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A Review of Tailed Amphibian Remains from Late Cenozoic Sediments of the East European Plain

Viatcheslav Yu. Ratnikov

Submitted October 15, 2008.

This paper presents a review of findings of tailed amphibians from the Late Cenozoic of the East European Plain, including materials from 13 localities. The descriptions of remains of *Mioproteus* sp., *Salamandrella* sp., *Triturus cristatus aut dobrogicus*, *Triturus cf. karelinii*, and *Lissotriton vulgaris* are given. Geographic and stratigraphic distributions of findings are listed. Determination of two vertebrae from Korotoyak and Vladimirovka as *Triturus cf. alpestris* is recognized invalid.

Keywords: tailed amphibians, Late Cenozoic, East European Plain.

INTRODUCTION

The remains of tailed amphibians (Urodela) in the Late Cenozoic continental sediments of the East European plain are rare. In addition to two localities, from which Averianov (2001) described remains of proteid salamanders, only 13 localities are known (Fig. 1), and the remains are, as a rule, represented by single specimens. Only five localities of 13 have produced more than one specimen (Table 1). All these materials are kept in the Geological Museum of the Voronezh State University (VSU). To my thinking, rarity of findings could be explained by small size of bones and, accordingly, the fragility of skeletal elements of tailed amphibians that inhabited East Europe at that time. The overwhelming majority of findings are vertebrae. Other elements of the skeleton are rarely found and represented by the most massive bones: humerus, femur and a few others.

All remains, except for the collection from Mastyuzhenka, have been studied by the author, and main results of these researches have been published (Ratnikov, 1996, 1997a, 1997b, 2002a, 2002b, 2005; Ratnikov and Krokhmal, 2003, 2005). However, in recently newt systematics have been changed. *Salamandrella keyserlingii* Dybowsky, 1870, from south-eastern part of the Russian Far East was distinguished (Berman et al., 2005) as a distinct cryptic species, *Salamandrella schrenckii* (Strauch, 1870). Species formerly included in the genus *Triturus* are distributed now between four genera (Carranza and Amat, 2005; Frost et al., 2006; Litvinchuk et al., 2005): *Lissotriton* Bell, 1839, *Mesotriton* Bolkay, 1927, *Ommatotriton* Gray, 1850, and *Triturus* Rafinesque,

![Fig. 1. Main Late Cenozoic occurrences of tailed amphibians in Eastern Europe: ▲. Pliocene; ●. Lower Neopleistocene; ■. Middle Neopleistocene.](image-url)

TABLE 1. List of Localities and Numbers of Specimens Studied (N)

<table>
<thead>
<tr>
<th>Locality</th>
<th>N</th>
<th>Locality</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korotoyak</td>
<td>1</td>
<td>Posevkinob</td>
<td>1</td>
</tr>
<tr>
<td>Kupino</td>
<td>1</td>
<td>Sergeevka-2</td>
<td>1</td>
</tr>
<tr>
<td>Kuznetsovkac</td>
<td>4</td>
<td>Veselovka</td>
<td>3</td>
</tr>
<tr>
<td>Mastyuzhenka</td>
<td>117</td>
<td>Vladimirovka</td>
<td>3</td>
</tr>
<tr>
<td>Musaid</td>
<td>1</td>
<td>Vol’naya Vershina-3</td>
<td>2</td>
</tr>
<tr>
<td>Nagormoye-l</td>
<td>1</td>
<td>Zmeevka-1</td>
<td>1</td>
</tr>
<tr>
<td>Ozyornoye-l</td>
<td>1</td>
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</tbody>
</table>

1 Voronezh State University, Universitetskaya pl. 1, 394006 Voronezh, Russia; E-mail: vratnik@yandex.ru
1815. Four subspecies of the former species *Triturus cristatus* have been elevated to the species level (Ananjeva et al., 1998; Kuzmin, 1999): *Triturus carnifex* (Laurenti, 1768), *Triturus cristatus* (Laurenti, 1768), *Triturus dobrogicus* (Kiritzescu, 1903), and *Triturus karelinii* (Strauch, 1870). Species status has also been given to the former subspecies of *Triturus vitatus ophryticus* (Litvinchuk et al., 2005) — *Ommatotriton ophryticus* (Berthold, 1846). Thus, criteria of generic and specific identification of bones have been changed. For this reason, I have decided to revise these materials. It became possible because recent years my comparative osteological collection has been considerably expanded and studied according to modern systematics (Ratnikov and Litvinchuk, 2007).

**REVIEW OF THE PLIOCENE AND QUATERNARY LOCALITIES OF TAILED AMPHIBIANS**

1. **Korotaya locality.** There are several localities of different age near Korotaya village in Voronezh oblast’, Russia. This site with remains of Pliocene caudates is situated on the high bank of Don River near the road between Korotaya and Pokrovka villages.

**Age.** Middle Pliocene, MN 16 zone of Main, Uralsian faunistic assemblage.

**Material and references.** VSU No. 530/524, one vertebra of *Triturus cf. alpestris* (Laur., 1768) (Ratnikov, 1996, 2002a).

**Comments.** At that time I had only one comparative specimen of alpine newt, specimens of other species were uncommon and satisfactory descriptions of newt vertebrae were absent. For this reason, it was very difficult to find criteria for specific identification. Besides that, the available vertebra is very badly damaged. Thus, I have regarded as attributes of alpine newt well developed neurapophysis and inclined flat surface of the condylias which was not observed on specimens of other species in my comparative collection.

After recent study of newt vertebrae on the basis of new comparative material and systematics (Ratnikov and Litvinchuk, 2007), taxonomic attribution of this vertebra is changed to *Triturus cf. karelinii* (see below).

2. **Kupino locality.** This locality is situated in a sand quarry in the right bank of Strizhkov Log ravine near the road to Nezhegol village, Shebekino rayon, Belgorod oblast’, Russia.

**Age.** Lower Neopleistocene, Muchkap horizon, Taraspol faunistic assemblage.

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**Material and references.** VSU No. 504/17, one vertebra of *Salamandrella cf. keyserlingii* (Ratnikov, 1989, 2002a, 2002b).

**Comments.** The new determination for this specimen is *Salamandrella* sp.

3. **Kuznetsovska locality.** This locality is situated in the left board of Podgorny Buerak ravine near Kuznetsinka village of Uvarovo rayon, Tambov oblast’, Russia.

**Age.** Lower Neopleistocene, Muchkap horizon, Taraspol faunistic assemblage.

**Material and references.** VSU Nos. 503/377 and 503/378, two humeri of *Salamandrella cf. keyserlingii*; VSU Nos. 503/376 and 503/706, vertebrae of *Triturus vulgaris* (L., 1758) and *Triturus sp.*, respectively (Ratnikov, 1997a, 2002a).

**Comments.** According to new systematics, these bones are determined as *Salamandrella sp.*, *Lissotriton vulgaris*, and *Salamandridae indet.*, respectively.

4. **Mastyuzhenka locality.** This locality is situated in the left board of Mastyuzhenka ravine, 5 km W from Srednii Ikorets village of Liski rayon, Voronezh oblast’, Russia.

**Age.** Formerly, the age of this fauna was considered to be Middle Neopleistocene, Lichvin horizon (Ratnikov, 2002). However, study of small mammals from this locality collected in 2007 suggests older (Lower Neopleistocene) age (A. K. Agadzhanyan, personal communication). It seems that this fauna corresponds to a new warm interval after Muchkap (Iosifova et al., 2006), but this question is in the stage of discussion. Herein, I designate the age of this fauna as the Lower Neopleistocene, Muchkap horizon.

**Material and references.** VSU Nos. 537/1-104, 104 vertebrae; VSU Nos. 537/105-108, four humeri; VSU Nos. 537/109-112, four femori; and VSU Nos. 537/113-114, two ilia of *Salamandrella* sp.

5. **Musaid locality.** This locality is situated on the right bank of Big Salcha River, in the ravine in front of Musaid village, Vulkaneshty Region, Moldova.

**Age.** Lower Pliocene, MN 16 zone of Main, Moldavian faunistic assemblage.

**Material and references.** VSU No. 620/2, one vertebra of *Mioproteus* sp. (Ratnikov, 2002a).

6. **Nagornoye-1 locality.** This locality is situated on the east shore of Kagul Lake near Nagornoye village in Reni District, Odessa Region, Ukraine.

**Age.** Lower Neopleistocene, Muchkap horizon, Taraspol faunistic assemblage.

**Material and references.** VSU No. 629-1/62, one vertebra of *Triturus cristatus* (Ratnikov and Krokhal, 2005).
Comments. According to new systematics, this vertebra is determined as *Triturus cristatus aut dobrogicus*.

7. Ozyornoye-1 locality. This locality is situated on the east bank of Yalpug Lake near Ozernoe village, Odessa Region, Ukraine.

**Age.** Middle Neopleistocene. More detailed age of this locality is disputable: Singil or Hazar faunistic assemblage.

**Material and references.** VSU No. 610 – 1/61, one vertebra of *Triturus cf. cristatus* (Ratnikov and Krokhmal, 2003).

Comments. According to new systematics, this vertebra is determined as *Triturus cristatus aut dobrogicus*.

8. Posevkino locality. This locality is situated on the bank of Vorona River near Posevkino village of Uvarovo rayon, Tambov oblast’, Russia.

**Age.** Lower Neopleistocene, Muchkap horizon, Tierraspol faunistic complex.

**Material and references.** VSU No. 515/47, one vertebra of *Salamandrella keyserlingii* (Ratnikov, 2002a, 2002b).

9. Sergeevka-2 locality. This locality is situated within 13.0 – 16.0 m depth interval of the well No. 218 near Sergeevka village, Roslavl’ rayon, Smolensk oblast’, Russia.

**Age.** Lower Neopleistocene, Muchkap horizon, Tierraspol faunistic complex.

**Material and references.** VSU No. 599/1, one vertebra of *Salamandrella keyserlingii* (Ratnikov, 2002a, 2002b).

Comments. The new determination for this vertebra is *Salamandrella* sp.

10. Veselovka locality. This locality is situated near Veselovka village on the Tamant Peninsula, Krasnodar kray, Russia.

**Age.** Middle Pliocene, MN 16 zone of Main, Uryan faunistic assemblage.

**Material and references.** VSU No. 619/15-17, three vertebrae of *Mioproteus* sp. (Ratnikov, 2002a).

11. Vladimirovka locality. This locality is situated on the left bank of Don River, 1.4 km NE from the south-eastern outskirts of Vladimirovka village, Pavlovsk rayon, Voronezh oblast’, Russia.

**Age.** Middle Neopleistocene, Lichvin horizon, Sinig faunistic assemblage.

**Material and references.** VSU No. 589/217, one vertebra of *Triturus cf. cristatus*; VSU No. 589/218, one vertebra of *Triturus vulgaris*; and VSU No. 589/219, one vertebra of *Triturus cf. alpestris* (Ratnikov, 1997b, 2002a, 2005).

Comments. Ventral part and haemal arch of caudal vertebra identified as *Triturus cf. alpestris* (Fig. 2) are destroyed. The identification was based on the same criteria, which were used for identification of the Korotoyak specimen. After our recent study of newt vertebrae (Ratnikov and Litvinchuk, 2007), a new determination of this vertebra can be given. It differs from vertebrae of *Salamandra salamandra* (L., 1758), *Lissotriton vulgaris*, *L. montandoni* (Boulenger, 1880), *Mesotriton alpestris* (Laur., 1768), and *Ommatotriton ophryticus* by undeveloped zygapophyseal crests. Such crests are not developed in *Mertensiella caucasica* (Waga, 1876) and representatives of the genus *Triturus*, but neurapophyses in the Caucasian salamander are not so high and begin much further posteriorly. I did not manage to find diagnostic differences in caudal vertebrae of different *Triturus* species and the fossil vertebra, and therefore I determine this specimen as *Triturus* sp.

The other two vertebrae are determined as *Triturus cristatus aut dobrogicus* and *Lissotriton vulgaris*.

12. Vol’naya Vershina-3 locality. This locality is situated in Volny ravine, 4 km SE from Vol’naya Vershina village of Muchkap rayon, Tambov oblast’, Russia.

**Age.** Lower Neopleistocene, Muchkap horizon, Tierraspol faunistic assemblage.

**Material and references.** VSU No. 501-3/91, 92, two vertebrae of *Salamandrella keyserlingii* (Ratnikov, 2002c).

Comments. The new determination for these specimens is *Salamandrella* sp.

13. Zmeevka-1 locality. This locality is situated in a sand quarry on the left bank of Gryaznaya Potudan’ River, NE from Zmeevka village, Staryy Oskol rayon, Belgorod oblast’, Russia.
Age. Lower Neopleistocene, Il’inka horizon, Tiraspol faunistic assemblage.

Material and references. VSU No. 523/11, one vertebra of *Triturus cf. cristatus* (Ratnikov, 2002a).

Comments. According to new systematics, this vertebra is determined as *Triturus cristatus aut dobrogicus*.

SYSTEMATIC PALEONTOLOGY

Family Proteidae

Genus *Mioproteus* Estes et Darevsky, 1977

*Mioproteus* sp.

Remains of an extinct form attributed to the genus *Mioproteus* are found in two localities (Veselovka and Musaid). The material is represented exclusively by fragments of vertebrae with damaged neural arches. The length of the best preserved fragment is about 6 mm. Amphicoelous centra (Fig. 3) have an “hour-glass” shape from below due to deep lateral excavations in the medial portion and show some features of the genus *Mioproteus*, pointed by Estes and Darevsky (1977). These are presence of the posterior basapophyses and flattened ventral surface of the centrum, co-extensive with the basapophyses. Large subcentral foramina are observed on their ventral surface, and the remains of horizontal and inclined laminae are visible laterally at the base of the neural arch. A well developed ventro-medial keel is present in the specimen from Veselovka. The described specimens are morphologically similar to the corresponding vertebral parts of *Mioproteus caucasicus* (Estes and Darevsky, 1977), but they can not be determined to the species level due to destroyed neural arches.

Family Hynobiidae

Genus *Salamandrella* Dybowski, 1870

*Salamandrella* sp.

Vertebrae of representatives of the family Hynobiidae are found in five localities: Vol’naya Vershina-3, Kupino, Mastyuzhenka, Posevkino, and Sergeevka-2. Previously, almost all specimens were determined as *Salamandrella keyserlingii* or *Salamandrella cf. keyserlingii*. Their morphology corresponds to modern specimens of this species (Ratnikov and Litvinchuk, 2007) and is characterized by the following features: amphicoelous centra, low and sufficiently flat laminae of neural arch, low or absent neurapophysis, lacking zygapophyseal and ventral crests (Fig. 4a–e). However, allocation of the cryptic species *Salamandrella schrenckii* (Berman et al., 2005), which has the same vertebral features, does not allow specific determination of these specimens. Therefore, here I redetermine them as *Salamandrella* sp. Vertebræ from Posevkino were determined as Hynobiidae indet. (Ratnikov, 2002), because of a damaged neural arch, although, most probably, they belong to *Salamandrella*, as no other hynobiid is known in this area.

The humeral bones from Kuznetsovka and Mastyuzhenka have a low and ridge-like crista dorsalis (Fig. 4f–g), while in Salamandridae this crista is much higher and spine-like. The probability that these bones belong to *Ranodon* Kessler, 1866 or *Onychodactylus* Tschudi, 1838 is very small, and from this reason I determine them as *Salamandrella*. Four femoral bones and two ilia from Mastyuzhenka were also assigned to *Salamandrella*, because of their morphological similarity with the corresponding bones of this genus. Besides that,
all remaining caudate specimens (more than 100 isolated bones) from this locality are assigned to *Salamandrella*.

**Family Salamandridae**

**Genus Triturus**

*Triturus cristatus aut dobrogicus*

Four opisthocoelous vertebrae come from four localities: Zmeevka-1, Vladimirovka, Ozyornoye-1, and Nagornoye-1. These specimens demonstrate features of the genus *Triturus* (Ratnikov and Litvinchuk, 2007) and formerly were determined as *Triturus cristatus*. According to the modern systematics, they are redetermined as *Triturus cristatus aut dobrogicus*, because they can belong to one of two species, morphological distinctions between which are unknown. These specimens differ from vertebrae of the third species of the genus, *Triturus karelinii*, by a low neurapophysis (Fig. 5).

**Triturus cf. karelinii**

One poorly preserved vertebra lacking posterior part comes from Korotoyak locality (Fig. 6). In this vertebra, the condylus is bigger than in modern species *Lissotriton montandoni*, *L. vulgaris*, and *Mesotriton alpestris*. Besides that, the anterior margin of its neural arch being at the level of the middle of prezygapophyseal articular facets, whereas in the three mentioned species the anterior margin of the neural arch is closer to the anterior margin of prezygapophyseal articular facets. Presence of the neurapophysis excludes attribution of the Korotoyak vertebra to *Triturus cristatus* or *T. dobrogicus*. The Korotoyak vertebra does not belong to *Ommatotriton ophryticus*, because the anterior margin of its neurapophysis rises gradually, whereas it rises abruptly in the latter species. Thus, the Korotoyak vertebra is most similar to *Triturus karelinii*. However, breakage of many diagnostic elements allows identification only to *Triturus cf. karelinii*.
Genus *Lissotriton*

*Lissotriton vulgaris*

Two very small vertebrae were found in two localities (Kuznetsovka and Vladimirovka). Their morphology corresponds to the vertebral morphology of *Lissotriton vulgaris* (Ratnikov and Litvinchuk, 2007).

**STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF LATE CENOZOIC TAILED AMPHIBIANS OF EASTERN EUROPE**

Occurrences of the genus *Mioproteus* remains studied are shown in Fig. 7a. Both localities are of the Pliocene age. In general, the geographical distribution of this genus is rather extensive: it is known from a number of Neogene localities in Moldova, Ukraine, Germany, Poland, Russia and Kazakhstan (Averianov, 2001; Bakradze and Chkhikvadze, 1988; Estes, 1981; Estes and Dzavanchyk, 1977; Malakhov, 2003; Mlynarski et al., 1984). However, no findings younger than the Eopleistocene are known.

Occurrences of *Salamandrella* sp. in the Eastern Europe are shown in Fig. 7b. At present, this species occupies an extensive area with its western border situated slightly to the East from the region shown on the map (Engelmann et al., 1985; Kuzmin, 1999). All our fossil

Fig. 7. Late Cenozoic occurrences of tailed amphibians in Eastern Europe. **a**, *Mioproteus*. **b**, *Salamandrella* sp.: vertical hatching, modern area of *Salamandrella keyserlingii* (after Kuzmin, 1999). **c**, *Triturus*: horizontal hatching, modern area of *Triturus cristatus*; vertical hatching, modern area of *Triturus karelinii*; specks, modern area of *Triturus dobrogicus* (after Kuzmin, 1999). **d**, *Lissotriton vulgaris*: horizontal hatching, modern area of *Lissotriton vulgaris* (after Kuzmin, 1999). ▲, Pliocene; ●, Lower Neopleistocene; ■, Middle Neopleistocene.
findings occur from the Muchkapian (Lower Neopleistocene) sediments. It is obvious, that at that time, the range of the species strongly differed from its present range. Other findings of representatives of the family Hynobiidae are known from the Neogene of Kazakhstan (Ranodon cf. sibiricus Kessler, 1866) (Averianov and Tjutkova, 1995) and from the Neogene and Lower Pleistocene of Central Europe, where two new species of a new genus are known (Venczel, 1999).

Occurrences of the genus Triturus are shown in Fig. 7c. The Early-Middle Neopleistocene vertebrae are determined as Triturus cristatus aut dobrogicus because of difficulty to give a more exact determination. However, the Lower Neopleistocene Nagornoye-1 and Middle Neopleistocene Ozornoye-1 localities are situated within the modern range of Triturus dobrogicus, whereas the Lower Neopleistocene Zmeevka-1 and the Middle Neopleistocene Vladimirovka locality are situated within the modern range of Triturus cristatus. At the Pliocene Korotoyak locality, a vertebra comparable to Triturus karelinii is far outside the modern range of this species (Kuzmin, 1999).

Occurrences of Lissotriton vulgaris are shown in Fig. 7d. Both localities are situated within the modern range of this species.

It is necessary to note that our findings of newts are not the oldest known. Remains of “Triturus cristatus” and “Triturus vulgaris” are known from the Pliocene deposits of Central Europe (Estes, 1981; Hodrova, 1984, 1985), whereas findings comparable to other modern European species of newts are known from the Miocene deposits (Estes, 1981).

As was demonstrated above, information about the geographic and stratigraphic distribution of fossil tailed amphibians until now has been highly fragmentary. However, it is also obvious that the ranges of some forms changed seriously during the Late Cenozoic. First of all, the range of Salamandrella in the Early Neopleistocene covered at least central part of the East European Plain. Unfortunately, the absence of fossils from the Asian part of Salamandrella present range prevents judgment about its last form and size.

Data on the stratigraphic distribution of tailed amphibians are presented in Table 2.

The remains of tailed amphibians are still not found in the Upper Neopleistocene and Holocene sediments from the East European Plain, and all known findings occur only in warm stratigraphic intervals.

Acknowledgments. The author thanks Drs. Chris Gleed-Owen (CGO Ecology Limited, Bournemouth, Dorset, United Kingdom) and Igor Danilov (Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia) for checking the English in the manuscript and Igor Danilov and Pavel Sku-

| TABLE 2. Stratigraphic Distribution of Localities of Tailed Amphibians |
|---|---|---|---|---|---|
| Divisions of West Europe | Divisions of East Europe | Horizons, superhorizons and zones of Mein | Mioproteus sp. | Salamandrella sp. | Triturus cf. karelinii | Triturus cristatus aut dobrogicus | Lissotriton vulgaris |
| Holocene | | | | | | | |
| Late | Late | Valdai | Mikulino | | | | |
| Middle | Middle Russia | Lichvin | Vladimirovka, Ozornoye-1 | | | | |
| Early | Oka | | Vladimirovka | Nagornoye-1 | | | |
| | Muchkap | Vol’naya Vershina-3, Kuznetsovka, Kupino, Mastuyzenka, Posevino, Sergeevka-2 | Kuznetsovka | | | |
| Pleistocene | | | | | | | |
| Middle | Late | Don | | | | | |
| Eopleistocene | Early | Zmeevka-1 | | | | | |
| Early | Late | Pokrov | | | | | |
| | Early | Petropavlovsk | | | | | |
| Pliocene | MN 17 | Veselovka | Korotoyak | | | | |
| | MN 16 | | | | | | |
| | MN 15 | Musaid | | | | | |
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