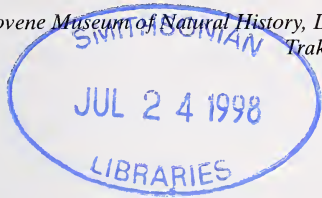




A new look at the identity and distribution of Water shrews (*Neomys* spp.) in Turkey

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Abstract

Examination of external, cranial, and penile characteristics of over 50 water shrews (*Neomys* spp.) from Turkey demonstrates the existence of two species. The smaller one, which is identical with *N. anomalus* Cabrera, 1907, occurs in both, European and the Asiatic Turkey, and is found from sea level to 2,100 m a.s.l. The larger species, previously ascribed to *N. fodiens* (Pennant, 1771), is reported here as *N. teres* Miller, 1908; *N. schelkovnikovi* Satunin, 1913 from the Caucasus is considered to be its junior synonym. *Neomys teres* occurs in the Pontic Mts. east of Bolu, and in the Van area. A single case of sympatric occurrence of the two species is reported from Lake Abant, north-western Anatolia.

Key words: *Neomys*, Turkey, distribution, nomenclature

Introduction

It is generally accepted that Turkey is inhabited by two species of water shrews of genus *Neomys*: *N. anomalus* Cabrera, 1907 and *N. fodiens* (Pennant, 1771) (SPITZENBERGER and STEINER 1962; OSBORN 1965; SPITZENBERGER 1968; KUMERLOEVE 1975; DOĞRAMACI 1989; OBUCH 1994). In addition, HUTTERER (1993) suggests that the Caucasian species *N. schelkovnikovi* Satunin, 1913 may also occur in Turkey.

The most comprehensive review of water shrew distributions in Turkey is that of SPITZENBERGER (1968). She reports *N. anomalus* in both European and Asiatic Turkey, but restricts *N. fodiens* to northeastern Anatolia – thirteen water shrew localities were known at that time. Since then, five mammal collecting trips to Turkey (1993 to 1995) have yielded new data which contribute further to our understanding of water shrew ranges and which have led us to new conclusions with regard to the identity of large Anatolian water shrews (thus far reported as *N. fodiens*).

Material and methods

Forty-four specimens from seventeen different localities were collected by snap trapping or live trapping, using various trap types, often baited with a mixture of canned fish and oat flakes. Voucher specimens (skins, skulls, and phalli in 70% alcohol) are housed in the Department of Zoology, Charles University, Prague (PFUK) and in the collection of B. KRYŠTUFEK, Ljubljana (BKC). In addition, we re-examined Turkish specimens in the following collections (acronyms in brackets): Naturhistorisches Museum Wien, Vienna (NMW), Zoologisches Forschungsinstitut und Museum A. Koenig, Bonn (ZFMK),

the collection of M. ÇAĞLAR, Istanbul University (ÇIU), and of J. OBUCH, Blatnica, Slovakia (JOC). Details of the NMW and ZFMK specimens have been published by SPITZENBERGER (1968).

External measurements used in this study were taken from fresh specimens by two of the authors (BK and VV): W – weight, HB – head and body length (from snout to anus), TL – tail length (from anus to tail tip; hairs excluded), and HF – hind foot length (without claws). Ten linear measurements were taken from each skull, using a vernier calliper accurate to the nearest 0.05 mm: CbL – condylobasal length, RL – rostral length, RB – rostral breadth, BB – braincase breadth, IoB – infraorbital breadth, PB – breadth across pterygoid process, PgB – breadth across postglenoidal process, RH – rostral height, ML – mandible length, and CH – height of coronoid process. For definitions of RL, RH, and PB, see TVRTKOVIĆ et al. (1980) (for the remaining measurements see NIETHAMMER and KRAPP 1990).

Morphometric dimensions were subjected to uni- and multivariate statistical analysis. Since our basic aim was the successful separation of taxa, stepwise discriminant function analysis (DFA) was used. This multivariate analysis identifies suitable linear combinations of the original variables that will allow the maximal possible separation between a priori defined groups (MANLY 1994). Once the original groups are defined, DFA permits the classification of unknown specimen(s) into appropriate groups. Since DFA requires a priori defined groups, 43 specimens were ascribed to 3 Operational Taxonomic Units (OTUs): OTU1 – *N. anomalus* from Turkish Thrace, OTU2 – *N. anomalus* from Anatolia (excluding sample from Lake Eber), and OTU3 – *N. teres*. Statistical analysis were undertaken using the STATISTICA analysis system (Release 5, StatSoft '97 Edition).

Results and discussion

Determination and identity of Turkish water shrews

The glans penis provides the most reliable discrimination between the three *Neomys* spp. currently recognised by HUTTERER (1993): *N. anomalus*, *N. fodiens*, and *N. schelkovnikovi* (for the reasons explained below we henceforth use the name *N. teres* for the last). Particularly characteristic are the anterior part of the glans (short and blunt in *N. fodiens* and *N. anomalus*, elongated and narrow in *N. teres*) and the lateral flaps (absent in *N. anomalus*, present but small and simple in *N. fodiens*, much expanded and with horny spines in *N. teres*) (PUCEK 1964; YUDIN 1970). According to these criteria, the phalli of our specimens are ascribable either to *N. anomalus* (European and Asiatic material) or to *N. teres* (Asia Minor). *Neomys fodiens* was not represented in our material, although this could be an artefact of the limited number of phalli examined ($n = 10$). However, molecular data and skull shape analysis also suggest the presence of only two species of water shrew in Turkey, none of which is identical with *N. fodiens*.

Since the majority of voucher specimens in different collections are skins and skulls (and lack phalli) we attempt here to provide simple morphological (and particularly, cranial) characteristics that can be used to distinguish between Turkish water shrews. Size, which is often used for this purpose (e.g. SPITZENBERGER 1990 a) shows geographic variation in *N. anomalus* (SPITZENBERGER 1990 b). Furthermore, in the case of sympatry with *N. fodiens*, the size of two species can covary (SPITZENBERGER 1980) which makes accurate determination even more difficult, particularly when examining unprovenanced material.

Cranial characteristics permitting discrimination between Balkan populations of *N. fodiens* and *N. anomalus* are listed by TVRTKOVIĆ et al. (1985), KRYŠTUFEK and PETKOVSKI (1989), and VOHRALÍK (1985). Our water shrews from European Turkey fitted fairly well with *N. anomalus* from Macedonia (based on KRYŠTUFEK and PETKOVSKI 1989 and unpublished data by BK) but attain larger sizes and partially overlap with Macedonian *N. fodiens* (Fig. 1). Since *N. anomalus* is the only water shrew in European Turkey, this might represent character release following niche release in the absence of the larger, more aquatic, *N. fodiens*.

The two species from Anatolia belong to two size classes – the larger one represents *N. teres*, and the smallest one, *N. anomalus*. Phenetic relations between the two are similar

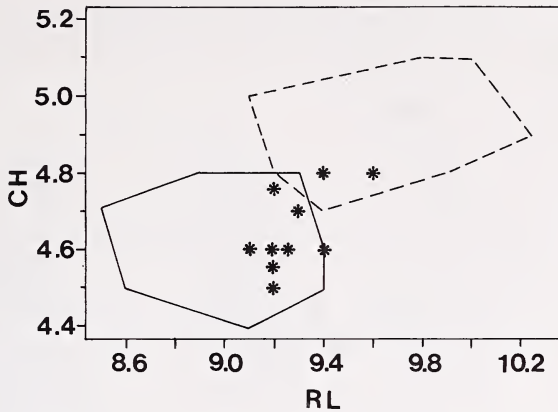


Fig. 1. Scatter diagram plot of coronoid height (CH) against rostral length (RL). Polygons enclose scores for 25 *Neomys fodiens* (broken line), and 28 *N. anomalus* (straight line) from Macedonia. Asterisks indicate specimens from European Turkey.

to those observed between *N. fodiens* and *N. anomalus* in Europe (SPITZENBERGER 1990 a). *Neomys teres* is more aquatic, with a longer tail and hind foot, and with more pronounced fringes of stiff hairs on the sides of the hind foot and along the ventral side of the tail. The skull lacked categoric traits, but several linear dimensions did not overlap, at least as long as the sample from Lake Eber was not considered. DFA of the three OTUs resulted in highly significant discrimination (Wilks' $\lambda = 0.0676$, $P < 0.00001$) and only single specimen of Thracian *N. anomalus* (OTU1) was mis-classified to OTU2. All *N. teres* were ascribed to the appropriate group. Six variables with F-to-enter > 1 were included into the final model (Tab. 1). Two longitudinal measurements (CbL, RL), which seem to represent overall size, contributed most to between-group discrimination, and the 1st Discriminant function (explaining 93.5% of all discriminatory power) distinguished *N. teres* from both *N. anomalus* samples (Fig. 2).

Specimens from Lake Eber attain considerable size which makes their identity more equivocal. Although the only phallus available from the locality was of the “*anomalus*” type, several larger specimens suggest the possible co-occurrence of *N. teres* in the sample. Since a discrimination model had been finalised and the discrimination functions had been derived, eight specimens from Lake Eber were examined for goodness-of-fit within the three OTUs. Six specimens (including the one with the “*anomalus*” phallus) had the highest posteriori probabilities ($P > 0.88$) for OTU1 (i.e. Anatolian *N. anomalus*), while the two largest specimens (CbL 21.3 and 21.8 mm, respectively) were classified as *N. teres*

Table 1. Summary of the Stepwise Discriminant Function Analysis of three Turkish *Neomys* OTUs. All F-values are significant at $P < 0.000001$.

Variable	Step	F-to-enter	λ	F-value
CbL	1	71.477	0.178	71.477
RL	2	5.315	0.132	26.352
PB	3	3.827	0.104	20.293
RB	4	2.693	0.087	16.690
PgB	5	2.009	0.076	14.188
IoB	6	1.608	0.068	12.329

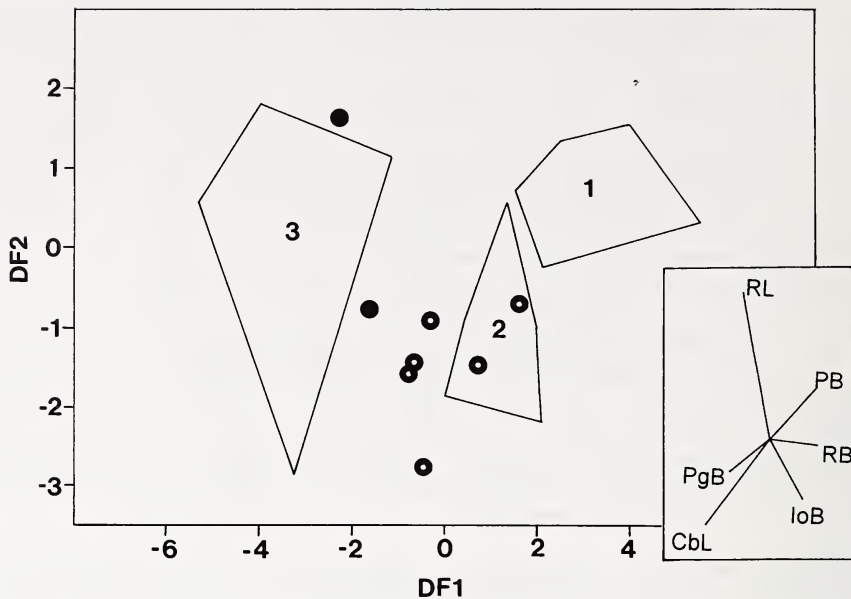


Fig. 2. Projection of three Operational Taxonomic Units (OTUs) of Turkish *Neomys* shrews onto the first two discriminant variates (DFs) derived from the stepwise DFA. Polygons enclose scores for all individuals within an OTU with identity numbers being placed on group centroids. Circles indicate specimens from Lake Eber (central Anatolia) which were superimposed onto the derived discriminant functions. Open circles = specimens with the highest posteriori probabilities for Anatolian *N. anomalus*; closed circles = specimens classified as *N. teres*. OTU1 = *N. anomalus* from Turkish Thrace (n = 10), OTU2 = *N. anomalus* from Anatolia (excluding sample from Lake Eber; n = 11), and OTU3 = *N. teres* (n = 14). The inset illustrates character vectors, based on their respective standardised coefficients for Canonical variables.

(posteriori probabilities 0.899 and 0.998, respectively). However, detailed examination of voucher skins of the two large water shrews showed no resemblance of the tail and hind foot to that of *N. teres*. Comparison of the Eber sample with *N. anomalus* and *N. teres* from lake Abant did not reveal such categoric external differences between large and the small size classes in the former as is evident between the two Anatolian species in Lake Abant (where they are sympatric). It is thus clear that the Lake Eber population belongs to *N. anomalus*. As a result, linear skull dimensions overlap to a certain degree between the two Anatolian water shrews, however, CbL, RL, and ML still permit fairly reliable discrimination (Tab. 2).

The first report on water shrew from Asia Minor is by MILLER (1908). His specimen, collected from the vicinity of Erzeroum (= Erzurum; pt. 26 on Fig. 3) serves as the type for *Neomys teres*. There is no consensus on the identity of this name, it being synonymised either with *N. anomalus* (ELLERMAN and MORRISON-SCOTT 1966; GROMOV and BARANOVA 1981; HUTTERER 1993) or *N. fodiens* (SPITZENBERGER and STEINER 1962; CORBET 1978). On the basis of size quoted from MILLER (1908) (CbL = 22.4 mm) this specimen is referable to *N. schelkovnikovi*. It clearly represents the oldest name for a large water shrew from Asia Minor and the Caucasus; *Neomys schelkovnikovi* is thus a junior synonym of *N. teres*.

Distribution

Water shrews are reported from 31 localities; 6 are from European Turkey and the remaining 25 from Asiatic Turkey. *Neomys anomalus* is the only water shrew in European

Table 2. Summary statistics (upper row: mean \pm standard deviation; lower row: range) and One way ANOVA of the external and craniometric measurements within 3 samples of Turkish *Neomys* shrews. See text for identities of morphometric characters. Weight is in grams, other linear measurements in mm.

	1 <i>N. anomalus</i> Thrace N = 10	2 <i>N. anomalus</i> Anatolia N = 17–21	3 <i>N. teres</i> Anatolia N = 11–20	F-value P <	Multiple range test
W	12.47 \pm 4.007 7–20	12.74 \pm 2.605 10–18	18.00 \pm 5.979 11–28	6.456 0.005	(1, 2) (3)
HB	82.3 \pm 5.186 74–89	82.5 \pm 4.174 76–90	92.91 \pm 7.314 85–101	15.151 0.0001	(1, 2) (3)
TL	51.90 \pm 0.830 14.8–17.8	55.05 \pm 4.143 46–60	67.75 \pm 5.065 57–73	51.249 0.0001	(1, 2) (3)
HF	15.90 \pm 0.830 14.8–17.8	16.70 \pm 0.709 15.5–18.3	16.93 \pm 1.143 18.2–22.1	59.678 0.0001	(1) (2) (3)
CbL	20.22 \pm 0.392 19.35–20.85	20.97 \pm 0.453 20.10–21.80	22.15 \pm 0.436 21.60–23.00	63.991 0.0001	(1) (2) (3)
RL	9.23 \pm 0.235 9.10–9.65	9.41 \pm 0.242 9.00–9.95	10.12 \pm 0.295 9.55–10.60	51.797 0.0001	(1, 2) (3)
RB	5.99 \pm 0.219 5.05–6.20	6.04 \pm 0.168 5.80–6.35	6.10 \pm 0.162 5.70–6.40	1.452 n.s.	
BB	10.27 \pm 0.296 9.65–10.65	10.46 \pm 0.284 9.90–11.10	11.05 \pm 0.379 10.40–11.75	20.870 0.0001	(1, 2) (3)
IoB	3.58 \pm 0.178 3.30–3.80	3.67 \pm 0.123 3.50–3.85	3.71 \pm 0.136 3.40–3.90	2.990 n.s.	
PB	2.92 \pm 0.102 2.75–3.05	2.80 \pm 0.089 2.55–2.90	2.78 \pm 0.139 2.50–2.95	5.321 0.01	(1) (2, 3)
PgB	6.11 \pm 0.166 5.70–6.30	6.20 \pm 0.137 5.90–6.45	6.37 \pm 0.170 6.10–6.70	9.635 0.0005	(1, 2) (3)
RH	3.75 \pm 0.123 3.50–4.00	3.83 \pm 0.119 3.60–4.00	3.87 \pm 0.171 3.60–4.20	1.284 n.s.	
ML	10.89 \pm 0.423 9.85–11.45	11.21 \pm 0.264 10.75–11.70	11.93 \pm 0.238 11.60–12.50	52.502 0.0001	(1) (2) (3)
CH	4.64 \pm 0.123 4.45–4.80	4.75 \pm 0.150 4.40–5.00	4.87 \pm 0.124 4.70–5.10	11.346 0.0001	(1) (2) (3)

Turkey (Fig. 3), where it ranges from sea level (pts. 4 and 5 on Fig. 3) to 650 m asl (pt. 2 b). Coastal records are from the Black Sea and Marmara Sea Coasts, and our specimens were collected along running waters (streams, rivers) in deciduous forest. This habitat is similar to that occupied by *N. fodiens* in much of Europe. The Anatolian range appears to be more scattered. The species occurs in the western-most Pontic Mts. (Kuzey Anadolu Dağları) eastwards to the Yenice River in north-western (pts. 8 and 9) and central Anatolia (pt. 15), and in the Taurus Mts. (Toros Dağları). Our results thus extend the known range of *N. anomalus* southwards by approximately 250 km.

SPITZENBERGER (1968) also reports *N. anomalus* for the Van area, which is separated from other Turkish localities by approximately 700 km. The voucher specimen on which the determination was based is stored in the ZFMK, and was examined by BK in December 1996. The skin, which is much contracted, does not permit any definite conclusion to be made about the species identity. The skull was not available for study at the time of

BK's visit to Bonn, however, SPITZENBERGER (1968) has published measurements for CbL and CH. Based on the former (20.6 mm) the specimen fits well with *N. anomalus*. Additional evidence on the occurrence of *N. anomalus* in eastern Anatolia emerged during a re-examining owl pellet material, previously identified as *N. fodiens* (OBUCH 1994). The single right mandible from Sarikamiş (pt. 29 on Fig. 3) is small (ML = 11.3 mm) and fits

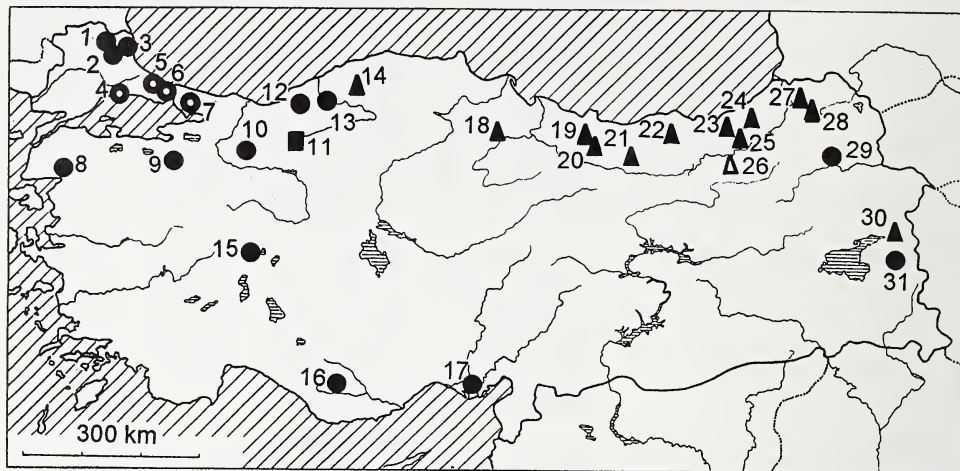


Fig. 3. Distribution of *Neomys* water shrews in Turkey. Circles = *Neomys anomalus*, triangles = *N. teres*, square = sympatric occurrence of the two. Filled symbols indicate specimens examined by BK.

List of localities includes exact location (including altitude if known), province of Turkey (villayet), and specimens examined (number, date, collection) (see text for collection abbreviations).

1 – Dupnisa Mağarasi, near Sarıdere (350 m), prov. Kırklareli (n = 2, 18 Oct. 1993, BKC); 2a – Demirköy, prov. Kırklareli; 2b – Velika Köprü, 12 km south-west of Demirköy (650 m), prov. Kırklareli (n = 8, 16–17 Oct. 1993, 22–23 June 1994, BKC and PFUK); 3 – Longoz (50 m), near Iğneada, prov. Kırklareli (n = 1, 3 July 1995, BKC); 4 – Paşa Alandere estuary (sea level), prov. Tekirdağ; 5 – Terkos Gölü (sea level), prov. İstanbul; 6 – Belgrad Orman, prov. İstanbul; 7 – Mahmutşevketpaşa, prov. İstanbul; 8–10 km south-east of Çirpilar, Kaz Mts., prov. Çanakkale (n = 1, 10 July 1995, PFUK); 9 – South-western slope of the Uludağ Mts., prov. Bursa (n = 1, 30 June 1994, PFUK); 10 – Hanyatak Köyü, Kapiorman Mts., prov. Sakarya (n = 1, 28 June 1994, BKC); 11 – Abant Gölü (950 m, 1050 m), prov. Bolu (*N. anomalus* n = 2, 26–27 June 1994, BKC and PFUK; *N. teres* n = 3, 26 June 1994, BKC); 12 – Çayir, prov. Zonguldak (n = 2, 21 October 1993, BKC); 13 – 8 km north-west of Yenice (c. 100 m), prov. Zonguldak (n = 4, 2–3 July 1995, BKC and PFUK); 14 – 5 km north of Safranbolu (500 m), prov. Zonguldak (n = 1, 4 July 1994, PFUK); 15 – Doganköy, Eber Gölü (995 m), prov. Afyon (n = 8, 6 July 1995, BKC and PFUK); 16 – Balkusan (1550 m), prov. Konya (n = 1, 12 Aug. 1993, PFUK); 17 – Yeşilobu (= Şahitlik, i.e. 15 km W of Adana) (24 m), prov. Adana (n = 1, 9 August 1969, ÇIU); 18 – 2 km east of Seyfe (c. 1100 m), prov. Amasya (n = 1, 19 Sept. 1995, PFUK); 19 – Ulubeş (800–1100 m), prov. Ordu (n = 3, 20 May–2 June 1961, NMW); 20 – Topçam (850 m), prov. Ordu (n = 1, 21 June 1995, BKC); 21 – Tamdere (1550 m), prov. Giresun (n = 4, 27 June 1995, BKC); 22 – Meryemana (1000–1300 m), prov. Trabzon (n = 1, 10 June 1961, NMW); 23 – Çamlık (1380 m), prov. Rize (n = 1, 24 June 1995, BKC); 24a – Çat (1150–1300 m), prov. Rize, 24b – Ülkü (500 m), prov. Rize; 25 – Ovitdağı Geçidi, prov. Rize, 2450 m (n = 1, 25 June 1995, BKC); 26 – 25 miles north of Erzurum (7000 ft), prov. Erzurum, (type of *N. teres*, obtained on 8 July 1905); 27 – Kutul (2200–2400 m), prov. Artvin (n = 5, 17–18 July 1962, NMW); 28 – Yalnızçam-Geçidi (2300–2500 m), prov. Kars (n = 1, 7 August 1962, NMW); 29 – Sarikamiş (1800 m), prov. Kars (n = 1, specimen from owl pellet, JOC); 30 – Bendimahi canyon, 5 km north-east of Muradiye (1900 m), prov. Van (n = minimally 3 owl pellet specimens, JOC); 31 – Erçek Dağı (2100 m), prov. Van (n = 1, 13 August 1935, ZFKM).

Corresponding references: KAHMANN (1962) 6, 11 (*N. anomalus*); MILLER (1908) 26; OBUCH (1994) 29, 30; OSBORN (1965) 7; SPITZENBERGER (1968) 2a, 4, 5, 19, 22, 24a, b, 27, 28, 31; SPITZENBERGER and STEINER (1962) 19, 22.

well with *N. anomalus*. Records of *N. anomalus* from eastern Turkey make LAY's (1967) statement of its occurrence on the Caspian coast of Iran (16 km ENE Goran) more likely also.

In Anatolia *N. anomalus* inhabits small brooks and rivers, occurring from the lowlands up to 2,100 m asl (on Erçek Dag; SPITZENBERGER 1968). The only central Anatolian record is from dense vegetation around Lake Eber (Eber Gölü). Specimens from southern Anatolia are from very different habitats: a garden at 45 m asl (near Adana) and dense vegetation along a stream in a karstic valley (Balkusan).

Neomys teres inhabits the Pontic Mts. as far west as Lake Abant, but the records became dense only to the east of Ordu. A single report from the Bendimahi Canyon, Van area, by OBUCH (1994) and considered as *N. fodiens*, is based on 2 left and 3 right mandibles and one complete rostrum, all from owl pellets. Dimensions (ML: 11.7, 11.85, 11.9, 12.0, and 12.35 mm; RL 10.25 mm) strongly suggest *N. teres*. This record, being the only one outside the Pontic Mts., also speaks in favour on the occurrence of *N. teres* in Iran, as suggested by HUTTERER (1993). All our *N. teres* specimens were taken along streams, mainly in mixed or coniferous forests, or from alpine meadows above the timber line. The altitudinal range encompassed was between 500 and 2,450 m asl.

The two water shrew species are mainly allopatric in Anatolia. *Neomys teres* was sympatric (but not syntopic) with *N. anomalus* in Lake Abant only (pt. 11), where the former occurred along a rapid mountain stream in a spruce (*Picea orientalis*) forest, approximately 100 m above the site where specimens of *N. anomalus* were obtained from a small river in mixed forest (950 m). Since *N. teres* is the only water shrew in the Caucasus (SOKOLOV and TEMBOTOV 1989), Lake Abant appears to be the only locality known in which it occurs in sympatry with another *Neomys*.

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Zusammenfassung

Erneute Betrachtung der Identität und Verbreitung türkischer Wasserspitzmäuse (Neomys spp.)

Das Studium von Merkmalen der äußeren Gestalt, des Schädels und des Penis bei über 50 Wasserspitzmäusen (*Neomys* spp.) aus der Türkei belegt die Existenz von zwei Arten. Die kleinere, identisch mit *N. anomalus* Cabrera, 1907, kommt sowohl in der europäischen als auch in der asiatischen Türkei vom Meeresniveau bis zu 2 100 m Höhe vor. Die größere Art, bisher *N. fodiens* (Pennant, 1771) zugeordnet, wird hier als *N. teres* Miller, 1908 bestimmt, mit *N. schelkovnikovi* Satunin, 1913 aus dem Kaukasus als jüngerem Synonym. *Neomys teres* kommt im Pontischen Gebirge östlich von Bolu und im Gebiet des Van-Sees vor. Ein einzelner Fall von Syntopie der beiden Arten wurde am Abant-See in NW-Anatolien konstatiert.

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