

ENDEMISM OF LAND AND FRESHWATER GASTROPODS IN THE LAKES REGION (TURKEY)

MEHMET ZEKİ YILDIRIM, ÜMİT KEBAPÇI

Abstract. *In this study, zoogeography and endemism of land and freshwater snails of Lakes Region, the richest inland water reservoir in Turkey, were evaluated. 40 species and subspecies from 21 genera and 10 families of the subclass Prosobranchia have been recorded in the Lakes Region (27 being endemic to Anatolia), also 24 species belonging to 14 genera and 4 families of the subclass Pulmonata have been recorded (2 out of 4 Anatolian endemics also present). Of 705 land snail taxa recorded so far in Turkey, 122 taxa, 53 being endemics, are also found to occur in Lakes Region. Zoogeographic characteristics of the area were discussed depending on the distribution of the gastropod species in the lakes.*

Keywords: *Lakes region, endemism, Mollusca, Zoogeography, Turkey.*

Rezumat. *Gasteropode endemice de uscat și apă dulce din Regiunea Lacurilor (Turcia). În cadrul acestui studiu, a fost analizată zoogeografia și speciile endemice de gasteropode de uscat și apă dulce din Regiunea Lacurilor, cea mai reprezentativă zonă lacustră din Turcia. În Regiunea Lacurilor, au fost înregistrate 40 de specii și subspecii din 21 de genuri și 10 familii din subclasa Prosobranchia (27 fiind endemisme din Anatolia) și alte 24 de specii aparținând la 14 genuri și 4 familii din subclasa Pulmonata (2 din cele 4 endemisme din Anatolia fiind de asemenea prezente). Din cele 705 specii de gasteropode de uscat înregistrate până în prezent în Turcia, 122 specii se regăsesc în această regiune, 53 dintre acestea fiind endemisme. Caracteristicile zoogeografice ale zonei au fost de asemenea discutate deoarece distribuția speciilor de gasteropode depinde de acestea.*

Cuvinte cheie: *Regiunea Lacurilor, endemism, moluște, zoogeografie, Turcia.*

INTRODUCTION

Both qualitatively and quantitatively, Lakes Region has the richest inland aquatic reservoir in Turkey. Being among the most important karstic areas, the area attained a relatively rich aquatic fauna through active paleogeographic history of Turkey. The geographical and biological structure and development process of the area, however, have been affected negatively by the eremial periods and recently by human impact. Therefore the area becomes more important with regard to the level of threat to the organisms (esp. birds) found in the area (ERTAN et al., 1996).

The Lakes District is situated within the western Toros Mountains in southwestern Turkey. The change in direction of the Toros Mountains to the north of Antalya Bay has resulted in the formation of narrow and long mountain belts surrounding depressions in some of which numerous lakes were formed. Lakes region and close areas fully became terrestrial by late Miocene. Tectonic character of the lakes like Beyşehir and Eğirdir relates to depressions formed during or after Miocene, which were filled by Neogene lakes. Recent activities and heavy use affected the lakes greatly resulting in drying of the lakes and extinction of local species. The three freshwater lakes, Söğüt, Kestel (Burdur) and Avlan (Antalya) have been systematically dried for agricultural needs so far (İNANDIK, 1965; ATALAY, 1997).

Although the area is a relatively well known area still the inventory of mollusks is far from complete. Researchers having intensive studies on gastropod fauna of the area are: SCHÜTT (1964; 1965; 1983; 1990; 1991; 1992; 1994), RADOMAN (1973; 1976; 1983), BILGIN (1967; 1980) and YILDIRIM (1999a, b).

MATERIAL AND METHODS

Study is based on the excursions performed between 1993 and 2009 and literature data. In excursions, aquatic habitats possessing permanent waters and terrestrial habitats representative of the faunas were chosen for sampling. Literature works mainly followed for identification are ZHADIN (1952); SCHÜTT (1964, 1965, 2005) and GLÖER et al. (2001).

RESULTS AND DISCUSSIONS

Freshwater Prosobranchia species

A total of 40 prosobranch species and subspecies from 21 genera and 10 families of the subclass Prosobranchia have been recorded in the Lakes Region. Of these, 27 are endemic to Anatolia (as compared to 46 in total), 25 endemics are strictly restricted to the region. Local endemism is thus 68% (57% for all species). In addition, 22 species and 6 subspecies of fossil prosobranchs have been described in sediments of different geological periods from various parts of Anatolia (YILDIRIM, 1999b). Present findings show that many species await description, as remote unvisited springs often present new species. The endemics can be listed as:

1. *Theodoxus heldreichi heldreichi* (MARTENS, 1879): Nominal subspecies is found only in Beyşehir and Eğirdir lakes. Fossils are found in Acıgöl, Konya Lake (Çumra) and Hotamış area Quaternary sediments (SCHÜTT & ŞEŞEN, 1989; SCHÜTT, 1991; YILDIRIM, 1999b).
2. *Theodoxus heldreichi fluviocola* SCHÜTT & ŞEŞEN, 1992: Much commoner than nominal subspecies. Widely distributed in many undisturbed aquatic systems in southern Aegean region (İzmir, Manisa, Aydın, Denizli, Isparta etc.) (BILGIN, 1980; SCHÜTT & ŞEŞEN, 1989; SCHÜTT, 1991; YILDIRIM, 1999b).
3. *Theodoxus altenai* SCHÜTT, 1965: It is found only in Kırkgöz Kaynağı (Döşemealtı, Antalya) (YILDIRIM, 1999b).
4. *Hydrobia anatolica* SCHÜTT, 1965: The taxonomic status of this species described from Düdenbaşı (Antalya) (SCHÜTT, 1965) is uncertain and it is possibly a *Graceoanatica* RADOMAN species.
5. *Pseudammnicola geldiyana* SCHÜTT & BILGIN, 1970: It is an endemic distributed in springs around Dinar, and Çivril (SCHÜTT & BILGIN, 1970; BILGIN, 1980; YILDIRIM, 1999b).
6. *Pyrgorientalia zilchi* (SCHÜTT, 1964): It is found only in Kırkgöz spring (SCHÜTT, 1964; BILGIN, 1980; RADOMAN, 1983; YILDIRIM, 1999b).
7. *Kirelia carinata* RADOMAN, 1973: It is found only in Lake Beyşehir (RADOMAN, 1973; YILDIRIM, 1999b).
8. *Falsipyrgula pfeiferi* (WEBER, 1927): It is endemic to Lake Eğirdir (SCHÜTT, 1965, 1990; RADOMAN, 1983).
9. *Falsipyrgula beysehirana* (SCHÜTT, 1965): It is found only in Lake Beyşehir (SCHÜTT, 1965, 1990; RADOMAN, 1983).
10. *Falsipyrgula schuetti* SCHÜTT & YILDIRIM, 1999: It is found only in Lake Beyşehir (SCHÜTT & YILDIRIM, 1999b).
11. *Horatia parvula* (NAEGELE, 1894): It has been reported at Isparta, Tokat (terra typica), Mardin, and Diyarbakır (SCHÜTT, 1965; BILGIN, 1967, 1980), but validity of these records are doubtful.
12. *Pseudorientalia natica smyrnensis* SCHÜTT, 1970: It is distributed in İzmir, Aydın, Denizli, and Isparta (SCHÜTT, 1965; SCHÜTT & BILGIN, 1970; BILGIN, 1967, 1980; YILDIRIM, 1999b).
13. *Tefennia tefennica* SCHÜTT & YILDIRIM: It is endemic to Başpınar spring in Tefenni, Burdur (SCHÜTT & YILDIRIM, 2003).
14. *Turkorientalia anatolica* RADOMAN, 1973: It is restricted to Yercey spring (Burdur) (YILDIRIM, 1999b).
15. *Graecoanatica lacustriturca* RADOMAN, 1973: It is widespread in Pleistocene sediments in Isparta and Burdur (SCHÜTT, 1990; YILDIRIM, 1999b), but now it can be found only in Eğirdir and Beyşehir Lakes and a few springs in Burdur (RADOMAN, 1973, YILDIRIM, 1999b).
16. *Graecoanatica tenuis* RADOMAN, 1973: It was described from Gemiş spring (Denizli) (YILDIRIM, 1999b).
17. *Graecoanatica conica* RADOMAN, 1973: This extinct species was described from springs connected to Acıgöl lake (YILDIRIM, 1999b).
18. *Graecoanatica brevis* RADOMAN, 1973: It is another extinct species once occurred in İncirlişar, a spring located in SW corner of lake Burdur (YILDIRIM, 1999b).
19. *Graecoanatica kocapinarica* RADOMAN, 1973: It is endemic to Kocapınar spring in Yukarı Gökdere village, (Eğirdir, Isparta) (RADOMAN, 1973; YILDIRIM, 1999b).
20. *Graecoanatica pamphylica* (SCHÜTT, 1964): This species, conchologically distinct from all congeners, can be found in Kırkgöz springs (terra typica), as well as in several other springs in Antalya (SCHÜTT, 1964, 1990; RADOMAN, 1973; YILDIRIM, 1999b; YILDIRIM & KARŞAHIN, 2000).
21. *Sadleriana byzantina demirsoyii* YILDIRIM & MORKOYUNLU, 1997: It is restricted to localities in Burdur and Antalya, while nominal subspecies is found in İzmir, Manisa, and Kütahya (SCHÜTT, 1965; SOYLU, 1990; YILDIRIM & MORKOYUNLU, 1997).
22. *Sadleriana minuta* (NAEGELE, 1903): It was described from Ereğli (Konya) (YILDIRIM, 1999b).
23. *Islamia pseudorientalica* RADOMAN, 1973: Like the other two congeners it is endemic to Kırkgöz springs.
24. *Islamia anatolica* RADOMAN, 1973.
25. *Islamia bunarbasa* (SCHÜTT, 1964).
26. *Bythinella turca* RADOMAN, 1976: It is an endemic of Isparta (RADOMAN, 1983; YILDIRIM, 1999b).
27. *Bithynia pseudemmericia* SCHÜTT, 1964: It is the most widespread endemic *Bithynia* species and found in localities of Afyon, Isparta, Antalya, Konya, Burdur. It is also common and widespread in Quaternary fossil strata: Hazar Lake, Gemiş vil. pond (SCHÜTT, 1965, BILGIN, 1980); Çumra, Çatalhöyük and Konya Quaternary sediments; Yarışlı, Burdur Lake Quaternary sediments (SCHÜTT, 1990; YILDIRIM, 1999a).

Endemic freshwater prosobranch taxa distributions can be used for the analysis of driving factors for the development of Anatolian malacofauna. Only three endemic species, *Th. heldreichi*, *G. lacustriturca* and *B. pseudemmericia*, can be accepted as widespread although they are only to be found in few parts of SW Anatolia outside the region. Most endemics show great impact of isolated position of Anatolia through geological history, also climatic and hydrogeographical conditions. For instance, Quaternary fossils of *B. pseudemmericia* are distributed in parts of Anatolia. Almost all the sites were once connected by an ancient lake system enabling faunal exchanges with Asia and Sarmatian Sea from Oligocene onwards (Figure 1). Present range, particularly formed by split of the lake into two basins and extensions towards SW Anatolia in Pliocene, represent only a small fraction of the former range. WILKE et al. (2007) demonstrated molecular evidence for the Sarmatian origin of Lakes region Pyrgulids (*Falsipyrgula* spp.) and notably a recent relative divergence time from the Sarmatian stock which may indicate consistency of faunal exchanges via river systems.



Figure 1. Ancient lake system (grey coloured) of Anatolia in its greatest extend (during Miocene) and distribution of present (empty squares) and fossil (asterisks) occurrences of *B. pseudemmericia* (Source: DEMIRSOY, 1999).

Figura 1. Sistem vechi de lacuri (colorat gri) în Anatolia în perioada de maximă extensiune (Miocene) și distribuția aparițiilor de *B. pseudemmericia* din prezent (pătrate goale) și a celor fosile (*) (sursa: DEMIRSOY, 1999).

Freshwater Pulmonates (Basommatophora)

Of 33 species to be found in Turkey, only 4 are endemics. 24 species (72%) and among them, 2 strictly endemic taxa can be encountered in the freshwaters of the region. The endemics can be listed as:

Although not endemics, several exemplified by *Bathymphalus contortus* (L., 1758) and *Hippeutis complanatus* (L., 1758) found in single spots in the region mark the refugial character of the region.

1. *Stagnicola tekecus* GLÖER & YILDIRIM, 2006: It is an interesting species conchologically similar to widespread *S. palustris* and can only be found in Kırkgöz and Konne springs (Antalya and Isparta);
2. *Gyraulus pamphylicus* GLÖER & RÄHLE, 2009: It is also a long unnoticed species from Kırkgöz spring (Antalya) having a distinctly angular body whorl.

Land Pulmonates (Stylommatophora)

Of 705 taxa occurring in Turkey, 112 can be found in the region (SCHÜTT, 2005). 53 of these (47%) are endemics. The endemics can be listed as:

1. *Euxinolauria superba zilchi* (SUBAI, 1993)
2. *Schileykula nordsiecki* HAUSDORF, 1996
3. *Schileykula scypus lycaonica* HAUSDORF, 1996
4. *Pilorcula trifilaris anatolica* HAUSDORF, 1996
5. *Pagodulina pisidica* SCHUTT, 1993
6. *Pagodulina subdola orientalis* HAUSDORF, 1996
7. *Buliminus carneus* (L. PFEIFFER, 1846)
8. *Buliminus lycicus* (L. PFEIFFER, 1846)
9. *Paramastus spratti* (L. PFEIFFER, 1846)
10. *Turanena albrechti* RAHLE, 1988
11. *Turanena tuccari* GITTENBERGER, 1986
12. *Jaminia loewii loewii* (PHILIPPI, 1844)
13. *Multidentula squalina eudoxinus* (NAEGELE, 1894)
14. *Chondrula lycaonica* (STURANY, 1904)
15. *Chondrula microtragus tricuspidata* (KÜSTER, 1843)
16. *Borlumastus yildirimi* (SCHUTT, 1995)
17. *Vitrea ernesti* RIEDEL & SUBAI, 2004
18. *Lindbergia karainensis* RAHLE & RIEDEL, 1987
19. *Zonites beydaglariensis* RIEDEL, 1982
20. *Zonites osmanicus* RIEDEL, 1987

21. *Turcozonites megistus* (ROLLE, 1894)
22. *Turcozonites wandae* (RIEDEL, 1982)
23. *Mesolimax escherichi* SIMROTH, 1899
24. *Strumosa strumosa meridiana* SCHUTT, 2001
25. *Phrygica euxinaeformis* H. NORDSIECK, 1994
26. *Phrygica ilegiensis* H. NORDSIECK, 2004
27. *Phrygica raehlei raehlei* H. NORDSIECK, 1994
28. *Phrygica raehlei pygmaea* H. NORDSIECK, 2004
29. *Phrygica riedeli jansseni* H. NORDSIECK, 1994
30. *Phrygica riedeli riedeli* H. NORDSIECK, 1994
31. *Phrygica riedeli orientalis* H. NORDSIECK, 2004
32. *Sprattia aksoylari* YILDIRIM, 1997
33. *Sprattia aksuensis aksuensis* H. NORDSIECK, 2004
34. *Sprattia aksuensis barlaensis* H. NORDSIECK, 2004
35. *Sprattia beycola beycola* H. NORDSIECK, 1994
36. *Sprattia beycola medoroides* H. NORDSIECK, 2004
37. *Sprattia blissi blissi* (O. BOETTGER, 1899)
38. *Sprattia blissi yalvacensis* H. NORDSIECK, 2004
39. *Sprattia pseudophrygica* H. NORDSIECK, 2004
40. *Sprattia sillyonensis candirensis* H. NORDSIECK, 2004
41. *Sprattia sowerbyana princeps* H. NORDSIECK, 2004
42. *Monacha pamphylica* HAUSDORF, 2000
43. *Monacha subaii* HAUSDORF, 2000
44. *Xeropicta smyrnoretica* (GERMAIN, 1933)
45. *Metafruticicola schuberti* (ROTH, 1839)
46. *Metafruticicola dedegoelensis* HAUSDORF, GÜMÜŞ, YILDIRIM 2004
47. *Metafruticicola oerstani* HAUSDORF, GÜMÜŞ, YILDIRIM 2004
48. *Isaurica callirhoe* (ROLLE, 1894)
49. *Isaurica lycia* (E. MARTENS, 1889)
50. *Isaurica pamphylica* SUBAI, 1994
51. *Isaurica riedeli* SUBAI, 1994
52. *Isaurica schuetti* SUBAI, 1994
53. *Helix dickhauti* (KOBELT, 1903)

Three endemic genera - *Sprattia* NORDSIECK, *Phrygica* NORDSIECK (Clausiliidae), and *Isaurica* KOBELT (Helicidae) - show spectacular diversity in the region, while remaining genera possess either narrow endemic members (like *Turanena tuccari*, *T. albrechti*) or widely distributed endemics centered in the region, like *Mesolimax escherichi* and *Helix dickhauti*. *Euxinolauria superba zilchi*, *Pagadulina subdola orientalis*, *Lindbergia karainensis*, *Strumosa strumosa meridiana* are quite disjunct from their nearest relatives. Probably *Borlumastus yildirimi*, *Chondrula lycaonica*, *Paramastus spratti*, *Metafruticicola dedegoelensis* and *M. oerstani*, which are almost all endemic solely to the region, represent quite distinct lineages. Of widespread endemics there are two discernible groups: the first one (*Piloricula trifilaris anatolica*, *Pagadulina pisidica*, *Buliminus carneus*, *Jaminia loewii loewii*, *Chondrula lycaonica*, and *Mesolimax escherichi*) comprises endemics widespread on Taurus mountains, the other (*Multidentula squalina eudoxinus*, *Chondrula microtragus tricuspudata*, *Xeropicta smyrnoretica*, and *Helix dickhauti*) comprising species having W Anatolian extensions in distribution.

Land snail faunas may also have been shaped by immigrations, geological and hydrological events affecting Taurus refugial area till Pliocene and perhaps early Pleistocene. Land snail assemblages in Pliocene deposits of Afyon-Burdur area (SCHÜTT, 1992; 1994), show a general resemblance with modern faunas except for the presence of several genera like *Caucasotachea* and *Cepaea*. Furthermore, Pleistocene glaciations locally without permafrost conditions would probably have acted in speciation via climatic vicariance.

CONCLUSIONS

As a conclusion SW Anatolia and Lakes Region is an important center for speciation and distribution of Gastropoda species. Due to isolated position of the faunas, supportive studies in molecular systematics and palaeontology would provide better understanding and explanation of the gastropod fauna of the Lakes Region.

REFERENCES

- BILGIN FH. 1967. *İzmir Civan Tatlısularında Yaşayan Gastropodlar Üzerinde Sistemik ve Ekolojik Araştırmalar*. Ege Univ. Fen Fak. İlmî Rapoerlar Serisi. **36**: 1-55.

- BILGIN H. 1980. *Systematics and Distribution of Mollusca species that collected from some important fresh waters in West Anatolia*. Tıp Fak. Dergisi. **8**(2): 1-64.
- DEMIRSOY A. 1999. *Genel ve Türkiye Zoocoğrafyası "Hayvan Coğrafyası"* (2nd Ed.). Meteksan A.Ş. Ankara: 965pp.
- ERTAN Ö., YILDIRIM M. Z., MORKOYUNLU A. 1996. *The Mollusca species and their feeding models that diastributes in Konne Spring (Eğirdir-Turkey). Könye Kaynağı'nda Yayılış Gösteren Mollusca Türleri ve Beslenme Tipleri*. II. International Symposium on Aquatic Products. September 21-23. Istanbul-Türkiye.
- İNANDIK H. 1965. *"Türkiye'nin Gölleri"*. Baha Matbaası. İstanbul: 313pp
- RADOMAN P. 1973. *New Classificacion of fresh and brakish Water Prosobranchia from the Balkans and Asia Minor*. Prir. Muz. Beograd. Mus. Hist. Nat. Beograd. **32**: 1-30. Beograd.
- RADOMAN P. 1976. *Speciation within the family Bythinellidae on the Balkans and Asia Minor*. Sond. aus Z.f. zool. Sys. u. Evol. **14**(2): 130-152.
- RADOMAN P. 1983. *Hydrobioidea a Superfamily of Prosobranchia (Gastropoda) I. Systematics*. Serb. Acad. Sci. Arts. Monogr. **547**: 1-256.
- SCHÜTT H. 1964. *Die Molluskenfauna eines reliktaeren Quellsees der südlichen Türkei*. Archiv für Molluskenkunde. **93**: 173-180. Frankfurt a. M.
- SCHÜTT H. 1965. *Zur Systematik und Ökologie Türkischer Süßwasserprosobranchier*. Zoologische Mededelingen. Deel 41 no: 3, 43-71.
- SCHÜTT H. 1990. *Die pleistozinen Mollusken dreier pisidischer Salzseen*. Mitteilungen der deutschen malakozoologischen Gesellschaft **46**: 15-24. Frankfurt a. M.
- SCHÜTT H. 1991. *Fossile Mollusken dreier anatischer Ovas*. Archiv für Molluskenkunde. **120**(4/6) (1989): 131-147.
- SCHÜTT H. 1992. *Die Altpleistozane Molluskenfundort Kurna bei Burdur in der Türkei*. Mitt. Dtsch. Malakozool. Ges. **49**, 17-18.
- SCHÜTT H. 1994. *Neogene Mollusken aus den Tertiarbecken bei Afyon, Türkei*. Geologica et Palaeontologica. **28**: 167-183.
- SCHÜTT H. 2005. *Turkish land snails 1758-2005*. 4th, revised and enlarged edition. Solingen, Verlag Natur & Wissenschaft: 559pp.
- SCHÜTT H. & BILGIN FH. 1970. *Pseudammicola geldiyana n. sp., a spring-inhabiting snail of the Anatolian Plateau*. Archiv für Molluskenkunde. Frankfurt a. M. **100**: 151-158.
- SCHÜTT H. & ŞEŞEN R. 1989. *Theodoxus in SE-Anatolia, Turkey (Gastropoda, Prosobranchia, Neritidae)*. Basteria. **53**: 39-46.
- SCHÜTT H. & YILDIRIM M. Z. 1999. *A new freshwater snail from the Beyşehir Lake in South-West Anatolia (Gastropoda: Prosobranchia: Hydrobioiden) Malak. Abh. mus. Tierkde. Dresden. 19 22: 243-246*.
- SOYLU E. 1990. *Sapanca Lake Mollusk Faunası*. İstanbul Üniv. Su Ürünleri Dergisi **4**(1): 73-88.
- WEBER A. 1927. *Eine neue Pyrgula, Pyrgula pfeiferi*. Zool. Anz. **70**: 313-314.
- WILKE T., ALBRECHT C., ANISTRATENKO V. V., KOSAL ŞAHİN S., YILDIRIM M. Z. 2007. *Testing biogeographical hypotheses in space and time: faunal relationships of the putative ancient Lake Eğirdir in Asia Minor*. Journal of Biogeography. **34**: 1807-1821.
- YILDIRIM M. Z. & MORKOYUNLU A. 1997. *Burdur Gölü Havzası'ndan (Türkiye) Yeni bir Sadleriana alttürü Sadleriana byzanthina demirsoyi n.ssp. (Gastropoda, Prosobranchia, Hydrobidae) 'e Alttürün Bazı Ekolojik Özellikleri*. 111. Ulusal Ekoloji ve Çevre Kongresi Bildirileri Kitabı: 1-12.
- YILDIRIM M. Z. 1999a. *Living and Fossil Molluscs of The Burdur Lake Basin*. Club Conchylia Informationen. **31**(1/2): 27-35.
- YILDIRIM M. Z. 1999b. *Prosobranchia (Gastropoda: Mollusca) Species and their Zoogeographic Distrubution, 1. Fresh and Brackish Waters*. Tr. J. Of Zoology **23** (Supp. 3): 877-900.
- YILDIRIM M. Z. & KARAŞAHİN B. 2000. *The Gastropoda species that distributed in fresh water collected from Antalya Vicinity*. SDÜ. Fen Bilimleri Enstitüsü Dergisi **4**(1): 199-207.
- ZHADIN VI. 1952. *Molluscs of Fresh and Brackish Waters of USSR*. Israel Program for Scientific Translations Ltd: 368 pp.

Mehmet Zeki Yıldırım, Ümit Kebapçı
 Mehmet Akif Ersoy Üniversitesi,
 Fen Edebiyat Fakültesi, Biyoloji Bölümü,
 15030 Burdur, Turkey
 E-mail: mzekiyildirim@gmail.com
 E-mail: kebabci@gmail.com

Received: June 3, 2009
 Accepted: September 15, 2009