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Helminth Fauna of the Caucasian Toad, *Bufo verrucosissimus* (Pallas, 1814) (Amphibia: Bufonidae), Collected from Türkiye

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ABSTRACT: This study presents a helminthological investigation of 35 individuals (13♀♀ and 22♂♂) of the Caucasian toad, *Bufo verrucosissimus* (Pallas, 1814), collected from Artvin and Mersin provinces in Türkiye during 2024–2025. Six helminth species were identified: 1 species of Cestoda (*Nematotaenia dispar* (Goeze, 1782) Lühe, 1899), 4 species of Nematoda (*Rhabdias bufonis* (Schrank, 1788); *Aplectana acuminata* (Schrank, 1788) Railliet and Henry, 1916; *Oxysomatium brevicaudatum* (Zeder, 1800); *Oswaldocruzia filiformis* (Goeze, 1782)), and 1 species of Acanthocephala (*Pseudoacanthocephalus caucasicus* (Petrochenko, 1953)). This is the first helminthological study of *B. verrucosissimus* in Türkiye, and *N. dispar* and *O. brevicaudatum* represent new records for the host.

KEY WORDS: Caucasian toad, *Bufo verrucosissimus*, Cestoda, Nematoda, Acanthocephala, Türkiye.

Bufo verrucosissimus (Pallas, 1814) occurs in Artvin Province in northeastern Türkiye; the Mediterranean coastal provinces of Osmaniye, Hatay, and Mersin; and Antalya Province in the south (Özdemir et al., 2020). According to Frost (2025), there are 14 anuran species in Türkiye: *Bombina bombina* (Linnaeus, 1761); *B. variegata* (Linnaeus, 1758); *B. bufo* (Linnaeus, 1758); *B. verrucosissimus* (Pallas, 1814); *Bufotes viridis* (Laurenti, 1768); *Hyla orientalis* Bedriaga, 1890; *H. savignyi* Audouin, 1827; *Pelobates balcanicus* Karaman, 1928; *P. syriacus* Bosettger, 1889; *P. caucasicus* Boulenger, 1896; *Pelophylax ridibundus* (Pallas, 1771); *Rana dalmatina* Fitzinger, 1838; *R. macrocnemis* Boulenger, 1885; and *R. tavasesnsis* Baran and Atatur, 1986. Of these Turkish anuran species, only *B. verrucosissimus* has not previously been examined helminthologically in Türkiye. Helminth parasites of the other remaining species were compiled in a checklist provided by Yıldırımhan and Birlik (2013). Subsequently, additional helminthological studies were published as follows: *B. viridis*, *P. ridibundus*, and *H. arborea* (Karakaş, 2015); *P. ridibundus* (Koyun et al., 2015); *P. bedriagae* (Demir et al., 2015); *H. orientalis* (Yakar et al., 2016); *R. dalmatina* (Yıldırımhan et al., 2016); *P. ridibundus* and *R. macrocnemis* (Tepe and Yılan, 2021); *B. bufo* (Hastürk et al., 2024); and *B. variegata* (Yıldırımhan et al., 2025).

To our knowledge, there is only 1 helminthological study of *B. verrucosissimus*; this study was conducted by Kidov et al. (2018) in the North Caucasus and Transcaucasia. They reported the presence of 4 acanthocephalan species (*Acanthocephalus falcatus*, *A. ranae*, *Pseudoacanthocephalus bufonis*, and *P. caucasicus*) from fecal samples and 4 nematode species (*Aplectana acuminata*, *Cosmocerca commutata*, *Oswaldocruzia filiformis*, and *Rhabdias bufonis*) found during necropsy.

This study contributes to the completion of the helminth fauna of Turkish anurans and represents the second helminthological examination of *B. verrucosissimus* overall, as well as the first conducted in Türkiye.

MATERIALS AND METHODS

Thirty-five individuals of *B. verrucosissimus* (13♀♀ and 22♂♂) were collected from the Black Sea Region (Artvin Province) and the Mediterranean Region (Mersin Province) of Türkiye during 2024 and 2025. The specimens were initially preserved in jars containing 70% alcohol at the Zoology Laboratory of Karadeniz Technical University and subsequently transferred to the Zoology Laboratory of the Department of Biology, Bursa Uludağ University, for helminthological examination. Collection data, including locality, sex, and morphometric measurements, were recorded before necropsy. The body cavity was opened by a

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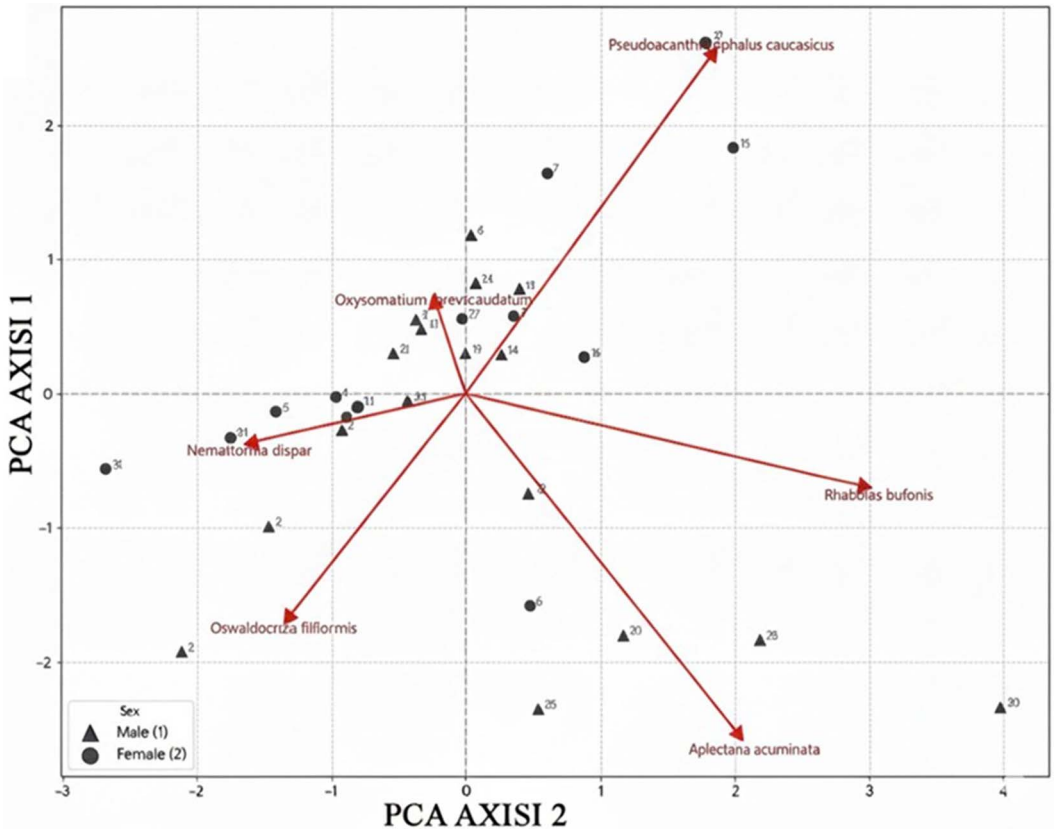


Figure 1. Principal component analysis (PCA) showing the distribution and prevalence patterns of helminth species in *Bufo verrucosissimus*. Numbers (1–35) represent individual toad specimens. Triangles (▲) indicate male individuals, and circles (●) indicate female individuals. Red vectors represent the distribution trends of helminth species.

longitudinal ventral midline incision, and the surfaces of the internal organs were examined. Subsequently, all internal organs were removed and placed in separate petri dishes. Each organ (urinary bladder, heart, liver, esophagus, stomach, and intestines) was examined externally and internally.

Recovered helminths were fixed and preserved in 70% ethanol. Specimens belonging to Cestoda and Acanthocephala were stained with acetocarmine following Georgiev et al. (1986), mounted on glass slides, and sealed with Entellan (R). Nematode specimens were cleared in lactophenol (Sigma-Aldrich) and examined unstained. Helminth identification was performed using keys and descriptions provided by Sharpilo (1976), Schmidt (1986), Petter and Quentin (1976), and Yamaguti (1961, 1963). Parasitological parameters including prevalence, mean intensity, and mean abundance were calculated according to Bush et al. (1997). All identified parasite specimens are deposited in the Parasitology Collection of the Zoology Museum, Bursa Uludağ University.

To evaluate the distributional relationships and patterns of helminth community structure in *B. verrucosissimus*, principal component analysis (PCA), a multivariate dimension-reduction technique, was conducted using CANOCO version 4.5, as illustrated in Figure 1.

RESULTS

Of the 35 examined *B. verrucosissimus* specimens, only 2 (5.7%) were parasite free, whereas the remaining 33 individuals (94.3%) were infected with at least 1 helminth species. In total, 2,218 helminth specimens were recovered and identified, representing 6 species.

The helminth fauna comprised 1 cestode species (*Nematotaenia dispar* [$n = 6$]), 4 nematode species (*Rhabdias bufonis* [$n = 187$], *Aplectana acuminata* [$n = 58$], *Oxysomatium brevicaudatum* [$n = 23$],

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and *Oswaldocruzia filiformis* [$n = 290$]), and 1 acanthocephalan species (*Pseudoacanthocephalus caucasicus* [$n = 1{,}654$]).

Cestoda
Nematotaenia dispar (Goeze, 1782) Lühe, 1899

Syns. *Taenia dispar* Goeze, 1782; *Taenia bufonis* Gmelin, 1790; *Halysis obvoluta* Zeder, 1803; *Nematotaenia viride* Mokhtar-Maamouri & Chakroun, 1984; *Nematotaenia kashmirensis* Fotedar, 1966; *Nematotaenia dollfusi* Yuen & Fernando, 1974; *Cylindrotaenia americana* Prokopic, 1957.

Prevalence, mean intensity and range: 2/35 (5.7%); 3, 2–4.

Temporal distribution: Çağlarca Taralar, Mersin Province, 2024, 2 hosts.

Site of infection: Intestine.

Type host and type locality: Undetermined toad, Germany (Goeze, 1782).

Specimens deposited: BUÜZM.H.2025.ND.7.

Other reported hosts: Aglyptodactylus madagascariensis (Meggitt, 1928); *Bombina bombina* (Buchvarov, 1977); *B. variegata* (Prokopic, 1957; Buchvarov, 1963; Hristovski and Riggio, 1971; Prokopic and Krivanec, 1975; Buchvarov, 1977); *Bufo alvarius* (Goldberg and Bursey, 1991); *B. americanus* (Leidy, 1855); *B. bufo* (Prudhoe and Bray, 1982; Jones, 1987); *B. calamita* (Dollfus, 1957; Fernandez et al., 1986); *B. marinus* (Goldberg and Bursey, 2002); *B. mauritanicus* (Joyeux, 1923; Joyeux and Gaud, 1945; Dollfus, 1957); *B. mazatlanensis* (Goldberg and Bursey, 2002); *B. melanostictus* (Southwell, 1922; Yuen and Fernando, 1974; Jones, 1987); *B. regularis* (Rysavy et al., 1974; Jones, 1987; Ibrahim, 2008); *B. spinulosus* (Hristovski and Riggio, 1971; Jones, 1987); *B. stomaticus* (Khan et al., 2021); *B. surdus* (Dollfus, 1965); *B. variabilis* (Rakhshandehroo et al., 2017); *B. viridis* (Prudhoe and Bray, 1982; Jones, 1987; Al-Sorkhy and Amr, 2003; Mashaii, 2005; Saeed et al., 2007; Mohammad et al., 2010); *Euphlyctis cyanophlyctis* (Khan et al., 2021); *Hyla arborea* (Nasher, 1979; Prudhoe and Bray, 1982; Jones, 1987; Saeed et al., 2007); *H. a. savignyi* (Mashaii, 2005); *H. meridionalis* (Jones, 1987); *H. savignyi* (Yıldırımhan et al., 2012); *Mertensiella caucasica* (Yıldırımhan et al., 2005a); *Necturus maculosus* (Leidy, 1855); *Pelobates fuscus* (Rudolphi, 1819; Dujardin, 1845; Lühe, 1910; Mazurmovich, 1951; Gasslein, 1954; Volgar-Pastukhova, 1959); *Pelophylax ridibundus* were given as *Rana ridibunda* (Prudhoe and Bray, 1982; Düşen and Öz, 2013; Mohammad et al., 2015); *Pseudepidalea viridis* (Yıldırımhan, 1999; Düşen et al., 2010a; Düşen and Oğuz, 2010; Düşen, 2011; Karakaş, 2015); *Rana arvalis* (Okulewicz et al., 2014); *R. dalmatina* (Joyeux and Baer, 1936; Jones, 1987); *R. esculenta* (Joyeux and Baer, 1936; Lopez-Neyra, 1944; Kozák, 1968; Prokopic and Krivanec, 1975); *R. kukunoris* (Cao et al., 2017); *R. macrocnemis* (Dinnik, 1926; Kalabekov, 1973; Yıldırımhan et al., 2006b as *R. camerani*); *R. pipiens* (Leidy, 1855; Wright, 1879); *R. temporaria* (Prudhoe and Bray, 1982); *Salamandra atra* (Frölich, 1789; Schmidt, 1855; Lühe, 1910; Fuhrmann, 1926); *S. salamandra* (Walton, 1939); *Sclerophrys arabica* (recorded as *Bufo orientalis*, Kuntz and Myers, 1968; recorded as *Bufo arabicus*, Nasher, 1979; Kardousha, 2002); *Triturus alpestris* (Walton, 1964); *Varanus griseus* (Dollfus, 1965; Al-Mohammed, 2009).

Nematoda
Rhabdias bufonis (Schrank, 1788)

Syns. *Ascaris nigrovenosa* Goeze in Zeder, 1800, *Rhabdias microoris* Sesmenov, 1929.

Prevalence, mean intensity and range: 19/35 (54.3%); 9.8, 1–42.

Temporal distribution: Borçka, Artvin Province, 2024/2025, 19 hosts.

Site of infection: Lung.

Type host and type locality: Frog (unidentified), Germany (Schrank, 1788).

Specimens deposited: BUÜZM.H.2025.RB.8.

Other reported hosts: Amietophrynus maculates (Akani et al., 2011); *A. regularis* (Morsy et al., 2018); *Bombina bombina* (Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Prokopic and Krivanec, 1975; Vojtková, 1976; Grabda-Kazubska and Lewin, 1989; Yıldırımhan et al., 2001); *B. variegata* (Prokopic, 1957; Buchvarov, 1965, 1977); *Bufo bufo* (André, 1912; Ivanitzky, 1940; Kozlowska, 1960; Vojtková, 1961; Buchvarov, 1962; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Canning et al., 1973; Frandsen, 1974; Prokopic and Krivanec, 1975; Vojtková, 1976; Messner and Kerstan, 1978; Cedhagen, 1988; Yıldırımhan et al., 1997; Shimalov and Shimalov, 2001; Yıldırımhan and Karadeniz, 2007; Düşen, 2011); *B. gargarizans* (Zeng et al., 2024); *B. maculatus* (Aisien et al., 2003); *B. orientalis* (Kuntz and Myers, 1968); *B. regularis* (Aisien et al., 2003); *B. verrucosissimus* (Kidov et al., 2018); *B. viridis* (Karakaş, 2015); *Epidalea calamita* (reported as *Bufo calamita*, Shimalov and Shimalov, 2001); *Hyla arborea* (Kozák, 1973; Vojtková, 1976); *Lissotrition vulgaris* (reported as *Triturus vulgaris*, Canning et al., 1973);

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Pelobates fuscus (Prokopic, 1957; Kozlowska, 1960; Hartwich, 1972; Kozák, 1973; Prokopic and Krivanec, 1975; Vojtková, 1976); *Pelodytes caucasicus* (Yıldırımhan et al., 2009); *Pelophylax bedriagae* (Demir et al., 2015); *P. lessonae* (reported as *Rana esculenta*, André, 1913; Chabaud and Campana-Rouget, 1955; Kozlowska, 1960; Vojtková, 1961; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1968, 1969, 1973; Rodrigues et al., 1972; Combes et al., 1973; Frandsen, 1974; Vojtková, 1976; Kuc and Sulgostowska, 1988a; reported as *R. lessonae*, Joly et al., 2007); *P. perezi* (reported as *Rana perezi*, Navarro and Lluch, 2006); *P. ridibundus* (reported as *R. ridibunda*, Ivanitzky, 1940; Buchvarov, 1962, 1965; Combes and Gerbeaux, 1970; Buchvarov et al., 1975; Prokopic and Krivanec, 1975; Vojtková, 1976; Skrjabin, 1979; Kuc and Sulgostowska, 1988b; reported as *R. ridibunda*, Yıldırımhan et al., 1996; Yıldırımhan et al., 1997; Kır et al., 2001; Sağlam and Arıkan, 2006; Düşen and Öz, 2006; Düşen and Öz, 2013; Koyun et al., 2015); *P. saharicus* (Navarro and Lluch, 2006); *Pseudepidalea viridis* (reported as *Bufo viridis*, Ivanitzky, 1940; Prokopic, 1957; Kozlowska, 1960; Buchvarov, 1962, 1965; Volna-Nabelkova, 1964; Fotedar, 1965; Hristovski, 1969; Kozák, 1969, 1973; Hartwich, 1972; Frandsen, 1974; Prokopic and Krivanec, 1975; Vojtková, 1976; Skrjabin, 1979; Vashetko and Siddikov, 1999; Yıldırımhan, 1999; Sey and Al-Ghairth, 2000; Shimalov and Shimalov, 2001; Düşen, 2011); *Rana arvalis* (Prokopic, 1957; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Hartwich, 1972; Frandsen, 1974; Prokopic and Krivanec, 1975; Vojtková, 1976; Cedhagen, 1988; Kuc and Sulgostowska, 1988a; Zhigileva, 2007; reported as *Rana terrestris*, Kozlowska, 1960); *R. camerani* (Yıldırımhan et al., 2006c); *R. dalmatina* (Buchvarov, 1962; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Frandsen, 1974; Prokopic and Krivanec, 1975; Vojtková, 1976; Düşen et al., 2009; Yıldırımhan et al., 2016); *R. macrocnemis* (Yıldırımhan et al., 2006b); *R. temporaria* (André, 1913; Baylis, 1928; Kozlowska, 1960; Lees, 1962; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Combes et al., 1971; Hartwich, 1972; Hristovski and Lees, 1973; Frandsen, 1974; Prokopic and Krivanec, 1975; Vojtková, 1976; Sattmann, 1986; Cedhagen, 1988; Kuc and Sulgostowska, 1988a).

Aplectana acuminata (Schrank, 1788) Railliet and Henry, 1916

Syns. *Ascaris acuminata* Schrank, 1788; *Fusaria acuminata* (Schrank, 1788) Zeder, 1803; *Oxyuris acuminata* (Schrank, 1788) Mayer, 1841; *Heteracis acuminata* (Schrank, 1788) Diesing, 1861; *Heterakis acuminata* (Schrank, 1788) Steward, 1914; *Oxysomatium acuminatum* (Schrank, 1788) Skrjabin, Schikhobalova and Mozgovoi, 1951; *Aplectana multipapillosa* Ivanitzky, 1940; *Oxysomatium srinagarensis* Fotedar, 1960; *Aplectana caucasica* Sharpilo, 1978; *Spinicauda mathevossinae* Skarbilovich, 1950.

Prevalence, mean intensity and range: 7/35 (20%); 8.3, 2–13.

Temporal distribution: Borçka, Artvin Province, 2024/2025, 7 hosts.

Site of infection: Intestine.

Type host and type locality: Rana temporaria, Germany (Schrank, 1788).

Specimens deposited: BUÜZM.H.2025.AA.9.

Other reported hosts: Bombina bombina (Ryzhikov et al., 1980); *Bufo bufo* (Ryzhikov et al., 1980); *B. calamita* (Frandsen, 1974); *B. verrucosissimus* (Kidov et al., 2018); *B. viridis* (Fotedar, 1960; Bacvarov, 1963; Frandsen, 1974; Ryzhikov et al., 1980; Shimalov and Shimalov, 2001); *Hyla arborea* (Ryzhikov et al., 1980); *Pelobates fuscus* (Ryzhikov et al., 1980); *Rana arvalis* (Ryzhikov et al., 1980); *R. esculenta* (Ryzhikov et al., 1980); *R. ridibunda* (Ivanitzky, 1940; Ryzhikov et al., 1980); *Mertensiella caucasica* (Sharpilo, 1978); *Triturus cristatus* (Ryzhikov et al., 1980).

Oxysomatium brevicaudatum (Zeder, 1800)

Syns. *Oxysoma schneider*, 1866 (preoccupied); *Fusaria brevicaudata* Zeder, 1800; *Neoxysomatium brevicaudatum* (Zeder, 1800); *Oxysoma contortum* Linstow, 1906; *Oxysomatium longespiculum* Railliet and Henry, 1916; *Neoxysomatium* Ballesteros-Marsquez, 1945.

Prevalence, mean intensity and range: 3/35 (8.6%); 7.6, 3–12.

Temporal distribution: Borçka, Artvin Province, 2024, 3 hosts.

Site of infection: Intestine.

Type host and type locality: No type host, Germany.

Specimens deposited: BUÜZM.H.2025.OB.10.

Other reported hosts: Oxysomatium brevicaudatum was reported from diverse hosts of amphibians and reptiles in Europe and Asia, including *Bombina*, *Bufo*, *Hyla*, *Pelobates*, *Rana*, *Salamandra* (Yamaguti, 1961); *Amnirana albolabris* (Oungbe et al., 2019); *Anguis colchica* (Kirillov et al., 2025); *Anguis fragilis* (Schad et al., 1960; Shimalov et al., 2000; Sharpilo, 2003; Borkovcová and Kopřiva, 2005; Düşen et al., 2010b; Sümer et al., 2019; Kirillov et al., 2019);

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Aubria occidentalis (Oungbe et al., 2019); *Bombina bombina* (Walton, 1933); *Bufo bufo* (Chikhlyaev et al., 2016); *B. regularis* (Schad et al., 1960); *B. viridis* (Walton, 1933; Schad et al., 1960; Buchvarov, 1977; Yıldırımhan, 1999; Düşen et al., 2010a); *Hoplobatrachus occipitalis* (Keita et al., 2025); *Hyla arborea* (Walton, 1933; Yakar et al., 2016); *Hyperolius guttulatus* (Oungbe et al., 2019); *Lacerta agilis* (Kirillov et al., 2025); *Natrix natrix* (Schad et al., 1960; Shimalov and Shimalov, 2000); *Pelobates fuscus* (Walton, 1933); *P. syriacus* (Yıldırımhan et al., 1997; Yıldırımhan and Bursey, 2010; Hastürk et al., 2024); *Pelophylax bedriagae* (Demir et al., 2015); *P. lessonae* (Chikhlyaev and Ruchin, 2022); *Pseudotriton ruber* (Walton, 1933); *Ptychadena longirotris* (Oungbe et al., 2019); *P. mascareniensis* (Oungbe et al., 2019); *Ptychadena pumilio* (Oungbe et al., 2019); *Rana dalmatina* (Buchvarov, 1977; Düşen et al., 2009; Yıldırımhan et al., 2016); *R. esculenta* (Walton, 1933); *R. graeca* (Božkov and Stojkova, 1970, Buchvarov, 1977); *R. kurtmuelleri* (Hristovski et al., 2006); *R. macrocnemis* (Schad et al., 1960); *R. ridibunda* (Schad et al., 1960; Kirin and Buchvarov, 2002; Yıldırımhan et al., 2005b; Sağlam and Arıkan, 2006; Düşen et al., 2010a; Düşen and Oğuz, 2010; Düşen and Öz, 2013; Koyun et al., 2015; Düşen et al., 2017); *R. temporaria* (Walton, 1933; Buchvarov, 1977; Kirin and Buchvarov, 2002; Chikhlyaev and Ruchin, 2014); *Salamandra atra* (Walton, 1933); *S. salamandra* (Walton, 1933); *Triturus karelinii* (Yıldırımhan, 2008); *T. vittatus* (Yıldırımhan, 2008); *Vipera berus* (Shimalov and Shimalov, 2000); *V. seoanei* (Roca et al., 2023). Schad et al. (1960) first time reported *O. brevicaudatum* in *B. regularis*, *B. viridis*, *R. macrocnemis*, *R. ridibunda*, and *A. fragilis* from Türkiye.

Oswaldocruzia filiformis Goeze 1782

Syns. *Ascaris filiformis*, Goeze, 1782; *Cucullanus ranae* Goeze, 1782; *Ascaris tennissima* Schrank, 1788; *Ascaris intestinalis* Gmelin, 1790; *Ascaris bufonis* Gmelin, 1790; *Strongylus auricularis* Zeder, 1800; *Ascaris setiformis* Goeze in Zeder, 1800; *Strongylus dispar* Dujardin, 1845; *Strongylus bialata* Molin, 1861; *Oswaldocruzia insulae* Morishita, 1923; *Oswaldocruzia molgeta* Lewis, 1928; *Oswaldocruzia skrjabini* Travassos, 1937; *Oswaldocruzia problematica* Ivanitzky, 1940; *Oswaldocruzia goezi* Skrjabin and Schulz, 1952.

Prevalence, mean intensity and range: 15/35 (42.8%); 19.3, 1–85.

Temporal distribution: Borçka, Artvin Province, 2024/2025, 15 hosts.

Site of infection: Intestine.

Type host and type locality: Rana temporaria, Europe (Goeze, 1782).

Specimens deposited: BUÜZM.H.2025.OF.11.

Other reported hosts: Anatololacerta pelasgiana (Birlik et al., 2024); *Bombina bombina* (Volna-Nabelkova, 1964; Kozák, 1969, 1973; Moravec and Vojtková, 1975; Prokopic and Krivanec, 1975; Rozman, 1976; Vojtková, 1976); *Anguis fragilis* (Schad et al., 1960; Sharpilo, 1962, 1976; Moravec, 1963; Bertman and Okulewicz, 1987; Lewin, 1990; Shimalov et al., 2000; Borkovcová and Kopriva, 2004); *Bufo bufo* (Yıldırımhan and Karadeniz, 2007; Düşen and Oğuz, 2010; Düşen, 2011; Baylis, 1928; Travassos, 1937; John, 1957; Prokopic, 1957; Kozlowska, 1960; Vojtková, 1961; Buchvarov, 1962; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Hristovski and Riggio, 1971; Schmidt and Enigk, 1972; Canning et al., 1973; Frandsen, 1974; Moravec and Vojtková, 1975; Prokopic and Krivanec, 1975; Rozman, 1976; Vojtková, 1976; Ryzhikov et al., 1980; Hendrikx, 1983; Galli et al., 2001; Shimalov and Shimalov, 2001); *B. regularis* (Schad et al., 1960); *B. variegata* (Prokopic, 1957; Buchvarov, 1962; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Prokopic and Krivanec, 1975; Rozman, 1976; Vojtková, 1976; Kirin and Buchvarov, 2002); *B. verrucosissimus* (Kidov et al., 2018); *B. viridis* (Schad et al., 1960; Yıldırımhan, 1999; Topçu and Bayrak, 2000; Düşen et al., 2010a; Düşen and Oğuz, 2010; Düşen, 2011; Karakaş, 2015); *Coronella austriaca* (Sharpilo, 1976); *Darevskia rudis* (Birlik et al., 2018); *Duttaphrynus himalayanus* (reported as *Bufo himalayanus*, Soota and Dey Sarka, 1980); *Epidalea calamita* (reported as *Bufo calamita*, Frandsen, 1974); *Euphlyctis cyanophlyctis* (Tandon et al., 2001); *Hyla arborea* (Kozlowska, 1960; Vojtková, 1961; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Frandsen, 1974; Hristovski and Riggio, 1974; Prokopic and Krivanec, 1975; Rozman, 1976; Vojtková, 1976; Ryzhikov et al., 1980; Yıldırımhan et al., 2006a; Karakaş, 2015); *H. meridionalis* (Baker, 1981; Galeano et al., 1990); *H. orientalis* (Yakar et al., 2016); *Hydromantes genei* (reported as *Speleomantes genei*, Ricci, 1987); *Lacerta agilis* (Shevechenko and Barabashova, 1958; Moravec, 1963; Moravec and Vojtková, 1975; Okulewicz, 1976; Lewin, 1992a; Shimalov et al., 2000; Sharpilo et al., 2001; Hastürk et al., 2025); *L. taurica* (Schad et al., 1960); *L. viridis* (Schad et al., 1960; Moravec, 1963;

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Marconcini and Triantafillu, 1970; Moravec and Vojtková, 1975; Biserkov and Kostadinova, 1998; Kirin, 2002a; Borkovcová and Kopriva, 2004; Yıldırımhan et al., 2020); *L. vivipara* (Travassos, 1937; Moravec, 1963; Moravec and Vojtková, 1975; Shimalov et al., 2000); *Leuciscus cephalus* (Moravec and Scholz, 1991); *Lota lota* (Novokhatskaya, 2007); *Lissotriton helveticus* (reported as *Triturus helveticus*, Lewis, 1928; Avery, 1971); *Lissotriton vulgaris* (reported as *Triturus vulgaris*, Baylis, 1928; Lewis, 1928; Hsü and Chow, 1938; Tranko-Tulecka, 1959; Kozlowska, 1960; Barus and Groschaft, 1962; Vojtková, 1963, 1976; Avery, 1971; Daiya, 1973; Frandsen, 1974; Moravec and Vojtková, 1975; Ryzikov et al., 1980); *Mesotriton alpestris* (reported as *Triturus alpestris*, Barus and Groschaft, 1962); *Natrix natrix* (Moravec, 1963; Kozák, 1967; Moravec and Vojtková, 1975; Bertman and Okulewicz, 1987; Lewin, 1992b; Biserkov, 1995; Shimalov and Shimalov, 2000; Kirin, 2002b); *Natrix tessellata* (Sharpilo, 1976); *Ophisaurus apodus* (Sharpilo, 1976); *Pelobates fuscus* (Kozlowska, 1960; Kozák, 1969, 1973; Prokopic and Krivanec, 1975; Antsyshkina et al., 1976; Vojtková, 1976; Ryzhikov et al., 1980); *Pelodytes caucasicus* (Yıldırımhan et al., 2009); *Pelophylax bedriagae* (Demir et al., 2015); *P. lessonae* (reported as *Rana esculenta*, Kozlowska, 1960; Vojtková, 1961; Vojtková et al., 1963; Volna-Nabelkova, 1964; Tscherner, 1966; Kozák, 1968, 1969, 1973; Plasota, 1969; Rozman, 1971, 1976; Frandsen, 1974; Prokopic and Krivanec, 1975; Vojtková, 1976; Messner and Kerstan, 1978; Ryzhikov et al., 1980; Kuc and Sulgostowska, 1988a; reported as *Rana lessonae*, Borisova, 1988); *P. ridibundus* (Dubinina, 1950; Buchvarov, 1962, 1965; Tscherner, 1966; Kozák, 1969, 1973; Combes and Gerbeauz, 1970; Frandsen, 1974; Buchvarov et al., 1975; Prokopic and Krivanec, 1975; Rozman, 1976; Ryzhikov et al., 1980; Kirin and Buchvarov, 2002; reported as *R. ridibunda*, Yıldırımhan et al., 2005b; Sağlam and Arikan, 2006; Düşen and Oğuz, 2010; Koyun et al., 2015); *Pseudepidalea viridis* (reported as *Bufo viridis*, Kolendo, 1959; Kozlowska, 1960; Volna-Nabelkova, 1964; Buchvarov, 1965; Kozák, 1969, 1973; Frandsen, 1974; Hristovski and Riggio, 1974; Buchvarov et al., 1975; Prokopic and Krivanec, 1975; Vojtková, 1976; Ryzhikov et al., 1980; Al-Barwari and Nassir, 1983; Vashetko and Siddikov, 1999; Rozman, 1976; Shimalov and Shimalov, 2001); *Rana amurensis* (Ryzhikov et al., 1980); *R. arvalis* (Prokopic, 1957; Kozlowska, 1960; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Plasota, 1969; Frandsen, 1974; Prokopic and Krivanec, 1975; Antsyshkina et al., 1976; Vojtková, 1976; Ryzhikov et al., 1980; Borisova, 1988; Cedhagen, 1988; Kuc and Sulgostowska, 1988a; Zhigileva, 2007); *Rana camerani* (Yıldırımhan et al., 2006c); *R. dalmatina* (Prokopic, 1957; Buchvarov, 1962; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Frandsen, 1974; Buchvarov et al., 1975; Prokopic and Krivanec, 1975; Rozman, 1976; Vojtková, 1976; Moravec and Scholz, 1991; Kirin and Buchvarov, 2002; Düşen et al., 2009; Yıldırımhan et al., 2016); *R. graeca* (Hristovski, 1974); *R. macrocnemis* (Schad et al., 1960; Ryzhikov et al., 1980; Yıldırımhan et al., 1997; Yıldırımhan et al., 2006b); *R. temporaria* (Baylis, 1928; Travassos, 1937; Ivanitzky, 1940; Kozlowska, 1960; Lees, 1962; Vojtková et al., 1963; Volna-Nabelkova, 1964; Kozák, 1969, 1973; Combes et al., 1971; Hristovski and Lees, 1973; Frandsen, 1974; Moravec and Vojtková, 1975; Prokopic and Krivanec, 1975; Rozman, 1976; Vojtková, 1976; Ryzhikov et al., 1980; Sattmann, 1986; Cedhagen, 1988; Kuc and Sulgostowska, 1988a; Griffin, 1988, 1989; Kirin and Buchvarov, 2002); *Salamandra salamandra* (Barus et al., 1963; Moravec and Vojtková, 1975; Grabda and Grabda, 1953; Bertman, 1986); *Takydromus amurensis* (Sharpilo, 1976); *Telescopus fallax* (Sharpilo, 1976); *Triturus cristatus* (Kozlowska, 1960; Frandsen, 1974; Vojtková, 1976; Bertman, 1994); *Vipera ammodytes* (Sharpilo, 1976); *V. berus* (Moravec, 1963; Markov and Mozgovoi, 1969; Moravec and Vojtková, 1975; Shimalov and Shimalov, 2000); *Zootoca vivipara* (Sanchis et al., 2000).

Acanthocephala
Pseudoacanthocephalus caucasicus (Petrochenko, 1953)

Syns. *Acanthocephalus caucasicus* Petrochenko, 1953

Prevalence, mean intensity and range: 30/35 (85.7%); 55.1, 2–220.

Temporal distribution: Borçka, Artvin Province, 2024/2025, 30 hosts.

Site of infection: Intestine.

Type host and type locality: Rana macrocnemis, North Ossetia (Petrochenko, 1953).

Specimens deposited: BUÜZM.H.2025.PC.12.

Other reported hosts: Bufo verrucosissimus (Kidov et al., 2018); *Pelodytes caucasicus* (Yıldırımhan et al., 2009); *Pelophylax ridibundus* (reported as *Rana ridibunda*, Skrjabin, 1979); *Pseudepidalea*

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viridis (reported as *Bufo viridis*, Petrochenko, 1953; Babaev and Annakulieva, 1978).

DISCUSSION

In total, 2,218 helminths were collected from 33 (94.3%) of the 35 examined *B. verrucosissimus* individuals. Six helminth species were identified, comprising 1 cestode species ($n = 6$), 4 nematode species ($n = 558$), and 1 acanthocephalan species ($n = 1{,}654$). Among the infected hosts, 7 individuals (20%) harbored 1 helminth species, 15 (42.8%) harbored 2 species, 5 (14.2%) harbored 3 species, and 6 (17.1%) were simultaneously infected with 4 helminth species; however, no individual was infected with 5 or more species. Two hosts (5.7%) were uninfected.

This study represents the first comprehensive investigation of the helminth fauna of *B. verrucosissimus* in Türkiye and provides the first helminth species list for this host in the country. The identification of *N. dispar* and *O. brevicaudatum* constitutes the first record of these species in *B. verrucosissimus*, thereby expanding the known parasite spectrum of this host. The occurrence of *N. dispar* exclusively in the Mersin locality suggests that this region may exhibit distinctive ecological and biogeographical characteristics influencing the distribution of cestode species.

The PCA indicated that the parasite community structure in *B. verrucosissimus* exhibited certain sex-related patterns (Fig. 1), although differences were not clearly separated. In males, a positive correlation was observed with *P. caucasicus* and *O. brevicaudatum* that may be associated with increased activity levels, hunting behavior, and territoriality. In females, weak but statistically significant correlations were detected with *R. bufonis* and *A. acuminata*, possibly reflecting immunosuppression during the reproductive cycle or differences in environmental exposure. The PCA axes further demonstrated variation in the prevalence and intensity of helminth species. *Oxysomatium brevicaudatum* and *N. dispar* were positioned near the center of ordination, indicating low infection intensity but wide distribution, whereas *R. bufonis* and *P. caucasicus* exhibited high infection intensities in certain individuals. *Aplectana acuminata* and *O. filiformis* displayed limited distribution (Fig. 1).

In conclusion, the parasite community structure of *B. verrucosissimus* may be shaped by a complex interplay of geographical, behavioral, and physiological factors, underscoring the importances of considering these variables in host–parasite studies. This research provides a valuable foundation for future systematic, ecological, and biogeographical investigations of amphibian helminths in Türkiye and represents the last anuran species in the country to be examined in terms of its helminth fauna.

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