https://doi.org/10.31489/2025BMG1/53-64

UDC 574.52 Received: 27.09.2024 | Accepted: 22.11.2024

E.G. Krupa[1, 2*], T.Zh. Amangeldiyeva[1, 3]

[1]*RSE "Institute of Zoology" of the Ministry of Science and Higher Education of the Republic of Kazakhstan, Almaty, Kazakhstan;*
[2]*"Kazakhstan Agency of Applied Ecology", Almaty, Kazakhstan;*
[3]*Al Farabi Kazakh National University, Almaty, Kazakhstan*
[*]*Corresponding author's e-mail:elena_krupa@mail.ru*

Zooplankton of Alakol lake (Southeastern Kazakhstan) and its interannual variability

This work aims to analyze the interannual variability of zooplankton in Lake Alakol during different periods of the hydrological cycle based on our own (2002, 2004–2007) and literature data. In zooplankton composition, 132 taxa were recorded, from 15 to 64 taxa over the years. The average long-term abundance of zooplankton was 172.5±58.2 thousand specimens/m^3, with a biomass of 0.9±0.2 g/m^3. In the long-term aspect, zooplankton abundance changed 36 times and the biomass 10 times. A tendency has been revealed for the quantitative variables of zooplankton to increase in high-water years (1954–1968, 1996–1997, 2005) and to decrease during low-water periods (1983, 2000, 2002, 2004, 2006, 2007). During all research periods, rotifers dominated, with a more minor role of crustaceans. The dominant species complex included rotifers *Brachinus plicatilis, Brachinus quadridentatus, Keratella quadrata*, crustaceans *Arctodiaptomus salinus, Mesocyclops leuckarti.* The relative stability of the composition of background species of planktonic invertebrates for more than half a century is due to their broad ecological plasticity.

Keywords: planktonic invertebrates, dominant species, biomass, abundance, interannual variability, hydrological regime.

Introduction

The Alakol-Sasykkol system includes four main lakes — Alakol, Sasykkol, Koshkarkol and Zhalanashkol. Lakes differ significantly in their morphometric and hydrochemical characteristics. The largest is the closed Alakol Lake, with water mineralization of 2.4–9.2 g/m^3 [1]. Lake Zhalanshkol is drainless and characterized by increased water mineralization — 2.1–4.9 g/dm^3. The flowing lakes Sasykkol and Koshkarkol are fresh, water mineralization is 0.2–0.7 g/dm^3.

Hydrobiological studies of the lakes of the Alakol depression have been carried out for over 80 years [2–10]. It was shown that the zooplankton of all lakes of the system included euryhaline species of crustaceans *Diaphanosoma lacustris* Korinek, *Arctodiaptomus salinus* (Daday), *Mesocyclops leuckarti* (Claus) and *Thermocyclops crassus* (Fischer). Quantitative variables of zooplankton in spatial, seasonal and interannual aspects varied widely. It has been established that the species composition and distribution of zooplankton throughout the Alakol Lake are significantly influenced by the spatial heterogeneity of hydrochemical conditions [11]. Mineralization and chemical composition of water, as crucial factors in species' existence [12], also determine the features of the interannual dynamics of biological communities [13, 14]. In arid conditions, the total content of dissolved salts depends on the hydrological regime of the water body: the mineralization decreases in high-water years and increases in low-water years. The hydrological regime directly or indirectly affects all intra-waterbody processes. In high-water years, the volume of surface runoff and, as a rule, the amount of nutrients introduced into the lake increases [1]. Enriching water bodies with nitrogen and phosphorus compounds in high-water years indirectly affects zooplankton by improving the food supply (increasing the bacterioplankton and phytoplankton abundance). For the freshwater Koshkarkol and Sasykkol Lakes, a positive relationship was identified between the interannual dynamics of the abundance of planktonic invertebrates and the water level [15, 16]. There is no such information for Lake Alakol that determines the relevance of this work. Its goal is to analyze the variability of zooplankton during high-water and low-water periods of the hydrological cycle of Lake Alakol based on our own and literature data.

Materials and methods

Brief Description of the Study Sites

The Alakol Lake is located at an altitude of 347 m above sea level. The water area is 2650 km^2, with a maximum depth of 54 m. The lake has an indented coastline with numerous bays and spits. The rivers

Urdzhar, Khatynsu, Beskopa and Emel flow into the northern and northeastern parts of Alakol. They account for 86 % of surface runoff [26]. Water from lakes Sasykkol and Koshkarkol flows into Alakol through ducts in high-water years. Like other water bodies in Kazakhstan, the lake is characterized by cyclical fluctuations in water level. One cycle lasts about 60 years, and the average annual water level value difference reaches 5.58 m [25]. Bottom sediments are represented by clay, sand and pebbles. In the coastal zone and bays, grey and black silts are common, sometimes with remains of vegetation and the smell of hydrogen sulfide. The northern, northeastern and southeastern coastal areas are overgrown with reeds and cattails. Water transparency varies within 1.0–2.5 m, with a maximum in the deep-water part of the water area. The maximum water temperature reaches 23-24°C.

Data Collection And Analysis Methods

Studies of the zooplankton of the Alakol Lake were carried out in the Summers of 2002–2007. Zooplankton samples were collected from a grid of pre-established hydrobiological stations covering desalinated (zone of influence of the Urdzhar, Katynsu, Beskopa, Emel Rivers) and deep-sea mineralized water areas of the Alakol Lake (Fig. 1). A total of 105 zooplankton samples were collected by pulling a small Judy net from the bottom to the surface [17]. Samples were fixed with 40 % formaldehyde solution to a final concentration of 4 %. Species of planktonic invertebrates were determined according to [18–22]. The organisms were calculated under a microscope in a certain part of the sample, followed by viewing the entire remainder to identify large and rare individuals. The individual weight of individuals of each species of planktonic invertebrates was calculated based on equations of linear weight dependence [17, 23]. The abundance and biomass of zooplankton were calculated per 1 m^3.

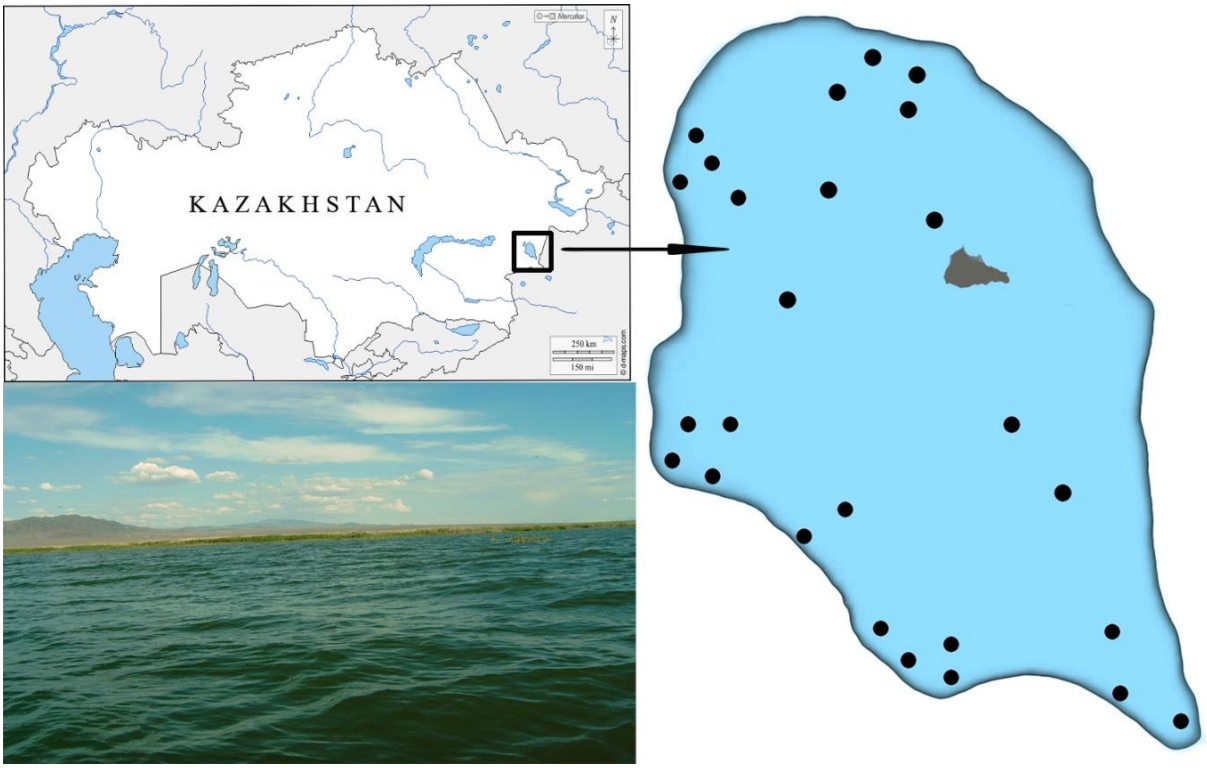

Figure 1. Schematic map of zooplankton sampling stations in the Alakol Lake, 2002–2007

Published information was used [2–10, 24] to analyze the long-term variability of zooplankton. For a correct comparison, we selected published data characterizing the quantitative variables of summer zooplankton. All available data on zooplankton were correlated with hydrological cycles [25]: level rise — 1954–1968, 1996, 1997, 2005, drop in level — 1983, 2000–2004, 2006-2007. Statistical data analysis was performed in Excel.

Results

Species Composition of Zooplankton

During the research period (2002–2007), 132 species and subspecies were noted in the zooplankton of Lake Alakol, of which 76 rotifers, 31 cladocerans and 25 copepods (Table 1). The genus *Brachionus* was the richest in species (20). The genera *Trichocerca, Asplanchna, and Lecane* were represented by 5–9 species; the genus *Ceriodaphnia* — 6, *Thermocyclops* — 5, *Daphnia* — 3 species. The composition of the background species included rotifers *Brachionus qaudridentatus, Keratella quadrata, Notholca acuminata, Testudinella patina, Filinia longiseta longiseta, Hexhartra fennica,* cladocerans *Daphnia galeata, Alona rectangula, Chydorus sphaericus, Moina brachiata,* copepods *Cyclops vicinus, Megacyclops viridis, Thermocyclops crassus, Mesocyclops leuckarti, Arctodiaptomus salinus.* From 8 to 12 species represented zooplankton in deep-sea mineralized areas of the water area. An increase in the species richness of zooplankton (up to 16–22) occurred in desalinated zones and thicket biotopes due to the appearance of planktonic invertebrates from the genera *Diaphanosoma, Ceriodaphnia, Thermocyclops, Daphnia* in the composition of zooplankton [11].

Table 1

Species composition of zooplankton in the Alakol Lake, 2002–2007

Taxon name	Research period				
	2002	2004	2005	2006	2007
Rotifera					
Notommatidae fam. gen.sp.	+	+	+	+	
Notommata sp.		+	+		
Monommata sp.		+			
Cephalodella sp.			+		
Eosphora sp.				+	
Paedotrochida fam. gen.sp.			+		
Trichocerca sp.		+			
Synchaeta sp. 1		+		+	+
Synchaeta sp. 2		+	+		
Polyarthra luminosa Kutikova					
Polyarthra vulgaris Carlin		+			
Polyarthra sp.		+	+	+	+
Trichocerca longiseta (Schrank)	+				
Trichocerca pusilla (Lauterborn)	+				
Trichocerca elongata (Gosse)	+				
Trichocerca rattus (Muller)					
Trichocerca sp.			+		
Asplanchna sieboldi (Leydig)		+	+	+	+
Asplanchna brightwelli Gosse			+	+	
Asplanchna priodonta Gosse	+	+			+
Asplanchna girodi Guerne	+				+
Asplanchna herricki Guerne	+		+		
Asplanchna silvestris Daday	+				
Asplanchna sp.				+	+
Lecane (Monostyla) bulla (Gosse)	+	+	+		
Lecane (Monostyla) bulla diabolica (Hauer)					
Lecane (Monostyla) cornuta (Muller)	+				
Lecane (Monostyla) crenata (Harring)		+			
Lecane (Monostyla) quadridentata (Ehrenberg)	+				
Lecane (Monostyla) lamellata (Daday)	+		+		
Lecane luna (Muller)	+	+	+		
Lecane luna balatonica Varga			+		
Lecan elsa Hauer		+			
Proalidae fam. gen.sp.	+				
Epiphanes sp.	+				
Euchlanis phryne Myers		+			
Euchlanis deflexa Gosse		+	+		

Continuation of Table 1

Taxon name	Research period				
	2002	2004	2005	2006	2007
Euchlanis sp.	+				
Trichotria truncata (Whitelegge)		+			
Mytilyna mucronata spinigera (Ehrenberg)	+	+			
Lopocharis rubens Wulfert		+			
Brachionus qaudridentatus Hermann	+	+	+		
Brachionus qaudridentatus zernovi Voronkov		+	+		
Brachionus qaudridentatus hyphalmyros Tschugunoff		+	+	+	+
Brachionus qaudridentatus brevispinus Ehrenberg				+	
Brachionus qaudridentatus ancylognathus Schmarda	+	+	+	+	
Brachionus diversicornis diversicornis (Daday)					
Brachionus plicatilis plicatilis Muller	+	+			+
Brachionus plicatilis longicornis Fadeev	+		+	+	+
Brachionus plicatilis asplanchnoides Charin					+
Brachionus plicatilis decemcornis Fadeev				+	
Brachionus plicatilis rotundiformes Müller			+		
Brachionus calyciflorus calyciflorus Pallas		+			
Brachionus calyciflorus amphiceros Ehrenberg					+
Brachionus calyciflorus anuraeformes Brehm		+			+
Brachionus calyciflorus dorsas Gosse					
Brachionus variabilis Hempel		+			
Brachionus nilsoni Ahlstrom		+			
Brachionus urceus (Linnaeus)					+
Brachionus angularis angularis Gosse	+		+		+
Brachionus angularis bidens Plate			+	+	+
Platyias quadricornis (Ehrenberg)					
Keratella quadrata quadrata (Muller)	+	+	+	+	+
Keratella cochlearis cochlearis (Gosse)		+			
Keratella cochlearis robusta (Lauterborn)				+	
Keratella irregularis (Lauterborn)		+			
Notholca acuminata (Ehrenberg)	+	+	+		+
Testudinella patina (Hermann)	+	+	+		+
Testudinella truncata (Gosse)	+				
Pompholyx sulcata Hudson	+				
Pompholyx complanata Gosse	+				
Filinia longiseta longiseta (Ehrenberg)	+	+	+	+	+
Filinia longiseta limnetica (Zacharias)				+	
Hexarthra oxyuris (Zernov)	+		+		
Hexarthra fennica (Levaner)	+	+	+	+	+
Hexarthra mira Hudson			+		
Cladocera					
Sida cristallina (Muller)		+			+
Diaphanosoma lacustris Korinek			+	+	+
Diaphanosoma mongolianum Ueno	+			+	
Diaphanosoma dubium Manuilova					
Diaphanosoma macrophthalma Korov. et Mirabd.	+		+		
Scapholeberis kingi Sars	+				
Ceriodaphnia reticulata (Jurine)	+		+	+	+
Ceriodaphnia quadrangula (Muller)	+		+	+	+
Ceriodaphnia setosa Matile		+			+
Ceriodaphnia laticaudata Muller			+		
Ceriodaphnia dubia Richard			+	+	
Ceriodaphnia pulchella Sars				+	
Daphnia galeata Sars	+	+	+	+	+
Daphnia longispina Muller					+
Daphnia pulex Leydig		+			

Continuation of Table 1

Taxon name	Research period				
	2002	2004	2005	2006	2007
Simocephalus sp.		+			
Alona rectangula Sars	+	+	+	+	+
Alona costata Sars				+	
Alona guttata Sars	+				
Macrothrix laticornis (Jurine)	+	+			
Macrothrix hirsuticornis Norman et Brady			+		
Macrothrix daday Behning	+				
Pleuroxus aduncus (Jurine)	+	+			
Graptoleberis testudinaria (Fischer)	+	+			
Capmtocercus rectirostris Schoedler		+			
Chydorus sphaericus (Muller)	+	+	+	+	+
Moina brachiata (Jurine)	+	+	+	+	
Moina micrura Kurz	+			+	
Bosmina longirostris (Muller)	+	+	+	+	+
Leptodora kindtii (Focke)	+				
Polyphemus pediculus (Linne)		+			
Copepoda					
Eucyclops serrulatus (Fischer)	+	+		+	+
Eucyclops macrurus (Sars)		+	+		
Paracyclops fimbriatus (Fischer)	+				
Ectocyclops phaleratus (Koch)	+				
Macrocyclops albidus (Jurine)	+				
Cyclops vicinus Uljanin	+	+	+	+	+
Megacyclops viridis (Jurine)	+	+	+	+	+
Diacyclops bisetosus (Rehberg)	+		+		
Acanthocyclops robustus Sars		+		+	
Thermocyclops crassus (Fischer)	+	+	+	+	+
Thermocyclops taihokuensis Harada	+		+	+	
*Thermocyclops rylovi (*Smirnov)	+				+
Thermocyclops fermifer Lindberg				+	
Thermocyclops sp.					+
Microcyclops varicans (Sars)	+				
Microcyclops sp.	+	+			
Mesocyclops leuckarti (Claus)	+	+	+	+	+
Arctodiaptomus salinus (Daday)	+	+	+	+	+
Nitokra typica Boeck			+	+	
Schizopera paradoxa (Daday)			+	+	+
Cletocamptus retrogressus Schmankewitsch		+			
Schizopera sp.				+	
Harpacticoida fam. gen.sp.	+	+	+		+
Ergasilidae fam. gen.sp.	+				
Total:	64	60	53	43	40

In the interannual aspect, the most significant number of species of planktonic invertebrates was recorded in 2002 and 2004, with a minimum value in 2007. In previous research periods, the number of species recorded in zooplankton varied from 15 to 49 (Fig. 2). The leading role in the total species richness of zooplankton belonged to rotifers.

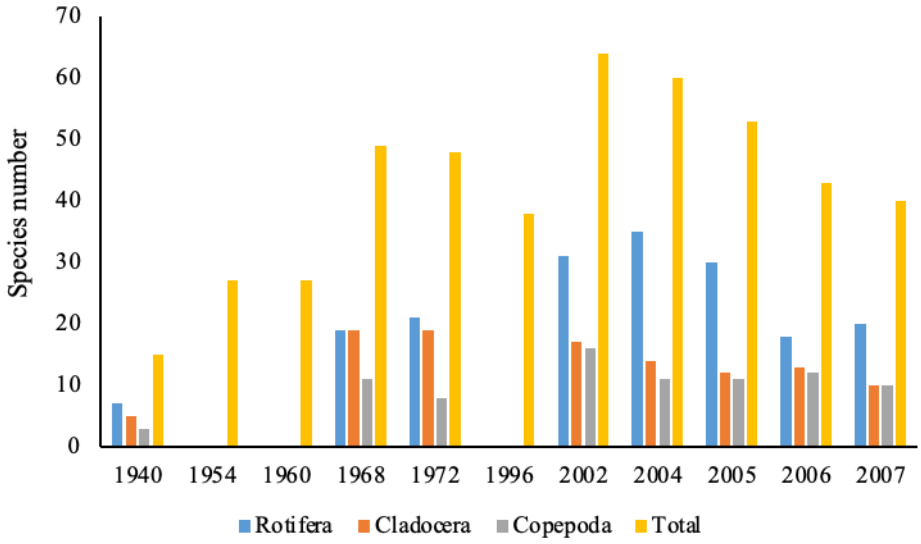

Figure 2. Long-term dynamics of zooplankton species richness in the Alakol Lake

Quantitative variables of zooplankton

The average long-term abundance of zooplankton was 172.5±58.2 thousand individuals/m^3, biomass 0.9±0.2 g/m^3. Over the years of research, zooplankton abundance has changed 36 times, and biomass has changed 10 times (Table 2). There was a tendency towards a significant increase in the quantitative indicators of zooplankton in high-water years and their decrease in low-water periods. The maximum abundance of planktonic invertebrates was noted in 1996-1997 and 2005, with a less pronounced outbreak in 1954–1968. For fresh Sasykkol and Koshkarkol Lakes [15, 16], the positive relationship between the zooplankton abundance and water level can be explained mainly by improving trophic conditions in high-water years [1]. Under conditions of high mineralization, interannual variability of zooplankton in Alakol Lake is caused not only by an increase in the phyto and bacterioplankton abundance but also by a decrease in the total content of dissolved salts in long-term years.

Table 2

Variability of zooplankton abundance and biomass in the Alakol Lake (average values with standard error)

Periods	* Hydrological cycle phase	Rotifera	Cladocera	Copepoda	Total
abundance, thousand specimens/m^3					
1954, 1961, 1968	level rise	70.2±25.8	26.5±14.3	39.4±10.8	136.1±29.9
1983	decrease in level	14.2±5.3	0.1±0.05	43.7±6.8	58.0±5.8
1996, 1997	level rise	456.4±152.1	74.2±4.8	43.2±17.2	576.3±176.3
2000, 2002, 2004	decrease in level	43.2±17.7	4.0±0.8	13.2±2.6	64.5±22.2
2005	level rise	427.7±96.8	0,5±0.4	42.4±6.1	470.7±97.9
2006, 2007	decrease in level	21.1±5.6	2.3±0.8	9.7±3.7	33.1±7.1
average		127.1±49.6	17.8±7.4	26.4±5.1	172.5±58.2
biomass, g/m^3					
1954, 1961, 1968	level rise	no data	no data	no data	no data
1983	decrease in level	0.03±0.01	<0.001	1.3±0.5	1.4±0.3
1996, 1997	level rise	0.9±0.3	1.0±0.6	0.4±0.2	2.3±0.1
2000, 2002, 2004	decrease in level	0.1±0.05	0.06±0.02	0.08±0.02	0.3±0.01
2005	level rise	0.8±0.2	0.005±0.002	0.3±0.06	1.1±0.2
2006, 2007	decrease in level	0.1±0.02	0.03±0.01	0.1±0.06	0.3±0.05
average		0.3±0.1	0.2±0.1	0.4±0.1	0.9±0.2
**Note.* According to [25].					

During all research periods, rotifers dominated in abundance, and copepods subdominated (Table 3). A sharp increase in the role of copepods was noted in 1983 when the lake was heavily polluted with pesticides against the background of a decrease in water level [27]. By biomass in 1983 and 2006, copepods dominated. Cladocerans and rotifers dominated zooplankton in 1996-1997 and rotifers in 2005.

Table 3

Changes in the share of taxonomic groups in the quantitative variables of zooplankton in Lake Alakol (average values with standard error)

Periods	Hydrological cycle phase	Rotifera	Cladocera	Copepoda
1954, 1961, 1968	level rise	49.2±9.2	17.0±5.9	33.9±12.5
1983	decrease in level	24.5±5.7 2.2±0.5	0.2±0.01 0.2±0.01	75.3±9.6 97.8±0.5
1996, 1997	level rise	78.5±2.4 40.4±14.7	13.9±3.4 41.9±24.6	7.3±0.8 17.7±9.8
2000, 2002, 2004	decrease in level	59.9±11.3 30.6±13.0	10.2±5.8 23.8±11.2	25.4±7.2 30.4±12.4
2005	level rise	77.1±16.0 71.9±14.0	0.1±0.09 0.4±0.08	22.7±16.1 27.4±14.2
2006, 2007	decrease in level	62.9±6.9 50.9±10.4	6.6±1.7 10.6±3.8	29.9±8.1 37.2±12.1
average		60.8±5.3 37.8±7.4	9.7±2.2 17.2±5.7	28.3±5.6 40.8±8.7

**Note.* The numerator is the group's share in the total abundance, the denominator is the group's share in the total biomass of zooplankton. With using data: [2–5, 10, 28]

For half a century, the composition of the dominant species retained significant similarities (Table 4). The zooplankton of the deep-sea mineralized part of the water area was dominated by species of the genus *Brachionus,* in some years *Keratella quadrata, Hexarthra oxyuris, Hexarthra fennica* and among crustaceans — *Arctodiaptomus salinus*. In 1968, the diaptomus *Eudiaptomus graciloides* played a significant role in the zooplankton of all lakes of the Alakol-Sasykol system [29]. In subsequent years, this species dropped out of the community. In the desalinated areas, the biomass was dominated by the rotifer *Asplanchna* sp., crustaceans *Mesocyclops leuckarti, Ceriodaphnia reticulata, Diaphanosoma lacustris, Bosmina longirostris, Moina mongolica.*

Table 4

Composition of the dominant zooplankton species of Lake Alakol

Year, month	Species names	Reference
1954, 08	*Hexarthra oxyuris, Brachionus plicatilis, Notholca acuminata*	[2]
1968, 07	*Arctodiaptomus salinus, Ceriodaphnia reticulata, Diaphanosoma lacustris, Brachionus angularis, Brachionus calyciflorus, Keratella cochlearis, Asplanchna herricki, Eudiaptomus graciloides*	[10]
1996, 07	*Brachionus quadridentatus, Brachionus plicatilis, Hexarthra oxyuris, Keratella quadrata, Asplanchna* sp., *Bosmina longirostris, Moina brachiata*	[5]
1996, 06-07	*Hexarthra fennica, Keratella quadrata,* p. *Brachionus, Moina mongolica, Bosmina longirostris*	[6]
1997, 06-07	*Brachionus quadridentatus, Brachionus plicatilis, Hexarthra oxyuris, Keratella quadrata, Mesocyclops leuckarti, Thermocyclops taihokuensis*	[5]
2000, 06	*Synchaeta stylata, Brachionus angularis, Asplanchna priodonta, Thermocyclops* sp., *Bosmina longirostris, Ceriodaphnia* sp.	[6]
2002, 06	*Brachionus quadridentatus, Brachionus plicatilis, Keratella quadrata, Filinia longiseta, Asplanchna priodonta, Diaphanosoma lacustris, Ceriodaphnia reticulata, Mesocyclops leuckarti*	authors' data
2004, 06	*Keratella cochlearis, Brachionus plicatilis longicornis, Arctodiaptomus salinus, Daphnia galeata*	the same

Continuation of Table 4

Year, month	Species names	Reference
2004, 09	*Hexarthra fennica, Brachionus quadridentatus, Brachionus plicatilis longicornis, Ceriodaphnia reticulata, Mesocyclops leuckarti, Arctodiaptomus salinus*	« »
2005, 06	*Hexarthra fennica, Hexarthra oxyuris, Asplanchna* sp., *Arctodiaptomus salinus*	« »
2005, 09	*Brachionus plicatilis longicornis, Brachionus quadridentatus, Asplanchna sieboldi, Asplanchna* sp., *Mesocyclops leuckarti, Arctodiaptomus salinus*	« »
2006, 06	*Brachionus quadridentatus, Brachionus plicatilis longicornis, Arctodiaptomus salinus*	« »
2006, 08	*Brachionus quadridentatus, Brachionus plicatilis longicornis, Asplanchna* sp., *Arctodiaptomus salinus*	« »
2007,05	*Asplanchna sieboldi, Asplanchna priodonta, Keratella quadrata, Hexarthra fennica, Mesocyclops leuckarti, Arctodiaptomus salinus*	« »
2007, 07	*Brachionus quadridentatus, Brachionus plicatilis longicornis, Asplanchna* sp., *Arctodiaptomus salinus, Diaphanosoma lacustris*	« »

Conclusion

In the absence of annual monitoring studies, we can only talk about the general trend of changes in the zooplankton communities of Lake Alakol in a long-term aspect. Zooplankton Lake was characterized by a rich species composition (132 taxa). The interannual dynamics of species richness (from 15 to 64) were primarily associated with the coverage of various biotopes by research. The mineralized deep-sea parts of the water area were inhabited by no more than 10–12 planktonic invertebrate species. Enrichment of communities with species occurred in desalinated and thicket biotopes. According to average values, lake zooplankton reached high abundance with low biomass. This ratio of quantitative variables is due to the dominance of small-sized rotifers with a more minor role of crustaceans. The dominant species complex included rotifers *Brachinus plicatilis, Brachionus quadridentatus, Keratella quadrata,* crustaceans *Arctodiaptomus salinus, Mesocyclops leuckarti.* The relative stability of the composition of background species of planktonic invertebrates for more than half a century is due to their broad ecological plasticity to changes in environmental conditions, primarily variability of hydrochemical parameters. Eliminating *Eudiaptomus graciloides* from zooplankton communities may be associated with increased anthropogenic pressure on all lakes in the system. Increased zooplankton abundance in high-water years may be related to more favourable hydrochemical and trophic conditions during rising water levels.

Funding

This work was carried out within the framework of the project BR21882199 “Cadastre of wild animals of arid territories of the Balkhash-Alakol basin with an assessment of threats for their conservation and sustainable use”.

References

1 Крупа Е.Г. Зоопланктон лимнических и лотических экосистем Казахстана. Структура закономерности формирования / Е.Г. Крупа. — Sarbrucken: Palmarium Academic Publishing. — 2012. — 346 с.

2 Савина Н.О. Сырьевая база и кормовые ресурсы внутренних водоемов Казахстана (система озер Алаколь) / Н.О. Савина, А.М. Самонов. — Алма-Ата: КазНИИРХ, 1940. — 43 с.

3 Малиновская А.С. Кормовая база Алакольских озер и ее использование рыбами: сб. работ по ихтиологии и гидробиологии / А.С. Малиновская. — Алма-Ата, — 1959. — Вып. 2. — С. 116–144.

4 Логиновских Э.В. Кормовая база Алакольских озер и ее использование рыбами / Э.В. Логиновских // Вопросы географии Казахстана. — 1965. — Вып. 12. — С. 223–235.

5 Стуге Т.С. О зоопланктоне Алакольских озер / Т.С. Стуге // Материалы междунар. конф. «Проблемы охраны и устойчивого использования биоразнообразия животного мира Казахстана». — Алматы, 1999. — С. 146–147.

6 Шарапова Л.И. Состояние планктофауны Алакольской системы озер в конце 90-х годов / Л.И. Шарапова // Материалы Междунар. науч. конф. «Проблемы охраны и устойчивого использования биоразнообразия животного мира Казахстана». — Алматы, 1999. — С. 159–160.

7 Шарапова Л.И. Разнообразие и продуктивность современных зоопланктоценозов Алакольской системы озер / Л.И. Шарапова // Материалы Междунар. науч. конф. «Зоологические исследования в Казахстане». — Алматы, 2002. — С. 193–194.

8 Шарапова Л.И. Структура и продуктивность ценозов низших гидробионтов Алакольской системы озер в конце 20-го столетия / Л.И. Шарапова, Ю.В. Эпова, Л.Т. Рахматуллина // Tethys Aqua Zoological Research. — 2002. — Т. 1. — С. 155–164.

9 Стуге Т.С. Краткие итоги изучения зоопланктона оз. Балхаш / Т.С. Стуге, Т.Т. Трошина // Tethys Aqua Zoological Research. — 2003. — Т. 2. — С. 53–60.

10 Стуге Т.С. Зоопланктон Алаколь-Сасыккольской системы озер / Т.С. Стуге, Е.Г. Крупа, Д.А. Смирнова // Тр. Алакольского государственного природного заповедника. — Алматы, 2004. — С. 119–137.

11 Крупа Е.Г. Зоопланктон озера Алаколь и его распределение в зависимости от минерализации и химического состава воды / Е.Г. Крупа, Н.А. Амиргалиев, Т.Я. Лопарева, А.К. Исаева, Б.Б. Биманбаева // Вестник КазНУ. Серия биологическая. — 2010. — № 1. — С. 96–101.

12 Хлебович В.В. Критическая соленость биологических процессов / В.В. Хлебович. — Л.: Наука, 1974. — 236 с.

13 Крупа Е.Г. Многолетняя динамика количественных показателей зоопланктона озера Балхаш / Е.Г. Крупа, К. Шарипова // Исследования. Результаты. — 2009. — № 4. — С. 15–18.

14 Krupa E. The effect of climatic factors on the long-term dynamics of aquatic ecosystem of the Balkhash Lake (Kazakhstan, Central Asia) / E. Krupa, G. Slyvinskiy, S. Barinova // Advanced Studies in Biology. — 2014. — Vol. 6. — № 3. — P. 115–136. http://dx.doi.org/10.12988/asb.2014.4523

15 Крупа Е.Г. Многолетняя динамика зоопланктона озера Кошкарколь (Алаколь-Сасыккольская система) / Е.Г. Крупа, К. Шарипова // Тэрра. — 2007. — № 2. — С. 61–67.

16 Крупа Е.Г. Многолетняя динамика структурных показателей зоопланктона озера Сасыкколь (Алаколь-Сасыккольская система) / Е.Г. Крупа, К. Шарипова // Вестник КазНУ. Серия экологическая. — 2007. — № 1(20). — С. 77–84.

17 Винберг Г.Г. Зоопланктон и его продукция / Г.Г. Винберг, Г.М. Лаврентьева (под ред.) // Методические рекомендации по сбору и обработке материалов при гидробиологических исследованиях на пресноводных водоемах. — Л., 1984. — 33 с.

18 Мануйлова Е.Ф. Ветвистоусые рачки фауны СССР / Е.Ф. Мануйлова. — М., Л.: Наука, 1964. — 328 с.

19 Боруцкий Е.В. Определитель Calanoida пресных вод / Е.В. Боруцкий, Л.А. Степанова, М.С. Кос. — СПб.: Наука, 1991. — 504 с.

20 Кутикова Л.А. Коловратки фауны СССР / Л.А. Кутикова. — Л.: Наука, 1970. — 744 с.

21 Рылов В.М. Фауна СССР. Ракообразные. Cyclopoida пресных вод / В.М. Рылов. — М., Л.: Изд-во АНСССР, 1948. — Т. 3, вып. 3. — 320 с.

22 Цалолихин С.Я. Определитель пресноводных беспозвоночных России и сопредельных стран. Ракообразные / С.Я. Цалолихин. — СПб., 1995. — Т. 2. — 627 с.

23 Балушкина Е.В. Зависимость между длиной и массой тела планктонных ракообразных. Экспериментальные и полевые исследования биологических основ продуктивности озер / Е.В. Балушкина, Г.Г. Винберг. — Л., 1979 — С. 58–79.

24 Стуге Т.С. Видовой состав зоопланктона Алаколь-Сасыкольской системы и его распределение по водоемам / Т.С. Стуге, Е.Г. Крупа // Selevinia. — 2005. — С. 36–44.

25 Бабкин А.В. Поверочный и фактический прогноз уровня воды озера Алаколь на ближайшую перспективу / А.В. Бабкин, А.С. Мадибеков, А. Мусакулкызы, А.В. Чередниченко // Гидрометеорология и экология. — 2017. — № 3(86). — 62 с.

26 Филонец П.П. Морфометрия Алакольских озер. Алакольская впадина и ее озера / П.П. Филонец // Вопросы географии Казахстана. — 1965. — Вып. 12. — С. 79–87.

27 Амиргалиев Н.А. Ихтиофауна и экология Алакольской системы озер / Н.А. Амиргалиев, С.Р. Тимирханов, Ш.А. Альпейсов. — Алматы: Бастау. — 2006. — 367 с.

28 Фокина А.С. Современное состояние зоопланктона оз. Сасыкколь и Кошкарколь / А.С. Фокина // Биологические основы рыбного хозяйства водоемов Средней Азии и Казахстана. — Фрунзе, 1981. — С. 384–386.

29 Логиновских Э.В. Количественная характеристика зоопланктона Алакольских озер / Э.В. Логиновских, Т. Дюсенгалиев // Рыбные ресурсы водоемов Казахстана и их использование. — 1972. — Вып. 7. — С. 89–93.

Е.Г. Крупа, Т.Ж. Амангелдиева

Алакөл көлінің зопланктоны (Оңтүстік-шығыс Қазақстан) және оның жыл аралық өзгергіштігі

Жұмыстың мақсаты гидрологиялық циклдің әртүрлі кезеңдеріндегі Алакөл көлінің зоопланктонының жыл сайынғы өзгергіштігін өзіндік (2002, 2004-2007 жж.) және әдеби деректер негізінде талдау. Зоопланктон құрамында жалпы 132 таксон, әр жылдары 15-тен 64 таксонға дейін тіркелген.

Зоопланктонның орташа көпжылдық саны 172,5±58,2 мың дана/м^3, биомассасы 0,9±0,2 г/м^3 құрады. Ұзақ мерзімді аспектіде зоопланктон саны 36 есеге, биомассасы 10 есеге өзгерді. Зоопланктонның сандық көрсеткіштері суы мол жылдары (1954–1968, 1996–1997, 2005 ж.) көбейіп, суы аз кезеңдерінде (1983, 2000, 2002, 2004, 2006, 2006 ж.) азаю тенденциясы анықталды. Басым көпшілігі коловраткалар болды ал, шаянтәрізділер аз болды. Доминантты түрлер кешеніне коловраткалардан: *Brachinus plicatilis, Brachinus quadridentatus, Keratella quadrata, шаянтәрізділерден Arctodiaptomus salinus, Mesocyclops leuckarti* кірді. Планктонды омыртқасыздардың фондық түрлері құрамының жарты ғасырдан астам уақыт бойы салыстырмалы тұрақты болуы олардың кең экологиялық төзімділігіне (эврибионтизм) байланысты.

Кілт сөздер: планктонды омыртқасыздар, доминантты түрлер, биомасса, саны, жыл аралық өзгергіштік, гидрологиялық режим.

Е.Г. Крупа, Т.Ж. Амангелдиева

Зоопланктон озера Алаколь (Юго-восточный Казахстан) и его межгодовая изменчивость

Целью настоящей работы является анализ межгодовой изменчивости зоопланктона озера Алаколь в различные периоды гидрологического цикла на основе собственных (2002, 2004–2007 гг.) и литературных данных. В составе зоопланктона суммарно зарегистрировано 132 таксона, от 15 до 64 таксонов в отдельные годы. Среднемноголетняя численность зоопланктона составила 172,5±58,2 тыс. экз/м^3, при биомассе 0,9±0,2 г/м^3. В многолетнем аспекте, численность зоопланктона изменялась в 36 раз, а биомасса — в 10 раз. Выявлена тенденция к увеличению количественных показателей зоопланктона в многоводные годы (1954–1968, 1996–1997, 2005 гг.) и к их снижению в маловодные периоды (1983, 2000, 2002, 2004, 2006, 2007 гг.). Доминировали коловратки, а роль ракообразных была менее значительной. Доминирующий комплекс видов включал коловраток *Brachionus plicatilis, Brachionus quadridentatus, Keratella quadrata,* ракообразных *Arctodiaptomus salinus, Mesocyclops leuckarti.* Относительная стабильность состава фоновых видов планктонных беспозвоночных на протяжении более полувека обусловлена их широкой экологической пластичностью (эврибионтностью).

Ключевые слова: планктонные беспозвоночные, доминирующие виды, биомасса, численность, межгодовая изменчивость, гидрологический режим.

References

1 Krupa, E.G. (2012). *Zooplankton limnicheskikh i loticheskih ekosistem Kazakhstana. Struktura, zakonomernosti formirovaniia [Zooplankton of limnic and lotic ecosystems of Kazakhstan. Structure, patterns of formation]*. Sarbrucken: Palmarium Academic Publishing [in Russian].

2 Savina, N.O., & Samonov, A.M. (1940*). Syrevaia baza i kormovye resursy vnutrennikh vodoemov Kazakhstana (sistema ozer Alakol) [Raw material base and feed resources of inland water bodies of Kazakhstan (Alakol lake system)]*. Alma-Ata: Kazakhskii Nauchno-issledovatelskii Institut Rybnogo Khoziaistva [in Russian].

3 Malinovskaya, A.S. (1959). Kormovaia baza Alakolskikh ozer i ee ispolzovanie rybami [Food supply of the Alakol lakes and its use by fish]. *Sbornik rabot po ikhtiologii i gidrobiologii — Collection of works on ichthyology and hydrobiology, 2*, 116–144 [in Russian].

4 Loginovskikh, E.V. (1965). Kormovaia baza Alakolskikh ozer i ee ispolzovanie rybami [Food supply of the Alakol lakes and its use by fish]. *Voprosy geografii Kazakhstana — Questions of the geography of Kazakhstan, 12*, 223–235 [in Russian].

5 Stuge, T.S. (1999). O zooplanktone Alakolskikh ozer [About the zooplankton of the Alakol lakes]. *Materialy mezhdunarodnoi konferentsii «Problemy okhrany i ustoichivogo ispolzovaniia bioraznoobraziia zhivotnogo mira Kazakhstana — Materials of the international conference "Problems of protection and sustainable use of biodiversity of the animal world of Kazakhstan" (*pp. 146–147). Almaty [in Russian].

6 Sharapova, L.I. (1999). Sostoianie planktofauny Alakolskoi sistemy ozer v kontse 90-kh godov [State of the planktofauna of the Alakol lake system in the late 90s.]. *Materialy Mezhdunarodnoi nauchnoi konferentsii «Problemy okhrany i ustoichivogo ispolzovaniia bioraznoobraziia zhivotnogo mira Kazakhstana» — Materials of the international scientific conference "Problems of protection and sustainable use of biodiversity of the animal world of Kazakhstan"* (pp. 159–160). Almaty [in Russian].

7 Sharapova, L.I. (2002). Raznoobrazie i produktivnost sovremennykh zooplanktotsenozov Alakolskoi sistemy ozer [Diversity and productivity of modern zooplanktocenoses of the Alakol lake system]. *Materialy mezhdunarodnoi nauchnoi konferentsii «Zoologicheskie issledovaniia v Kazakhstane» — Materials of the international scientific conference "Zoological research in Kazakhstan*". Almaty [in Russian].

8 Sharapova, L.I., Epova, Yu.V., & Rakhmatullina, L.T. (2002). Struktura i produktivnost tsenozov nizshikh gidrobiontov Alakolskoi sistemy ozer v kontse 20-go stoletiia [Structure and productivity of cenoses of lower hydrobionts of the Alakol lake system at the end of the 20th century]. *Tethys Aqua Zoological Research, 1*, 155–164 [in Russian].

9 Stuge, T.S., & Troshina, T.T. (2003). Kratkie itogi izucheniia zooplanktona ozera Balkhash [Brief results of the study of zooplankton in Lake Balkhash]. *Tethys Aqua Zoological Research, 2*, 53–60 [in Russian].

10 Stuge, T.S., Krupa, E.G., & Smirnova, D.A. (2004). Zooplankton Alakol-Sasykkolskoi sistemy ozer [Zooplankton of the Alakol-Sasykkol lake system]. *Trudy Alakolskogo gosudarstvennogo prirodnogo zapovednika — Proceedings of the Alakol State Natural Reserve.* Almaty [in Russian].

11 Krupa, E.G., Amirgaliev, N.A., Lopareva, T.Ya., Isaeva, A.K., & Bimanbaeva, B.B. (2010). Zooplankton ozera Alakol i ego raspredelenie v zavisimosti ot mineralizatsii i khimicheskogo sostava vody [Zooplankton of Lake Alakol and its distribution depending on the mineralization and chemical composition of water]. *Vestnik Kazakhskogo Natsionalnogo Universiteta. Seriia biologicheskaia — Bulletin of Kazakh National University. Biological series*, 1, 96–101 [in Russian].

12 Khlebovich, V.V. (1974). *Kriticheskaia solenost biologicheskikh protsessov [Critical salinity of biological processes]*. Leningrad: Nauka [in Russian].

13 Krupa, E.G., & Sharipova, K. (2009). Mnogoletniaia dinamika kolichestvennykh pokazatelei zooplanktona ozera Balkhash [Long-term dynamics of quantitative zooplankton variables in Lake Balkhash]. *Issledovaniia, rezultaty — Research. Results*, 4, 15–18 [in Russian].

14 Krupa, E., Slyvinskiy, G., & Barinova, S. (2014). The effect of climatic factors on the long-term dynamics of the aquatic ecosystem of the Balkhash Lake (Kazakhstan, Central Asia). *Advanced Studies in Biology, 6*, 115–136. http://dx.doi.org/10.12988/asb.2014.4523

15 Krupa, E.G., & Sharipova, K. (2007a). Mnogoletniaia dinamika zooplanktona ozera Koshkarkol (Alakol-Sasykkolskaia sistema) [Long-term zooplankton dynamics in Lake Koshkarkol (Alakol-Sasykkol system)]. *Terra*, 2, 61–67 [in Russian].

16 Krupa, E.G., & Sharipova, K. (2007). Mnogoletniaia dinamika strukturnykh pokazatelei zooplanktona ozera Sasykkol (Alakol-Sasykkolskaya sistema) [Long-term dynamics of structural indicators of zooplankton in Lake Sasykkol (Alakol-Sasykkol system)]. *Vestnik Kazakhskogo Natsionalnogo Universiteta*. *Seriia ekologicheskaia — Bulletin of Kazakh National University*. *Ecological series*, 1(20), 77–84 [in Russian].

17 Vinberg, G.G., & Lavrentieva, G.M. (Eds.). (1984). Zooplankton i ego produktsiia [Zooplankton and its products]. *Metodicheskie rekomendatsii po sboru i obrabotke materialov pri gidrobiologicheskikh issledovaniiakh na presnovodnykh vodoemakh — Methodological recommendations for collecting and processing materials during hydrobiological studies in freshwater bodies.* Leningrad [in Russian].

18 Manuilova, E.F. (1964). *Vetvistousye rachki fauny SSSR [Cladocerans of the fauna of the USSR]*. Moscow-Leningrad: Nauka [in Russian].

19 Borutsky, E.V., Stepanova, L.A., & Kos, M.S. (1991). *Opredelitel Calanoida presnykh vod [Key to freshwater Calanoida]*. St. Petersburg: Nauka [in Russian].

20 Kutikova, L.A. (1970). *Kolovratki fauny SSSR [Rotifers of the fauna of the USSR]*. Leningrad: Nauka [in Russian].

21 Rylov, V.M. (1948). *Fauna SSSR. Rakoobraznye. Cyclopoida presnykh vod [Fauna of the USSR. Crustaceans. Freshwater Cyclopoida]*. Moscow-Leningrad: Izdatelstvo ASUSSR [in Russian].

22 Tsalololikhin, S.Ya. (1995). *Opredelitel presnovodnykh bespozvonochnykh Rossii i sopredelnykh stran. Rakoobraznye [Key to freshwater invertebrates of Russia and neighbouring countries. Crustaceans]*. St. Petersburg [in Russian].

23 Balushkina, E.V., & Vinberg, G.G. (1979). *Zavisimost mezhdu dlinoi i massoi tela planktonnykh rakoobraznykh. Eksperimentalnye i polevye issledovaniia biologicheskikh osnov produktivnosti ozer [Relationship between length and body weight of planktonic crustaceans. Experimental and field studies of the biological basis of lake productivity]*. Leningrad [in Russian].

24 Stuge, T.S., & Krupa, E.G. (2005). Vidovoi sostav zooplanktona Alakol-Sasykolskoi sistemy i ego raspredelenie po vodoemam [Species composition of zooplankton in the Alakol-Sasykol system and its distribution among water bodies]. *Selevina,* 36–44 [in Russian].

25 Babkin, A.V., Madibekov, A.S., Musakulkyzy, A., & Cherednichenko, A.V. (2017). Poverochnyi i fakticheskii prognoz urovnia vody ozera alakol na blizhajshuyu perspektivu [Verification and actual forecast of the water level of Lake Alakol for the near future]. *Gidrometeorologiia i ekologiia — Hydrometeorology and Ecology*, 3(86), 62 p. [in Russian].

26 Filonets, P.P. (1965). Morfometriia Alakolskikh ozer. Alakolskaia vpadina i ee ozera [Morphometry of the Alakol lakes. Alakol depression and its lakes]. *Voprosy geografii Kazakhstana — Questions of the geography of Kazakhstan, 12*, 79–87 [in Russian].

27 Amirgaliev, N.A., Timirkhanov, S.R., & Alpeisov, Sh.A. (2006). *Ikhtiofauna i ekologiia Alakolskoi sistemy ozer [Ichthyofauna and ecology of the Alakol lake system]*. Almaty: Bastau [in Russian].

28 Fokina, A.S. (1981). Sovremennoe sostoianie zooplanktona ozera Sasykkol i Koshkarkol [Current state of zooplankton in lakes Sasykkol and Koshkarkol]. *Biologicheskie osnovy rybnogo hoziaistva vodoemov Srednei Azii i Kazakhstana — Biological foundations of fisheries in Central Asia and Kazakhstan water bodies*, 384–386. Frunze [in Russian].

29 Loginovskikh, E.V., & Dyusengaliev, T. (1972). Kolichestvennaia kharakteristika zooplanktona Alakolskikh ozer [Quantitative characteristics of zooplankton in the Alakol lakes]. *Rybnye resursy vodoemov Kazakhstana i ikh ispolzovanie — Fish resources of water bodies of Kazakhstan and their use, 7*, 89–93 [in Russian].

Information about the authors

Krupa, Elena Grigorievna — Doctor of Biological Sciences, Head of the Laboratory of Hydrobiology and Ecotoxicology at the RSE "Institute of Zoology" of the Ministry of Science and Higher Education of the Republic of Kazakhstan, Almaty, Kazakhstan; e-mail: *elena_krupa@mail.ru;* ORCID: https://orcid.org/0000-0001-9401-0258;

Amangeldiyeva, Togzhan Zhandoskyzy — Junior Researcher, Laboratory of Hydrobiology and Ecotoxicology at the RSE "Institute of Zoology" of the Ministry of Science and Higher Education of the Republic of Kazakhstan, Almaty, Kazakhstan; e-mail: *togzhanka-1995@mail.ru.*