lactuca, Cirsium, Silene dioica*)
53.	*Vibidia duodecimguttata* (Poda, 1761)	mycophagous: feeding on the powdery mildew fungus (*Oidium*)
Chrysomelidae		
54.	*Donacia marginata* Hoppe, 1795	phytophagous; host plants: *Sparganium ramosum*
55.	*Lilioceris merdigera* (Linnaeus, 1758)	phytophagous; host plants: *Convallaria majalis*, *Polygonatum multiflorum*, *Lilium*, *Allium*
56.	*Oulema melanopus* (Linnaeus, 1758)	phytophagous; host plants: *Agropyron*, *Lolium*, *Dactylis*, *Avena*, *Hordeum*
57.	*Clytra laeviuscula* (Ratzeburg, 1837)	phytophagous; host plants: *Prunus*, *Salix*, *Dorycnium*, *Fraxinus*
58.	*Labidostomis longimana* (Linnaeus, 1761)	phytophagous; host plants: *Lotus, Trifolium*, Brassicaceae
59.	*Smaragdina xanthaspis* (Germar, 1824)	phytophagous; host plants: *Corylus avellana*, *Quercus*, *Crataegus*
60.	*Cryptocephalus janthinus* Germar, 1824	phytophagous; host plants: *Phragmites*
61.	*Cryptocephalus moraei* (Linnaeus, 1758)	phytophagous oligophagous; host plants: *Hypericum*
62.	*Cryptocephalus octacosmus* Bedel, 1891	phytophagous; host plants: *Fraxinus*, *Alnus*
63.	*Cryptocephalus sericeus* (Linnaeus, 1758)	anthophagous: Asteraceae and Ranunculaceae
64.	*Cryptocephalus sexpunctatus* (Linnaeus, 1758)	phytophagous; host plants: *Salix*, *Quercus*, *Betula*, *Corylus*, *Crataegus*
65.	*Chrysolina chalcites* (Germar, 1824)	phytophagous
66.	*Chrysolina fastuosa* (Scopoli, 1763)	phytophagous; host plants: *Galeopsis*, *Lamium*
67.	*Chrysolina herbacea* (Duftschmidt, 1825)	phytophagous; host plants: *Mentha, Marrubium,Calamintha*
68.	*Chrysolina polita* (Linnaeus, 1758)	phytophagous; host plants: *Mentha, Nepeta, Melissa, Origanum, Lycopus, Salvia, Glechoma*
69.	*Colaphus sophiae* (Schaller, 1783)	phytophagous: usually on the wild plants of the family Brassicaceae
70.	*Gastrophysa polygoni* (Linnaeus, 1758)	phytophagous; host plants: *Rumex*, *Polygonum*
71.	*Gonioctena fornicata* (Brüggemann, 1873)	phytophagous; host plants: *Sorbus aucuparia*, *Medicago sativa*
72.	*Galeruca tanaceti* (Linnaeus, 1758)	phytophagous: host plants: *Scabiosa, Centaurea nigra*, *Achillea*, *Cerastium*, *Sinapis arvensis*
73.	*Phyllobrotica quadrimaculata* (Linnaeus, 1758)	phytophagous: host plants: *Scutellaria galericulata*
74.	*Xanthogaleruca luteola* (Müller, 1766)	phytophagous: host plants: *Ulmus campestris*
75.	*Epitrix pubescens* (Koch, 1803)	phytophagous: host plants: *Solanum dulcamare*, *S. nigrum*, *Lycium*, *Hyoscyamus*
76.	*Hermaeophaga mercurialis* (Fabricius, 1792)	phytophagous: host plants: *Mercurialis perennis*
77.	*Neocrepidodera transversa* (Marsham, 1802)	phytophagous: host plants: *Cirsium*
78.	*Phyllotreta nemorum* (Linnaeus, 1758)	phytophagous: host plants: Cruciferae
79.	*Phyllotreta ochripes* (Curtis, 1837)	phytophagous: host plants: Cruciferae
80.	*Phyllotreta vittula* (Redtenbacher, 1849)	phytophagous: the adults eat parenchyma on upper side of leaves of wheat, barley, rye; larvae feed on small roots of cereals
81.	*Cassida lineola* Creutzer, 1799	phytophagous: host plants: *Artemisia campestris*, *A. absinthium*
82.	*Cassida murraea* Linnaeus, 1767	phytophagous: host plants: *Pulicaria*, *Inula*, *Mentha*, *Verbascum*
83.	*Cassida rubiginosa* Müller, 1776	phytophagous: host plants: *Carduus*, *Cirsium*, *Arctium*
84.	*Pilemostoma fastuosa* (Schaller, 1783)	phytophagous: host plants: *Pulicaria*, *Inula squarrosa*, *Senecio jacobaea*
Melolonthidae		
85.	*Mellolontha mellolontha* Linnaeus, 1758	phytophagous: the larvae feed on plant roots; the preferred food for adults is oak leaves, but they will also feed on conifer needles

86.	*Anoxia orientalis* (Krynicki, 1832)	phytophagous: the larvae feed on plant roots
87.	*Rhizotrogus aequinoctialis* (Herbst, 1790)	phytophagous: the larvae feed on the roots; the adults do not feed
88.	*Amphimallon solstitiale* (Linnaeus, 1758)	phytophagous: the adults eat plants and tree foliage in meadows, hedgerows and gardens; the larvae feed on plant roots
Cetoniidae		
89.	*Cetonia aurata* Linnaeus, 1758	phytophagous: the adults feeds on pollen, petals and wound fluids of trees (elder and hawthorn), Apiaceae; the larvae live and hibernate in decayed wood
90.	*Tropinota* (= *Epicometis*) *hirta* (Poda, 1761)	phytophagous, anthophagous: the adults feed on stamens and pistils
91.	*Oxythyrea funesta* (Poda, 1761)	phytophagous, anthophagous: the adults rode the floral organs; the larvae feed on plant roots
Rutelidae		
92.	*Phyllopertha horticola* Linnaeus, 1758	phytophagous: larvae feed on the roots of grasses, including cereals; the adults feed mainly on the leaves, flowers and fruit of deciduous trees and shrubs
93.	*Anomala solida* (Erichson, 1847)	phytophagous: the adults feed the foliage of vine, walnuts tree, cherry, apple tree, chestnut, willow, oak, mulberry, tile, elm; the larvae feed on plant roots
94.	*Anomala dubia* Scopoli, 1763	phytophagous: the adults feed the foliage of *Populus, Salix, Rhamnus, Vitis, Euphorbia, Cirsium*
95.	*Anisoplia segetum* (Herbst, 1783)	phytophagous: the adults feed on cereal crops (oat, corn), sun flower, *Agropyrum, Calamagrostis*
96.	*Anisoplia austriaca* (Herbst, 1783)	phytophagous: the adults feed on cereal crops (oat, corn), sun flower, *Agropyrum*, *Bromus*
97.	*Anisoplia lata* Erichson, 1847	phytophagous: the adults feed on cereal crops, *Agropyrum*, *Calamagrostis*
Scarabaeidae		
98.	*Onthophagus taurus* (Schreber, 1759)	coprophagous: feeds on the dung of large herbivorous mammals
99.	*Geotrupes stercorarius* (Linnaeus, 1758)	coprophagous: both the adults and larvae feed on the droppings of herbivorous animals
Dynastidae		
100.	*Oryctes nasicornis* Linnaeus, 1758	detritophagous: larvae develop in decaying vegetal substances, rarely in rotten wood
Lucanidae		
101.	*Lucanus cervus* Linnaeus, 1758	phytophagous: the adults feed on nectar and tree sap; the larvae feed on the decaying wood of a wide variety of broad-leaved trees and shrubs
102.	*Dorcus parallelopipedus* (Linnaeus, 1785)	phytophagous: the larvae feed on decaying wood of broad-leaved trees (*Fraxinus*, *Fagus*, *Quercus*, *Tilia*, *Ulmus*, *Malus*); the adults eat tree sap
Curculionidae		
103.	*Tanymecus dilaticollis* Gyllenhal, 1834	phytophagous: the adults feed on maize, oat, barley, beet, sunflower
104.	*Sitona crinitus* (Herbst, 1795)	phytophagous: the adults feed on the leaves of *Pisum*, *Vicia, Astragalus, Medicago*; the larvae feed on nitrifying root tubercles
105.	*Sitona lineatus* (Linnaeus, 1758)	phytophagous: the adults feed on the leaves of *Trifolium*, *Pisum*, *Lotus*, *Lupinus*, *Medicago*, *Melilotus*, *Phaseolus*; the larvae feed on nitrifying root tubercles
106.	*Sitona hispidulus* (Fabricius, 1777)	phytophagous: the adults feed on leaves of *Medicago*, *Trifolium*, *Lotus*, *Coronila*; the larvae feed on nitrifying root tubercles
107.	*Protapion apricans* (Herbst, 1797)	phytophagous: the adults feed on the seeds of *Trifolium*; the larvae develop in the blooms of the *Trifolium*
108.	*Apion frumentarium* (Linnaeus, 1758)	phytophagous: the adults feeds on *Rumex* leaves (*R. crispis*, *R. hycholapathus*, *R. conglomestus*, *R. obtusifolius*)
109.	*Hypera postica* (Gyllenhal, 1813)	phytophagous: feed almost exclusively on *Medicago sativa*; the adults notch main stems and side shoots; the larvae feed in leaf buds and terminal growing areas, then on leaves

110.	*Curculio glandium* Marsham, 1802	phytophagous oligophagous: the larvae feed and develop inside oak acorns; the adults feed on buds and leaves
111.	*Curculio elephas* Gyllenthal, 1836	phytophagous oligophagous: the larvae feed and develop inside chestnuts (*Castanea*) and acorns (*Quercus*); the adults feed on the base of young nuts and oviposit eggs inside chestnut or acorns
112.	*Curculio nucum* Linnaeus, 1758	phytophagous oligophagous: the larvae feed and develop inside hazel nuts *Corylus avellana*; the adults feed on buds and leaves of hazel
Attelabidae		
113.	*Byctiscus betulae* Linnaeus, 1758	phytophagous: the larvae live inside the leaf rolls ("cigar") made by females from leaves of *Betula*, *Populus*
114.	*Attelabus nitens* (Scopoli, 1763)	phytophagous oligophagous: the larvae feed in the oak curled up leaf ("Oak Leaf-roller")
Rhynchitidae		
115.	*Deporaus betulae* Linnaeus, 1758	phytophagous oligophagous: the larvae feed in curled up leaf of *Alnus* and *Corylus*
Scolytidae		
116.	*Hylesinus fraxini* (Panzer, 1779)	phytophagous xylophagous: the larvae bores gallery in the inner bark of *Fraxinus excelsior*

Table 2

Hymenoptera species recorded in the Comana Natural Park

No	Taxa	Trophic category
Tenthredinidae		
1.	*Pontania vesicator* (Bremi, 1849)	phytophagous larvae: galls on the upper side of the leaves of *Salix*
2.	*Pontania* (*Eupontania*) *viminalis* (Linné, 1758)	phytophagous larvae: gall on the mid nervure of upper side of the leaves of *Salix*
3.	*Arge rosae* (Gmelin, 1790)	phytophagous larvae: feed on the leaves of wild and cultivated roses; adults feed on nectar and pollen
Cephidae		
4.	*Cephus pygmaeus* (Linné, 1767)	phytophagous larvae: feed on the internal tissues of the stem of grain cereal and different wild grasses; adults feed on nectar
Cynipidae		
5.	*Neuroterus lanuginosus* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; gall on the underside of leaves of *Quercus cerris*
6.	*Neuroterus minutulus* Giraud, 1859	phytophagous larvae: parthenogenetic generation; galls on nervures, on the both sides of the leaves of *Quercus cerris* only
7.	*Neuroterus laeviusculus* (Schenck, 1863)	phytophagous larvae: parthenogenetic generation; galls on the both sides of the leaves of *Quercus robur*
8.	*Neuroterus quercus-baccarum* (Linnaeus, 1758)	phytophagous larvae: parthenogenetic generation; galls on the underside of the young leaves of *Quercus*
9.	*Neuroterus numismalis* (Geoffroy in Fourcroy, 1785)	phytophagous larvae: parthenogenetic generation; galls on the underside of the leaves of *Quercus robur*, *Q. cerris*, *Q. frainetto*, *Q. petraea*, and *Q. pubescens*
10.	*Neuroterus glandiformis* (Giraud, 1859)	phytophagous: bisexual generation; galls on the fruits of *Quercus* sp.
11.	*Neuroterus macropterus* (Hartig, 1843)	phytophagous larvae: parthenogenetic generation, galls within the apex of the shoots 1-2 years old of *Quercus cerris*
12.	*Cynips quercusfolii* (Linnaeus, 1758)	phytophagous larvae: bisexual generation; galls on the nervures on underside of the leaves of *Quercus petraea*, *Q. pubescens*, *Q. robur*, *Q. frainetto*; less frequently on *Q. cerris*
13.	*Cynips longiventris* (Hartig, 1881)	phytophagous larvae: parthenogenetic generation, galls on the nervures on underside of the leaves of *Quercus*
14.	*Cynips divisa* (Hartig, 1840)	phytophagous larvae: parthenogenetic generation, galls on the nervures on underside of the leaves of *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*

15.	*Cynips quercus* (Fourcroy, 1785)	phytophagous larvae: parthenogenetic generation; galls on the nervures on underside of the leaves of *Quercus robur*, *Q. petraea*, *Q. pubescens*, and *Q. frainetto*
16.	*Cynips agama* (Hartig, 1840)	phytophagous larvae: parthenogenetic generation; galls on the lateral nervures, on the underside of the leaves of *Quercus petraea*, *Q. robur*, *Q. pubescens*, and *Q. frainetto*
17.	*Trigonaspis megaptera* (Panzer,1801)	phytophagous larvae: parthenogenetic generation; galls on the nervures of the underside of the leaves of *Quercus*
18.	*Trigonaspis synaspis* (Hartig, 1841)	phytophagous larvae: parthenogenetic generation; galls on the underside of the leaves of *Quercus*
19.	*Biorhiza pallida* (Olivier, 1791)	phytophagous larvae: bisexual generation; bud galls at the extremity of the shoots of *Quercus petraea*, *Q. robur*. *Q pedunculata*
20.	*Aphelonyx cerricola* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; galls at the end of shoots of *Quercus cerris*
21.	*Andricus amblycerus* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; bud galls on *Quercus petraea*, *Q. pubescens*, and *Q. robur*
22.	*Andricus kollari* (Hartig, 1843)	phytophagous larvae: bisexual generation; galls on the apical buds, and less frequently on the lateral buds of *Quercus petraea*, *Q. robur*, and *Q. frainetto*; less frequently of *Q. pubescens*
23.	*Andricus gallaetinctoriae* (Olivier, 1791)	phytophagous larvae: bisexual generation; bud galls on *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*
24.	*Andricus caliciformis* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; galls on accessory buds of *Quercus robur* (most common), *Q. pubescens*, *Q. frainetto*, and *Q. petraea*
25.	*Andricus caputmedusae* Hartig, 1843	phytophagous larvae: parthenogenetic generation; galls on acorns and on acorn cups of *Quercus petraea*, *Q. robur*, and *Q. pubescens;* occasionally of *Q. cerris* and *Q. frainetto*
26.	*Andricus conglomeratus* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; bud galls on shoots of *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*
27.	*Andricus polycerus* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; bud galls on *Quercus petraea*, *Q. robur*, *Q. pubescens*, and *Q. frainetto*
28.	*Andricus coriarius* (Hartig, 1843)	phytophagous larvae: parthenogenetic generation; galls on lateral buds, less frequently on terminal buds of *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*
29.	*Andricus coronatus* (Giraud, 1859)	phytophagous larvae: parthenogenetic generation; lateral bud galls, more frequently on the second year's shoots of *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*
30.	*Andricus hungaricus* (Hartig, 1843)	phytophagous larvae: parthenogenetic generation; bud galls on the previous year's shoots on *Quercus robur*
31.	*Andricus quercustozae* (Bosc, 1792)	phytophagous larvae: parthenogenetic generation; bud galls on *Quercus petraea*, *Q. pubescens*, *Q. robur*, *Q. frainetto*
32.	*Andricus caputmedusae* (Hartig, 1843)	phytophagous larvae: parthenogenetic generation; galls on acorns and on acorn cups on *Quercus robur*, *Q. petraea*, and *Q. pubescens*; occasionally of *Q. cerris* and *Q. frainetto*
33.	*Andricus quercuscalicis* (Burgsdorf, 1783)	phytophagous larvae: bisexual generation; galls at the borderline of acorns and cups of *Quercus robur*
34.	*Andricus fecundator* (Hartig, 1840)	phytophagous larvae: bisexual generation; galls on lateral and apical buds of the previous year's shoots of *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*
35.	*Andricus ostrea* (Hartig, 1840)	phytophagous larvae: parthenogenetic generation; galls on the nervure on the underside of the leaves of *Quercus*
36.	*Andricus curvator* Hartig, 1840	phytophagous larvae: parthenogenetic generation; galls on both leaf sides of *Quercus*
37.	*Andricus quercusramuli* (Linnaeus, 1761)	phytophagous larvae: bisexual generation; galls on catkins and male buds of *Quercus*
38.	*Andricus solitarius* (Fonscolombe, 1832)	phytophagous larvae: bisexual generation; bud galls, usually found in the leaf axils of *Quercus*

39.	*Andricus seckendorffi* (Wachtl, 1879)	phytophagous larvae: parthenogenetic generation; galls on acorn cups of *Quercus petraea*, *Q. pubescens*, and *Q. robur*
40.	*Andricus panteli* Kieffer, 1897	phytophagous larvae: parthenogenetic generation; bud galls on *Quercus*
41.	*Andricus lucidus* (Hartig, 1843)	phytophagous larvae: parthenogenetic generation; galls on buds, occasionally on acorns of *Quercus petraea*, *Q. pubescens*, *Q. robur*, and *Q. frainetto*
42.	*Andricus cydoniae* Giraud, 1859	phytophagous larvae: bisexual generation; galls at the tip of shoots of *Quercus cerris*
43.	*Andricus multiplicatus* (Giraud, 1859)	phytophagous larvae: bisexual generation; bud galls, usually at shoot tips of *Quercus cerris* only
44.	*Andricus aestivalis* Giraud, 1859	phytophagous larvae: bisexual generation; catkin galls of *Quercus cerris*
45.	*Andricus grossulariae* Giraud, 1859	phytophagous larvae: bisexual generation; galls on the axes of the male flower of *Quercus*
46.	*Andricus vindobonensis* Mullner, 1901	phytophagous larvae: bisexual generation; catkin galls of *Quercus cerris*
47.	*Synophrus politus* Hartig, 1843	phytophagous larvae: bud galls of *Quercus*
48.	*Xestophanes potentillae* (Ratzeburg, 1783)	phytophagous larvae: galls on the leave petiole of *Potentilla*
49.	*Diastrophus mayri* Reinhard, 1876	phytophagous larvae: galls in the stem of *Potentilla argentea*, *P. canescens*
50.	*Diastrophus rubi* (Bouché, 1834)	phytophagous larvae: galls in the stem or petiole of *Rubus* (*R. fruticosus*, *R. caesius*, *R. idaeus*)
51.	*Diplolepis rosae* (Linnaeus, 1758)	phytophagous larvae: galls on the leaves, flower buds and on the stems of *Rosa*
52.	*Diplolepis rosarum* (Giraud, 1859)	phytophagous larvae: galls on the leaves of *Rosa*
53.	*Diplolepis eglanteriae* (Hartig, 1840)	phytophagous larvae: galls on the leaves of *Rosa*
54.	*Liposthenes glechomae* (Linnaeus, 1758)	phytophagous larvae: galls on the leaves of *Glechoma*
Megaspilidae		
55.	*Trichosteresis glabra* (Boheman, 1832)	parasitoid in syrphid puparia (*Syrphus*, *Sphaerophoria*, *Metasyrphus*)
56.	*Trichosteresis syrphii* (Bouché, 1834)	parasitoid in syrphid puparia (*Syrphus ribesii*, *Episyrphus balteatus*, *Sphaerophoria*, *Metasyrphus*
57.	*Dendrocerus* (*Macrostigma*) *aphidum* (Rondani, 1877)	hyperparasitoid of aphids; primary parasite of Aphidiidae (*Aphidius*, *Praon*, *Ephedrus*, *Trioxys*, *Diaeretiella* and *Lysiphlebus*)
58.	*Dendrocerus* (*Macrostigma*) *bicolor* (Kieffer, 1907)	hyperparasitoid of aphids; primary parasite of Aphidiidae (*Lipolexis*, *Ephedrus*, *Diaeretiella*, *Lysiphlebus* and *Trioxys*)
59.	*Dendrocerus* (*Macrostigma*) *carpenter* (Curtis, 1829)	hyperparasitoid of aphids; primary parasite of Aphidiidae (*Aphidius*, *Diaeretiella*, *Ephedrus*, *Praon*, *Lysiphlebus*)
60.	*Dendrocerus* (*Macrostigma*) *puparum* (Boheman, 1832)	parasitoid of puparia Syrphidae (Diptera)
61.	*Dendrocerus* (*Macrostigma*) *serricornis* (Boheman, 1832)	parasitoid of puparia Chamaemyiidae (Diptera)
62.	*Dendrocerus* (*Dendrocerus*) *halidayi* (Curtis, 1829)	ectoparasitoid of cocoons of Coniopterygidae (Neuroptera)
63.	*Dendrocerus* (*Dendrocerus*) *ramicornis* (Boheman, 1858)	parasitoid (probably secondary) of aphids, mainly from subfamilies Cinarinae (associated with coniferous forests) and Lachninae (associated with deciduous forests)
64.	*Lagynodes pallidus* (Boheman, 1832)	biology: unknown; often inhabits nests of the ants (*Formica*, *Lasius*, *Myrmica*, *Eciton*, *Solenopsis*)
65.	*Lagynodes thoracicus* Kieffer, 1906	biology: unknown
66.	*Megaspilus dux* (Curtis, 1829)	presumably species of *Megaspilus* are parasitic on Diptera
67.	*Megaspilus bispinosus* Kieffer, 1907	presumably species of *Megaspilus* are parasitic on Diptera
Ceraphronidae		
68.	*Ceraphron flaviventris* Kieffer, 1907	parasitoid of *Contarinia lentis* (Cecidomyidae)
69.	*Aphanogmus abdominalis* (Thomson, 1858)	parasitoid of *Dasyneura brassicae* (Cecidomyidae)
70.	*Aphanogmus terminalis* Foerster, 1861	biology: unknown

Heloridae		
71.	*Helorus anomalipes* (Panzer, 1798)	parasitoid on larvae of *Chrysopa carnea*, *C. prasina* (Neuroptera)
72.	*Helorus corruscus* Haliday, 1857	parasitoid on larvae of *Chrysopa ventralis* (Neuroptera)
73.	*Helorus ruficornis* Forster, 1856	parasitoid on larvae of *Chrysopa prasina* (Neuroptera)
Serphidae (= Proctotrupidae)		
74.	*Exallonyx ater* (Gravenhorst, 1807)	parasitoid on larvae of *Staphylinus olens*, *Creophillus maxilosus* (Staphylinidae), *Pterostichus* (Carabidae), *Lithobius forficatus* (Chilopoda)
75.	*Exallonyx niger* Panzer, 1801	parasitoid on larvae of Mycetophilidae (Diptera); *Ocypus* (Staphylinidae) considered possible host
76.	*Exallonyx ligatus* (Nees von Esenbeck, 1908)	parasitoid on larvae of *Quedius vexans*, *Q. simplicifrons*, *Hantholinus*, *Phylonthus*, *Tachyporus* (Staphylinidae)
77.	*Exallonyx microcerus* Kieffer, 1908	parasitoid on *Xantholinus* and Tachyporini (Staphylinidae)
78.	*Exallonyx pallidistigma* Morley, 1911	parasitoid on *Nebria brevicollis* (Carabidae), *Ocypus ater* (Staphylinidae)
79.	*Phaenoserphus* (*Phaenoserphus*) *calcar* (Haliday, 1839)	parasitoid on *Quedius simplicifrons*, *Bolithochara obliqua* (Staphylinidae), *Lithobius forficatus* (Chilopoda)
80.	*Phaenoserphus* (*Phaenoserphus*) *viator* (Haliday, 1839)	parasitoid on the larvae of *Carabus*, *Calosoma*, *Pterostichus*, *Nebria*, *Leistus* (Carabidae) *Creophilus* (Staphylinidae)
81.	*Cryptoserphus longitarsis* Thomson, 1857	parasitoid on *Mycetophila fungorum* (Diptera, Mycetophilidae)
82.	*Cryptoserphus flavipes* Provancher, 1881	parasitoid on *Mycetophila fungorum* (Diptera, Mycetophilidae)
83.	*Cryptoserphus aculeator* Haliday, 1839	parasitoid on *Exechia contaminata*, *Mycetophila ruficollis*, *M. ichneumonea*, *Allodia grata* (Diptera, Mycetophilidae)
84.	*Serphus gravidator* Linnaeus, 1758	parasitoid on larvae of *Amara*, *Harpalus* (Carabidae)
85.	*Serphus brachypterus* Schrank, 1780	parasitoid on *Harpalus rufipes*, *Zabrus tenebrioides* (Carabidae)
Diapriidae		
86.	*Spilomicrus crasiclavis* Kieffer, 1911	parasitoid on *Maruca testulalis* (Lepidoptera, Pyralidae)
87.	*Spilomicrus integer* Thomson, 1858	possibly associated with Diptera
88.	*Entomacis perplexa* (Haliday, 1857)	possibly associated with Ceratopogonidae (Diptera)
89.	*Psilus* (*Schizogalesus*) *gestroi* Kieffer, 1911	parasitoid on puparia of *Lucilia sericata* (Calliphoridae)
90.	*Aneuropria forsteri* (Kieffer, 1910)	parasitoid on puparia of *Piophila casei* (Piophilidae), *Rhagoletis cerasi* (Tephritidae)
91.	*Basalys tritoma* (Thomson, 1859)	parasitoid on larvae of *Oscinis fritt* (Chloropidae)
92.	*Diapria conica* (Fabritius, 1775)	parasitoid on *Eristalis tenax* (Syrphidae), *Ravinia striata* (Sarcophagidae)
93.	*Trichopria bipunctata* Kieffer, 1911	parasitoid on Diptera species
94.	*Trichopria cilipes* Kieffer, 1909	parasitoid on puparia of *Lucilia*, *Calliphora* (Calliphoridae), *Piophila* (Piophilidae), *Agromyza puparia*, *A. spiraeae* (Agromyzidae)
95.	*Trichopria lonchaearum* Kieffer, 1911	parasitoid on puparia of *Piophila casei* (Piophilidae), *Lonchaea tarsata* (Lonchaeidae)
96.	*Trichopria major* (Priesner, 1953)	parasitoid on puparia of *Piophila* (Piophilidae), *Paregle* (Anthomyiidae), *Lucilia* (Calliphoridae)
97.	*Trichopria nigra* (Nees, 1834)	parasitoid on puparia of *Piophila casei* (Piophilidae)
Scelionidae		
98.	*Telenomus acrobates* Giard, 1895	eggs parasitoid of Chrysopidae (Neuroptera); adults feed on pollen and nectar
99.	*Telenomus phalaenarum* (Nees, 1834)	egg parasitoid of *Lymantria dispar*, *Euproctis chrysorrhoea*, *Malacosoma neustria*, *Paranthrene tabaniformis*, *Bupalus piniarius*, *Elasmucha grisea*
100.	*Telenomus laeviusculus* (Ratzeburg, 1844)	egg parasitoid of *Lymantria dispar*, *Malacosoma neustria*; adults feed on pollen and nectar
101.	*Telenomus tetratomus* (Thomson, 1861)	egg parasitoid of *Lymantria dispar*, *Malacosoma neustria*, *Dendrolimus sibiricus*, *D. superans*, *Dasychira albodentata*, *Lasiocampa segregata*; adults feed in pollen and nectar

102.	*Telenomus macroceps* Szabo, 1957	eggs parasitoid of *Lymantria dispar*, *Malacosoma neustria*; adults feed pollen and nectar
103.	*Habronotus howardi* (Mokrzecki & Ogloblin, 1931)	egg parasitoid of *Lymantria dispar*
104.	*Telenomus nitidulus* Thomson, 1844	egg parasitoid of *Leucoma salicis*
105.	*Telenomus chloropus* (Thomson, 1860)	eggs parasitoid of *Aelia*, *Carpocoris*, *Dolycoris*, *Eurygaster*, *Graphosoma*, *Palomena*, *Nezara*
106.	*Trissolcus grandis* (Thomson, 1861)	eggs parasitoid of *Aelia*, *Carpocoris*, *Dolycoris*, *Eurydema*, *Eurygaster*, *Graphosoma*, *Palomena*
107.	*Trissolcus basalis* (Wollaston, 1858)	eggs parasitoid of *Aelia*, *Carpocoris*, *Eurydema*, *Eurygaster*, *Graphosoma*, *Nezara*
108.	*Trissolcus flavipes* (Thomson, 1861)	eggs parasitoid of *Aelia*, *Carpocoris*, *Eurygaster*, *Palomena*
109.	*Trissolcus pseudoturesis* (Rjachovsky 1959)	eggs parasitoid of *Eurygaster*, *Graphosoma*
110.	*Trissolcus rufiventris* (Mayr, 1907)	eggs parasitoid of *Aelia*, *Carpocoris*, *Dolycoris*, *Eurygaster*, *Graphosoma*
111.	*Trissolcus semistriatus* (Nees, 1834))	eggs parasitoid of *Aelia*, *Carpocoris*, *Dolycoris*, *Eurydema*, *Eurygaster*, *Graphosoma*, *Palomena*
112.	*Trissolcus simoni* (Mayr, 1879)	eggs parasitoid of *Aelia*, *Carpocoris*, *Dolycoris*, *Eurydema*, *Eurygaster*, *Graphosoma*
Eupelmidae		
113.	*Anastatus disparis* Ruschka, 1920	egg parasitoid of *Lymantria dispar*
114.	*Anastatus bifasciatus* (Geoffroy, 1785)	eggs parasitoid of Lepidoptera (Lymantriidae, Lasiocampidae, Notodontidae, Nymphalidae, Papilionidae, Sphingidae, Saturniidae), Heteroptera (Scutelleridae, Coreidae, Pentatomidae) and Orthoptera (Acrididae, Tettigoniidae)
Encyrtidae		
115.	*Ooencyrtus kuwanae* Howard, 1910	egg parasitoid of *Lymantria dispar*
116.	*Ooencyrtus tardus* (Ratzeburg, 1844)	eggs parasitoid of *Malacosoma neustria*, *Lymantria dispar*
Aphelinidae		
117.	*Azotus celsus* (Walker, 1839)	eggs parasitoid of Lepidoptera (*Malacosoma neustria*), Homoptera (*Quadraspidiotus perniciosus*)
Chalcididae		
118.	*Brachymeria intermedia* (Nees, 1834)	parasitoid in larval and pupal stages of Lepidoptera and Diptera
Torymidae		
119.	*Monodontomerus aereus* Walker, 1834	both a primary and a secondary parasite in larval and pupal stages of Lepidoptera (*Lymantria*, *Euproctis*, *Malacosoma*, *Orgyia*), Diptera (*Blepharipa*, *Compsilura*, *Carcelia*, *Exorista*) and Hymenoptera (*Apanteles*, *Meteorus*)
Ichneumonidae		
120.	*Collyria coxator* (Villers, 1789)	parasitoid of *Cephus pygmaeus* (Hymenoptera, Cephidae)
Vespidae		
121.	*Polistes gallicus* (Linnaeus, 1761)	predatory: adults feed on sugar and nectar; they catch flies and caterpillars to feed the larvae; progressive provisioning, bringing softened caterpillar flesh to the larvae multiple times throughout their development
122.	*Vespa crabro* Linnaeus, 1758	predatory: adults feed on the honeydew and catch bees and many other insects to feed its larvae
123.	*Vespula germanica* (Fabricius, 1793)	predatory: adults feed on the honeydew and catch many other insects, including caterpillars, to feed its larvae
Scoliidae		
124.	*Megascolia maculata flavifrons* (Fabricius, 1775)	larvae are parasitoid on larvae of *Oryctes nasicornis* (Coleoptera); adults feeds on nectar
Formicidae		
125.	*Camponotus* (*Camponotus*) *ligniperda* (Latreille, 1802)	omnivorous: feed on small insects, nectar, honeydew, and fruits

126.	*Camponotus* (*Camponotus*) *herculeanus* (Linnaeus, 1758)	omnivorous: feed on honeydew and insects
127.	*Formica rufa* Linnaeus, 1761	omnivorous: feed on other insect and on honeydew; a top predator in the forest soil food-web
128.	*Formica polyctena* Förster, 1850	predatory: feed on many invertebrates species (Carabidae, Staphylinidae, Lycosidae)
129.	*Formica sanguinea* Latreille, 1798	omnivorous, predominantly predatory: feeds on other insects and honeydew
130.	*Lasius flavus* (Fabricius, 1782)	omnivorous: feed honeydew from the root aphids of several species and small insects
131.	*Lasius niges* (Linnaeus, 1758)	omnivorous: feed insects, nectar, and even the bodies of their own dead, or ants from other colonies
Apidae		
132.	*Apis mellifera* (Linnaeus, 1758)	social insect, workers forage for nectar and pollen for the colony; the main pollinator species
133.	*Bombus lapidarius* (Linnaeus, 1758)	social insect, that feed on nectar; workers forage for nectar and pollen for the colony; pollinator species
134.	*Bombus* (*Fernaldaepsithyrus*) *sylvestris* (Lepeletier, 1832)	it is a cuckoo bumblebee (an obligate social inquilines of *Bombus pratorum*)
135.	*Bombus terrestris* (Linnaeus, 1758)	social insect that feeds on nectar; workers forage for nectar and pollen for the colony; pollinator species
Megachilidae		
136.	*Megachile centuncularis* (Linnaeus, 1758)	feed on nectar and pollen; pollinator species

Over 48.52% from hymenopterans are parasitoids, mainly primary parasitoids. Their larval stage is predominant endoparasitoids, developing inside hosts (eggs, larvae or pupae of other insect species) (Safavi, 1968; Teodorescu & Ursu, 1979; Teodorescu & Mustață, 1980; Townes & Townes, 1981; Teodorescu & Vădineanu, 2001; Hedqvist, 2007; Teodorescu, 2008 c). Only few species are ectoparasitoids. Parasitoid species are dependent upon their hosts as larvae, but as adults are free-living. From parasitoids, 28.78% of Scelionidae species are egg parasitoids, their hosts being species of Lepidoptera and Heteroptera (Teodorescu, 1980, 1988; Teodorescu & Simionescu, 1994; Teodorescu & Vădineanu, 2001; Kocak & Kilincer, 2003). Species richness of Hymenoptera predators or omnivorous was low (Reznikova & Dorosheva, 2003). The most common of hymenopterans are cynipid gall inducing wasps, and omnivorous or predaceous Formicidae.

Trichosteresis glabra, *Megaspilus dux*, *Exallonyx microcerus* and *Exallonyx pallidistigma* are recorded for the first time in the Romanian fauna. According to IUCN Red List of Threatened Species, *Formica polyctena* is considered as species with Lower Risk/Near Threatened.

Diptera order was represented by 71 species from 9 families (Rohacek, 1986) (Table 3). A number of 44 species (61.97 %) are predators, especially in larval stage. Chamaemyiidae and Syrphidae predaceous larvae, except for *Eumerus strigatus*, feed on homopterans (aphids, scales, mealybugs). The adults feed with nectar and honeydew (Syrphidae), honeydew (Chamaemyiidae), or with pollen and nectar (some Calliphoridae) (Sluss & Foote, 1973; Tanasiychuk, 1986; Ghadiri *et al.*, 2003). Most part of Chamaemyiidae species were collected as larvae or pupae from colonies of *Brachycaudus cardui*, *Hyalopterus pruni*, *Myzus persicae*, from galls of *Pemphigus* species, or as adults in the same colonies or in the others, feeding with the aphid honeydew. Syrphidae species were obtained especially as adults flying near aphid colonies, and as larvae or pupae from different aphid colonies (Ionescu & Teodorescu, 1969; Teodorescu, 2008 a).

Table 3
Diptera species recorded in the Comana Natural Park

No.	Taxa	Trophic category
Cecidomyiidae		
1.	*Mikiola fagi* (Hartig, 1839)	phytophagous larvae: make galls on leaves of *Fagus sylvatica*
2.	*Rhabdophaga rosaria* (H. Loew, 1850)	phytophagous larvae: the galls consist of 30-60 leaves, shortened and crowded together in rosettes on *Salix* (*S. alba, S. fragilis, S. caprea, S. purpurea, S. cinerea*)
3.	*Rhabdophaga saliciperda* (Dufour, 1841)	phytophagous larvae: make galls on the branches of *Salix*
4.	*Rhabdophaga terminalis* Loew, 1850	phytophagous larvae: make galls on terminal buds of *Salix*
5.	*Aphidolethes aphidimyza* (Rondani, 1847)	predatory polyphagous larvae: feed on over 70 aphid species
6.	*Contarinia medicaginis* (Kieffer, 1909)	phytophagous larvae: feed on the floral bud of *Medicago sativa*
Chamaemyiidae		
7.	*Leucopis gallicola* Tanasijtshuk, 1972	predatory larvae in galls of *Pemphigus* (Homoptera – Sternorrhyncha, Pemphigidae); adults feed on honeydew
8.	*Leucopis glyphinivora* Tanasijtshuk, 1958	predatory larvae feed on various stages of scale insects, mealy bugs and aphids; apparently preferring aphids
9.	*Leucopis atritarsis* Tanasijtshuk, 1958	predatory larvae feed on *Aphis pimpinellae, Hyalopterus pruni*, *Microlophium urticae*, *Brachycaudus cardui*; adults feed on honeydew
10.	*Leucopis caucasica* Tanasijtshuk, 1961	predatory larvae feed on aphids *Hyalopterus pruni, Myzus persicae, Brevicoryne brassicae;* adults feed on honeydew
11.	*Leucopis melanopus* Tanasijtshuk, 1959	predatory larvae feed on aphids *Dactynotus, Brachycaudus tragopogonis*; adults feed on honeydew
12.	*Leucopis rufithorax* Tanasijtshuk, 1958	predatory larvae feed on many aphid species; adults feed on honeydew
13.	*Leucopis ninae* Tanasijtshuk, 1966	predatory larvae feed on about 100 aphid species; adults feed on honeydew
14.	*Leucopis salicis* Tanasijtshuk, 1962	predatory larvae feed on aphid *Stomaphis bobretzkyi*; adults feed on honeydew
15.	*Leucopomyia silesiaca* (Egger, 1862)	predatory larvae feed on eggs and hatched larvae within ovisacs of 20 Pseudococcidae and Coccidae species (*Pseudococcus, Filippia, Pulvinaria, Eriopeltis*); adults feed on honeydew
16.	*Parochthiphila coronata* Loew, 1858	predatory larvae feed on *Pseudococcus*; adults feed on honeydew
17.	*Parochthiphila inconstans* Becker, 1902	predatory larvae feed on scale insects under leaf sheaths of grasses; adults feed on honeydew
18.	*Chamaemyia juncorum* (Fallen, 1823)	predatory larvae: prey upon feed on Coccids (scale insects) on grasses; adults feed on honeydew
19.	*Chamaemyia geniculata* (Zetterstedt, 1838)	predatory larvae: adults feed on honeydew
20.	*Chamaemyia elegans* Panzer, 1806	predatory, aphidophagous larvae; adults feed on honeydew
21.	*Chamaemyia polystigma* (Meigen, 1830)	predatory larvae feed on Pseudococcidae from *Lolium perenne*, coccidae on *Phalaris arundinacea* aphid and scale from barley, brome grass and ryegrass, blue grass mealybug, *Heterococcus nudus* (Homoptera: Pseudococcidae)
Bombyliidae		
22.	*Bombylius discolor* Mikan, 1796	larvae are ectoparasitic on the larvae and pupae of *Andrena* and *Halictus*; adults are nectarivorous

23.	*Bombylius major* Linnaeus, 1758	larvae are ectoparasitic on the larvae and pupae of *Andrena* and *Halictus*; adults are nectarivorous
Asilidae		
24.	*Asilus crabroniformis* Linnaeus, 1758	predatory adults, prey are grasshoppers, bees and wasps, beetles and other robber flies; larvae prey upon the larvae of dung beetles
25.	*Laphria flava* (Linnaeus, 1761)	predatory adults; larvae feed upon dead Coleoptera larvae in tree trunks
Syrphidae		
26.	*Cheilosia loewi* Becker, 1894	predatory larvae; adults feed with nectar and honeydew
27.	*Cheilosia scutellata* (Fallen, 1817)	predatory larvae; adults feed with nectar and honeydew
28.	*Cheilosia venosa* Loew, 1857	predatory larvae; adults feed with nectar and honeydew
29.	*Episyrphus balteatus* (De Geer, 1776)	predatory larvae: feed upon aphids; adults feed with nectar and honeydew
30.	*Eristalis* (*Eoseristalis*) *arbustorum* (Linnaeus, 1758)	predatory larvae; adults feed with nectar and honeydew
31.	*Eristalis* (*Eoseristalis*) *horticola* (De Geer,1777)	predatory larvae; adults feed with nectar and honeydew
32.	*Eristalis* (*Eoseristalis*) *intricaria* (Linnaeus, 1758)	predatory larvae; adults feed with nectar and honeydew
33.	*Eristalis* (*Eoseristalis*) *pertinax* (Scopoli, 1753)	predatory larvae; adults feed with nectar and honeydew
34.	*Eristalis* (*Eristalis*) *tenax* (Linnaeus, 1758)	predatory larvae in foul pools and ditches; adults feed with nectar and honeydew
35.	*Eumerus strigatus* (Fallén, 1817)	larvae attack onion bulbs; adults feed with nectar and honeydew
36.	*Eumerus tarsalis* Loew, 1848	predatory larvae; adults feed with nectar and honeydew
37.	*Eumerus tricolor* Meigen, 1822	predatory larvae; adults feed with nectar and honeydew
38.	*Melanostoma mellinum* (Linnaeus, 1758)	facultative predatory larvae, feed on aphids, but have the ability to make use of rotting plant material; adults feed with nectar and honeydew
39.	*Metasyrphus corollae* (Fabricius, 1788)	predatory larvae; feed on 12 aphid species; adults feed with nectar and honeydew
40.	*Metasyrphus luniger* (Meigen, 1822)	predatory larvae; adults feed with nectar and honeydew
41.	*Lasiopticus seleniticus* Meigen, 1892	predatory larvae; adults feed with nectar and honeydew
42.	*Paragus cinctus* Schiner & Egger, 1853	predatory larvae; adults feed with nectar and honeydew
43.	*Pipiza fenestrata* Meigen, 1822	predatory larvae; adults feed with nectar and honeydew
44.	*Pipiza quadrimaculata* (Panzer, 1802)	predatory larvae; adults feed with nectar and honeydew
45.	*Rhingia campestris* Meigen, 1822	predatory larvae; adults feed with nectar and honeydew
46.	*Scaeva pyrastri* (Linnaeus, 1758)	predatory larvae; adults feed with nectar and honeydew
47.	*Sphaerophoria loewi* (Zetterstedt, 1843)	predatory larvae; adults feed with nectar and honeydew
48.	*Sphaerophoria menthastri* (Linnaeus, 1758)	predatory larvae; adults feed with nectar and honeydew
49.	*Sphaerophoria scripta* (Linnaeus, 1758)	predatory larvae (feed upon aphids); adults feed with nectar and honeydew
50.	*Syritta pipiens* (Linnaeus, 1758)	predatory larvae; adults feed with nectar and honeydew
51.	*Syrphus ribesii* (Linnaeus, 1758)	predatory larvae (feed upon aphids); adults feed with nectar and honeydew
52.	*Syrphus vitripennis* Meigen, 1822	predatory larvae; adults feed with nectar and honeydew
Tabanidae		
53.	*Chrysops pictus* Meigen, 1820	haematophagous adults; larvae feed upon organic matter in the soil
54.	*Chrysops flavipes* Meigen, 1804	haematophagous adults; larvae feed upon organic matter in the soil
55.	*Chrysozona variegata* (Fabricius, 1805)	haematophagous adults
56.	*Chrysozona bigoti* Gobert, 1880	haematophagous adults
57.	*Chrysozona pluvialis* Linnaeus, 1758	haematophagous adults
58.	*Tabanus solstitialis* Meigen, 1820	adult feed on nectar and pollen, and the females also are haemato-phagous; larvae feed on other insects, worms, etc.
59.	*Tabanus quatuornotatus* Meigen, 1820	haematophagous adults
60.	*Tabanus sudeticus* Zeller, 1842	haematophagous adults
61.	*Tabanus bovinus* Linnaeus, 1758	haematophagous adults; larvae feed upon insect larvae, crustaceans, and earthworms in the soil

62..	*Tabanus autumnalis* Linnaeus, 1761	haematophagous adults
63.	*Tabanus bromius* Linnaeus, 1758	haematophagous adults
Calliphoridae		
64.	*Lucilia caesar* (Linnaeus, 1758)	adults feed on pollen and nectar; larvae feed mainly on carrion
65.	*Phaenicia serricata* (Meigen, 1826)	adults feed on pollen and nectar; larvae feed on the dead or necrotic tissue of carcass or corpse
66.	*Calliphora vicina* Robineau-Desvoidy, 1830	adults feed on pollen and nectar; larvae feed on the dead or necrotic tissue of carcass or corpse
67.	*Calliphora vomitoria* (Linnaeus, 1758)	adults feed on pollen and nectar; larvae feed decomposing matter (decaying meat, garbage, or faeces)
68.	*Pollenia rudis* (Fabricius, 1794)	adults feed on many types of organic matter (plant sap, fruit, flowers and faeces); larvae are parasitic on earthworms
69.	*Phormia regina* Meigen, 1826	adults feed on dung; larvae feed on the dead or necrotic tissue of carcass or corpse
Sarcophagidae		
70.	*Sarcophaga carnaria* (Linnaeus, 1758)	larvae feed on carrion or the flesh of living animals; adults feed on nectar, rotting carrion and dung
Muscidae		
71.	*Stomoxys calcitrans* (Linnaeus, 1758)	adults are haematophagous (suck blood from cattle, horses, and even humans); larvae feed on faecal materials and decaying organic matter, such as silage, rotting hay and grass clippings

Larvae of five Cecidomyiidae species are phytophagous, gall makers. *Aphidolethes aphidimyza* predaceous red larvae were detected in many aphid colonies (Teodorescu, 2008 b). The adults of 12 Tabanidae and Muscidae species are haematophagous. In Diptera order, parasitism was not frequent, only Bombyliidae larvae being ectoparasitic.

CONCLUSIONS

A total of 323 species belonging to 52 families and 3 orders were recorded from the Comana Natural Park. Hymenoptera and Coleoptera orders were dominant, with 136 and, respectively, 116 species.

The families Cynipidae, Chrysomelidae and Syrphidae were the best represented. The parasitoid species were dominant in Hymenoptera, the phytophagous species in Coleoptera and the predators in Diptera.

A number of 138 species, especially from Coleoptera (73 species) and Hymenoptera (59 species) are phytophagous, mainly polyphagous. Among them, 57 species are gall-making insects (Tenthredinidae, Cynipidae and Cecidomyiidae).

The predators, as adults and larvae, or only as larvae, were represented by 74 species (27 species of Coleoptera, 44 species of Diptera and 3 species of Hymenoptera). They are oligophagous or polyphagous, partially, predominant or exclusively entomophagous.

The parasitoids Hymenoptera, as larvae, are mainly primary parasitoids, endoparasitoids, and egg parasitoids, the adults being free-living organisms.

Omnivorous (predominant predaceous or predominant phytophagous), necrophagous, coprophagous and detritophagous species were less represented.

The higher number of parasitoid and predator species assure an effective natural control of arthropod populations, the ratio between zoophagous (parasitoids and predators) and phytophagous species being the main indicator to establish the ecosystems stability (Teodorescu, 2010).

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FOOD AND FEEDING ECOLOGY OF FIDDLER CRABS SPECIES FOUND ALONG THE COAST OF PAKISTAN

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The food and feeding behaviour of four fiddler crab species commonly inhabiting Sandspit and Korangi creek mangrove areas in Pakistan were investigated (50 specimens per species). The mean number of spoon tipped setae on the second maxillipeds ranged from 111 to 247 and were the highest in *Uca iranica* followed by *U. annulipes, U. urvillei* and *U. sindensis*. The number of spoon tipped setae on the second pair of maxillepeds did not differ between the sexes, but did differ among species ($F_{3, 199} = 31.9$, $P < 0.005$ and $F_{3, 199} = 25.8$, $P < 0.005$, respectively). The foraging distance away from the burrow, and the shape of the radiating paths were species specific and positively correlated with the diameters of burrows. The relative percent mud content in the stomach was significantly different among the four species. Stomach contents of all four species largely consisted of the plant debris, different interstitial organisms, their eggs, spines, animal tissues, and filamentous algae, including organic detritus. *U. urvillei* is the only species that was observed as predator species.

Keywords: Fiddler crab, feeding path, food, Spoon tipped setae, Pakistan.

INTRODUCTION

Foraging activities of fiddler crabs produce measurable changes in the sediment structure and characteristics (Posey, 1987; Botto & Iribarne, 2000). These crabs along with members of grapsids are considered as ecosystem engineers as they continuously modify the surface sediment structure through their burrowing and feeding activities (Teal, 1958; Kostka *et al*., 2002). Fiddler crabs are surface deposit-feeders and forage upon the substrate (Macintosh, 1984; Robertson & Newell, 1982) and are important consumers of detritus, bacteria, fungi, and benthic micro algae in coastal marsh, mangrove, sand flat, and mudflat habitats (Backwell *et al*., 2006; Mokhlesi *et al*., 2011). Their main food resource is organic matter, including the endofauna sorted out from the substrate (Murai *et al*., 1982). The unwanted sediment material left from sorting is formed into irregular cohesive masses called food pellets or mud balls that are deposited on the surface sediment near the burrow openings.

In decapods, the feeding ecology in their natural environment is frequently determined directly from an analysis of their stomach contents, and the structure and function of the mouthparts (Hill, 1976; Williams, 1981; Choy, 1986; Chande & Mgaya, 2004; Hegele Drywa & Normant, 2009). The frequency of feeding and the quality of the food ingested depend on the morphology of mouth parts, locality inhabited (Takahashi & Kawaguchi, 2001; Turra & Denadai, 2003). Actual food supply depends on the productivity of the ecosystem, microbial activity, substrate texture, and tidal action (Twilley *et al*., 1995; Moura *et al*., 2000) such that the optimal conditions for foraging can be affected by texture, organic matter and water content of the sediment (Reinsel & Rittschof, 1995). A comparison of local population in different feeding environments reveals correlations among food habits, feeding behaviour and feeding organs, which reflect the adaptation of organisms to the food sources, the process of adaptation, and possibly speciation in fiddler crabs (Colpo & Negrieros-Fronsozo, 2003).

Female crabs possess two isomorphic feeding chelipeds, and male fiddler crabs are equipped with dimorphic chelipeds comprising of one small chelae mainly use for feeding and one enlarged hypertrophied or major cheliped. The feeding process involves two organs, the small chelipeds (minor cheliped in case of male) that are used to scoop up sediments from the surface of the substrate and transfer these to the mouth or buccal cavity, and the other are the spoon tipped setae of the second maxillipeds that perform the function of sorting of food material for ingestion (Miller, 1961; Ono, 1965; Crane, 1975; Robertson & Newell, 1982 a, b). The food particles are sorted by water passing through the buccal cavity that suspends fine particles, which are trapped among the setae on the feeding appendages (Ono, 1965; Crane, 1975; Robertson & Newell, 1982a). The 'spoon tipped' setae have broad tips that are cupped and arched inwards (Lim, 2004). The morphology of the minor cheliped is also adapted to the substrate texture; its frame shape differs between fiddler crabs inhabiting mud and sand (Crane, 1975; Icely & Jones, 1978; Rosenberg, 2002).

The objective of this study was to investigate the food and feeding behaviour of four species of fiddler crabs found along the coastal line. There is not much information on the feeding ecology of fiddler crabs commonly inhabiting the mangrove areas of the Pakistan Coast. This is the first attempt to investigate the feeding biology and ecology of fiddler crabs along the coast of Pakistan. Present study mainly based on the hypothesis that the food preference is found among the species and vary among the four species of fiddler crabs as preferred habitats of these species varying in tidal height, vegetation and sediment composition.

MATERIAL AND METHODS

Study site

Two sites, the Sandspit and Korangi creek, were selected for studying the food and feeding behaviour of the fiddler crabs. The Sandspit back waters mangrove area (24°50'N, 66°56'E) is located in the south west of Karachi and is connected to the Arabian Sea through the Manora Channel. The Sandspit beach is bifurcated by a dry strip of land, with mud flats and dense stands of the mangrove *Avicennia marina* on the northern side, and of sandy beach on the south side. The

Korangi creek mangrove area (24°79’N, 67°20’E) near the salts works in the fishing village, Ibrahim Hyedri. Korangi Creek is the northern most creek of the Indus Delta and connected at its northeastern end with Phitti creek and Kadiro creek, while at its southwestern end, it connects with open sea and with Gizri creek, and is bounded on its sides by extensive mangrove vegetation of *A. marina*.

Methodology

The shapes of feeding pellets and their distribution pattern around the burrow were observed for three species of fiddler crab (*Uca annulipes*, *U. sindensis* and *U. iranica*). The foraging distances (Fig. 1) of at least six pathways were measured and correlated with the burrow diameter (BD). It was not possible to study the feeding ecology of a fourth study candidate, *U. urvillei*, as this species is usually found under the canopy of mangrove vegetation in moist swampy soil that collapse, making the evaluation of foraging track and the shapes of feeding pellets unreliable. Male *U. urvillei* at the study sites can wander many meters from their burrows and sometimes predate on small shells and crabs.

Fig. 1. Foraging tracks of three species of fiddler crabs (*Uca iranica, U. annulipes*, *U. sindensis*) at the study sites.

It was observed that the male *Uca* crabs usually use their one small chelipede for feeding and female use the both pincers. It was also observed the use of one sided chelae for feeding in male crabs effect the directional use of male crabs mouth parts for the processing of food or the handedness makes any correlation with the feeding process and organs involved in the process. In the laboratory, the left and right second maxillipeds of each crab were placed on a cavity slide. The presence and numbers of spoon tipped setae were counted under the compound microscope and the differences in numbers of spoon tipped setae between the left and right side of the maxillipeds were compared. Two factorial analysis of variance (ANOVA) tested if the numbers of spoon tipped setae varied with sex or among the species.

For the stomach content analysis about 50 specimens of each species of four fiddler crab species *(U. annulipes*, *U. sindensis, U. iranica* and *U. urvillei)* were randomly collected during the low tide period. The collected crabs (n = 200) were immediately fixed in 10 percent formalin in the field and transferred into 70% alcohol after 24 hours. Each crab stomach contents were examined.

Firstly a visual estimation of the percent gut fullness based on an index of 1–4, with 1 equal to 0 to 25% gut fullness and 4 equal to 75 to 100% fullness of the gut was made before opening dissecting out the contents into a petri dish. The percent occurrence of mud or sand was categorized 1: 10%, 25%, 50%, 75% and 90%. The stomach contents were washed with alcohol in a petri dish and the food categories (eggs of invertebrate, crustacean appendages, nematode worms, plant tissue debris, spines, animal tissues, and filamentous algae, etc.) were identified under a compound microscope. The occurrence of the food categories quantified using the percentage occurrence method (Williams, 1981; 1982), frequency of food item/number of crabs' %. This method gives a measure for the regularity with which food has been taken in the highest value as the most important one in the sample or population.

RESULTS

Lengths and shapes of foraging paths

One way analysis of variance (ANOVA) showed a significant difference between the three species of fiddler crab in the lengths of foraging tracks ($F_{2, 363} = 13.61$, $P < 0.001$).

In *U. sindensis* the shape of the feeding pellets was biconvex and rounded (Fig. 1). The mean feeding passage distance was 77 ± 25.4 mm with an average burrow diameter of 10.2 ± 2.9 mm. Positive linear relationship ($r^2 = 0.82$) was observed between the size of burrow diameters and an average distance of feeding passages around the burrows.

The feeding pellets of *U. annulipes* were usually crudely rounded in shape. The mean feeding passage distance was 99 ± 36 mm with the mean BD of 11 ± 2.6 mm, the relationship between the BD and the feeding passage distance was also positive ($r^2 = 0.6$).

The feeding pellets of *U. iranica* were barrel in shape. The mean feeding passage distance of *U. iranica* was 102 ± 37.8 mm with an average BD of 10.2 ± 3.2 mm (Table positive relationship ($r^2 = 0.66$) was observed between BD and the average feeding passage distance around the burrows.

Spoon tipped setae

The number of spoon tipped setae separately showed a significant difference among species, but they were not significantly different between the sexes ($F_{3,199} = 31.9$, $P < 0.005$ and $F_{3,199} = 25.8$, $P < 0.005$ respectively). Post hoc analysis showed that the spoon tipped setae were significantly highest in *U. iranica,* compared to *U. annulipes* which were in turn significantly greater than *U. urvillei* and *U. sindensis* (*U. ira.* > *U. ann.* > *U. ur.* > *U. sin.*).

Gut content analyses

Initially the gut fullness of the specimens of each species collected for analysis was observed through binocular visual estimation (Fig. 2). Gut contents of all four species were largely comprised of plant debris, different interstitial organisms and their eggs and organic detritus (Fig. 3). The percent proportions of mud in the stomachs was significantly different among the four species ($F_{3,199} = 18.29$, $P < 0.005$). The highest mud content was found in *U. urvillei* followed by *U. sindensis* (Fig. 3).

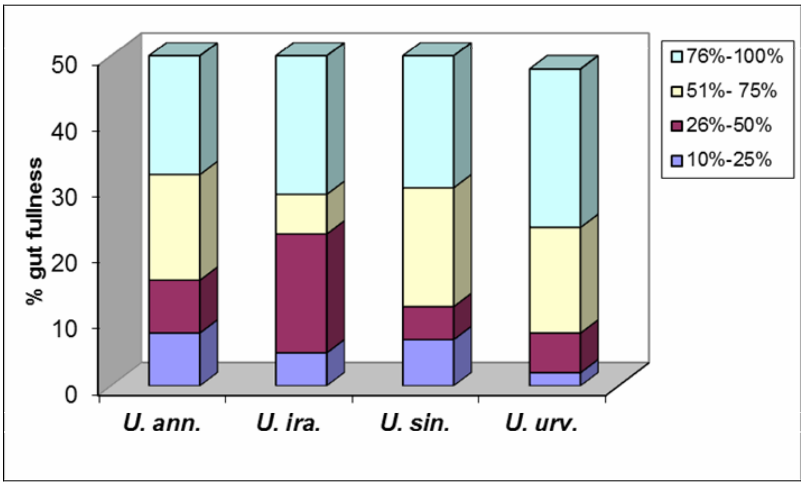

Fig. 2. Percent gut fullness estimated in the four species of *Uca*.

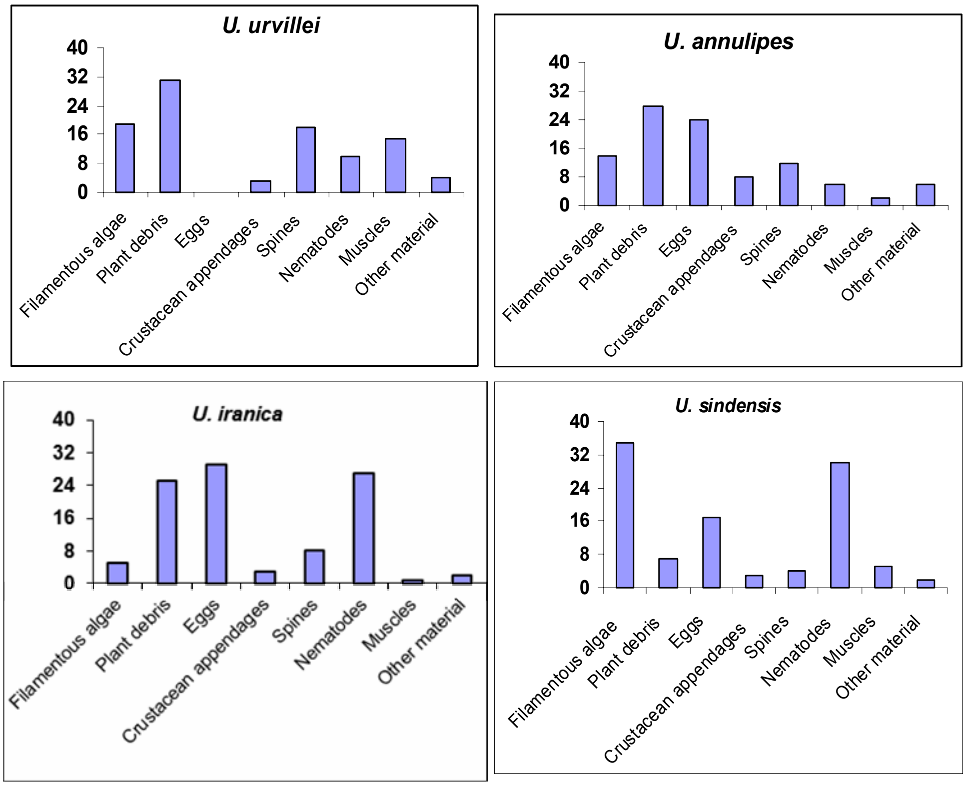

Fig. 3. Percent frequency occurrence of the various food items identified in the stomach of four Fiddler crab species.

The diet of *U. annulipes* was mainly based on the plant tissue debris and filamentous algae and the leaves of *Avicennia marina* (Forsk), identified on the basis of tissue and stomata feature. *U. sindensis* and *U. iranica* had invertebrate and crustaceans and animal remains in their diets. *U. urvillei* rarely fed on fresh leaves of mangrove trees and displayed opportunistic diet, the male crabs were observed wandering many meters from their burrows, predating small crabs and molluscs by crushing their shells with the major cheliped; they were also seen to feed on surface algae. This is reflected in the significant difference in the ratio of animal to plant matter in the stomach contents of each species.

DISCUSSION

The three species of *Uca* (*U.iranica, U. sindensis and U. annulipes*) were observed to forage around their burrows in circular or radiating paths. Crabs that forage moving in a circular area, conserve the time and distance travelled away from a burrow, for a given total area harvested. Radiating circular paths optimize net resource yields, especially when resources are homogeneously distributed (Smith, 1968; Covich, 1976; Andersson, 1978; Hixon, 1980, Schoener, 1983). It was also observed that crabs maintain their positions by orienting to the pellets and subsequent troughs that are created as they forage. The arrangement of feeding pellets around the crabs burrow showed interspecific variability. Mukhlesi *et al.* (2011) observed the intersexual difference in *the U. sindensis* during their mesocosm studies. Circular paths erase the selection among food concentrations, especially when the burrow provides an essential or limiting resource constraining foragers to balance conflicting demands (Zimmer-Faust, 1987). The burrows provide crabs with their only reliable source of water during an ebb tide. A resource that is essential to continue feeding activity and to resist desiccation. Systematic grazing also reduces the chance to feed in previously grazed areas and it was commonly observed among other invertebrate and vertebrate grazers (Davies & Houston, 1981; Waddington & Heinrich, 1981). The shapes of the feeding pellets also varied in three species studied, *U. sindensis, U. iranica* and *U. annulipes.* This difference can be related to the shape and the depth of the spoon tipped setae, arrangement of spoon tipped setae on maxillepede, and structure of small cheliped and these observations indicated the need of a detailed study.

Spoon tipped setae on the second maxilliped decreased in abundance in the following order: *U. iranica* > *U. annulipes* > *U. urvillei* > *U. sindensis. Uca iranica* and *U. annulipes* were found in sandy habitat and *U. urvillei* and *U. sindensis* inhabited muddy areas. Ocypodidae inhabiting sandy habitat generally have more numerous spoon tipped setae on the inner surface of the second maxilliped and the outer surface of the first maxilliped compared to those inhabiting muddy flats, which have a few spoon tipped and many plumose setae (Miller, 1961; Ono, 1965; Icely & Jones, 1978). Lim (2004) compared spoon tipped setae in two species *U. annulipes* and *U. vocans* and also found more spoon tipped setae in *U. annulipes* which inhabits the sandy habitat.

The number of spoon tipped setae differed between sexes. Weissburg (1991) found quantitative differences in spoon tipped setae of male and female *U. pugnax*. Lim (2004) found a difference in the area of maxilliped that was covered by spoon tipped setae and a number of setae and observed no significant difference of spoon tipped setae between male and female crabs of *U. vocans* and *U. annulipes*.

The food composition of Decapoda in their natural environment is usually determined directly from an analysis of their stomach contents, even though identification of the food remains is difficult. This is due to the structure and function of the mouthparts (Hill, 1976; Williams, 1981; Chande & Mgaya, 2004).

In the present study, the stomach contents analyses of four species of *Uca* revealed that they primarily feed on the plant debris, different interstitial organisms and organic detritus. The eggs of invertebrates, crustacean appendages, nematode worms, plant tissue debris, spines, animal tissues, and filamentous algae were the main food categories identified from the gut material of four species of *Uca*. These results show that the species of fiddler crabs were identified as omnivorous, feeding on detritus, animal and plant matter. The three studied species (*U. annulipes* and

U. urvillei) were reported as algal feeders (Icely & Jones, 1978) but in the present study the presence of various food items including algae indicates the studied *Uca* species can be considered as omnivorous rather than algal feeders. Omnivorous organisms with more feeding options have greater ability to optimize nutritional balance compared to ones with narrower diet breadth (Bjorndal, 1991).

Table 1

Mean, minimum and maximum number of spoon tipped setae on the left and right maxillipeds of four species of fiddler crab (STS = Spoon Tipped Setae)

Variable	Crab species	N	Mean± SD	Min	Max
STS ON LEFT MAXILLEPEDE					
	Uca urvillei	5	157.8±26.3	12	196
	Uca sindensis	5	102.3±11.9	85	119
	Uca annulipes	5	210.5±65.4	82	302
	Uca iranica	5	247.1±48.8	147	320
STS ON RIGHT MAXILLEPEDE					
	Uca urvillei	5	162.4±30.7	110	210
	Uca sindensis	5	111.5±18.6	84	137
	Uca annulipes	5	207.3±64.7	74	298
	Uca iranica	5	246.8±41.8	156	310

Table 2

Summary of descriptive statistics for the foraging distance around their burrow and burrow diameter of three species of fiddler crab

Variable	Species	N	Mean± SD	Min. (cm)	Max. (cm)
Feeding distance (cm)					
	U. sindensis	252	7.7 ± 2.5	4.0	14.0
	U. iranica	279	10.2 ±3.7	4.5	17.5
	U. annulipes	243	9.9 ± 3.6	4.5	19.0
Burrow diameter (cm)					
	U. sindensis	50	1.02 ± 0.3	0.5	1.5
	U. iranica	50	1.02 ± 0.3	0.4	1.6
	U. annulipes	50	1.11 ± 0.4	0.6	1.8

Table 3

The presence of food content in the stomach of *Uca* species along the coast of Pakistan (+ very few, ++few, +++ Numerous)

Food content	*Uca urvillei*	*Uca sindensis*	*Uca iranica*	*Uca annulipes*
Percent mud	50%–90%	40%–75%	5%–50%	10%–60%
Filamentous algae	++	+++	+	++
Plant debris	+++	+	+++	++
Eggs	–	++	+++	+++
Crustacean appendages	+	+	+	+
Spines	+++	+	++	++
Nematodes worms	++	+++	+++	+
Muscles	++	+	+	+
Other material	+	+	+	++

According to Marshall & Orr (1960), most crustaceans are omnivorous, including fiddler crabs ingesting the available organic food particles available on the moist marsh surface. Shanholtzer (1973) analyzed the stomach content of *U. pugnax* and revealed that one third diatoms, one fourth fungi, one fifth unknown, one fourteenth vascular plants and small amounts of arthropod parts and foraminifers were found in the gut. The diet of *Uca* species studied may contain greater amounts of the detritus-microbe complex. The detritus-microbe complex is widely believed to provide a suitable energy source for detritivores. A variety of micro flora and micro fauna living on these detrital particles are suitable food for fiddler crabs (Darnell, 1967). *Uca* may supplement their protein intake by ingesting bit of carrion, arthropods and nematodes (Darnell, 1967; Montague, 1980). This highly opportunistic feeding habit, known also for West Indies Grapsidae (Von Hagen, 1977), seems to be a common feature of mangrove crabs. The presence of plant material in the diets likely indicates that multiple type of food provides complementary nutritional resources for fiddler crabs. It has been reported that crustaceans frequently select small and medium-sized high-energy food items from which the nutrients were readily assimilated (Morales & Antezana, 1983; Juanes, 1992; Kennish & Williams, 1997).

Mud content in stomachs was highest in *U. urvillei.* Shwartz & Safir (1915) believed fiddler crabs to have a feeding preference for mud high in algal biomass. Skov & Hartnoll (2002) suggested sesarmid crabs might feed on mangrove mud to supply their diets with microbial nitrogen on decaying leaf litter fragments. It has been suggested that stomach contents often reflect the availability of food in the environment rather than an animal's Preferences (Hegele Drywa & Normant, 2009). Large male crabs of *U. urvillei* were observed predating small gastropods by crushing their shells, similar observations have been made for the omnivorous crab *Hemigrapsus sanguineus* which prefers small bivalve prey as well as for *Armases cinereum* (Buck *et al*., 2003). The choice of food to be consumed depends not only on its availability in the environment, but also on its assimilability sensu lato. It has been reported that crustaceans frequently select small and medium-sized high-energy food items from which the nutrients are readily assimilated (Juanes, 1992; Kennish & Williams, 1997).

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TUTA ABSOLUTA POVOLNY (LEPIDOPTERA: GELECHIIDAE), THE EXOTIC PEST IN TURKEY

SEVCAN OZTEMIZ

The tomato leaf miner, *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae), is an alien pest of tomato and other Solanaceae crops. It is native to South-America and is presently distributed in Europe, North Africa and Asia. *T. absoluta* was first detected in the Aegean and Marmara Regions of Turkey in 2009, but now almost all the regions of Turkey are infested. Infestation by *T. absoluta* could reduce crop yield and fruit quality, causing up to 100% yield losses in both greenhouse and open-field tomato production if no control measures are applied. *T. absoluta* is a very challenging pest to control because of having 10–12 generations per year and resistance to many insecticides. Therefore, a combination of all available control measures is required to control the pest. A review of efficient management strategies for control of *T. absoluta* in invaded areas is presented.

Keywords: *Tuta absoluta*, exotic, invasive species, management, Turkey.

INTRODUCTION

Invasive species cause significant damage to both natural environments and agricultural crops. In agricultural crops, invasive pests can cause ecological disruption, reduce yield and increase costs of management in invaded areas. The tomato leafminer, *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae) is one of the invasive pests in agricultural crops of Turkey that recently became a major threat to tomatoes in field and under protected conditions.

MATERIAL AND METHODS

The results were obtained with the latest references and our studies on the biology, population monitoring, distribution, damage, host plants, natural enemies, biological control, other management strategy – integration of control measures between 2009–2013 in Turkey. Biological materials used in the study were our native species collected from nature and analyzed in the laboratory under controlled conditions. The specimens have been deposited in the insect museum unit of the Biological Control Research Station in Adana, Turkey.

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RESULTS AND DISCUSSION

Description and Taxonomic History

Tuta absoluta (Meyrick) belong to the order Lepidoptera and family Gelechiidae. Meyrick (1917) described it for the first time as *Phthorimaea absoluta* in Peru. The pest, called with the names of different genera (*Gnorimoschema absoluta*, *Scrobipalpula absoluta*, *Scrobipalpuloides absoluta*), was finally described as *Tuta absoluta* by Povolny in 1994.

Geographic Distribution

Tuta absoluta is a neotropical pest, originating from South America and it became widespread in all South American countries, but with few occurrences in Central America (EPPO, 2011). The moth spread from America to the European continent in 2006 (Urbaneja *et al*., 2007). It was first recorded in Spain and then spread to other European countries. In 2008, it spread throughout the African continent; particularly North African countries. It continued in 2010 with the Asian continent, respectively, and more broadly to most countries of the Afro-Eurasian continent (Desneux *et al*., 2010). The pest showed rapid intercontinental spread in three continents, traveling about 4,000 km in five years (Tropea Garzia *et al*., 2012), and was mainly found in countries bordering the Mediterranean Sea (USDA, 2011). It was detected for the first time in Turkey in 2009 (Kilic, 2010). Firstly, *T.absoluta* appeared in the regions of Aegean and Marmara, west of Turkey. Later on, this newly introduced pest spread very quickly to all the regions of Turkey within one year. Climate change has been effective in the spreading of invasive species (Hellmann *et al*., 2008). However, *T. absoluta* has been identified at as high an altitude of 1000 m above sea level (Viggiani *et al*., 2009), also found at higher altitudes at 3246 m in Peru (Povolny, 1975). We have found an altitude of about 2000 m in South-eastern part of Turkey (Portakaldali *et al*., 2013).

Economic impact

Tomato (*Solanum lycopersicum* L.) is the most important vegetable crop in Turkey. Tomato production is 11 million tons per year (TUIK, 2012). In the production of the tomatoes, Turkey is the fourth in the world. With the entry of pests into the country, there has been a 6.5% decrease in the tomato production in Turkey, and a 45 million € loss has occurred in the economy. Since it was first detected in Turkey, the pest has caused serious damages to Solanaceae crops, especially tomatoes in invaded areas. *Tuta absoluta* has become the key pest of the greenhouse-grown tomatoes and in open fields of Turkey. If control measures against the pest are not taken, significant crop losses ranging from about 50% to

100% may occurr. If control measures are applied, crop losses will range from 1% to 5%. In Turkey, pesticides have been applied about 13 times per growing season to control of *T. absoluta*. Considering tomato production area in Turkey, the annual cost of chemical control of *T. absoluta* costs approximately 160.7 million €.

Biology

Adults are nocturnal and during the day usually hide between leaves. Adult lifespan ranges between 10 and 15 days for females and 6–7 days for males. Females lay eggs mainly on the leaves, stalks, stems, buds, flowers, fruits and green fruit underneath the sepals that form the calyx. A single female can lay a total of about 120–260 eggs during its lifetime. Egg hatching takes 4–6 days, and the complete four larval periods take about 13–15 days. Pupation may take place in the soil, on the leaf surface or within galleries or other parts of the plant depending on environmental conditions. Pupa period lasts 9–11 days. The pest may overwinter as eggs, pupae or adults. Larvae do not enter diapause as long as food and weather conditions are available, and when conditions are appropriate it has 10 to 12 off-springs per year. A life cycle is completed in 24–76 days depending on environmental conditions. The lower developmental threshold for *T. absoluta* is about 8.14ºC. This temperature is 6.9°C, 7.6ºC and 9.2ºC for the period of the eggs, larvae, and pupae, respectively. Thermal constant for the total development from egg to adult of the pest is 459.6 degree-days. Sex ratio 1:1.33 male: female (Barrientos *et al*., 1998; Desneux *et al*., 2010; CABI, 2011).

Damage

The larvae feed on all parts of the plant except for the root, and attack all growing stages of the crop from the seedling stage. Larvae attack on leaves, stems, shoots, apical buds, flowers and fruits of the crop.

Leaves. Larvae mine the leaf tissue, and feed only on the mesophyll of the leaf, only the epidermis remains intact. Leaf mines formed by the larvae are of an irregular shape. When the pest continues to feed, gallery discharge and consists of large transparent cavities, and later transformed into brown and then dry. Black droppings of the larvae in galleries are remarkable. Photosynthetic capacity of the plant is reduced due to dried galleries, which results in a reduction of yield.

Shoots and Stem. Larvae mine the stems and cause damage to the plant's nutritional channels, then necrosis occurs. The galleries in the stems may adversely affect the development of the plant. Larvae can also pull together new shoots using silk produced by specialized salivary glands.

Flowers and Fruit. Larvae can attack the flowers, but the most serious damage is found in fruit. Larvae usually enter the fruit under the calyx and open galleries. Infested fruit drops and rots. The galleries open by the larvae can be invaded by secondary pathogens that cause fruit rot (EPPO, 2005). Fruit deformation occurs by a larval feeding and results in the reduction of fruit quality and yield losses; consequently, damages fruits lose their commercial value.

Host Plants

Plant species from the Solanacaeae, Fabaceae, Convolvulaceae and Chenopodiaceae families have been identified as hosts of *T. absoluta* in Turkey (Table 1). Although the primary host of *T. absoluta* is tomato (*Solanum lycopersicum*), it can also attack other cultivated Solanaceae, such as: aubergine (*Solanum melongena)*, potato (*Solanum tuberosum*), pepino (*Solanum muricatum*), pepper (*Capsicum annuum*), tobacco (*Nicotiana tabacum*), cape gooseberry (*Physalis peruviana*) and goji berry (*Lycium* sp.) (Vargas, 1970; Campos, 1976; EPPO, 2009; Tropea Garzia, 2009; Desneux *et al*., 2010), as well as on non-cultivated Solanaceae (*Solanum nigrum*, *S. eleagnifolium*, *S. bonariense*, *S. sisymbriifolium*, *S. saponaceum*, *Lycopersicum puberulum*.) and other naturally available host-plants, such as: *Datura ferox*, *D. stramonium*, *Nicotiana glauca* and *Malva* sp. (Garcia & Espul, 1982; Caponero, 2009). Furthermore, it was reported in Fabaceae on the common bean (*Phaseolus vulgaris*) in Sicilia, Italy (EPPO, 2009). These show that *T. absoluta* has a high tendency to use various plants as secondary hosts. The alternative host plants allow *T. absoluta* to survive in many habitats in the absence of tomato crops.

Table 1
Host plants of *Tuta absoluta* in Turkey*

Species	Family
Solanum lycopersicum L. (*Lycopersicon esculentum* Miller)	Solanaceae
Lycopersicon hirsutum Dunal *Lycopersicum puberulum* Phil.	
Solanum melongena L.	
Capsicum annuum L.	
Solanum tuberosum L.	
Solanum muricatum Aiton	
Solanum nigrum L.	
Nicotiana tabacum L. *Nicotiana glauca* Graham	
Datura stramonium L. *Datura ferox* Kunth	
Schizanthus spp.	
Petunia spp.	
Phaseolus vulgaris L.	Fabaceae
Convolvulus arvensis L.	Convolvulaceae
Chenopodium album L.	Chenopodiaceae

* Anonymous (2011); Karabuyuk *et al.* (2011); Portakaldali *et al*. (2013).

Spread Pathways

Natural spread. Climate conditions are important to the spread of invasive species. *T. absoluta* maintains viability in the greenhouse during the winter months and spreads to the open fields during the spring and summer months (Potting *et al.*, 2009). If conditions are favorable, diapause does not appear, and generation continues throughout the year. *T. absoluta* has an active and passive dispersal capacity. Adult moths can move up to a few kilometers by flying (active) or floating in the wind (passive) through the open fields (Van Deventer, 2009). The oligophagous leaf miner, *T. absoluta* has many alternative hosts in order to maintain the viability and spread in the invaded areas. *T. absoluta* is a multivoltine species with high reproductive potential to spread. It continues development as long as the food and weather conditions are favorable.

Human-induced spread. Otherwise, *T. absoluta* spreads through agricultural trade with intra community or between countries and continents in border crossings (Cáceres, 1992). Therefore, populations of *T. absoluta* were transported with infested plants left in greenhouses or fields after harvest or were spread by consignments of seedlings for planting and fruits of tomatoes, either from production sites and packing sites infested with *T. absoluta.* Also, *T. absoluta* was carried with human, equipment (frames, boxes, etc.) and shipping vehicles. Lastly, the consumers might also serve as a pathway for the spread of *T. absoluta*.

Management Strategy – Integration of Control Measures

To prevent damages, control measures should be taken urgently against this pest. The use of chemical pesticides is a common practice to control the pest, but it does not give the desired result because of having a high reproductive capacity, very short generations and an increased risk of developing resistance by this pest (Siqueira *et al*., 2000). Negative impacts of pesticides are the natural enemies, and predatory bugs in the early growth stages of the crop should not be forgotten. To control the pest effectively it is very important to combine all of the control measures available and not only rely on insecticide sprays. Integrated pest management (IPM) is being developed in many countries where *T. absoluta* is a serious pest of the tomato.

Cultural Control

– Using clean seedlings, and not to be contaminated with the pest. Tomato production and packing sites with production nurseries should follow sanitation guidelines to prevent spread of *T. absoluta*.

– Using transplants free of pests.

– Screening the greenhouse vents and installation of double self-closing doors to prevent entry or exit of *T. absoluta*. Using quality nets with a minimum density of 9 × 6 threads/cm² to ventilation and covering windows and other openings with 1.6 mm (or smaller) insect mesh.

– Remove and destroy infested plant parts, leaves, stems, fruits from production area to prevent population build up, especially at the beginning of cultivation;

– Remove and destroy weeds that may be hosting the pest in order to prevent the build-up of a potential population reservoir.

– Destruction of infested plants, post-harvest plant debris and crop residues as soon as possible after harvesting.

– Soil solarisation to kill pupae in the soil.

– Rotation with non-solanaceous crops or non host plants of the pest.

– Deep ploughing after harvesting.

– Adequate cultivation technique, fertilization and irrigation, etc.

– Using resistant varieties, the susceptibility of tomato cultivars to *T. absoluta* varies and plant resistance is being investigated.

– Greenhouse workers should inspect their clothing and greenhouse tools, pots, carts, etc. They should be thoroughly cleaned before moving to other greenhouses for the existence of eggs, larvae, pupae and adults of *T. absoluta*.

Biological Control

Biological control is a promising candidate in IPM strategy to control *T. absoluta* in the invaded area (Roderick & Navajas, 2003; Oztemiz *et al*., 2012). There are numerous natural enemies of *T. absoluta*, the most important being given in Table 2. Parasitoids are the most common natural enemies of *T. absoluta* in South America, where the pest originates. More than 20 species of parasitic wasps have been described for *T. absoluta* (Luna *et al.*, 2007). One of them is the egg parasitoid *Trichogramma* species (Medeiros *et al*., 2006) as *Trichogramma pretiosum* (Riley) (Villas-Boas & Franca, 1996) and *T. achaeae* Nagaraja Nagarkatti (Nagaraja *et al*., 2002; Cabello *et al*., 2009).

In Turkey, *Trichogramma evanescens* Westwood (Hymenoptera: Trichogrammatidae) has been identified as a potential biological control agent of the pest and is currently being released in tomato greenhouses.

Oztemiz *et al.* (2012) reported that when *Trichogramma* releases were combined with *Nesidiocorus tenuis* to control *T. absoluta* in greenhouses of the East-mediterranean part of Turkey, efficient control was obtained. The egg parasitization rate of *T. absoluta* was 60.27% and 63.51% when releasing *Trichogramma* alone and combined with *N. tenuis*, respectively. The numbers of *T. absoluta* eggs were decreased by 63.29% and 82.91% in the treatments with *T. evanescens* alone, and combined with *N. tenuis*, respectively. Besides, numbers of infested fruit were decreased by 85.29% and 97.05% in the treatments with *T. evanescens* alone, and combined with *N. tenuis*, respectively.

Table 2
Some important natural enemies of *Tuta absoluta* in Turkey*

Parasitoids	Order/Family
Egg	
Trichogramma evanescens Westwood	Hymenoptera: Trichogrammatidae
Larvae	
Pseudapanteles dignus (Muesenbeck)	Hymenoptera: Braconidae
Bracon hebetor Say	
Bracon didemie Beyarslan	
Necremnus sp.	Hymenoptera: Eulophidae
Closterocerus clarus (Szelenyi)	
Pnigalio cristatus (Ratzeburg) (= *Ratzeburgiola christatus*)	
Pnigalio incompletus (Boucek) (= *Ratzeburgiola incompleta*)	
Baryscapus bruchophagi (Gahan)	
Pteromalus intermedius (Walker)	Hymenoptera: Pteromalidae
Pupae	
Brachymeria secundaria (Ruschka)	Hymenoptera: Chalcididae
Hockeria unicolor Walker	
Predators	
Nesidiocorus tenuis Reuter	Hemiptera: Miridae
Macrolophus caliginosus W. = *Macrolophus pygmaeus* (Rambur)	
Nabis pseudoferus Remane	Hemiptera: Nabidae
Entomopathogens	
Bacillus thuringiensis var. *kurstaki*	Bacilliales

* Anonymous (2011); Doganlar & Yigit (2011); Oztemiz *et al.* (2012).

Furthermore, several species of predators have been evaluated as the most promising natural enemies of *T. absoluta*, mainly the mirid bugs, *Nesidiocoris tenuis* and *Macrolophus pygmaeus* (Urbaneja *et al.*, 2008), which are large consumers of the pest eggs. In the Mediterranean, these two species naturally colonize tomato crops where broad spectrum insecticides are not sprayed and released for biological control in greenhouse tomato crops. The important factor for predatory bugs is releasing time because of their slow establishment in the early growth stages of the crop (Oztemiz *et al.*, 2012). Larvae of *T. absoluta* spend most of their life inside mines, but second instars can leave the mines; this is well-timed for predation and parasitism. Microorganisms such as bacteria, fungi, viruses, and nematodes are also available to control of *T. absoluta*. Promising results have been obtained in studies of *Bacillus thuringiensis* var. *kurstaki*, which has been widely used to control the pest in crops where IPM programmes are based on biological control (Gonzales-Cabrera *et al*., 2011). When *Beauveria bassiana* (GHA strain 1991) was used alone and in combination with *Bacillus thuringiensis*, a decrease in the number of damaged fruits was obtained (Torres Gregorio *et al*., 2009). An entomopathogenic *Metarhizium* *anisopliae* did not reduce *T. absoluta* oviposition or fecundity, however, infection with *M. anisopliae* resulted in 37% female mortality. Eggs exposed to *M. anisopliae* were all infected after 72 hours (Pires *et al*., 2009). The entomopathogenic nematodes, *Steinernema carpocapsae, S. feltiae* and *Heterorhabditis bacteriophora* have been proved to be capable of infecting late larval instars and pupae of *T. absoluta.* Larval mortalities ranging from 78.6% to 100%, and pupae mortalities fewer than 10% have been recorded (Batalla-Carrera *et al*., 2010).

Biotechnical Control

The major component of the female sexual pheromone for mating disruption of *T. absoluta* was identified as (3E,8Z,11Z)-3,8,11-tetradecatrien-1-yl acetate (E3Z8Z11-14Ac) (Attygalle *et al*., 1995). Lures are loaded with different amounts of synthetic pheromone (0.1 mg, 0.3 mg, and 0.5 mg). Pheromone lures can be used in Delta traps, pan traps, McPhail traps, and bucket traps. Trap densities can be adjusted according to the attractant and trap type. Pheromone traps (10–20 traps/ ha) are used for pest monitoring and as many as 3–4 moths are captured in one week in traps, start mass trapping of moths. For mass trapping of moths, use sticky traps or water + oil traps baited with pheromone to be 20–40 traps /ha in greenhouses and 40–60 traps/ha in open field (Anonymous, 2010). Delta type traps for monitoring, water traps (20–30 water traps/ ha) and ferolite traps are used for mass trapping of moths. Ferolite traps are more effective than the standard pheromone traps (Russell, 2009; Hassan & Al-Zaidi, 2010). Traps are monitored weekly. Longevity of pheromones lures is 4–6 weeks. Besides, Tutaroll and Tutaroll+ can be used for the mass trapping and control of *T. absoluta* in greenhouses. Pheromone and pesticide formulation (Lure and Kill) also reduce the possibility of pesticide over application and resistance (Russell IPM, 2009). If the numbers of moths in traps continue to increase, the other control methods should be initiated. The registered pheromone and traps for *T. absoluta* in Turkey are given in Table 3.

Table 3
Registered pheromone and traps for *Tuta absoluta* in Turkey

Date	Trade name	Crop	Company
11.10.2010	QLURE TUA	Tomato (greenhouse)	VERIM Construction Tourism Trade Limited Company
25.02.2011	BIOCILL	Tomato (greenhouse)	KOPPERT Biological Systems Biological Control Natural Pollination
21.10.2011	SMC EBUO	Tomato (greenhouse)	SMC Medicine Chemical Structure Industry and Incorporated Company
29.09.2011	KAPAR DG	Tomato (field)	KAPAR Organic Farming Industry Trade Limited Company
20.03.2012	TUTABS	Tomato (greenhouse)	AKDENİZ FLORA Agricultural Advisory Limited Company
06.04.2012	PARAMOUNT	Tomato (greenhouse)	CANSA Chemical Industry Trade Limited Company

Chemical Control

Chemical control is still the most common pest control method in Turkey, like South American countries. Larvae of *T. absoluta* are protected in mines and galleries, so effective control is difficult to achieve because of a high reproductive capacity, very short generations and an increased risk of developing resistance (Lietti *et al.*, 2005; Urbaneja *et al.*, 2007). Therefore, it is very important to avoid systematic applications, and rotate insecticides with different active ingredients for managing Insecticide resistance in *T. absoluta*. The plant protection products recommended for *T. absoluta* are given in Table 4.

Table 4

The plant protection products recommended for *T. absoluta* in Turkey*

Active Ingredient	Formulation	Dosage (preparation) 100 liters of water and/or ml/da
Azadirachtin 10 g/l	EC	300 ml
Metaflumizone 240 g/l	SC	100 ml/da
Spinosad 480 g/l	SC	25 ml
Spinosad 240 g/l	SC	50 ml
Indoxacarb 150g/l	SC	20–40 ml
Indoxacarb % 30	WG	12,5 g/da
Chlorantraniliprole % 35	WG	10 g
Chlorantraniliprole 45 g/l + Abamectin 18 g/l	SC	80 ml
Lufenuron 50 g/l	EC	50 ml
Emamectin benzoate %5	SG	40g
Bacillus thuringiensis kurstaki ABTS 351 strain	DF	100 g
Bacillus thuringiensis kurstaki EG 2348 strain	EC	150 ml
Bacillus thuringiensis var. *aizawai* GC-91 strain delta endotoksin 11x10 10	WG	100 g

* Anonymous (2010, 2011).

CONCLUSIONS

Since its introduction into Turkey in 2009, in the following 5 years, *T. absoluta* has continued to spread rapidly to all the regions of Turkey, and caused serious damages to Solanaceae crops, especially tomatoes in greenhouses and open fields. The pest has many alternative hosts in order to maintain the viability and spread in the invaded areas. Without adequate controls, infestations of *T. absoluta* can reach 100%. To prevent damage, control measures mentioned above should be taken urgently against this pest. Because invasion of pests is irreversible, management requires coordinated efforts of research scientists, extension services and growers in invaded countries. Integrated pest management (IPM) is the most promising strategy to control *T. absoluta* in the invaded area in Turkey.

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MONITORING ELEMENTS FOR *ZINGEL STREBER* (SIEBOLD, 1863) IN THE CONTEXT OF NATURA 2000 IN CROATIA

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The action framework at European Union level for the biodiversity conservation was set up based on the Birds Directive and Habitats Directive. One principal element of the implementation of these significant Directives in Croatia is the setting up of a Natura 2000 network, which should be based on a specific national monitoring plan for each species of community interest. Monitoring elements were suggested for *Zingel streber* for the Croatian Continental Biogeographical Region, based on eight criteria: national borders proximity sectors overlay; very good quality populations in terms of population density and structure in characteristic habitats; habitats which need ecological reconstruction to allow the structure of this fish population amelioration or natural repopulation; key sectors with importance for connectivity; sectors influenced by human impact, sectors influenced by habitat modifications, geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in the range of this species and in the near outer proximities of these extremes.

Keywords: *Zingel streber*, specific monitoring, Croatia, Danube Watershed.

INTRODUCTION

The Croatia accession to European Union brings new commitments related with environment conservation and improvement, like for all EU countries.

The important goals of the European Community regarding the nature are the conservation, protection and continuous improving of the environment structures and functions quality for a better use of the nature services and resources, including that of the aquatic and semiaquatic ecosystems. In this context the biodiversity became one of the most important issues.

The action frame for biodiversity management of the European Community was based mainly on the Birds Directive (79/409/EEC) and the Habitats Directive (92/43/EEC). These two very important European Directives have as main goals to conserve the biodiversity in the European Union based on a continental protected areas network, namely the Natura 2000 network, to protect key significant species and habitats for all the European biogeographic regions: Atlantic, Arctic, Boreal, Alpine, Continental, Mediterranean, Pannonian, Steppic, Black Sea, Anatolian and Macaronesian. Croatia has a good biogeographic regions diversity, including Continental, Alpine, Pannonian and Mediterranean regions.

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One main element for these areas conservation based on Directives is a proper functioning of a Natura 2000 network in Croatia, a network which needs a specific national monitoring plan for each species and habitat of community interest. Croatia joining to the EU makes this monitoring proposal an important key element for the needed future management related plans in this country.

The range of *Zingel streber* includes the Danube Basin from Bavaria in Germany to the Danube Delta in Romania, and also the Vardar basin. This species is present in Croatia, only in the Danube Watershed, and in some of its neighboring countries: Slovenia, Hungary, Serbia and Bosnia and Herzegovina. The distribution data in Croatia was not completely acquired, but its relative sporadic presence is known in the Danube and some of its direct (Drava and Sava) and idirect tributaries (Kupa, Sutla and Una). *Zingel streber* is considered as rare and very rare in different areas, mainly in the Continental region, in the suitable habitats; one exception in the alpine region, in the near proximity of the continental biogeographical region. Often it disappears in some regions and reappears in nearby areas. The range and abundance in Croatian continental biogeographical region are considered relatively rare. This species has a high conservation priority status in the Habitats Directive, in spite of the fact that in some Central and Eastern Europe regions it is considered rather a common species with a high potential as umbrella species; a similar situation is in Croatia too.

Assessments were done before this country integration in the EU, in the following zones: rivers Drava (2–15% proportion of the population in relation to the size of the population at the state level), Sutla (2%), Sava (15–30%), Una (15–30%), Kupa (2–15%). In the next three years through the Natura 2000 Integration Project (NIP) inventory of freshwater ichthyofauna is expected to be done in the areas with present data gaps.

In spite of the fact that no complete data about this fish species distribution in Croatian national territory is known, otherwise a relatively common situation in other European countries too, the present known data represent reliable data for the proposal of a medium/long term monitoring elements proposal for this country.

Zingel streber is a benthopelagic, not very mobile, freshwater and rheophilic species which is living rather solitary, in the Danube, respectively in the hilly and plain rivers, exclusively in the sectors with high water velocity, with riverbeds of pebbles and/or sand, sometimes on clay substrata, in the barbell and bream zone (Bănărescu & Bănăduc, 2007; Oțel, 2007).

The individuals of this species stay in small flocks. It is active at night in shallow waters for food which consist in aquatic invertebrates and occasionally in roes and alevines. The reproduction has happened in March–April, in the clean gravelly bottoms, females leaving sticky big eggs on rocks or on wood pieces. In the reproduction period the females are deformed. This species is listed in Annexes II and IV of the EU Habitats Directive, and in the Annex III of the Berne Convention. In the Croatian Nature Protection Law it is strictly protected). In Croatia it is considered as a vulnerable (VU) species (Bănărescu & Bănăduc, 2007).

It is threatened by the decrease of the proper habitats (for spawning, schooling, feeding, sheltering) quality due to pollution, habitat degradations (channelling, watercourses regulation, remodelling), unnatural water level fluctuations, rheophilic habitats diapering, and illegal extraction of sand and sand overexploitation. Non-indigenous species can have a negative impact on this species. At present there are noted significant fluctuations in the number of this species locations and sub-populations.

Conservative and protective measures should be done where the local situation requires actions for that: preserving and improving the favorable ecological balance of the natural waters inhabited by this fish species, ichthyologic protected areas (reserves) of conservative interest, preventing and avoiding of water and sediments flow regulation as much as is possible close to the natural regime, preserve habitats with rapid course, bans of alien/invasive species entry and reproduction, live baits prohibition, construction of appropriate devices for water recycling, avoiding lotic fragmentations due to different categories of constructions in the river bed.

The suggested monitoring elements for *Zingel streber* for the Croatian Continental Biogeographical Region were based on the present known distribution data (Budihna, 1984; Habeković *et al.,* 1986; Povz & Sket, 1990; Mrakovčić *et al*., 1996, 2006, 2008; Ćaleta *et al*., 2009; Mrakovčić *et al*., 2010; *Fact sheet) and on the human activities threat (Picer *et al*., 1995; Šmit *et al*., 1987; Vidaček *et al*., 1998; Schwarz & Bloesch, 2004; Frančišković-Bilinski *et al*., 2005; Znaor *et al*., 2005; Baptist, 2006; Bošnir *et al*., 2007; Bonacci & Oskorus, 2008; Popović, 2008; Bačani *et al*., 2011; Dragun *et al*., 2011; Gvozdic *et al*., 2011; *National Study, 2010; *SINP, 2009; *Inventory of agricultural pesticide use in the Danube river, *ISRBC, 2009; *ISCDR, 2009). Based on the overlapping of the data regarding the distribution of this fish species on the human disturbed aquatic areas, the dimension of a spatial grid for monitoring can be suggested and the monitoring frequency in space and time can be also proposed. "Theoretical/blind theory" in suggesting the spatial and temporal frame of this fish species monitoring can be only a theoretical exercise, with low quality results in data interpretation, bringing numerous later on adjustments of the monitoring system.

Due to the fact that the lotic systems are very dynamic ecosystems, even the most appropriate selected monitoring elements proposals, sooner or later, will need to be readjusted.

The potential amelioration of the *Zingel streber* species distribution data on the Croatian territory can facilitate the identification of new monitoring suggestions, the process of improving this species monitoring should be a flexible one.

RESULTS AND DISCUSSION

The suggested *Zingel streber* monitoring sectors, at the national Croatian level/Continental Biogeographical Region, were proposed based on eight identified criteria: ❶ national borders proximity sectors coverage; ❷ good quality populations of *Zingel streber* in terms of population structure and density (ex. protected areas) in characteristic good habitats; ❸ habitats which should be ecologically reconstructed to allow the *Zingel streber* populations structure improving or natural repopulation; ❹ key habitats with importance for connectivity (ex. lotic sectors between different important river sectors, rivers confluence areas, etc.); areas influenced by human impact: ❺ industrial pollution point sources, ❻ sectors influenced by agricultural diffuse sources of pollution, ❼ sectors influenced by habitats modifications (watercourses remodeling, watercourses regulation, etc.), ❽ geographically speaking extreme monitoring sectors in the most-upstream and most-downstream sectors of the rivers, in this fish species range and in the near outer proximities of these extremes.

Spatial monitoring elements

❶ National borders proximity areas of interest coverage

These monitoring sections were proposed due to their importance for international monitoring systems and methods intercalibrations, and in real time data checking. It has to be stated that these sections represent the national limits of the Croatian responsibility for conserving this fish species status. As a consequence these monitoring sectors should be covered once every year. Based on this proposed monitoring criterion, ten monitoring sections (Fig. 1, ❶) were selected.

One sampling station should be on Mura River, under an once per year monitoring, on the Croatian-Slovenian-Hungarian border, in the proximity of Novakovec locality.

Two sampling stations should be on Drava River, under an once per year monitoring, on the Croatian-Hungarian border, at approximatively 50 km and respectively 100 km downstream the Novakovec locality (locality situated on Mura river).

One sampling section should be on Kupa River, under an once per year monitoring, on the 118 km long north-west Croatian-South-east Slovenian border, approximatively 50 km downstream from Mandli locality.

Two sampling sections should be on Sutla River, under an once per year monitoring, on the Croatian-Slovenian border (section 1 road number 205 access to Sutla River and bridge from Razvor locality through Razvor Street; section 2 road number 225 access to Sutla River and bridge from Harmica locality through Ivana Perkovca Street).

One sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Una River, in the Kostajnica locality proximity, with road and bridge access from the road number 47.

The second sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Una River, in the Hrvatska Dubica locality, with road access from the road number 47.

One sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Sava River, in the Stara Gradišca locality proximity, with road and bridge access from the road number 5 and E 661.

The second sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Sava River, in the Slavonsky Šamac locality proximity, with road and bridge access from the road number 7/E 73.

Any human impacts or pressures from the upstream neighboring countries which induce qualitative (disappearance of the species) and quantitative (changing relative abundance, age structure) modifications of the monitored populations, create a negative future prospects related with this species habitat quality, long-term viability, range and conservation status, situation which should be assessed once in a year at the national level.

❷ Good quality populations of *Zingel streber* in terms of population density and structure in characteristic good habitats.

This second category of monitoring sections were chosen due to their genetic value/importance for keeping a healthy status of this species populations in Croatia and in the neighboring countries, including for the natural repopulation of the areas where this species can exist and spread in the future. Based on this monitoring criteria three monitoring sections (Fig. 1, ❷) were selected/proposed at:

1. One sampling section should be on the Sutla River, under an once per year monitoring, on the Croatian-Slovenian border, access on the road number 205 to Sutla River and bridge from Razvor locality through Razvor Street.

2. One sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Una River, in the Kostajnika locality proximity, with road and bridge access from the road number 47.

3. One sampling station should be on Drava River, under an once per year monitoring, on the Croatian-Hungarian border, at approximatively 50 km down-stream the Novakovec locality (locality situated on the Mura River).

Any human impacts or pressures in this areas which induce qualitative (disappearance of the species) and quantitative (changing in relative abundance, age structure) modifications of the monitored populations, create negative future prospects related with this species habitat quality, long-term viability, range and conservation status, situation which should be assessed once per year at the national level.

Human activities impact on these areas of protection, which can induce quantitative (relative abundance and/or age structure modifications) and qualitative (species disappearance) variations of the assessed populations, will induce negative future prospects associated to the species habitat quality, conservation status and range, long-term viability, situation which has to be monitored once every six years at national level, if no accidental events happen (natural and/or human events which induce important habitat or/and biocoenosis modifications).

❸ River sectors which should be ecologically reconstructed/proposed for ecological reconstruction to allow the *Zingel streber* populations structure improving or natural repopulation. This is the case only if the lack of actual data induces some fake gaps in this species geographical continuity data.

This third category of monitoring sections was chosen due to the discontinuities in spatial continuity of this fish species, possibly as an effect of the human activities impact, but also a gap in the scientific knowledge.

Based on these monitoring criteria four sections (Fig. 1, ❸) were selected.

One sampling section should be on Sutla River, under an once per six years period monitoring, on the Croatian-Slovenian border, access on the road and bridge to Sutla River from Kraj Donji locality to the road number 676.

One sampling section should be on Mura River, under an once per six years period monitoring, on the Croatian-Hungarian border, in the proximity of the Hungarian locality Muraratka.

One sampling station should be on Sava River, under an once per six years monitoring, on the Croatian-Bosnia-Hertzegovina border, one in the proximity of Slavonski Brod, with road access on Stjepana Radicá Street.

The second sampling station on Sava River, under an once per six years monitoring, on the Croatian-Bosnia-Hertzegovina border, was proposed in the proximity of the Mačkovac locality.

Any human impacts or pressures in these lotic sectors which induce the lacking of this species, create negative future prospects related with this species habitat quality, long-term viability, range and conservation status, situation which should be assessed once in every six years period at the national level).

❹ key sections with high importance for ichthyofauna connectivity (ex. intermediate river sectors between diverse important fish populations' areas; rivers confluence areas, etc.).

This fourth category of monitoring sections was selected due to their potential importance as connectivity corridors for the geographical continuity of this fish species; it can be only a gap in the knowledge. If these sections prove to be only gaps in the knowledge, gaps which will be completed by future information, they can be deleted from the suggested list of monitoring sections.

Based on these monitoring criteria four monitoring sections (Fig. 1, ❹) were selected.

One sampling section should be on the Sutla River, under an once per six years period monitoring, on the Croatian-Slovenian border, access on the road and bridge to Sutla River from Kraj Donji locality to the road number 676.

One sampling section should be on Drava River, under an once per six years period monitoring, on the Croatian-Hungarian border, in the proximity of the Hungarian locality Muraratka.

One sampling station should be on Sava River, under an once per six years monitoring, on the Croatian-Bosnia-Hertzegovina border, one in the proximity of Slavonski Brod, with road access on Stjepana Radicá Street.

The second sampling station on Sava River, under an once per six years monitoring, on the Croatian-Bosnia-Hertzegovina border, was proposed in the proximity of the Mačkovac locality.

Any human impacts or pressures in these lotic sectors, which induce the lack of at least accidental presence of *Zingel streber* individuals, create negative future prospects related with this species range and conservation status, situation which should be assessed once in every six years period at national level.

❺ industrial and/or waste water pollution point source area (Fig. 1, ❺)

One sampling station on the Sava River, under an once per six years monitoring, on the Croatian-Bosnia-Hertzegovina border, was proposed in the proximity of the Mačkovac locality.

❻ sectors influenced by agricultural pollution diffuse sources (Fig. 1, ❻)

One of the Sava River tributaries was approached regarding the agricultural pollution diffuse sources, which need monitoring sectors.

Sutla, due to the proximity of large corn fields cultivation have high heavy metal concentration values in the water due to K_2O, Co, Cu sulphate and Ti used in chemical fertilizers used, need a monitoring section between the localities Ključ Brdovečki and Drenje Brdovečko. In this section there were also constantly found high values for enterococcus numbers (coming from the farms situated in this basin), N total, P total, humic substances (including U complexes) from chemical fertilizers.

The Sava River is the main collector for agricultural waste waters, including with organoclorurates, a monitoring section downstream the lower sector where *Zingel streber* was found on this river in Croatia is a necessity, respectively in the proximity of Babina Greda locality.

❼ changed sectors influenced by modifications of habitat (remodeling, channeling, watercourses regulation, dams, etc.) (Fig. 1, ❼)

On the Drava River, upstream Donja Dubrava locality, hydroelectric power plant dams were built (Varaždin, Čakovec, Medmurje, Dubrava). Downstream Donja Dubrava locality, before the confluence with Mura River a monitoring section for this fish species should be settled, with access from the road 20.

On the Sava River, downstream the Trebez Dam, location from which *Zingel streber* is no more present for over 50 km, a monitoring station for this species should be settled in the proximity of Trebez locality (road and bridge access).

❽ geographically extreme monitoring sections (Fig. 1, ❽) in the most downstream and upstream sectors, in *Zingel streber* range and in the near outer proximities of these extremes.

One sampling station should be on the Mura River, under an once per six years monitoring frequency, on the Croatian-Slovenian-Hungarian border, in the proximity of Novakovec locality.

One sampling station should be on the Drava River, under an once per six years monitoring frequency, on the Croatian-Hungarian border, at aproximatively 100 km downstream the Novakovec locality (locality situated on Mura river).

Two sampling sections should be on the Sutla River, under an once per six years monitoring, on the Croatian-Slovenian border, (section 1 road number 205 access to Sutla River and bridge from Razvor locality through Razvor Street; section 2 road number 225 access to Sutla River and bridge from Harmica locality through Ivana Perkovca Street).

One sampling section should be on Kupa River, under an once per year monitoring, on the 118 km long north-west Croatian-South-east Slovenian border, approximatively 50 km downstream from Mandli locality.

The second sampling station in the proximity of the Southern Croatian-Bosnia and Herzegovina border on the Sava River, in the Slavonsky Šamac locality proximity, with road and bridge access from the road number 7/E 73.

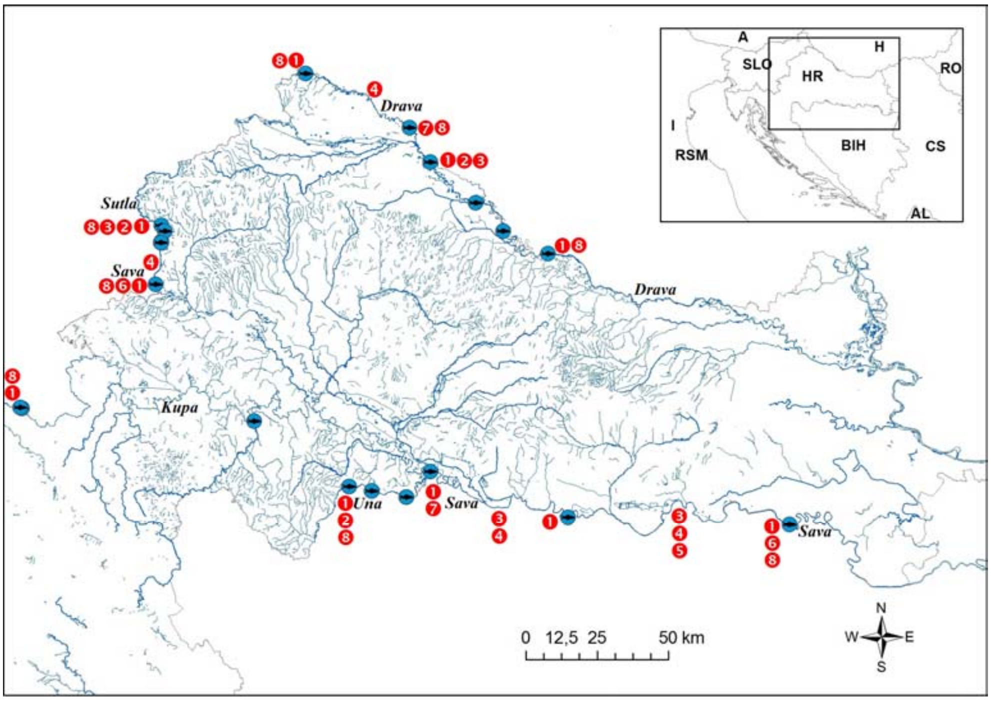

Fig. 1. *Zingel streber* proposed monitoring sections.

Zingel streber distribution, update situation (SINP, 2009; Duplić, 2012, pers. comm.).

Evaluation of the conservation status

First a complete systematic survey of this species range on the national territory should be done and the range of this species should be continuously compared by the future monitoring data.

These fish species population units quantitative and qualitative elements, units selected in the upper monitoring sections, can be based on some specific fish biotic index criteria. The selected combination of metrics was designed to reflect insights of assemblage and population comparable perspectives. Each metric value should be compared with the value estimated from other similar sites. It should be considered that as the biotic integrity (found on the following metrics) decreases, the habitat and lotic ecosystem quality decrease too (Karr, 1981; Karr & Dudley, 1981; Fausch *et al*., 1984; Karr *et al*., 1986; Fausch & Schrader, 1987; Van Helmond *et al.,* 1996; Bănăduc & Bănăduc, 2002; Teskeredžić *et al*., 2009).

The proposed categories of metrics are: I species richness and composition (with the metrics: 1. total number of fish species; 2. proportion of benthic fish species; 3. proportion of water column species; 4. proportion of individuals of intolerant species, 5. proportion of individuals of typically tolerant species); II trophic composition (1. proportion of individuals as omnivorous feeders, 2. proportion of individuals as insectivore feeders); III fish abundance and condition (1. numbers of individuals in a sample; 2. introduced will be assigned to each metric species, on zoogeographic basis).

Ratings of 5 to 1 should be assigned to each metric according to whether its assessed value approximates deviates somewhat or strongly from the value expected by the best expert judgement at a comparable site that is relatively similar but also relatively undisturbed.

The total score for each site should represent all the nine-metrics sum and the scores can be interpreted with the following intervals comparison: 45–43 – excellent, this score reflects excellent, comparable to pristine conditions, exceptional assemblage of fish species; 42–36 – very good, shows a decreased species richness, intolerant species in particular, sensitive species present; 35–31 – good, describe fair intolerant and sensitive species absent, skewed trophic structure; 30–24 – fair, reflects some expected species absent or rare, omnivores and tolerant species dominant; 23–17 – fairly poor shows few species and individuals present, tolerant species dominant; 16–10 – poor, will describe very few species and individuals present, tolerant species dominant; 9–1 – very poor, this score reflects extremelly few species and individuals present, tolerant species or no fish. A real assessment of any fish species population conservative status can be done only in the ichthyocenosis assessment context! Any other monitoring/assessment approaches will have a relatively low quality or no quality at all!

An assessment of any fish species population conservative status can be done in the ichthyocenosis assessment context! Any other assessment approaches will have a low quality! Using these fish metrics permits the possibility to assess the conservative status of the target populations in the local specific ichthiologic assemblage context and also of the habitat!

At every six years period, supplementary sampling stations should be done in all the upstream and/or downstream extreme (concerning the geographical position) areas can highlight the potential territorial expansion of the species. The reduction in range can be highlighted through the presence or absence of the species in the monitoring stations.

Evaluation Grid

A 50/50 km grid was used in the Danube Basin map of Croatia (Fig. 2). A smaller scale is not realistic now to be covered in the field by monitoring activities.

The minimum number of monitoring areas – 12, for *Zingel streber* should be at least one monitoring sector in each 50/50 km plot (❋); these plots were proposed based on the previous eight selected criteria (Fig. 3).

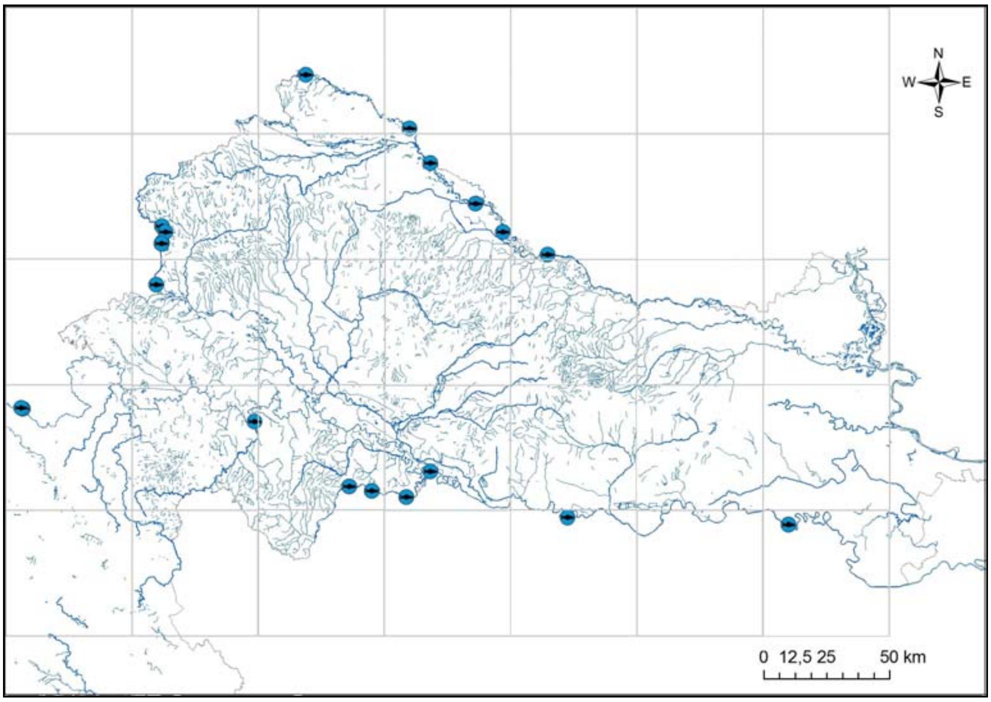

Fig. 2. 50/50 km grid, used as a base for *Zingel streber* monitoring areas. *Zingel streber* distribution , update situation (SINP, 2009; Duplić, 2012, pers. comm.).

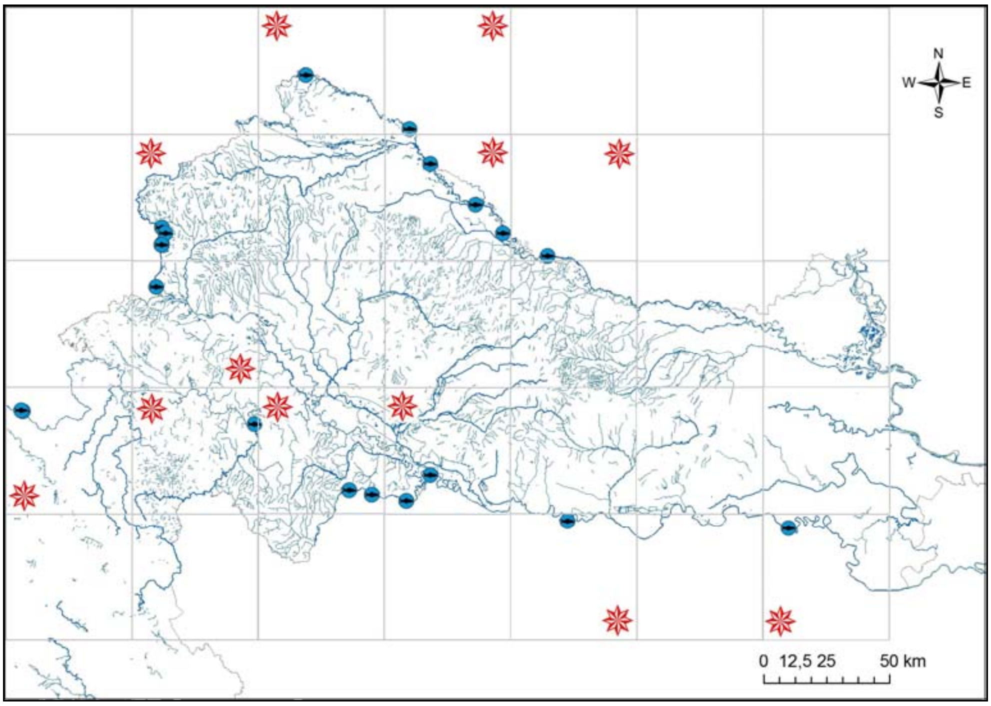

Fig. 3. The minimum 12 sampling stations for *Zingel streber* should be in the marked (❋)50/50 km plots.
Zingel streber distribution , update situation (SINP, 2009; Duplić, 2012, pers. comm.).

If the financial, time and working teams potential is over these 12 monitoring stations, this number can be multiplied with 2, 3, etc., for every 50/50 km plot.

1. From the qualitative point of view the presence of the monitored fish species individuals in each of the 12 50/50 km plots, offer a first level of information regarding its conservation status in Croatian Danube Basin, in terms of future prospects, suitable habitats, populations and least but not last area and range. The presence of this species in all 12 50/50 km plots reveals an excellent conservation status at the Croatian national territory, in 11 very good conservation status, in 10 good conservation status, in 9 fair conservation status, in 8 fairly poor conservation status, in 7 poor conservation status and in 6 or less a very poor conservation status.

2. The second needed level is also a qualitative approach, in respect of: age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals. Every plot of 50/50 km is evaluated based on the presence/absence of the age classes. A plot with all 6 age classes will be evaluated as being in an

excellent conservation status; presence of 5 age classes will reflect a very good conservation status, 4 classes mean good conservation classes, 3 classes fair conservation status, 2 classes fairly poor conservation classes, 1 class poor conservation status. This approach is made independently for each 50\50 km plot and in the end an average for all the plots, which is the mean of a national conservation status.

3. The third needed level is also a qualitative approach, in respect of species composition; *Zingel streber* species presence represents a poor conservation status; *Zingel streber* + another species represents a fairly poor status of conservation, *Zingel streber* + two fish species represent a fair conservation status, *Zingel streber* + three fish species represent a good conservation status, *Zingel streber* + four fish species represent a very good conservation species, *Zingel streber* + five or more fish species represent an excellent conservation status. The results are relevant for each local ichthyofauna/populations status. The monitoring should be realized in the same season every time. This approach is made independently for each 50/50 km plot and in the end an average for all the plots, which is the mean of a national conservation status.

4. The fourth needed level is the integrated approach. That is why, for every monitoring section the results should be obtained in terms of: fish biotic criteria score (45–43 – excellent, 42–36 – very good, 35–31 – good, 30–24 – fair, 23–17 – fairly poor, 16–10 – poor, 9–1 – very poor), which reveal at quantitatively level the conservation status for the *Zingel streber* population in the ichthyocenosis assessment context. This approach is made independently for each 50/50 km plot and in the end an average for all the plots, which is the mean of a national conservation status.

5. Finally an average among the previous 4 steps at national level should be made and this is the obtained national conservation status for *Zingel streber*, as a result of the monitoring activities programme.

CONCLUSIONS

The selected *Zingel streber* monitoring sectors, at the Croatian national level, were proposed based on eight criteria: ❶ Croatian national borders proximity sectors overlay; ❷ very good quality populations of *Zingel streber* in terms of population density and structure (ex. protected areas) in characteristic good habitats; ❸ habitats which need ecological reconstruction to allow this fish species populations structure ameliorate or natural repopulation; ❹ key sectors with importance for connectivity (ex. lotic sectors between different important sectors, rivers confluence areas, etc.); sectors influenced by human impact like: ❺ industrial pollution point sources, ❻ sectors influenced by agricultural diffuse sources of pollution, ❼ sectors influenced by habitats modifications (watercourses remodeling, watercourses regulation), ❽ geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes. These criteria based monitoring sector selection is a relevant sum of influences which can negatively affect this fish species distribution, survival and abundance of its populations, and conservation status.

It was considered that these proposed criteria elements can influence the future conservation status of this fish species in Croatia. The monitoring sectors selection was based on these specific criteria and the monitoring sectors were identified one by one on the maps, based on the existent fish related bibliography and data.

It should be stated the fact that the potential improvement of *Zingel streber* distribution data on the Croatian territory in the future can improve the monitoring sectors situation, the process of improving this proposed monitoring system being a flexible one.

The ecological and biological monitoring in this context cannot be replaced by the physico-chemical monitoring, not even in the monitoring sites selected for the human impact analysis; but some physico-chemical criteria of the fish species habitat quality should be included in the monitoring, if the fish monitoring sectors will overlap with the national Croatian integrated monitoring sectors in the future.

Zingel streber conservation status elements

The future prospects as one of the four components of *Zingel streber* conservation status are revealed using the following criteria for monitoring sector selection: national border proximity; habitats which should be ecologically re-constructed; and areas/sectors negatively influenced by human impact. Thus, also the trends regarding the human induced pressures and threats towards this species can be revealed.

The habitat of *Zingel streber* is the second element of its conservation status, related to the area and quality of the suitable habitats. Thus, also the trends considering the occurrence areas of this fish species, increasing *versus* decreasing areas situations, increasing *versus* decreasing habitat quality situations can be revealed. For these aims, monitoring sectors criteria based on selection was done, including the following criteria like: Croatian national borders proximity sectors overlay; very good quality populations of *Zingel streber* in terms of population density and structure (ex. protected areas) in characteristic good habitats; habitats which need ecological reconstruction to allow this fish species populations structure ameliorate or natural repopulation; key sectors with importance for con-nectivity (*e.g.*: lotic sectors between different important sectors, rivers confluence areas); sectors influenced by human impact like: industrial pollution point sources, sectors influenced by agricultural diffuse sources of pollution, sectors influenced by habitats modifications (watercourses remodeling, watercourses regulation), geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes. In this context also the following metrics were proposed: I absence/presence; II age structure, absence/presence of 0+ age individuals, absence/presence of 1+ age individuals, absence/presence of 2+ age individuals, absence/presence of 3+ age individuals, absence/presence of 4+ age individuals, absence/presence of 5+ age individuals; III species composition; IV relative abundance.

The population is the third element of the conservation status for *Zingel streber*. It is evaluated based on population size and structure in terms of age structure and reproduction. To cover this element, namely the favorable reference populations which are considered as appropriate to ensure the long-term viability of *Zingel streber*, some metrics were proposed: I absence/presence; II age structure, absence/presence of 0+ age individuals, absence/presence of 1+ age individuals, absence/presence of 2+ age individuals, absence/presence of 3+ age individuals, absence/presence of 4+ age individuals, absence/presence of 5+ age individuals; II species composition; IV relative abundance in the local ichthyofauna.

The fourth component of *Zingel streber* conservation status is the range, which corresponds to the spatial limits within which this fish species occurs. The trend of this species range increasing or decreasing can be revealed based on some criteria, which were proposed for the choosing of some monitoring sectors: Croatian borders proximity sectors coverage; sectors with significant importance for fish populations connectivity; geographically extreme monitoring sections in the downstream-most and upstream-most sectors of rivers, in this fish species range and in the near outer proximities of these extremes.

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STATUS OF THE EUROPEAN OTTER (*LUTRA LUTRA* LINNAEUS, 1758) IN ROMANIA

GEORGE BOUROȘ

The existing data regarding the European otter (*Lutra lutra* Linnaeus, 1758) occurrence in Romania is scarce since no national field survey has been undertaken. In Romania, management and conservation measures for the otter are currently being developed based on the evaluation made by game keepers and hunters in every hunting fund from Romania. Unfortunately, the data is not credible, due to the absence of an evaluation methodology, widely accepted by the scientific community. The otter is a flagship species for freshwater ecosystems and is protected by the national and international legislation. Although the Romanian Vertebrates Red Book evaluated it as vulnerable, we do not know much about the distribution and population number. The aim of this study is to give an answer to the question: what is the situation of the otter population in Romania? In order to find an answer I used only official data from the national data sheets of the hunting funds, standard data forms of the sites of community importance and the otter data from the online report on Article 17 of the EU Habitats Directive, reported by Romania. Even if it was official data, I got three different answers to my question, because the sources comprise different types of information. Official data were compared with those collected personally in the field, during 2012–2014 and we found that official data cannot be correlated with those collected in the field. A national survey of the otter population, conducted based on a widely accepted scientific methodology, could clarify the real situation of the otter in Romania.

Keywords: *Lutra lutra*, European otter, conservation status, national evaluation, Romania.

INTRODUCTION

According to the Red List of the International Union for Conservation of Nature IUCN (assessment year: 2008), the Eurasian otter is considered Near Threatened (NT) due to the population recovery in Western Europe, until 2000, when it was considered vulnerable (VU). However, according to the Red Book of Vertebrates from Romania (Botnariuc & Tatole, 2005), the otter has the status of vulnerable species.

The otter population has seen a continuous decline in the twentieth century, the presence of the species is restricted to small areas in Western and Central Europe and in Eastern Europe there is little historical information on the distribution and abundance of this species (Chanin, 2003). Among the causes of this population decline we can list: the destruction or degradation of riparian habitat, reducing the amount of food, by polluting rivers with various chemical compounds, hydro technical and hydropower development, hunting and persecution by humans, who consider it a pest because of predation fisheries (Prigioni *et al*., 2005).

In Romania, the economic development in the socialist era determined a decline of the otter population, by the occurrence of many polluters, such as: large chemical plants, industrialized agriculture, that led to serious damage to the physic-chemical inland waters (Bifolchi & Lode, 2005). The negative effect is increased due to the lack of real interest in the protection and conservation of biodiversity. Many rivers and streams in Romania have become unsuitable for life. Therefore, the otter distribution area was considerably limited in our country. Since the 1990s, many sources of pollution have disappeared, due to the adoption of environmentally friendly technologies or by stopping production process, which contribute to the natural restoration of affected habitats and biocenosis.

Natural restocking of fish, crustaceans and amphibians may determine an increasing number and the gradual expansion of the otter population in Romania. However, official data does not support this idea.

The status of the otter in Romania is still unknown, due to a lack of interest for the assessment of this species that is a major indicator of habitat quality. Assessments made so far have been based mainly on expert opinion and on the dates of the hunting funds records.

MATERIAL AND METHODS

To identify the status of the otter in Romania, I have used various sources of official information, in order to create a better image of the situation by checking their coherence.

During the first stage, a total of 1974 sheets of the hunting funds were analyzed from the 41 counties of Romania. The entire data concerning the number of otter individuals in each hunting fund for the 2001–2010 period have been centralized, thus creating a database which was then statistically analyzed. The used data derives from the Ministry of Environment and Climate Change website (2014, Hunting funds).

In order to create a distribution map of the otter in Romania, we used the database created which has been transposed using GIS in spatial file format: .shp, which resulted in creating the map of distribution and density of otter population for each year from 2001 to 2010.

In the following stage the Sites of Community Importance (SCI) were analyzed the sites that have been declared, among other species, suitable for otters. Using the spatial data regarding the protected areas limits available on the Ministry of Environment and Forests website (2014, Protected areas) and the data provided by the interactive map of protected areas in the European Union, Natura 2000 Network Viewer (2014, Natura 2000 Network Viewer). The data was subsequently transposed in GIS, resulting in a distribution map of the otter population in Romania, based on SCI sites declared suitable for this species.

We analyzed the Romanian report for the 2007–2012 period for otter species, achieved under Article 17 of the Habitats Directive (Online report on Article 17 of the Habitats Directive, 2014) and we compared the data with those already analyzed (hunting records and standard data forms of SCI). To check the accuracy of the analyzed data, having as origin different sources, we correlated with the data of abundance and the distribution of the otter, collected personally in the field, during 2012–2014, applying the standard method for otter population assessment recommended by IUCN Otter Specialist Group. Field data collection was carried out in different projects in Romania in which I participated as species expert (mammals). All the analyzed data presented different and various information, which cannot be correlated.

RESULTS

The data sheets analysis of hunting funds in Romania

A total of 1974 data forms of the hunting funds in Romania, during 2001–2010 were analyzed, thus obtaining official historical information about the distribution and abundance of the otter population in Romania. In order to estimate the existing number of otter specimens on a national level, we used the information provided by the hunting funds data sheets. Romania is divided into approximately 2.500 hunting funds. Each of these funds is provided with a game keeper who is required to assess, together with hunters and foresters, the species of cynegetic interest present in the respective hunting fund.

The data provided by these sheets regarding the hunting funds is important, but not credible, because there are many sources of information that cannot be explained in terms of biology and ecology, for example: sudden increase in the number of individuals in certain hunting funds. As an example, we took the hunting fund Condratu in Vrancea County has recorded 0 individuals in 2001, and in 2002 the number has increased to 25 individuals and 27 individuals in 2003 and 2004. Also, during the analysis we realized that the otter population is missing from areas where its occurrence is already known, based on the scientific literature. Those areas are historical habitats for otter population. According to the hunting funds sheets in Tulcea County (considered to be a huge wetland area, represented by the Danube Delta), there is no record of any individual of the otter in the Danube Delta (Table 1). However, this data is official, which was obtained by field evaluation conducted by each hunting fund manager.

According to the hunting funds data sheets the otter population has recorded a continuous decline at national level (Fig. 1). Since 2001 when the otter population was assessed, a number of 1110 individuals were identified, but by 2010 the population has fallen to less than a half, reaching a total of 456 individuals. Between 2001 and 2003 an upward trend was recorded, and from 2003 to 2010 a sharp decline was identified between individuals (Table 1).

We notice that at national levels the number of individuals was not the only one reduced, their habitat being more and more diminished, so the area of distribution of the otter species was considerably reduced (Fig. 2). In 2001 the otter was present in 248 hunting funds, until 2010, when the number of hunting funds where the otter specimens were present was continuously reduced, reaching a total of 104 specimens in 2010.

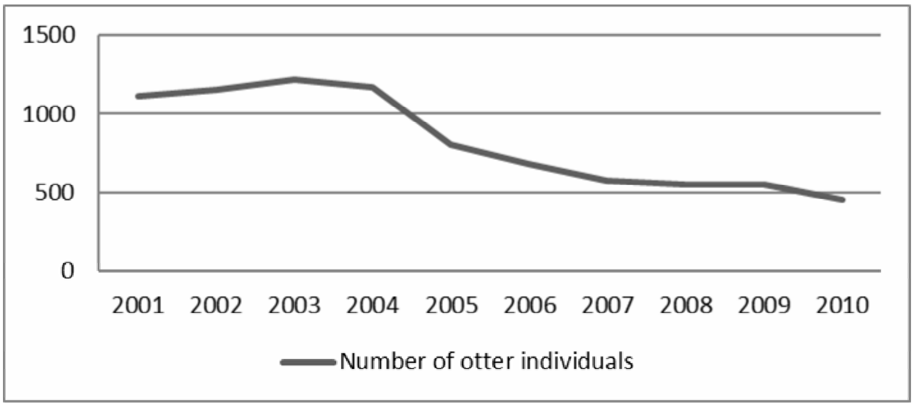

Fig. 1. The numerical evolution of the national population of the otter (2001–2010).

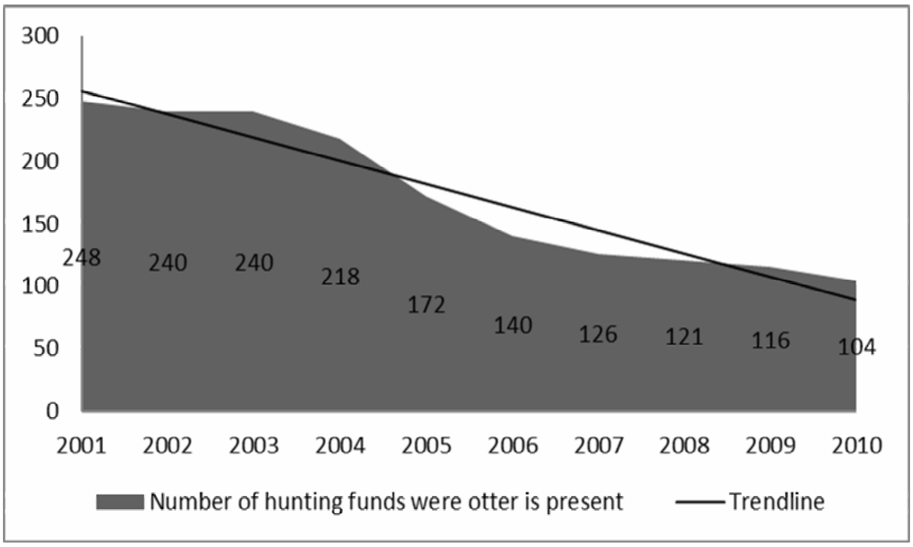

Fig. 2. Trend of hunting funds number where the otter is present.

Table 1
The assessment of otter individuals based on hunting funds sheets during 2001–2010

Otter numbers by year and county	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
ALBA	34	39	60	57	43	33	4	4	2	1
ARAD	149	152	145	110	132	104	82	88	64	65
ARGEŞ	42	62	46	42	30	30	30	30	32	20
BACAU	25	19	32	6	2	2	0	3	3	8
BIHOR	52	55	34	38	18	20	14	13	24	24
BISTRIŢA-NĂSĂUD	2	2	2	2	2	2	5	5	2	2
BOTOŞANI	0	0	0	4	0	0	0	0	0	0
BRĂILA	0	0	0	0	0	0	0	0	0	0
BRAŞOV	8	7	3	4	1	2	1	1	1	0
BUZĂU	5	5	4	3	0	0	0	0	0	0
CĂLĂRAŞI	5	6	0	0	0	0	0	0	0	0
CARAŞ-SEVERIN	27	30	31	25	26	33	22	23	16	11
CLUJ	5	5	5	3	5	5	5	5	5	10
CONSTANŢA	3	5	10	5	5	0	0	0	0	0
COVASNA	63	58	46	43	47	33	31	36	26	20
DÂMBOVIŢA	0	13	0	17	0	0	0	0	0	0
DOLJ	0	0	0	0	0	0	0	0	0	0
GALAŢI	0	0	0	0	0	0	0	0	0	0
GIURGIU	22	25	30	35	0	0	0	0	0	0
GORJ	17	0	0	0	0	0	0	0	0	0
HARGHITA	48	56	56	56	54	16	13	9	9	9
HUNEDOARA	68	65	69	65	65	69	71	73	74	73
IALOMIŢA	0	0	0	0	0	0	0	0	0	0
IAŞI	84	92	120	154	18	18	18	18	18	16
ILFOV	8	10	0	0	0	0	0	0	0	0
MARAMUREŞ	17	16	17	15	5	2	1	1	1	1
MEHEDINŢI	0	0	0	0	0	0	0	0	0	0
MUREŞ	109	106	109	110	103	56	48	42	38	35
NEAMŢ	57	59	75	46	7	6	6	4	4	4
OLT	0	0	0	0	0	0	0	0	0	0
PRAHOVA	12	9	8	0	0	0	0	0	0	0
SALAJ	5	15	15	15	0	0	0	0	0	0
SATU-MARE	55	70	60	70	105	100	100	87	87	72
SIBIU	35	32	43	39	34	36	36	36	46	26
SUCEAVA	77	70	77	91	70	80	75	65	57	51
TELEORMAN	0	0	5	10	12	15	0	0	0	0
TIMIŞ	59	56	73	60	16	16	10	10	10	8
TULCEA	0	0	0	0	0	0	0	0	0	0
VÂLCEA	3	0	0	0	0	0	0	0	0	0
VASLUI	0	0	0	0	0	0	0	0	0	0
VRANCEA	14	15	45	44	0	0	0	0	32	0
TOTAL	**1110**	**1154**	**1220**	**1169**	**800**	**678**	**572**	**553**	**551**	**456**

If we look to the past the situation should alarm us more, in a study presented by Ionescu & Ionescu (1994) during a seminar about otter conservation held in Leeuwarden in the Netherlands, the otter population in Romania has decreased from about 3200 specimens evaluated in 1955 to about 1500 from assessments made in 1994 (Fig. 3).

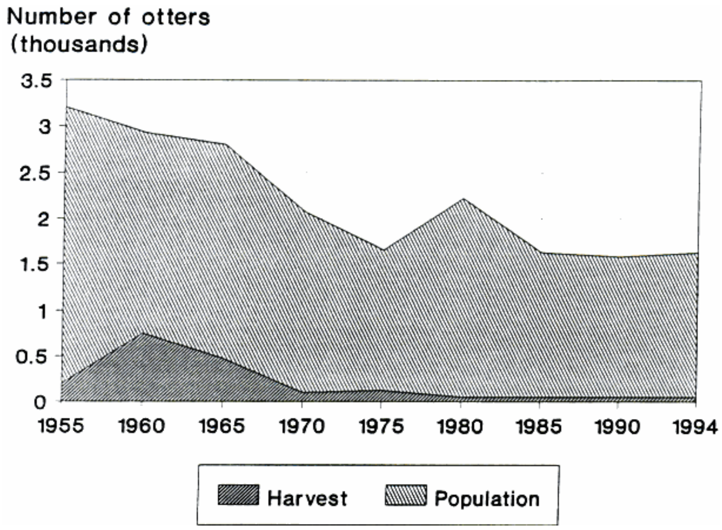

Fig. 3. Estimated otter population in Romania between 1955–1994
(modified after Ionescu & Ionescu, 1994)

The information obtained from the analysis of the hunting funds is alarming; the otter populations have registered an emphasized downward trend. If this situation would be a real one, immediate conservation measures would be needed to ensure the survival of the European otter at national levels.

Sites of Community Importance (SCI) analysis

Standard data from sites of the Sites of Community Interest (SCI) in Romania were analyzed, thus we identified a number of 99 SCI (Fig. 4) designated for the otter, it was present in the list of species for which the SCI has been designated. Sites of Community Importance have a varied distribution, covering all five biogeographical regions of Romania. Most of the protected areas are located along rivers characterized by high flow and valuable riparian habitats (Fig. 4), these being the optimal habitats for *Lutra lutra*.

Based on standard data forms of SCI sites and using the limits of SCI sites in a spatial format, through GIS, we generated a distribution map of the otter population, selecting the sites that have been designated for the otter.

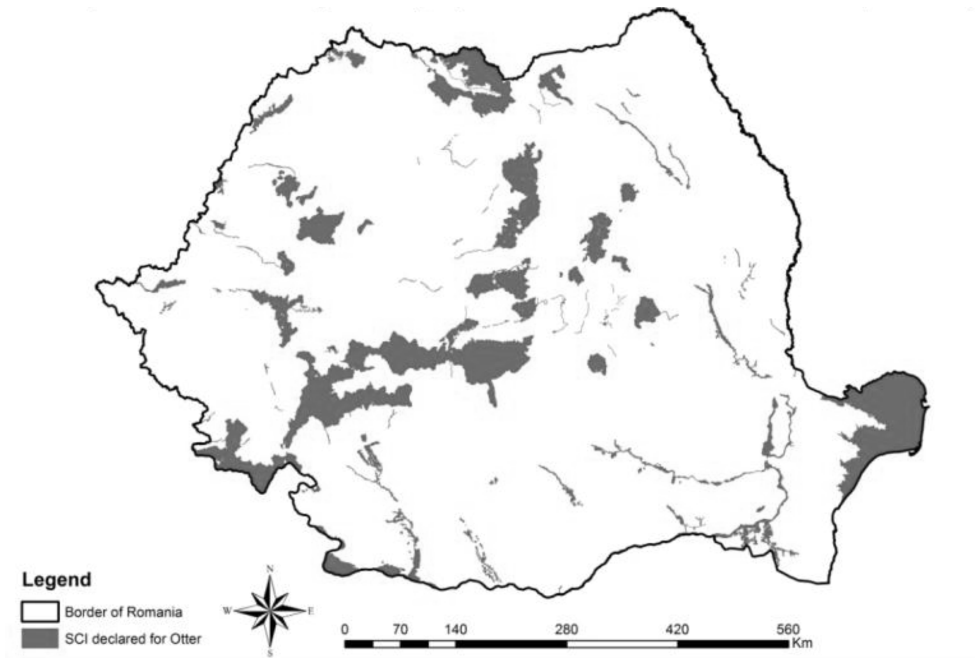

Fig. 4. Sites of Community Interest (SCI) in Romania designated for the otter.

This map gives us important information regarding the distribution of the otter population in Romania. Ongoing activities for inventory and mapping of species distribution are currently being developed in many of these sites, thus the number of otter individuals and the areas used as habitat by the otters would be correctly estimated.

The analysis of the report for the period 2007–2012 under Article 17 of the Habitats Directive

According to the report for the 2007–2012 period, the national otter population ranges between 1700–1898 individuals (Table 2). The number of individuals was distributed according to the biogeographic regions of Romania.

In contrast to the results of the analysis of the hunting funds data sheets, where the otter population registered a downward trend, in this report the otter conservation status is assessed as favorable in all grids where the species is present (FV) at national levels.

The methodology that has been applied to determine this data is not stated, therefore we cannot trust this information, let alone to rely on it in achieving conservation strategies in order to improve otter management in Romania.

At the same time we cannot dispute this information, because there is no national assessment of the otter population in Romania, based on a methodology accepted at international levels.

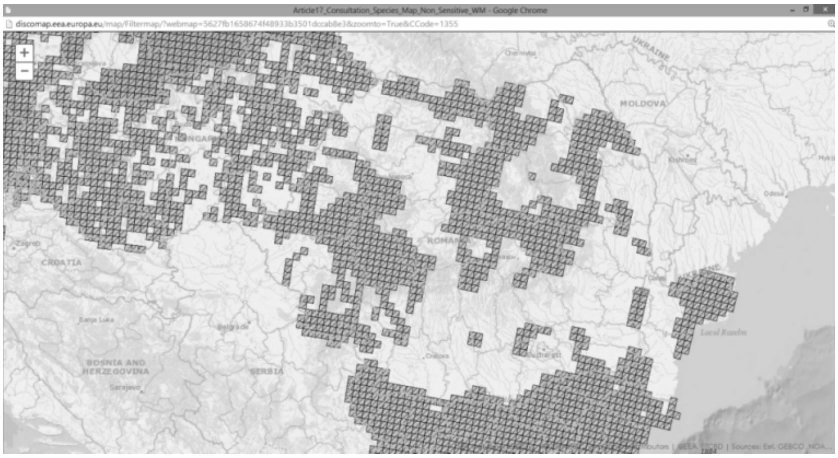

Fig. 5. Map of distribution area of the otter in Romania according to the online report Article 17 on Habitats Directive.

Table 2
Number of *Lutra lutra* individuals from biogeographical regions of Romania

Number of *Lutra lutra* individuals/ biogeographical regions	**Minimum**	**Maximum**
Alpine (ALP)	560	620
Black Sea (BLS)	60	68
Continental (CON)	790	870
Pannonian (PAN)	100	120
Steppic (STE)	190	220
TOTAL	**1700**	**1898**

The map of the otter distribution in Romania (Fig. 5) cannot be correlated with the SCI sites designated for otter species, because the map is missing a large amount of information, considering it as incomplete. Overall, this map is similar with that of the distribution based on the hunting funds, except for the Danube Floodplain and Danube Delta area. On the other hand, this map has many similarities, bringing a high degree of suspicion that the map of otter distribution according to the hunting funds data sheets has been a source of information for the map shown in the report. Also, the methodology of this map is not specified, neither is the basis of its conception, making it unreliable.

Although the otter population in Romania is reduced in number and in density (between 1700–1898 individuals, according to the report), comparing the numbers with the high otter population of other countries (Lithuania, Latvia, Poland, Britain, Denmark, Czech Republic, Bulgaria, etc.) which have smaller areas than

Romania and smaller surfaces of aquatic habitats, it is considered that the otter population has a favorable conservation status, according to the country report presented in 2014 for the 2007–2012 period. The otter population is regarded as having a favorable conservation status in all five biogeographical regions of Romania; even if in some biogeographical regions there are only 60 otter individuals.

Distribution data collected during 2012–2014

To check the accuracy of the data presented above, we have correlated it with the personal data collected in the field from 2012 until now, from studies of inventory and assessment of the state of conservation of the otter population in different areas of Romania. In these studies we applied the standard method recommended by the IUCN/SSC Otter Specialist Group (Reuther *et al.*, 2000). The standard method requires dividing the study area into 10×10 grids, each grid representing a site of observation. In each of these sites a number of four transects are carried out, of 600 m each. These transects should be investigated for signs of otter presence and where signs are identified the search stops in the respective site, which will then be declared positive and otherwise will be declared negative. In most of the conducted studies, no large areas have been inventoried; instead I chose to make a complete assessment in the area by evaluating the otter population in small areas (“Full Survey”) to avoid the lack of signs of presence.

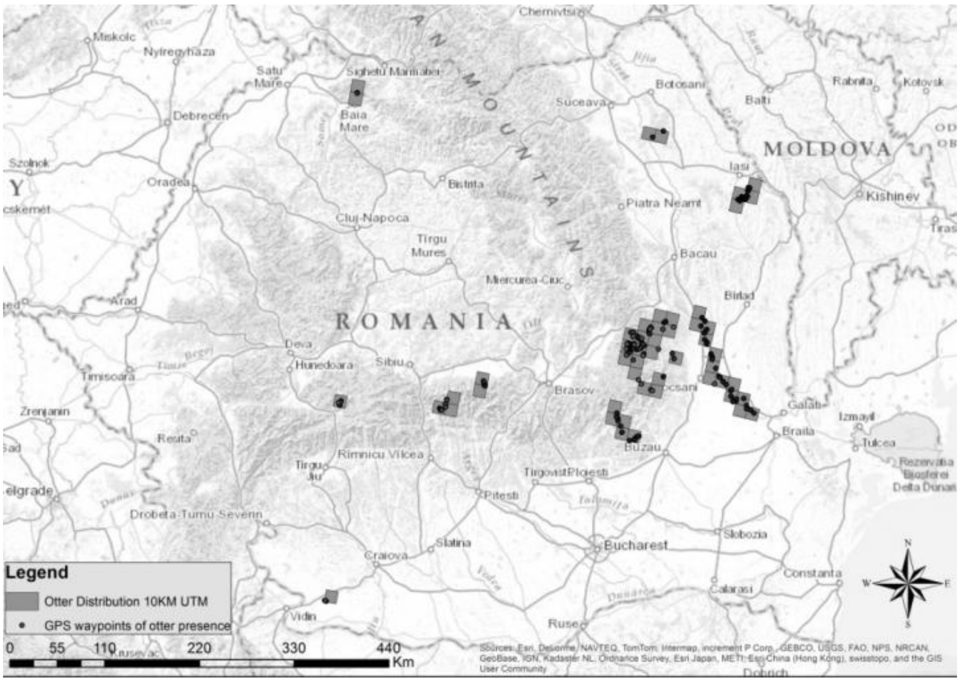

Fig. 6. Preliminary map of otter distribution in Romania conducted during 2012–2014.

Fig. 6 shows the points of otter presence, collected in the field, using a GPS device, the blue marks the UTM grids of 10×10 km, where the otter presence has been identified. It is clearly obvious that by comparing this map with those reported, some areas where the otter presence was confirmed personally in the field were missing from the distribution map at national levels in the report. A good example is the Lower Siret Valley SCI which does not appear on the map based on hunting funds data sheets or the map reported under Article 17, even if in this region we identified a population of approximately 70 otter individuals.

National survey of distribution and abundance of otter population

As a solution to resolve the mismatch of information concerning the status of the otter population in Romania, I propose a national assessment of the otter population, which should be repeated every 10 years in order to achieve proper management of the species and to establish and implement specific conservation measures viable for otter species.

The time and financial costs needed do not imply major efforts in order to achieve a national assessment of the otter population, in less than a year. Using this methodology the national survey would be hardly contestable. The duration of this study may decrease if a large number of evaluators are involved and if the sites would be visited more than seven times per day (Table 3).

Many European countries have achieved such national assessment since 1977, of which include: United Kingdom, Ireland, Denmark, Poland, Portugal, Spain, Italy, Germany, etc. All these countries may represent a model for Romania, as these countries have a standardized set of data concerning otter assessment, collected over a long period of time. Therefore these countries have the ability to analyze the time evolution of the otter population, thus taking decisions, if it is necessary taking measures to ensure optimal preservation conditions for the otter.

By knowing the actual otter population, conservation measures can be established and more effective policies for better management of the national otter population could be adopted.

Table 3

Theoretical analysis of the time cost spent for a national survey of the otter population in Romania

Country	ROMANIA
Surface (km²)	238 391
Number of UTM grids 10 × 10 km	2384
The number of sites if four sites in a grid are visited	9536
Number of working days if seven sites are visited per day	1362
Number of weeks if each week has 5 working days	272
Number of weeks if four evaluators are involved	68

As proposed methodology for achieving this national survey, we suggest using the standard method recommended by the IUCN/SSC Otter Specialist Group (Reuther *et al*., 2000), that is an internationally accepted method for studies on the distribution and inventory of the otter population in a given area. At the same time information at grid level about the disturbing factors and habitat features will also be collected a fact that will help improve the management of the species in the area and at national levels. This would imply using the map with UTM grids of 10 × 10 km, which are further subdivided into four grids of 2.5 × 2.5 km, thus providing better data accuracy.

DISCUSSION

The analysis of all the official data sets revealed a real image on the status of the otter population in Romania, the main goal of this article being the need to know the real situation of the otter in Romania. Unfortunately the low level of confidence in these official sources of data and their lack of correlation make us cautious in drawing conclusions.

What is certain is that all data accessed shows a sharp decrease in the number of otter individuals, considering the data from the hunting funds records, from 1955 to 2010 the population decreased from 3.200 individuals to 456 individuals, otter population declines by 86%, becoming in just 55 years lower by about 2,744 individuals. This information gives us reasons of concern, considering that the otter is a "sentinel" species, an indicator of environmental quality. The main causes of this population decline are defined by accentuated human interventions over natural habitats and the increasing pressure performed over aquatic ecosystems.

The hydro technical river regulation, hydropower development, destruction or degradation of riparian vegetation, capturing the water sources for domestic and industrial use, expansion of residential, commercial and industrial areas, chemical and physical pollution of inland waters in Romania, are just a few examples of disturbing factors of otter population development in the country.

The actual situation of the otter population and many other species of flora and fauna in Romania will not be known until a national evaluation will be conducted by using a widely accepted methodology by the scientific community.

CONCLUSIONS

Through this study we wanted to review the official data on the distribution and on the number of otter individuals, which reveals the otter conservation status in Romania, based on which management strategies are developed on biodiversity and based on which are developed management measures for species, at national and European levels. We also wanted to point out that each of these sets of data shows gaps that need to be corrected and correlated.

At the end of the study I proposed a solution to avoid the unreliable and inaccurate data, a solution implying a national survey of the otter population, which would shed light on the state of conservation of the otter status in Romania.

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