

Spalax denizliensis sp. nov. (Spalacidae, Rodentia) from an Early Pleistocene-aged locality in the Denizli Basin (southwestern Turkey)

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Abstract: It is thought that Spalacidae (Rodentia, Mammalia) originated in Anatolia. They are widespread among Neogene-aged faunas in Anatolia and they are used as zonal fossils because of their strong evolutionary dynamics. Only one fossil species (*S. odessanus*, Middle Pliocene) has been identified from the genus *Spalax*, which has more than 14 species presently. There are no fossil findings of this genus in Anatolia. Early Pleistocene-aged *Spalax denizliensis* sp. nov. from the Denizli Basin is the youngest fossil *Spalax* species and it will be helpful to understand the evolution of recent *Spalax* species.

Key words: *Spalax*, new species, Early Pleistocene, Denizli, Turkey

1. Introduction

Spalacidae taxa are burrowing muroid rodents that are adapted to subterranean life. The family Spalacidae has a present-day dispersal extending both in Anatolian Turkey and in surrounding countries, as well as northeastern Africa (Topachevski, 1969). In most of the classifications about the phylogeny of Spalacidae, it is accepted that it diverged from Muroidea together with Cricetidae, Rhizomyidae, and Muridae (Topachevski, 1969; Nevo and Piechaczyk, 1989; Butler et al., 1993).

The earliest representatives of spalacids from Turkey, specimens of *Debruijnina arpati* Ünay, 1996, are from the Keseköy locality in the early Miocene (MN3). In addition to the extant genus *Spalax* of the family Spalacidae identified by Gueldenstaedt (1770), samples of fossil genera *Pliospalax* (Kormos, 1932), *Heramys* (Klein Hofmeijer and de Bruijn, 1985), *Debruijnina* (Ünay, 1996), and *Sinospalax* (Şen and Sarıca 2011) have been identified in Anatolia. The fossil genera from Anatolia have been dated from oldest to youngest within these time intervals: *Debruijnina* (MN3–4, Lower Miocene), *Sinapospalax* (MN5–10, Middle and Upper Miocene), *Heramys* (MN9, Upper Miocene), and *Pliospalax* (MN12–16, Upper Miocene to Middle Pliocene). Şen and Sarıca (2011) stated that the spalacids probably originated in Anatolia according to the fossil records.

The genus *Spalax* first emerged in the Late Pliocene (Topachevski, 1969; de Bruijn, 1984). *S. odessanus* is the only fossil species of *Spalax* from the two Late Pliocene

(MN 15) localities in Ukraine and Greece (Topachevski, 1969; de Bruijn, 1984). The recently described *Spalax denizliensis* sp. nov. is the first fossil *Spalax* species found in Anatolia and is the subject of this study.

Spalax denizliensis sp. nov. has been found in the Early Pleistocene-aged Gökpınar locality of the Denizli Basin. Erten (2014) found this locality during his dissertation studies and *Dryomys tosyensis*, *Dryomys* sp., *Mus denizliensis*, and *Apodemus sylvaticus-flavicollis* species were identified and dated as MNQ18–19 in this locality (Erten et al., 2014, 2016) (Figure 1). Erten continued his studies in the Gökpınar locality for new findings after finishing his dissertation and identified *Extrarius orhuni* (Erten, 2017). The Gökpınar locality is one of the Early Pleistocene-aged small mammal localities that are the rarest in Anatolia.

2. Materials and methods

Almost 5 t of the fluviolacustrine sediment was washed by screen-wash technique using a stack of sieves of decreasing mesh size (4–0.7 mm) within the period of 2010–2016 to increase the number of the samples. The fossils were classified and studied with a stereomicroscope (Olympus SZX9) after they were separated from the concentrates.

Dental terminology is used in this paper (Figure 2). An Olympus SZX9 stereomicroscope was used for measuring the maximum length and width of each tooth and the results are given in millimeters (Table). The photographs

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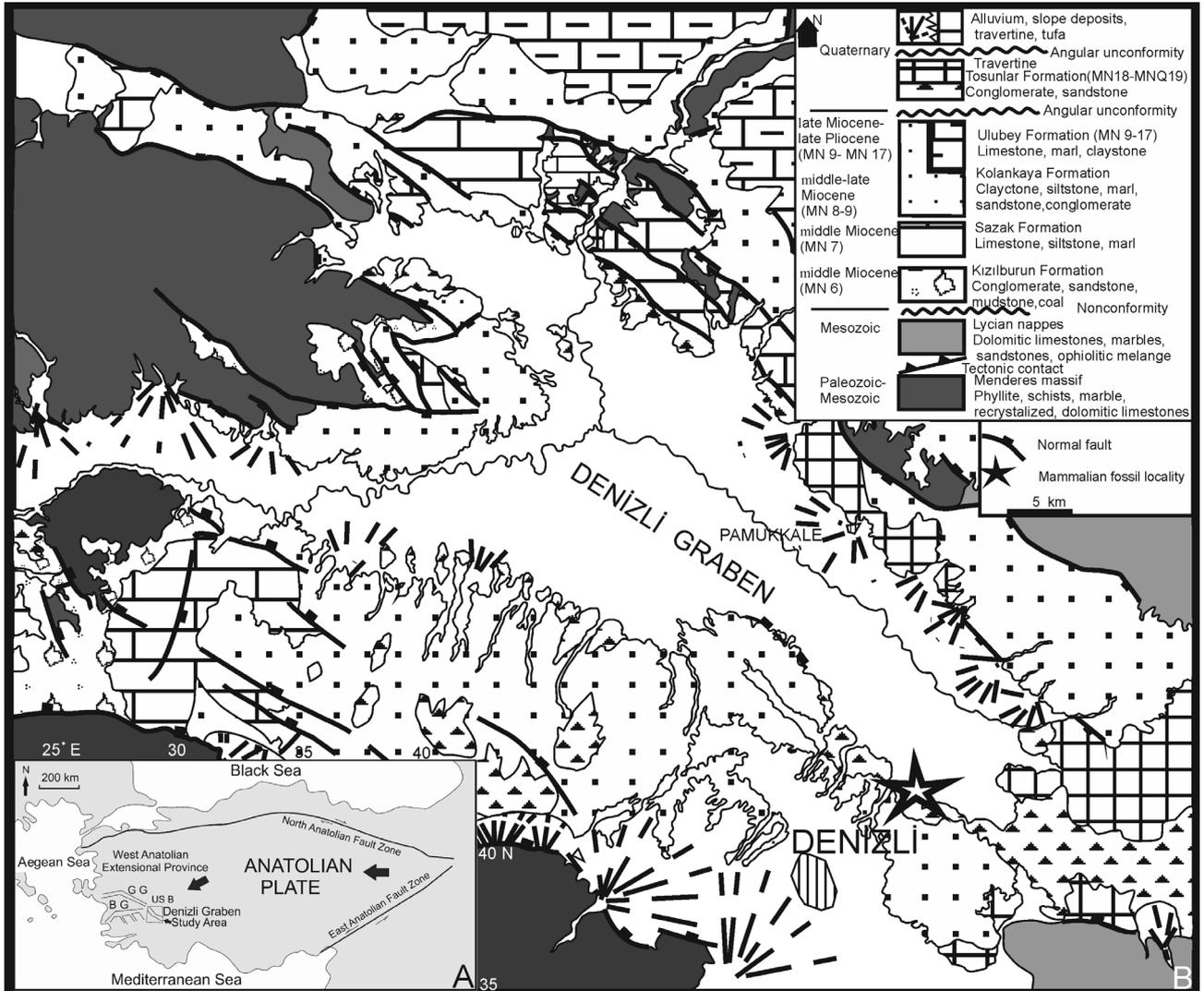


Figure 1. A) Gökpinar location of the Denizli Basin in western Turkey (modified from Bozkurt, 2003); B) geological map of the Denizli Basin modified from Erten (2017) with the position of Gökpinar locality.

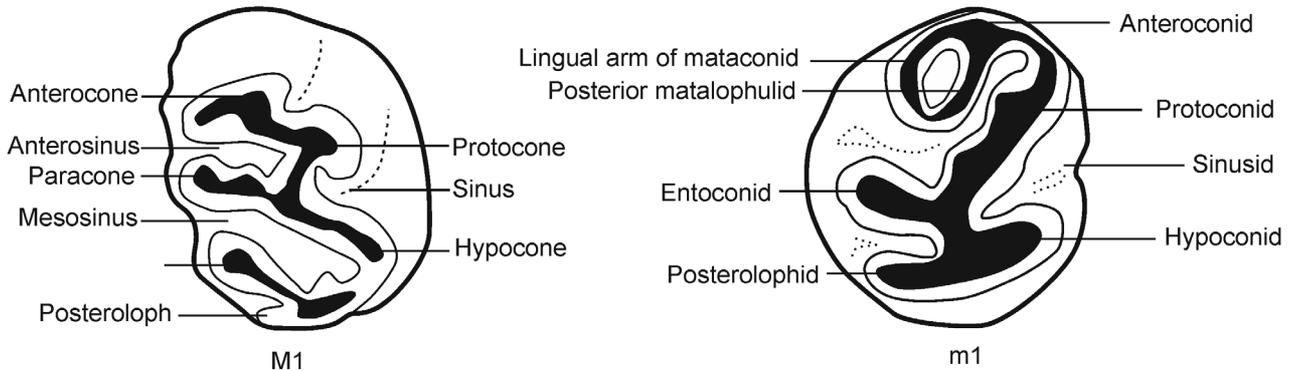


Figure 2. Dental terminology of *Spalax* (Spalacidae) upper (M1) and lower (m1) molars.

Table. Material and measurements of *Spalax denizliensis* sp. nov. from the Gökpinar locality (GOP).

Specimen number	Molar	Length	Width
GOP-7001	M1	29.6	20.3
GOP-7002	M2	2.18	1.80
GOP-7003	m1	25.7	18.8
GOP-7004	m1	26.0	19.2
GOP-7005	m2	21.2	20.3
GOP-7006	m2	20.8	19.8
GOP-7007	m3	18.7	18.0
GOP-7008	m3	18.2	18.0

were taken with a Zeiss Supra 40 VP field emission scanning electron microscope at the Electron Microscope Unit of Pamukkale University. The upper molars are abbreviated as M1, M2, and M3 whereas lower molars are m1, m2, and m3. The Gökpinar locality is abbreviated as GOP. Drawings that aim to compare *Spalax denizliensis* sp. nov. with other genera (Figure 4) were done by using the drawing attachment of the Olympus. They are kept as a part of the fossil collection of the Geological Engineering Department at Pamukkale University.

3. Results

A morphological description of *Spalax denizliensis* sp. nov. small mammal assemblages from the Gökpinar locality follows.

3.1. Systematic paleontology

Order RODENTIA Bowditch, 1821

Family SPALACIDAE Gray, 1821

Spalax Guldenstaedt, 1770

Spalax denizliensis sp. nov.

(Figure 3; Table)

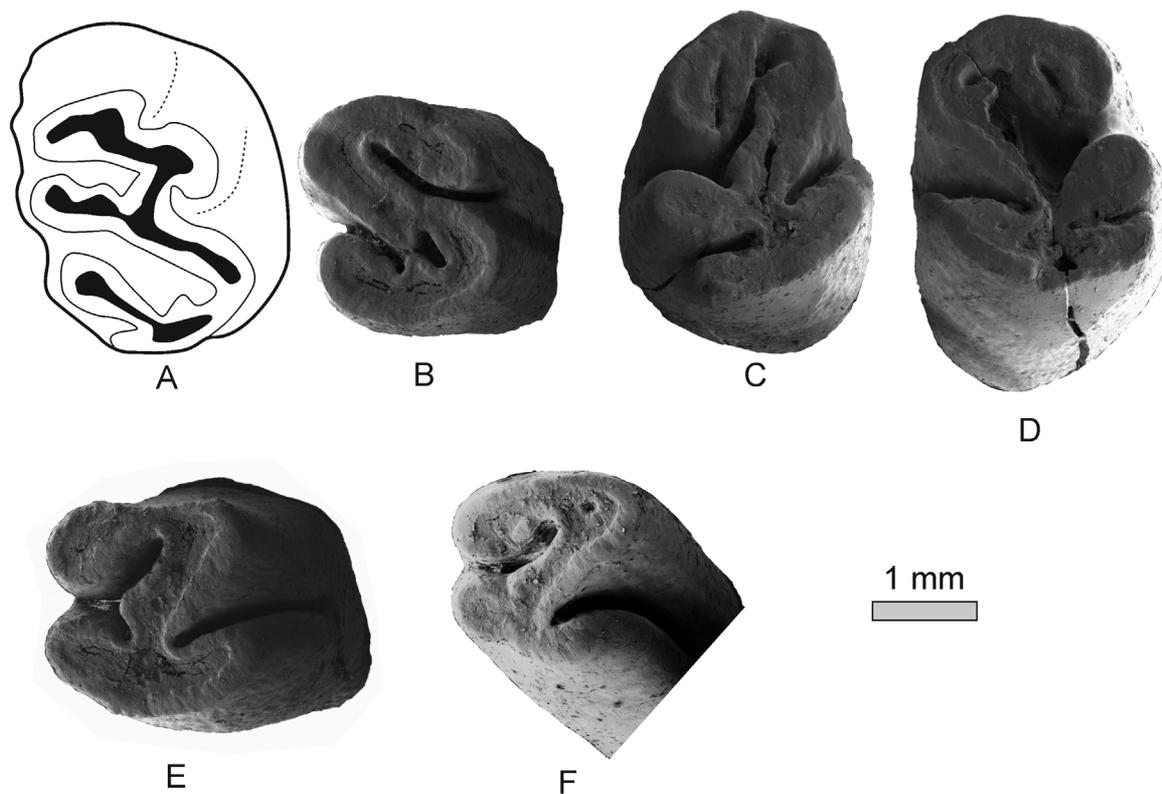


Figure 3. Occlusal views of *Spalax denizliensis* sp. nov. from Gökpinar (GOP): A) left M1 (GOP-7001); B) left M2 (GOP-7002); C) right m1 (GOP-7003); D) left m1 (GOP-7004); E) right m2 (GOP-7005); F) right m3 (GOP-7007).

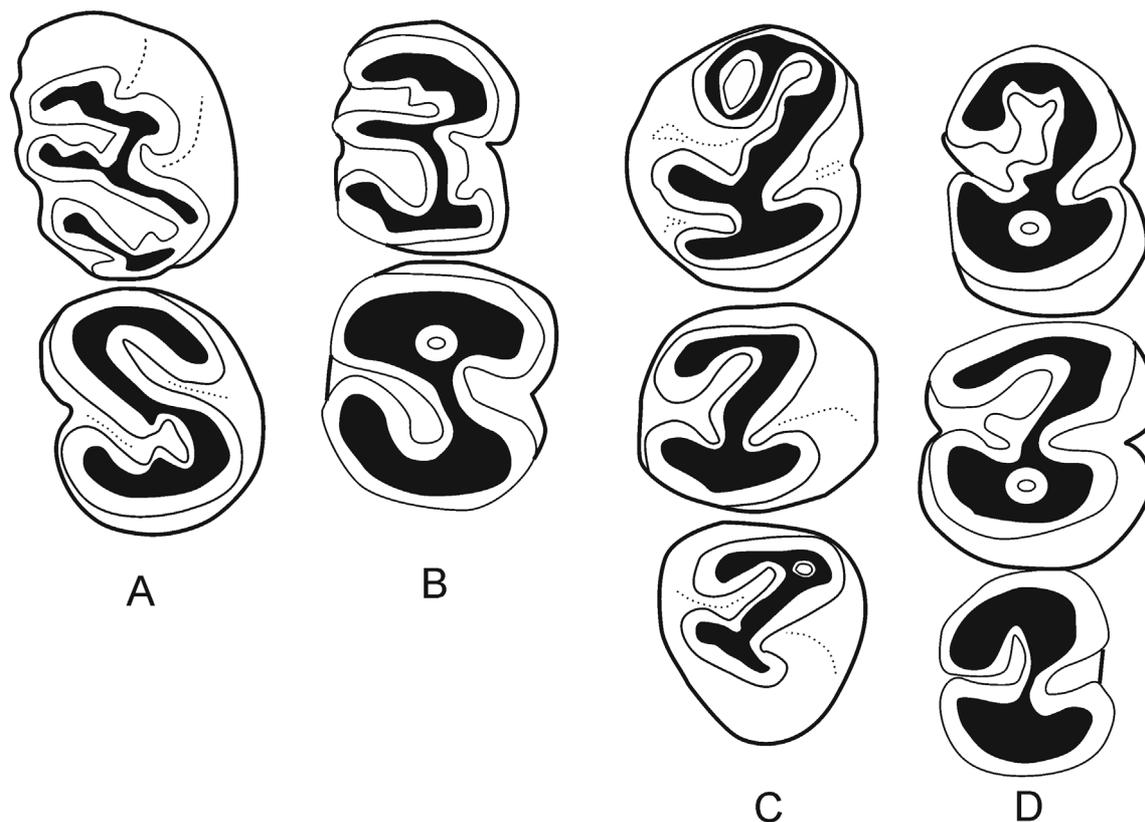


Figure 4. Comparison of the upper and lower molars of *Spalax denizliensis* sp. nov. with *Spalax odessanus*. The length of teeth has been made the same in order to facilitate morphological comparison and to draw attention to differences in shape. Illustrations used in the chart are from: A) *Spalax denizliensis* sp. nov. (M1, M2), B) *Spalax odessanus* (M1, M2) (Topachevski, 1969, fig. 2), C) *Spalax denizliensis* sp. nov. (m1–m3), *Spalax odessanus* (m1–m3) (Topachevski, 1969, fig. 2).

Type specimen. Right m1 (GOP-7003)

Referred specimens. Left M1 (GOP-7001), left M2 (GOP-7002), left m1 (GOP-7004), right m2 (GOP-7005), right m3 (GOP-7007).

Type locality. Gökpınar, Denizli Basin, Turkey. Tosunlar Formation, Quaternary.

Derivatio nominis. Derived from the name of the city of Denizli.

Type locality and horizon. Gökpınar Locality (68°72'64"N, 42°845'75"E; Figure 1), Denizli Basin, Turkey.

Occurrence. Early Pleistocene (MNQ19).

Diagnosis. In M1, deep labial valleys separate the anterocone, paracone, and metacone from each other. In M2, the protocone-anterocone-hypocone and posteroloph connection is strong and S-shaped. The occlusal outline of m1 is rather elongated. It has two lingual and one labial reentrant folds. The lingual arm of the metaconid and posterior metalophid are observed to be quite developed. The anterolophid is weak and very short

while the entoconid is developed and rounded. There appears a very strong connection between the hypoconid and posterolophid. In m2, the protoconid and metaconid have a strong arc-shaped connection. The hypoconid and posterolophid also have a strong connection, which forms the posterior part of the tooth.

3.2. Description of the material

M1. We have an M1 sample that is slightly worn (GOP-7001) and is longer than wide. Deep labial valleys of this sample separate the anterocone, paracone, and metacone from each other. The valley between the metacone and posteroloph is not as deep as the other two. There is a strong connection between the anterocone and protocone and it is parallel to the connection observed between the paracone and hypocone, which lengthens starting from the labial side to the lingual side. It has a quite developed anterior loph. The posterior arm of the hypocone is quite short. The sinus is directed forwards and penetrates the occlusal surface. The roots are not preserved.

M2. We have a moderately worn M2 sample (GOP-7002). It has a rather rounded outline and is longer than wide. Only the protocone-anterocone-hypocone and posteroloph are observed in the tooth, which has a quite simple structure. The protocone-anterocone-hypocone and posteroloph connection is strong and S-shaped. The posterior arm of the hypocone is very similar to that of the M1 sample and is observed to be quite short. The roots are not preserved.

m1. We have two samples that are slightly worn (GOP-7003–7004). Their occlusal outline is rather elongated. In both samples, the lingual arm of the metaconid and posterior metalophid are observed to be quite developed and elongated towards the posterior part of the teeth. They are connected to each other there. The anterolophid is weak and very short in both samples. The entoconid is developed and has a rounded shape. There is a very strong connection between the hypoconid and posterolophid. In our samples two lingual folds and one labial reentrant fold are observed. Whereas the anterosinusid is transverse and deeply penetrates the occlusal surface, the posterosinusid is narrower compared to the anterosinusid. The roots are not preserved.

m2. We have two samples that are quite worn (GOP-7005–7006). Their occlusal outline is rather rounded. Our samples lack the anterolophid. The protoconid and metaconid have a strong arc-shaped connection. The hypoconid and posterolophid have a reverse mushroom-shaped strong connection, which constitutes the posterior part of the tooth.

m3. We have two slightly worn samples (GOP-7007–7008), which have a subrounded outline. Our samples lack the anterolophid. The protoconid-metaconid and hypoconid-posterolophid have strong connections in our samples, which have a quite simple occlusal surface.

3.3. Comparison

The genera of the family Spalacidae are the extant genus *Spalax* (Middle Pliocene and Recent) Gueldenstaedt (1770) and the fossil genera *Pliospalax* (Upper Miocene–Upper Pliocene) Kormos (1932), *Heramys* (MN9, Upper Miocene) Klein Hofmeijer and de Bruijn (1985), *Debruijnna* (Lower Miocene) Ünay (1996), and *Sinospalax* (Middle and Upper Miocene) Sen and Sarıca (2011). The family Spalacidae usually diverges into its genera according to the dental pattern of m1 and the dimensional features of molars (Ünay, 1999; Sen and Sarıca, 2011). The m1 of these genera, which start to appear in the Lower Miocene, shows a simpler dental pattern in younger genera samples.

The occlusal surface of m1 in the genera *Spalax* and *Pliospalax* has a simpler structure compared to other genera and they are similar to our samples. The genera

of *Spalax* and *Pliospalax* are separated from each other according to the number of reentrant folds in the labial and lingual parts of m1 molars and while two reentrant folds are present in both sides of *Pliospalax*, *Spalax* has two lingual folds and one labial reentrant fold (Ünay, 1999). Since our m1 samples have two lingual folds and one labial reentrant fold (Figures 3 and 4), they must be species of the genus *Spalax*.

The only fossil species identified as *Spalax* is *S. odessanus*, known from the late Pliocene (MN15) (Topachevski, 1969; de Bruijn, 1984). When our samples are compared with *S. odessanus*, the main differences are as follows: the posterior metalophid, which is quite developed in both of our m1 samples, is lacking in *S. odessanus*; while the entoconid lengthens towards the anterior part of the tooth in our m1 sample, it lengthens towards the posterior part in *S. odessanus*; whereas our samples lack a connection between the entoconid and posterolophid, this connection is strong in *S. odessanus*; and the mesolophid, which is observed in the unworn m1 and m2 of *S. odessanus* although it is short, is not present in our samples (Figure 4). Because of all these differences, our samples are different from *S. odessanus* and are thus described as a new species.

4. Discussion

The family Spalacidae probably evolved from the family Cricetidae in the Early Miocene or before and has been in Anatolia since the Oligocene (Sen and Sarıca, 2011). Fossils of this genus have been described in many localities of Neogene-aged faunas in Turkey.

The family Spalacidae has been recognized as a monophyletic taxon (Ünay, 1996, 1999; Sarıca and Şen, 2003; Sen and Sarıca, 2011). Four fossil genera have been included in the family Spalacidae so far: *Debruijnna*, *Heramys*, *Sinapospalax*, and *Pliospalax*, as well as the extant genus *Spalax*, which was represented with only one fossil species (*S. odessanus*, Middle Pliocene) before our samples.

The genus *Spalax* (including *Nannospalax*) emerged in the middle Pliocene (Topachevski, 1969; de Bruijn, 1984, Sen and Sarıca, 2011). It does not have any findings except the fossils of one species (*S. odessanus*) from the Middle Pliocene in Ukraine and Greece and there are no records of any fossils of this genus in Anatolia. The newly described early Pleistocene-aged *Spalax denizliensis* sp. nov. is the first fossil *Spalax* in Anatolia as well as being the youngest fossil species of its genus and it will contribute to the understanding of the evolutionary dynamics of the recent *Spalax* species (Figure 3).

Nomenclatural acts

This work and the nomenclatural acts it contains have been registered in ZooBank. The ZooBank Life Science Identifier (LSID) for this publication is: <http://zoobank.org/urn:lsid:zoobank.org:pub:6EBADD32-CECB-44CC-BF7A-EDBC3F758724>

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