Hydrobiologia (2025) 852:2581–2594
https://doi.org/10.1007/s10750-025-05822-4

Recent advances in freshwater zooplankton in a conservation hotspot: Türkiye case

Gürçay Kıvanç Akyıldız · Ahmet Altındağ · Ülkü Nihan Tavşanoğlu

Received: 29 March 2024 / Revised: 6 February 2025 / Accepted: 12 February 2025 / Published online: 26 February 2025

Abstract Freshwater ecosystems are vital for providing essential services such as water supply and food production. However, increasing human demands have led to significant environmental degradation in these ecosystems. Türkiye, recognized as a global biodiversity hotspot, faces numerous threats from altered flow regimes, land-use changes, pollution, and invasive species. Despite these challenges, Türkiye's diverse environments support a rich assemblage of zooplankton, with over 662 identified taxa spanning rotifers, cladocerans, and copepods. This study conducted a bibliometric analysis of zooplankton research at both global and national (Türkiye) levels to understand research trends, identify knowledge gaps, and highlight key areas of focus. Globally, stress factors and climate change dominate the research agenda, whereas, in Türkiye, topics such as abundance, diversity, water quality, and bioindicators have gained attention, albeit with relatively low frequency. Since 2013, these themes have shaped the direction of Turkish zooplankton research. The findings of this study emphasize the need for targeted research to better understand the impacts of environmental stressors on zooplankton communities in Türkiye, while also contributing to the global discourse on ecosystem functionality. By using zooplankton as key biotic indicators, this research offers insights into ecosystem health, providing critical information for future conservation and management efforts.

Keywords Bibliographic analyses · Multiple stressors · Water-quality · Biodiversity · Abundance

Handling editor: Andrew Dzialowski.

Guest editors: María Florencia Gutierrez, Ülkü Nihan Tavşanoğlu & Jörg Dutz / Zooplankton under Multiple Stressors.

G. K. Akyıldız
Biology Department, Pamukkale University, Denizli, Türkiye

A. Altındağ
Biology Department, Ankara University, Ankara, Türkiye

Ü. N. Tavşanoğlu (✉)
Biology Department, Çankırı Karatekin University, Çankırı, Türkiye
e-mail: unyazgan@gmail.com

Introduction

Zooplankton play a crucial role in aquatic food webs, serving as key intermediaries for energy transfer from phytoplankton to fish populations (Declerck & de Senerport, 2023). Shifts in zooplankton communities can trigger significant ecological impacts, including algal blooms, disrupted energy flow, and altered nutrient cycling (Goleski et al., 2010). Extensive research has documented the effects of climate change and various stressors—such as salinity, eutrophication, and human activity—on zooplankton through predictive

scenarios (e.g., Brucet et al., 2009; Havens et al., 2015; Tavşanoğlu et al., 2017; Gutierrez et al., 2018). Focusing on zooplankton is essential, as they occupy a critical position in freshwater food webs and respond sensitively to environmental changes (Paquette et al., 2022).

The topography of the Türkiye has played a significant role in shaping its present-day biodiversity and ecological pattern (Sarıkaya et al., 2011). It is also notable that there are 26 river basins and 200 natural lakes in Türkiye with a total area of 500,000 ha (Akbulut et al., 2021). In addition to its vast land area, Türkiye is also surrounded by seas on three sides: The Black Sea, the Agean, and the Mediterranean Sea. Inland, the Marmara Sea is connected to these seas via Bosphorus and Dardanelles straits, creating a diverse and important coastal ecosystem. One notable feature of coastal regions in Türkiye is the presence of lagoons, which cover more than 60,000 hectares of coastline (Ustaoğlu et al., 2012a, b). Furthermore, during the last glaciation period, also known as the Last Glacial Maximum (LGM), which occurred around 26,000 to 19,000 years ago, the topography of Türkiye acted as a refuge for various organisms (Sarıkaya et al., 2011). This allowed them to survive in isolated microhabitats, leading to the development of unique and diverse species assemblages (Sekercioglu et al., 2011). In total, 668 zooplankton taxa have been identified in Turkish water bodies (Ustaoğlu, 2004; Ustaoğlu et al., 2012a, b; Ustaoğlu, 2015; Bozkurt, 2017; Tavşanoğlu & Akbulut, 2019; Akbulut et al., 2021; Bozkurt, 2021a, b).

However, inland waters and lagoons are confronted with several threats including climate change, pollution, invasive species, and habitat degradation, all of which pose significant risks to their biodiversity and ecological function (Dudgeon et al., 2006; Dudgeon & Strayer, 2025). Particularly, a recent study using global circulation models (GCMs) predicts at least a 2 °C increase in mean spring and summer temperatures and a 10% reduction in annual precipitation in Türkiye by 2100 (Bağçaci et al., 2021). Additionally, water abstraction, especially for irrigation, is expected to rise significantly (Rodrigues Diaz et al., 2007; Yano et al., 2007). These changes pose serious threats to the water balance of many lakes, which may dry up temporarily or even permanently, with shallower areas being particularly vulnerable (Jeppesen et al., 2015; Çolak et al., 2022).

Given the threats to inland waters and lagoons in Türkiye, zooplankton—which play a crucial role in these ecosystems' food webs—offer valuable insights into ecosystem dynamics. The exploration of zooplankton in Türkiye traces its roots to the 1940s, marked by pioneering studies conducted by Daday (1903), Vavra (1905) and Zederbauer & Brehm (1907), as highlighted by Ustaoğlu (2004). In subsequent years, Geldiay (1949) published a seminal comparative investigation on the macro- and microfauna inhabiting lakes, making the very first scientific inquiry into zooplankton within the geographical domain of Türkiye. However, data collection and quantitative findings over the past 23 years remain limited.

This study aims to shed light on potential future trajectories and challenges within the country's limnology with a focus on zooplankton, allowing for comparison with the biodiversity and ecological dynamics of neighboring basins and providing a regional perspective. Through bibliographic analyses, we underscore the threats facing both global and Turkish inland waters (excluding dams and artificial ponds) and lagoon ecosystems. The quantitative data from our study, alongside literature-based findings, have been organized under specific themes, including taxonomy and molecular studies, multiple stressors, toxicology, and behavioral responses.

Material and methods

Data collection and quantitative findings in this study cover the past twenty-three years. Bibliometric analyses were applied to the collected data, enabling a comparative analysis on both a global scale (Glb) and within the context of Türkiye (Tr). Key areas of focus include taxonomic and molecular studies, multiple stressors, toxicology, and behavioral responses.

To conduct this study, we searched Clarivate Analytics Web of Science (WoS) Core Collection for papers published between 2000 and 2023, using the "zooplankton stressors" search phrase in the advanced search. In addition to global analysis, we also evaluate the data for the same period using the keywords "zooplankton stressors" and "Turkey/Türkiye" from both WoS and Turkish literature. Studies from Türkiye were also collected as TR index within the scope of Dergipark which is an online academic publishing

platform and digital library primarily used by Turkish academic institutions and scholars. The process of transferring the BibTeX file via the WoS involves the extraction and compilation of comprehensive record information. This encompasses gathering key metadata such as author names, titles, publication sources, abstracts, and the list of cited references. The extraction methodology relies on the structured data provided by WoS, which is parsed and organized into a BibTeX format. This structured approach ensures the completeness and accuracy of the transferred data, facilitating seamless integration into bibliographic databases and citation management systems.

Data collection and preparation

This bibliometric analysis explored keyword dynamics in scientific literature from 2000 to 2023. Publications were sourced from the WoS bibliometric databases, covering multiple research fields. The corpus was curated to capture each keyword's relevance and prevalence over time, enabling an examination of longitudinal trends. Keywords were extracted and aggregated annually to compute yearly frequency values, with data preprocessing standardizing keyword formats (e.g., "Climate_change" instead of "climate change") to ensure consistency. Each keyword's annual frequency represented its occurrence within the corpus, and these frequencies were plotted as time series from 2000 to 2023. This visual representation allowed for comparative analysis of temporal usage patterns, reflecting shifts in research focus and thematic prominence. Statistical analyses were conducted to assess the significance of observed trends, highlighting increases or decreases in keyword usage over time. The Bibliometrix package (Massimo & Cuccurullo, 2017) in R was employed to furnish a range of tools for conducting quantitative research within the database. To uphold the integrity of result interpretation, publications were limited to those in the English and native languages, as determined by the WoS field tag LA. The scanning range is determined as the year 2000 to the year 2023 by the WoS field tag PY. Additionally, since this study belongs to inland waters, studies on marine systems were excluded from the analysis. The bibliometric analysis exclusively incorporated original articles, identified through the bibliometrix field tag DT, while any documents classified as both articles and other types (thesis, reports, etc.) were omitted from the analysis. The shiny app Biblioshiny was utilized to offer a graphical web interface within the RStudio (2020) environment. The standard Clarivate Analytics WoS Field Tags encoding used in data processing is given in Table 1.

The synthesis of key findings from the bibliometric analysis was achieved through the application of several generic functions given in the R package. The included functions and their arguments were used to extract key information from the dataset and create tables highlighting various aspects of scholarly output and impact. Returned variables allowed for the aggregation of essential metrics like annual scientific production, top-cited manuscripts, leading countries in research productivity, and total citations per country. This approach provided a comprehensive view of the bibliometric landscape, showing scholarly output, citation patterns, and influential contributors across different dimensions.

The three-field plot analysis was applied to integrate scientific journals, countries, and keywords, establishing associations among these entities to elucidate overarching trends and relationships within the bibliometric dataset. The core sources were categorized into three zones according to Bradford's Law.

Table 1 Primary field tags used in data processing by Clarivate Analytics Web of Science (WoS)

Field tag	Description
AU	Authors
TI	Document title
SO	Publication name (or source)
JI	ISO source abbreviation
DT	Document type
DE	Authors' keywords
ID	Keywords associated by SCOPUS or ISI database
AB	Abstract
C1	Author address
RP	Reprint address
CR	Cited references
TC	Times cited
PY	Year
SC	Subject category
UT	Unique article identifier
DB	Bibliographic database

This categorization methodology relies on the principles outlined in Bradford's Law, which posits that scholarly publications within a particular field or discipline tend to cluster into a small number of highly productive journals, followed by a larger number of moderately productive journals, and finally a vast number of minimally productive journals. The dataset was initially processed to extract the most frequent words. Subsequently, the usage frequencies of these extracted keywords over time were analyzed to identify their temporal patterns as primary keywords. This involved isolating the primary keywords based on their high frequency of occurrence within the dataset. Average number of citations per articles counts the cumulative number of times an author's articles have been cited by other articles and then divides this number by this author's total number of articles written, to calculate the average number of citations per article.

Results

Annual production and citation

The exported bibliometric data from the WoS span the years 2000 and 2023, encompassing material from 297 peer-reviewed journals, resulting in a dataset comprising 1193 articles on a global scale. During this timeframe, the global group (Glb) exhibited a fluctuating trend in production over the years (4.13%), with peaks observed around 2016–2017 and a subsequent decline in more recent years. Unlike global trends, the number of publications from 23 different journals, comprising a total of 87 documents, fluctuated between 0 and 13 in Türkiye (Tr) (Table 2, Fig. 1a). The annual growth rate of these publications was calculated to be 1.61% (Table 2). The average annual production for Glb was approximately 47.125 articles, whereas for Tr, it was around 5.833 articles. A significant correlation was detected between Glb and Tr in terms of productivity in studies on zooplankton (Fig. 1b). Over this period, each document garnered an average of 28.22 citations, contributing to a cumulative total of 50,890 references across the dataset. In terms of document contents, the dataset included 3994 Keywords Plus (ID) and 3328 Author's Keywords (DE), reflecting the diverse thematic range covered by the publications (Table 2). The dataset involved contributions from 4279 authors, with only 31 authors having authored single-authored documents. Collaborative efforts were prevalent, with an average of 4.55 co-authors per document, and 35.12% of these collaborations being international. For Türkiye case, each document received an average of 5.418 citations, and collectively, the documents reference a total of 1677 sources. In terms of document contents, 144 distinct ID and 134 author's DE were identified across the analyzed documents. The study involved 95 unique authors, with 9 authors contributing to single-authored documents. There were 11 documents that were single-authored, while the average number of co-authors per document was 2.73. International co-authorships were observed in 1.818% of the documents (Table 2).

Table 2 Annual publication production counts and mean citations per year on global and Türkiye scales

Year	Production		Mean citation	
	Global	Türkiye	Global	Türkiye
2000	13	2	1.88	0.1
2001	15	1	2.68	0.1
2002	31	2	2.21	0.1
2003	23	0	2.03	0.1
2004	27	5	3.68	0.1
2005	27	8	2.7	0.62
2006	31	5	3.14	0.21
2007	26	7	1.95	0.11
2008	38	7	3.07	0.47
2009	42	7	2.08	0.44
2010	47	8	2.12	0.75
2011	44	11	2.45	0.64
2012	63	8	2.54	1.15
2013	68	5	2.78	0.42
2014	72	10	2.4	0.27
2015	74	8	1.99	0.77
2016	97	8	2.74	0.11
2017	95	13	2.92	0.41
2018	89	5	2.74	1.14
2019	82	9	2.42	0.22
2020	57	8	3.09	0.6
2021	47	2	2.56	0.25
2022	52	3	1.19	0.1
2023	33	4	0.42	0.1

Data retrieved from Clarivate Analytics Web of Science (WoS) using bibliometric analysis methods

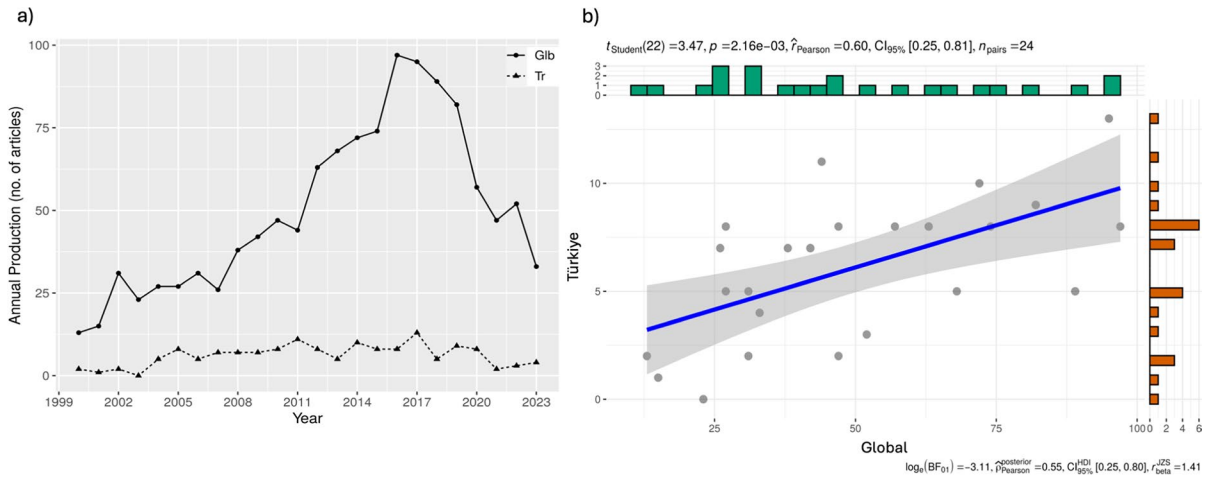

Fig. 1 Zooplankton studies: **a** annual production trends for global and Türkiye from 2000 to 2023, **b** Correlation of production in zooplankton studies between global and Türkiye

The annual citation data for Glb and Tr from 2000 to 2023 were analyzed to compare and interpret the mean total citations per year for each group. The mean total citations per year for Glb varied over the years, ranging from a high of 3.68 in 2004 to a low of 0.42 in 2023 (Fig. 2a). Notably, there were fluctuations in citation counts throughout the analyzed period, with peaks and troughs observed at different points in time. The overall trend for Glb indicated some variability but generally maintaining citation rates above 1.0 for most years. In contrast, the mean total citations per year for Tr remained relatively low throughout the years, with a peak of 1.15 citations in 2012. However, for most years, the citation counts for Tr were below 1.0, indicating lower citation rates compared to the global group. The comparison between Glb and Tr showed a significant difference in citation patterns (Fig. 2b).

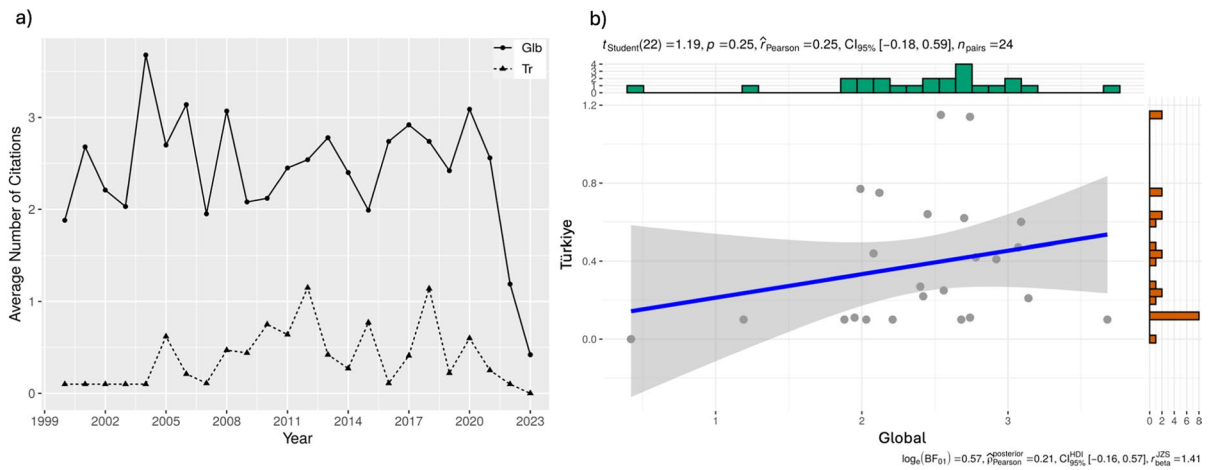

Fig. 2 Citation pattern: **a** mean total citation per year for global and Türkiye from 2000 to 2023, **b** Correlation pattern of citation between global and Türkiye

Keyword dynamics

The frequency of specific words in a bibliometric analysis on a global scale over the years from 2000 to 2023 is given in Fig. 3a. Each word was associated with a certain frequency value across different years. The analyzed words included "Climate_change", "Temperature", "Growth", "Stress", "Dynamics", "Toxicity", "Response" and "Oxidative Stress".

The words that attract the most attention among these: the frequency of "Climate_change" steadily increased from 7 in 2000 to 114 in 2023, indicating a growing emphasis on this topic over the years. "Temperature" and "Growth" showed similar patterns of gradual increase in frequency, suggesting sustained interest in these areas. "Stress" exhibited a notable increase in frequency from 13 in 2000 to 92 in 2023, reflecting heightened attention to stress-related phenomena. "Dynamics" also demonstrated a consistent rise in frequency, indicating ongoing research and discussions on dynamic processes. "Toxicity" showed a relatively stable increase in frequency, reflecting sustained interest in toxicological studies. "Response" displayed a steady growth in frequency, suggesting a continuous focus on response mechanisms in various contexts. "Oxidative Stress" started with minimal frequency in 2000 but showed a significant increase over time, indicating a growing awareness and research focus on oxidative stress-related topics.

Word dynamics for Türkiye differ from those globally. The frequency of specific words for Türkiye spanning from 2000 to 2023 is given in Fig. 3b. The analyzed words included "Rotifers", "Indicators", "Fauna", "Abundance", "Diversity", "Salinity", "Water_quality", "Biodiversity" and "Brackish". Observing the dynamics of these words over time revealed several trends: the word "Rotifers" exhibited a consistent increase in frequency from 1 in 2000 to 18 in 2023, indicating a growing focus or interest in this topic over the years. "Indicators" showed a gradual increase in frequency, starting from 0 in early years to 13 in 2023, suggesting an emerging significance or relevance of indicators in the analyzed context. "Fauna" demonstrated a progressive rise in frequency, indicating an increasing emphasis on fauna-related aspects within the studied literature. "Abundance" displayed fluctuations but generally increases from 1 in 2000 to 9 in 2023, suggesting a sustained interest in abundance-related topics. "Diversity" initially showed no frequency but begins to appear in later years, indicating a growing recognition or exploration of diversity-related themes. "Salinity" showed sporadic growth in frequency, suggesting varying degrees of attention or relevance over the analyzed period. "Water_quality" demonstrated a gradual increase in frequency, reflecting ongoing discussions and research on water quality-related issues. "Biodiversity" and "Brackish" also exhibited increasing frequencies over time, suggesting growing research interest or recognition of these topics within the analyzed literature.

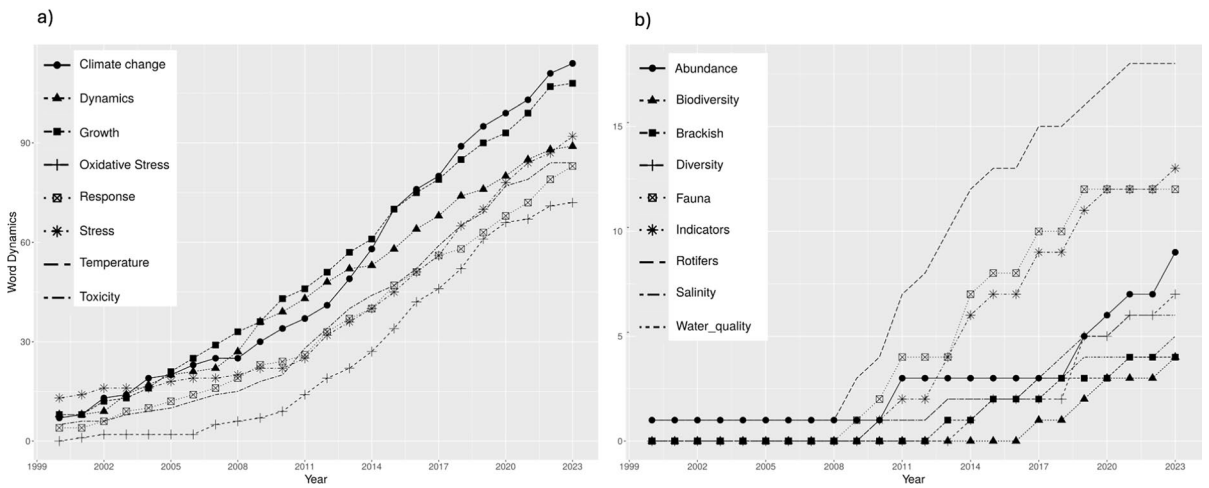

Fig. 3 Frequency of specific words in a bibliometric analysis: **a** Global scale, **b** Türkiye

Discussion

In recent years, there has been a growing trend in research activity focused on zooplankton in Türkiye. Since the turn of the millennium, approximately 87 publications have emerged, covering a spectrum of zooplankton species, encompassing both field surveys, laboratory and mesocosm experiments as well as modelling. These data represent a gradual growth in zooplankton-related publications over time, with an annual growth rate of 1.61%. The relatively modest growth rate suggests a steady but not rapid expansion of research output in this specific area. The average of the documents, calculated at 9.67 years, indicates that the body of literature on zooplankton in Türkiye comprises both recent and relatively older publications. In contrast, Türkiye's production (Tr) showed relatively stable but fluctuating levels, particularly noticeable in the earlier years of the analyzed period. The average annual production for global (Glb) was found to be significantly higher than that of Tr. This indicates a notable disparity in production scales, with the global production consistently exceeding Türkiye's production throughout the examined years. These findings suggest that while both groups experienced production fluctuations over time, the global group consistently maintained a higher average production level compared to Türkiye.

This diversity in documents underscores the ongoing relevance and historical context of zooplankton studies within the country. Each document, on average, received approximately 5.418 citations, highlighting the impact and recognition of zooplankton research within scholarly circles. The global group consistently had higher mean total citations per year compared to Türkiye, reflecting potentially greater research impact, visibility, and influence in academic or scholarly circles. The fluctuation in citation counts for both groups could be attributed to various factors such as changes in research focus, publication output, collaboration networks, and the impact of seminal works within specific fields. In addition, the substantial number of references (1677) across these documents further emphasizes the depth and breadth of knowledge integration within the zooplankton research landscape in Türkiye. Examining the document contents reveals a rich tapestry of keywords, with 144 Keywords Plus (ID) and 134 Author's Keywords (DE) identified. This diverse keyword landscape reflects the multidisciplinary nature of zooplankton studies, encompassing various thematic and methodological aspects.

Taxonomic and molecular studies

Following the checklist compiled by Ustaoğlu (2015), several new zooplankton species have been identified in water bodies, with a total of 103 cladocerans, 143 copepods, and 422 rotifer species recorded. Overall, a total of 668 taxa have been found in Turkish water bodies (Ustaoğlu, 2004; Ustaoğlu et al., 2012a, b; Ustaoğlu, 2015; Bozkurt, 2017; Tavşanoğlu & Akbulut, 2019; Akbulut et al., 2021; Bozkurt, 2021a, b). There is only one published paper that considered the molecular approaches on the diversity of zooplankton species specifically belonging to the genus *Daphnia* (Özdemir et al., 2017). Mainly the published papers in Türkiye have explored the abundance, composition, diversity, seasonal dynamics, and community structure of zooplankton in various environment including lakes, streams, lagoons, mountain lakes as well as reservoirs and sinkholes (Gürbüzer et al., 2019; Özdemir et al., 2021; Durmaz et al., 2022; Saler, 2022; Gürbüzer et al., 2023; Bulut et al., 2024). However, in global research, questions using molecular approaches vary from exploring the local adaptation and phenotypic plasticity of zooplankton under temperature increase to molecular mechanisms at play in phytoplankton–zooplankton interactions. For instance, a study conducted in Lake Baikal revealed insights into the mechanisms of temperature-mediated selection, showcasing the ability of these organisms to adapt to novel environmental pressures (Bowman et al., 2018). Furthermore, copepods adjusted their gene expression patterns based on chlorophyll levels rather than temperature fluctuations. Despite facing low food conditions in 2016, copepods maintained normal protein synthesis and muscle function, showcasing their remarkable ability to acclimate at the molecular level to environmental stressors (Roncalli et al., 2022). Collectively, these studies emphasize the dynamic nature of molecular responses in aquatic organisms facing environmental challenges. From temperature-mediated selection and predator interactions to fluctuations in food availability, the intricate molecular mechanisms uncovered in these

studies provide valuable insights into the resilience and adaptability of marine ecosystems in the face of ongoing environmental changes. Understanding these molecular processes is crucial for predicting and managing the impacts of environmental stressors on aquatic ecosystems.

Multiple stressors: eutrophication, salinity, temperature

Recent studies have demonstrated that combined effects of climate change and mismanagement practices induced salinization and eutrophication in Türkiye and thereby strongly influence the community structure of the zooplankton (i.e. Tavşanoğlu et al., 2015; Beklioğlu et al., 2020; Yılmaz et al., 2021; Çolak et al., 2022). The observed shift from large-bodied grazer Daphnids to small-sized rotifers is likely to reduce the top-down effect of zooplankton, thereby altering the ecosystems' structure and function (Beklioğlu et al., 2020). These findings are supported by pan-European mesocosm experiments spanning over Türkiye (Tavşanoğlu et al., 2017) and snap-shot field samplings with 42 lakes covering wide climatic, hydrological, and nutrient constraints (Beklioğlu et al., 2020). Moreover, the escalation of climate warming has intensified salinization in lakes due to decreased net precipitation (Brucet et al., 2009), consequently impacting the structure and function of zooplankton, exacerbating eutrophication (Gutierrez et al., 2018). Consequently, elevated salinity levels may alter zooplankton richness and diversity (Schallenberg et al., 2003; Brucet et al., 2009; Jensen et al., 2010; Jeppesen et al., 2015). To explore past changes in lake environment under multiple stressors, sub-fossil cladocera remains were collected from surface sediment samples using Kajak corer in 40 Turkish lakes. Contemporarily cladocera assemblages were also sampled from both littoral and pelagic zones of same lakes. The study revealed that there is a robust relationship between samples of modern cladoceran assemblages and their sedimentary remains. Thus, sub-fossil cladoceran assemblages from sediment cores can be used with confidence to track long-term changes in this environmentally sensitive group and in Mediterranean lakes, subjected to large inter-annual variation in water level, salinity, and nutrients (Çakıroğlu et al., 2014).

Toxicology

Daphnia are widely used model organism in aquatic toxicology for testing hypotheses for hundreds of years (Ebert, 2022). Thus, Daphnia have also been used to evaluate the environmental factors such as nutrient, salinity, and pollutants in Türkiye. According to these studies, salinity-induced reduction in population growth rate of freshwater keystone species *Daphnia*—despite acclimation—indicates that global warming-induced salinity may cascade through the food web and lead to dramatic environmental consequences in the structure of lake ecosystems. At the end, the researchers stated that it is important to investigate multiple stressor effects in ecotoxicological bioassays complemented with molecular techniques (Bezirci et al., 2012). In addition, the survival and life history properties of *Simocephalus vetulus* (Müller, 1776) and *Scapholeberis mucronata* (Müller, 1776) were also negatively influenced by increasing salinity (Gökçe & Turhan, 2014). The pollutant 4-nonylphenol and fish kairomone-induced delay in the age at first reproduction reduced the size at first reproduction in *Daphnia magna* Straus 1820, respectively (Beklioğlu et al., 2010). Another mesocosm experiment performed in Türkiye revealed that the biomass of Rotifera was decreased when exposed to TiO_2 but not the other monitored groups including cladocerans and copepods (Jovanovic et al., 2016). In addition, there are also papers published on the impacts of new emergent contaminant in aquatic environment, microplastics, to zooplankton species in both laboratory experiments and filed surveys. In contrast to several studies conducted in marine environments, microplastic ingestion in freshwater ecosystems is predominantly influenced by the size of the zooplankton. A study conducted in a river basin in Türkiye revealed that small-bodied zooplankton species, such as *Filinia* and *Keratella*, are unable to ingest microplastic particles (Başaran-Kankılıç, et al., 2023). Accordingly, a mesocosm experiment performed in Türkiye confirmed that the microplastic ingestion of zooplankton was low, and mostly by large-bodied *Daphnia* (Yıldız et al., 2022), while a laboratory exposure experiment of polyethylene microsphere on *Brachionus plicatilis* and *Daphnia magna* revealed that 10–22 µm beads have negative impacts on these organisms (Berber & Yurtsever, 2018). Consequently, extensive exploration has been

undertaken regarding the reaction of zooplankton communities to contamination events, with a particular emphasis on pollution-induced community tolerance (PICT) (Hebert et al., 2021). Their findings reveal that tolerant zooplankton species adeptly compensate for the decline of sensitive species following initial exposure to contaminants, thereby bolstering the community's resilience against subsequent pollution incidents. Furthermore, current toxicological inquiries are delving into the impacts of nanoparticles on zooplankton (e.g., Mattsson et al., 2024), although no research pertaining to this significant issue has been published in Türkiye yet.

Behavioral response studies

Zooplankton species have behavioral response, either vertical or horizontal daily migration to protect themselves from the predators (Gliwicz, 1986; Burks et al., 2002; Castro et al., 2007). During the 2000s, migration studies were mainly conducted in the temperate region and focused on vertical migration. However, increasing studies from the southern regions related to migration pattern of zooplankton from several southern countries suggested the variations in migration pattern (e.g. Iglesias et al., 2007). In north temperate lakes, large-bodied zooplankton may seek refuge from predation among macrophytes, whereas in subtropical lakes, avoidance of macrophytes has been observed (Lauridsen et al., 1998). The prevalent behavior probably depends on the characteristics of the fish community, which in Mediterranean lakes is typically dispersed both in the open water zone and in the littoral, as in temperate lakes, and is dominated by small size classes, as in subtropical lakes. Similarly, in Türkiye the migration pattern of the zooplankton was size dependent and high number of small fish trigger the horizontal migration (Tavşanoğlu et al., 2015). Accordingly, the simulation of shallow lake in a laboratory experiment to evaluate the habitat choice of *Daphnia* in Türkiye showed that in the presence of predation cues and absence of plants, *Daphnia* moved towards areas with sediment. In the presence of both plants and sediments, *Daphnia* moved away from the plants towards the sediments under both shallow and deep-water treatment conditions (Tavşanoğlu et al., 2012). Furthermore, copepods demonstrate remarkable abilities to detect and evade solar ultraviolet (UV) radiation, underscoring their potential adaptations to environmental stressors (Ma et al., 2013). Niche processes also play a significant role in shaping zooplankton community structure (Yang et al., 2023). Various environmental factors such as turbidity, nitrogen levels, oxygen demand, pH, water depth, temperature, and chlorophyll-*a* act as pivotal drivers influencing zooplankton community dynamics. These insights offer valuable understanding into how zooplankton communities navigate environmental shifts and can be extrapolated to comprehend and manage other aquatic organisms and ecosystems. Overall, both studies enrich our comprehension of the adaptive strategies and ecological resilience exhibited by zooplankton communities in the face of environmental variability.

Trend topics

In this study, countries and prominent keywords, identified using Bradford's Law for highly productive journals (Fig. 4), serve as key indicators. The prominent countries include the USA, Canada, China, Germany, Norway, France, Brazil, Spain, the UK, and Italy. Notable keywords such as climate change, multiple stressors, and eutrophication stand out. For Türkiye, this correlation is limited to zooplankton and rotifers. This analysis underscores the significance of highly productive journals in identifying key trends and priorities within the field of zooplankton research. The inclusion of countries like the USA, Canada, and China among the prominent ones suggests their substantial contributions to the scientific literature in this area. Furthermore, the prioritization of topics such as climate change and eutrophication reflects the global concerns surrounding environmental issues and their impact on inland water ecosystems. The limitation of the analysis to zooplankton and rotifers in the context of Türkiye highlights potential areas for further research and collaboration within the country's scientific community. From a global point of view, zooplankton research exhibits divergent trends between the global community and Türkiye.

Trend topic frequencies and intervals created based on keywords are given in Table 3. As a result of the bibliometric analysis, there are a total of 17 significant keywords that create trends for the global scale. The period between 2008–2014 and 2015–2019 is important because many hot topics emerged in high

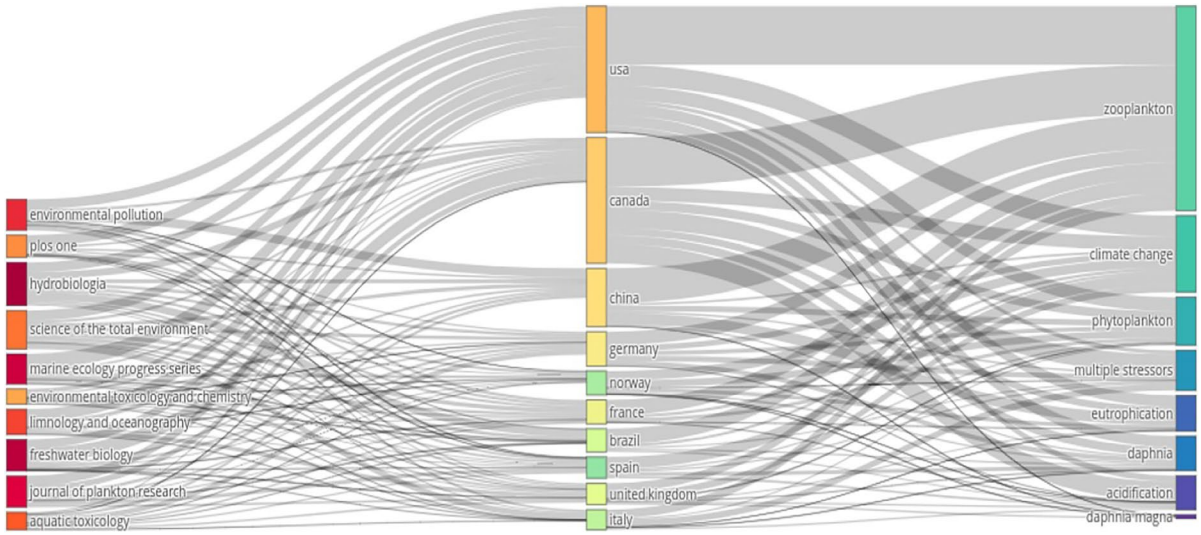

Fig. 4 Prominent keywords according to Bradford's Law for highly productive journals

frequencies, including temperature and stress topics at the forefront (Ma et al., 2013; Smolina et al., 2015), especially in the first quarter, while stress factors (Hylander et al., 2012) and climate change topics are at the forefront in the second quarter. In Türkiye, trend topics vary, and the frequency values of these topics are relatively low. Prominent topics include abundance, diversity, water quality, and indicators. It is observed that water quality and related indicator topics have become trending since 2013. In the contemporary scientific landscape, the discourse surrounding zooplankton ecology has witnessed a notable paradigm shift. While past research laid a foundation by elucidating temperature-dependent responses in zooplankton, the current emphasis is on understanding how ongoing climate change is altering their habitats and ecological dynamics.

Table 3 Top trending topics from 2000 to 2023, ranked by frequency

Topics	Freq	Year			
		Q1	Median	Q3	Scale
Zooplankton	441	2008	2014	2018	Glb
Temperature	114	2009	2014	2018	Glb
Growth	108	2007	2013	2018	Glb
Stress	92	2011	2016	2019	Glb
Dynamics	89	2008	2012	2017	Glb
Toxicity	84	2011	2014	2018	Glb
Oxidative stress	72	2012	2016	2019	Glb
Acidification	52	2004	2010	2016	Glb
Lake	32	2006	2012	2017	Glb
Rotifers	18	2002	2013	2016	Tr
Indicators	13	2013	2015	2019	Tr
Fauna	12	2000	2014	2017	Tr
Feeding behavior	12	2000	2005	2015	Glb
Abundance	9	2005	2019	2021	Tr
Diversity	7	2000	2017	2020	Tr
Salinity	6	2014	2018	2019	Tr
Phytoplankton	5	2000	2019	2023	Tr
Water-quality	5	2007	2014	2019	Tr

Glb: Global, Tr: Türkiye

Conclusions

Since 2001, the trending themes in Turkish limnology research have exhibited variability, ranging from the impacts of climate change to eutrophication, with a notable concentration on freshwater environments. Analysis indicates a discernable shift in research emphasis, with current investigations primarily centered around the effect of environmental changes on zooplankton composition rather than taxonomical inquiries. This shift in focus may be attributed to escalating negative impacts of various disturbances and deterioration of aquatic environments.

Accordingly, phytoplankton emerges as the second most prevalent term in the literature, underscoring the critical interplay between zooplankton and phytoplankton in assessing the ecosystem structure.

While studies concerning zooplankton in global context often demonstrate an increase focus on understanding the impacts of multiple stressors, research in Türkiye predominantly resolves around evaluating abundance and biodiversity across various lakes. Challenges associated with fieldwork, including substantial effort, high costs, and lengthy data evaluation intervals, may have prompted researchers to increasingly turn towards metadata analysis or modeling studies. Consequently, these factors significantly influence the direction of zooplankton research, steering it away from traditional field surveys. Moreover, the exclusion of zooplankton, a vital component of aquatic food webs, from being designated as a biological quality element (BQE) during the implementation of the EU Water Framework Directives (WFD) could significantly impact the overall balance and integrity of aquatic ecosystems. In summary, there exist a notable dearth of data concerning the effects of multiple stressors on the zooplankton community in Türkiye when compared to global trends. Consequently, urgent investigation is warranted in this region, particularly given the severe disturbances it faces, including warming, drought, eutrophication, salinization, and pollution.

Acknowledgements We would like to express our sincere gratitude to the Editor and the anonymous reviewers for their valuable contributions to this manuscript.

Author contributions Gürçay Kıvanç Akyıldız contributed to methodology, investigation, formal analysis, formal analysis, writing—original draft, and writing—review and editing. Ahmet Altındağ performed review and editing. Ülkü Nihan Tavşanoğlu contributed to supervision, conceptualization, and writing—review and editing. All authors read and accepted the final manuscript.

Funding Open access funding provided by the Scientific and Technological Research Council of Türkiye (TÜBİTAK). Not applicable.

Data availability Data can be obtained upon request from the corresponding author.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethical approval Not applicable.

Consent for participate Not applicable.

Consent for publication Not applicable.

References

Akbulut, N., S. Bayarı, A. Akbulut & Y. Şahin, 2021. Rivers of Turkey, Rivers of Eu-rope 2nd ed. Elsevier, Amsterdam: 853–882. https://doi.org/10.1016/B978-0-08-102612-0.00021-3.

Bagçaci, S. Ç., I. Yucel, E. Duzenli & M. T. Yilmaz, 2021. Intercomparison of the expected change in the temperature and the precipitation retrieved from CMIP6 and CMIP5 climate projections: A Mediterranean hot spot case, Turkey. Atmospheric Research 256: 105576. https://doi.org/10.1016/j.atmosres.2021.105576

Başaran-Kankılıç, G., İ Koraltan, B. Erkmen, S. A. Çağan, T. Çırak, M. Özen, M. Seyfe, A. Altındağ & Ü. N. Tavşanoğlu, 2023. Size-selective microplastic uptake by freshwater organisms: fish, mussel, and zooplankton. Environmental Pollution 336: 122445. https://doi.org/10.1016/j.envpol.2023.122445.

Beklioglu, M., S. B. Akkas, H. E. Ozcan, G. Bezirci & I. Togan, 2010. Effects of 4-nonylphenol, fish predation and food availability on survival and life history traits of *Daphnia magna* straus. Ecotoxicology 19: 901–910. https://doi.org/10.1007/s10646-010-0470-7.

Beklioğlu, M., T. Bucak, E. E. Levi, Ş Erdoğan, A. Özen, N. Filiz, G. Bezirci, A. İ Çakıroğlu, Ü. N. Tavşanoğlu, D. Gökçe, N. Demir, M. Özuluğ, M. Duran, K. Özkan, S. Brucet & E. Jeppesen, 2020. Influences of climate and nutrient enrichment on the multiple trophic levels of Turkish shallow lakes. Inland Waters 10(2): 173–185. https://doi.org/10.1080/20442041.2020.1746599.

Berber, A. A. & M. Yurtsever, 2018. Toxicological effect of polyethylene microsphere on *Brachionus plicatilis* and *Daphnia magna*. Fresenius Environmental Bulletin 27: 4973–4979.

Bezirci, G., S. B. Akkas, K. Rinke, F. Yildirim, Z. Kalaylioglu, F. Severcan & M. Beklioglu, 2012. Impacts of salinity and fish-exuded kairomone on the survival and

macromolecular profile of *Daphnia pulex*. Ecotoxicology 21: 601–614. https://doi.org/10.1007/s10646-011-0820-0.

Bowman, L. L., E. S. Kondrateva, M. A. Timofeyev & L. Y. Yampolsky, 2018. Temperature gradient affects differentiation of gene expression and SNP allele frequencies in the dominant Lake Baikal zooplankton species. Molecular Ecology 21(11): 2544–2559. https://doi.org/10.1111/mec.14704.

Bozkurt, A., 2017. First Record of *Epactophanes richardi* Mrázek, 1893 (Copepoda, Harpacticoida, Camptocamptidae) for Turkish Inland Waters. Turkish Journal of Fisheries and Aquatic Sciences 17: 25–29. https://doi.org/10.4194/1303-2712-v17_1_04.

Bozkurt, A., 2021a. A preliminary study on zooplankton fauna of Iskenderun Technical University campus pond and first record of *Pleuroxus wittsteini* Studer, 1878 (Anomopoda, Chydoridae) for Turkish inland waters. Marine and Life Sciences 3(2): 93–99. https://doi.org/10.51756/marlife.1015900.

Bozkurt, A., 2021b. First record of *Metacyclops subdolus* Kiefer, 1938 (Copepoda, Cyclopidae) from Turkey. Acta Aquatica Turcica 17(1): 78–87. https://doi.org/10.22392/actaquatr.756011.

Brucet, S., D. Boix, S. Gascón, J. Sala, X. D. Quintana, A. Badosa, M. Søndergaard, T. L. Lauridsen & E. Jeppesen, 2009. Species richness of crustacean zooplankton and trophic structure of brackish lagoons in contrasting climate zones: north temperate Denmark and Mediterranean Catalonia (Spain). Ecography 32: 692–702. https://doi.org/10.1111/j.1600-0587.2009.05823.x.

Bulut, H., S. Saler & D. Fidan, 2024. Zooplankton of Deriner dam lake (Artvin-Türkiye). Acta Aquatica Turcica 20(1): 14–22. https://doi.org/10.22392/actaquatr.1285631.

Burks, R. L., D. M. Lodge, E. Jeppesen & T. L. Lauridsen, 2002. Diel horizontal migration of zooplankton: costs and benefits of inhabiting the littoral. Freshwater Biology 47(3): 343–365. https://doi.org/10.1046/j.1365-2427.2002.00824.x.

Çakıroğlu, A. İ, N. Ü. Tavşanoğlu, E. E. Levi, T. A. Davidson, T. Bucak, A. Özen, G. K. Akyıldız, E. Jeppesen & M. Beklioğlu, 2014. Relatedness between contemporary and subfossil cladoceran assemblages in Turkish lakes. Journal of Paleolimnology 52: 367–383. https://doi.org/10.1007/s10933-014-9799-x.

Castro, B. B., S. M. Marques & F. Goncalves, 2007. Habitat selection and diel distribution of the crustacean zooplankton from a shallow Mediterranean lake during the turbid and clear water phases. Freshwater Biology 52: 421–433. https://doi.org/10.1111/j.1365-2427.2006.01717.x.

Çolak, M. A., B. Öztaş, İK. Özgencil, M. Soyluer, M. Korkmaz, A. Ramírez-García, M. Metin, G. Yılmaz, S. Ertuğrul, Ü. N. Tavşanoğlu, C. A. Amorim, C. Özen, M. Apaydın Yağcı, A. Yağcı, J. P. Pacheco, K. Özkan, M. Beklioğlu, E. Jeppesen & Z. Akyürek, 2022. Increased water abstraction and climate change have substantial effect on morphometry, salinity, and biotic communities in lakes: examples from the semi-arid Burdur Basin (Turkey). Water 14(8): 1241. https://doi.org/10.3390/w14081241.

Daday, E., 1903. Mikroskopiche Süsswassertiere aus Kleinasien, Sitzungsber. Akad. Wiss. Wien 112. Abt. 1: 139–167.

Declerck, S. J. & L. N. de de Senerport-Domis 2023. Contribution of freshwater metazooplankton to aquatic ecosystem services: an overview. Hydrobiologia. https://doi.org/10.1007/s10750-022-05001-9.

Diaz, J. R., J. W. Knox & E. K. Weatherhead, 2007. Competing demands for irrigation water: golf and agriculture in Spain. Irrigation and Drainage 56(5): 541–549. https://doi.org/10.1002/ird.v56:5 10.1002/ird.317

Dudgeon, D., & D, Strayer. 2025. Bending the curve of global freshwater biodiversity loss: what are the prospects? Biological Reviews 100(1): 205–226. https://doi.org/10.1111/brv.v100.1 10.1111/brv.13137

Dudgeon, D., A. H. Arthington, M. O. Gessner, Z. I. Kawabata,D. J. Knowler, C. Lévêque, R. J. Naiman, A. H. Prieur-Richard, D. Soto, M. L. Stiassny & C. A. Sullivan, 2006. Freshwater biodiversity: importance threats status and conservation challenges. Biological Reviews 81(2): 163–182. https://doi.org/10.1017/S1464793105006950

Durmaz, O., A. Altındağ, G. Gürgen & D. Berdi, 2022. Zooplankton Faunaand seasonal changes of two Karstic Sinkhole lakes: Meyil and Kızören (Konya-Türkiye). Journal of Limnology and Freshwater Researh 8(3): 251–257.

Ebert, D., 2022. *Daphnia* as a versatile model system in ecologyand evolution. EvoDevo 13: 1–13. https://doi.org/10.1186/s13227-022-00199-0.

Geldiay, R., 1949. Çubuk Barajı ve Eymir Gölü'nün Makro ve Mikro Faunasının Mükayeseli Olarak İncelenmesi. A.ü Fen Fak. Mec. 2: 146–252.

Gliwicz, M. Z., 1986. Predation and evolution of vertical migration in zooplankton. Nature 320: 746–748. https://doi.org/10.1038/320746a0.

Gökçe, D. & D. Ö. Turhan, 2014. Effects of salinity tolerances on survival and life history of 2 cladocerans. Turkish Journal of Zoology 38(3): 343–353. https://doi.org/10.3906/zoo-1304-21.

Goleski, J. A., F, Koch, M. A. Marcoval, C. C. Wall, F. J. Jochem, B. J. Peterson & C. J. Gobler, 2010. The role of zooplankton grazing and nutrient loading in the occurrence of harmful cyanobacterial blooms in florida bay USA. Estuaries and Coasts 33(5): 1202–1215. https://doi.org/10.1007/s12237-010-9294-1

Gürbüzer, P., E. T. Tereshenko, A. Altındağ & S. Akıska, 2019. Zooplankton fauna of Abant lake: past and present. Journal of Limnology and Freshwater Research 5(1): 41–46. https://doi.org/10.17216/limnofish.448525.

Gürbüzer, P., A. Altındağ, Ç. Tekatlı & G. Tekatlı, 2023. Zooplankton Fauna of high mountain lake: Sarıncof (Çamlıhemşin, Rize, Turkey). Journal of Agriculture and Nature 26(3): 673–679. https://doi.org/10.18016/ksutarimdoga.vi.1083850.

Gutierrez, M. F., Ü. N. Tavşanoğlu, N. Vidal, J. Yu, F. Teixeirade Mello, A. I. Çakiroglu & E. Jeppesen, 2018. Salinity shapes zooplankton communities and functional diversity and has complex effects on size structure in lakes. Hydrobiologia 813(1): 237–255 https://doi.org/10.1007/s10750-018-3529-8

Havens, K. E., R. M. Pinto-Coelho, M. Beklioğlu, K. S. Christoffersen, E. Jeppesen, T. L. Lauridsen, A. Mazumder, G.

Méthot, B. P. Alloul, U. N. Tavşanoğlu, Ş. Erdoğan & J. Vijverberg, 2015. Temperature effects on body size of freshwater crustacean zooplankton from Greenland to the tropics. Hydrobiologia 743(1): 27–35 https://doi.org/10.1007/s10750-014-2000-8

Hébert, M. P., V. Fugère, B. E. Beisner, N. B. Da Costa, R. D. H. Barrett, G. Bell, B. J. Shapiro, V. Yargeau, A. Gonzalez & G. F. Fussmann, 2021. Widespread agrochemicals differentially affect zooplankton biomass and community structure. Ecological Applications 31(7): e023423. https://doi.org/10.1002/eap.2423.

Hylander, S., M. S. Souza, E. Balseiro, B. Modenutti & L. A. Hansson, 2012. Fish-mediated trait compensation in zooplankton. Functional Ecology 26(3): 608–615. https://doi.org/10.1111/j.1365-2435.2012.01976.x.

Iglesias, C., G. Goyenola, N. Mazzeo, M. Meerhoff, E. Rodo & E. Jeppesen, 2007. Horizontal dynamics of zooplankton in subtropical Lake Blanca (Uruguay) hosting multiple zooplankton predators and aquatic plant refuges. Hydrobiologia 584: 179–189. https://doi.org/10.1007/s10750-007-0599-4.

Jensen, E., S. Brucet, M. Meerhoff, L. Nathansen & E. Jeppesen, 2010. Community structure and diel migration of zooplankton in shallow brackish lakes: role of salinity and predators. Hydrobiologia 646: 215–229. https://doi.org/10.1007/s10750-010-0172-4.

Jeppesen, E., S. Brucet, L. Naselli-Flores, E. Papastergiadou, K. Stefanidis, T. Nõges, P. Nõges, J. L. Attayde, T. Zohary, J. Coppens, T. Bucak, R. Fernandes Menezes, F. R. Sousa Freitas, M. Kernan, M. Søndergaard & M. Beklioğlu, 2015. Ecological impacts of global warming and water abstraction on lakes and reservoirs due to changes in water level and related changes in salinity. Hydrobiologia 750: 201–227. https://doi.org/10.1007/s10750-014-2169-x.

Jovanović, B., G. Bezirci, A. S. Çağan, J. Coppens, E. E. Levi, Z. Oluz, E. Tuncel, H. Duran & Meryem Beklioğlu, 2016. Food web effects of titanium dioxide nanoparticles in an outdoor freshwater mesocosm experiment. Nanotoxicology 10(7): 902–912. https://doi.org/10.3109/17435390.2016.1140242.

Lauridsen, T. L., E. Jeppesen, M. Søndergaard & D. M. Lodge, 1998. Horizontal migration of zooplankton: predator-mediated use of macrophyte Habitat. In Jeppesen, E., M. Søndergaard, M. Søndergaard & K. Christoffersen (eds), The Structuring Role of Submerged Macrophytes in Lakes. Ecological Studies, Vol. 131. Springer, New York. https://doi.org/10.1007/978-1-4612-0695-8_13.

Ma, Z. L., W. Li, A. L. Shen & K. S. Gao, 2013. Behavioral responses of zooplankton to solar radiation changes: in situ evidence. Hydrobiologia 711(1): 155–163. https://doi.org/10.1007/s10750-013-1475-z.

Massimo, A. & C. Cuccurullo, 2017. *bibliometrix*: An R-tool for comprehensive science mapping analysis. Journal of Informetrics 11(4): 959–975. https://doi.org/10.1016/j.joi.2017.08.007.

Mattsson, K., S. Jocic, J. Aristéia de Lima, L.-A. Hansson & A. Gondikas, 2024. Nanoplastics in aquatic environments – sources, sampling techniques, and identification methods, Microplastic Contamination in Aquatic Environments 2nd ed. Elsevier, Amsterdam: 381–397.

Özdemir, E., A. Altındağ & İ Kandemir, 2017. Molecular diversity of some species belonging to the genus *Daphnia* O. F. Müller, 1785 (Crustacea:Cladocera) in Turkey. Mitochondrial DNA Part A 28(3): 424–433. https://doi.org/10.3109/19401736.2015.1136303.

Özdemir, C. D., Y. Saygı, E. Gündüz, F. Y. Demirkalp & Ç. Karacaoğlu, 2021. Assesment of the zooplankton community structure of the coastal Uzungöl Logoon (Kızılırmak Delta, Turkey based on community indices and physicochemical parameters. Turkish Journal of Zoology 45: 33–45. https://doi.org/10.3906/zoo-2006-9.

Paquette, C., I, Gregory-Eaves & B. E. Beisner, 2022. Environmental drivers of taxonomic and functional variation in zooplankton diversity and composition in freshwater lakes across Canadian continental watersheds. Limnology and Oceanography 67(5): 1081–1097. https://doi.org/10.1002/lno.v67.5 10.1002/lno.12058

Roncalli, V., J. Niestroy, M. C. Cieslak, A. M. Castelfranco, R. R. Hopcroft & P. H. Lenz, 2022. Physiological acclimatization in high-latitude zooplankton. Molecular Ecology 31(6): 1753–1765. https://doi.org/10.1111/mec.16354.

RStudio Team (2020). RStudio: integrated development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.

Saler, S., 2022. Zooplankton diversity of Sevsak stream (Elazığ-Türkiye). Asian Journal of Fisheries and Aquatic Researh 18(6): 15–21. https://doi.org/10.9734/ajfar/2022/v18i630458.

Sarıkaya, M. A., A. Çiner & M. Zreda, 2011. Quternary glaciations of Turkey. Developments in Queternary Science 15: 393–403. https://doi.org/10.1016/B978-0-444-53447-7.00030-1.

Schallenberg, M., C. J. Hall & C. W. Burns, 2003. Consequences of climate-induced salinity increases on zooplankton abundance and diversity in coastal lakes. Marine Ecology Progress Series 251: 181–189.

Sekercioglu, C. H., S. S. Anderson, E. Akcay, R. Bilgin, E. Ö. Can, G. Semiz, et al., 2011. Turkey's globally important biodiversity in crisis. Biological Conservation 144: 2752–2769. https://doi.org/10.1016/j.biocon.2011.06.025.

Smolina, I., S. Kollias, E. F. Moller, P. Lindeque, A. Y. M. Sundaram, J. M. O. Fernandes & G. Hoarau, 2015. Contrasting transcriptome response to thermal stress in two key zooplankton species, *Calanus finmarchicus* and *C. glacialis*. Marine Ecology Progress Series. 534: 79–93. https://doi.org/10.3354/meps11398.

Tavşanoğlu, U. N. & N. Akbulut, 2019. Seasonal dynamics of riverine zooplankton functional groups in Turkey: Kocaçay delta as a case study. Turkish Journal of Fisheries and Aquatic Sciences 20(1): 69–77. https://doi.org/10.4194/1303-2712-v20_1_07.

Tavşanoğlu, Ü. N., A. İ Çakıroğlu, Ş Erdoğan, M. Meerhoff, E. Jeppesen & M. Beklioğlu, 2012. Sediments, not plants, offer the preferred refuge for *Daphnia* against fish predation in Mediterranean shallow lakes: an experimental demonstration. Freshwater Biology 57(4): 795–802. https://doi.org/10.1111/j.1365-2427.2012.02745.x.

Tavşanoğlu, Ü. N., S. Brucet, E. E. Levi, T. Bucak, G. Bezirci, A. Özen, L. S. Johansson & E. Jeppesen, 2015.

Size-based diel migration of zooplankton in Mediterranean shallow lakes assessed from in situ experiments with artificial plants. Hydrobiologia 753: 47–59. https://doi.org/10.1007/s10750-015-2192-6.

Tavşanoğlu, Ü. N., M. Sorf, K. Stefanidis, S. Brucet, S. Türkan, H. Agasild, D. L. Baho, U. Scharfenberger, J. Hejzlar, E. Papastergiadou, R. Adrian, D. G. Angeler, P. Zingel, A. İ Çakıroğlu, A. Özen, S. Drakare, M. Søndergaard, E. Jeppesen & M. Beklioğlu, 2017. Effects of nutrient and water level changes on the composition and size structure of zooplankton communities in shallow lakes under different climatic conditions: a pan-European mesocosm experiment. Aquatic Ecology 51: 257–273. https://doi.org/10.1007/s10452-017-9615-6.

Ustaoğlu, M. R., 2015. An updated zooplankton biodiversity of Turkish Inland waters. Journal of Limnology and Freshwater Fisheries Research 1(3): 151–159. https://doi.org/10.17216/LimnoFish-5000151941.

Ustaoğlu, M. R., D. Özdemir-Mis & C. Aygen, 2012a. Observation on zooplankton in some lagoons in Turkey. Journal of Black Sea/mediterranean Environment 18(2): 208–222.

Ustaoğlu, M. R., A. Altındağ, M. Kaya, N. Akbulut, A. Bozkurt, D. Özdemir-Mis, S. Atasagun, S. Erdoğan, A. Bekleyen, S. Saler & H. C. Okgerman, 2012b. A checklist of Turkish rotifers. Turkish Journal of Zoology 36(5): 607–622. https://doi.org/10.3906/zoo-1110-1.

Ustaoğlu, M. R., 2004. A Check-list for zooplankton of Tukish Inland waters. Journal of Fisheries & Aquatic Sciences 21(3–4): 191–199. ISSN 1300–1590.

Vavra, V., 1905. Rotatorien and Crustaceen. Ann. K. K. Naturhist. Hofmuseums 20: 106–113.

Yang, Z. J., B. Z. Pan, X. Y. Liu, E. Hu, J. X. Hu & Z. Y. Huang, 2023. Niche processes shape zooplankton community structure in a sediment-laden river basin. Hydrobiologia. https://doi.org/10.1007/s10750-023-05355-8.

Yano, T., M. Aydın, T. Haraguchi, 2007. Impact of climate change on irrigation demand and crop growth in a Mediterranean environment of Turkey. Sensors 7(10): 2297–2315. https://doi.org/10.3390/s7102297.

Yıldız, D., G. Yalçın, B. Jovanović, D. S. Boukal, L. Vebrová, D. Riha, J. Stanković, D. Savić-Zdraković, M. Metin, Y. N. Akyürek, D. Balkanlı, N. Filiz, D. Milošević, H. Feuchtmayr, J. A. Richardson & M. Beklioğlu, 2022. Effects of a microplastic mixture differ across trophic levels and taxa in a freshwater food web: in situ mesocosm experiment. Science of the Total Environment 836(7–9): 155407. https://doi.org/10.1016/j.scitotenv.2022.155407.

Yılmaz, G., M. A. Çolak, İK. Özgencil, M. Metin, M. Korkmaz, S. Ertuğrul, M. Soyluer, T. Bucak, Ü. N. Tavşanoğlu, K. Özkan, Z. Akyürek, M. Beklioğlu & E. Jeppesen, 2021. Decadal changes in size, salinity, waterbirds, and fish in lakes of the Konya Closed Basin, Turkey, associated with climate change and increasing water abstraction for agriculture. Inland Water 11(4): 538–555. https://doi.org/10.1080/20442041.2021.1924034.

Zederbauer, E. & V. Brehm, 1907. Das plankton einiger seen Kleinasiens. Archives of Hydrobiology Plankton 3(1): 92–99.