Turkish Journal of Bioscience and Collections
Volume 5, Number 2, 2021
E-ISSN: 2601-4292

RESEARCH ARTICLE

Invasive freshwater jellyfish has become established in artificial impoundments of Anatolian Peninsula

Nurçin Killi[1], Sadi Aksu[2], Sera Övgü Kabadayı[3], Sercan Başkurt[4], Özgür Emiroğlu[4], Pinar Öztopçu-Vatan[4], Irmak Kurtul[5], Serdar Aksan[6], Ali Serhan Tarkan[1]

[1] Muğla Sıtkı Koçman University, Faculty of Fisheries, Department of Basic Sciences, Muğla, Turkey
[2] Eskişehir Osmangazi University, Vocational School of Health Services, Eskişehir, Turkey
[3] Isparta University of Applied Sciences, Faculty of Fisheries, Department of Basic Sciences, Isparta, Turkey
[4] Eskişehir Osmangazi University, Faculty of Arts and Sciences, Department of Biology, Eskisehir, Turkey
[5] Ege University, Faculty of Fisheries, Department of Marine-Inland Waters Science and Technology, İzmir, Turkey
[6] Kocaeli University, Faculty of Arts and Sciences, Department of Biology, Kocaeli, Turkey

ORCID: N. K. 0000-0002-6095-2674;
S.A. 0000-0003-2770-561X;
S.Ö.K. 0000-0002-0060-2445;
S.B. 0000-0001-5438-7042;
Ö.E. 0000-0002-4433-4286;
P.O.V. 0000-0003-4339-4129;
I.K. 0000-0002-3566-9172;
S.A. 0000-0002-8842-9332;
A.S.T. 0000-0001-8628-0514;

Received: 19.08.2021
Revision Requested: 03.09.2021
Last Revision Received: 06.08.2021
Accepted: 08.08.2021

Correspondence: Nurçin Killi
nurcinkilli@mu.edu.tr

Citation: Killi, N. et al. (2021). Invasive freshwater jellyfish has become established in artificial impoundments of Anatolian Peninsula. *Turkish Journal of Bioscience and Collections, 5*(2), 155-161. https://doi.org/10.26650/tjbc.2021984242

Abstract

Objective: A freshwater jellyfish *Craspedacusta sowerbii* is frequently found in disturbed or artificial bodies of water, e.g. quarry ponds and gravel pits, reservoirs, aquaria and even wastewater treatment facilities, it can also thrive in natural lentic and lotic habitats. In the present study, we present two new records for *C. sowerbii* which is non-native to Turkey and provide the distribution data of the species in Turkey and Europe.

Materials and Methods: The jellyfish samples were obtained from two localities by fishing nets and hand net. Temperature, pH and dissolved oxygen values of the two sampling areas were measured in both of the sampling areas.

Results: Non-native freshwater jellyfish *Craspedacusta sowerbii* is recorded from two different localities namely Akdeğirmen Reservoir (Afyon) and Atabey Reservoir (Isparta) in Turkey. Twelve individuals and two individuals of *C. sowerbii* were sampled in Akdeğirmen Reservoir (Afyon) and Atabey Reservoir (Isparta), respectively. Temperature, pH and dissolved oxygen values of the two sampling areas were 18.7ºC, 7.9, 6.34 mg/l in Akdeğirmen Reservoir, and 10.9ºC, 7.94, 9.36 mg/l in Atabey Reservoir.

Conclusion: Many studies suggested that it could tolerate a wide range of temperatures from 10°C to 28°C and spread by fish stocking activities as well as by migratory birds in Turkey. It may have been possible for *Craspedacusta sowerbii* to be introduced to Akdeğirmen Reservoir where there are many actively moving cormorants colonies. Also, spread of this species may have been facilitated by fish stocking activities in Turkish inland waters.

Keywords: *Craspedacusta sowerbii*, reservoir, invasiveness potential, Akdeğirmen, Atabey

Introduction

Craspedacusta sowerbii is a freshwater jellyfish belonging to the Olindiidae family (Classis: Hydrozoa). The origin of *C. sowerbii* is Yangtze-Kiang River System in China (Kramp, 1950) but it is now found all over the world. It was firstly observed out of its native range in a lily tank in Regent's Park in England, 1880 (Allman, 1880; Lankester, 1880a; Lankester, 1880b). The non-native ranges of this species have been reported to expand in Europe, North America, and Australia for more than two decades now (Marchessaux & Bejean, 2020).

Although *C. sowerbii* is frequently found in disturbed or artificial bodies of water, e.g. quarry ponds and gravel pits, reservoirs, aquaria and even wastewater treatment facilities, it can also thrive in natural lentic and lotic habitats (Deevey & Brooks, 1943; Dexter *et al*., 1949; Beckett & Turanchik, 1980; Rayner & Appleton, 1992; Lundberg & Svensson, 2003; Fritz *et al*., 2007).

Its chitin-covered drought resistant resting stage enables it to withstand long periods of food shortage and tolerate extreme environmental conditions, as well as serve as a convenient life-stage for anthropogenic transport (Jankowski, 2000). The life cycle of *C. sowerbii* includes both polyp and medusa stages. The species reproduces asexually, via a budding polyp and a motile frustule, and produces sexually reproducing free swimming medusae, which bud off from the polyp (Reisinger, 1957). About 50 tentacles of medusae are provided with nematocysts, which are used for capturing food and defense for predators (Sarkar & Mude, 2010).

Increasing number of reports on *C. sowerbii* in the last two decades in both Turkey (Table 2) and the world suggested that it has been spreading to new areas due to fishing and recreational activities, migratory birds, through newly constructed reservoirs, pools and ponds (Fritz *et al*., 2007). In the present study, we present two new records of *C. sowerbii* in Turkey and provide inventory for the distribution of the species in Turkey and Europe. We suggest that new findings of the species with the distribution data given in the present study is indicative of its invasiveness potential and that two additional records reported in the present study are important, as these new locations are in different regions that are far from each other and both are artificial man-made reservoirs.

Material and Methods

Data Collection

The study was carried out in two localities, namely Atabey Reservoir (Isparta, 37°56'50"N 30°36'39"E) and Akdeğirmen Reservoir (Afyon, 38°49'04"N 30°11'15"E) (Fig. 1). Atabey Reservoir with an area of 345 km² is used for recreational and irrigation purposes. There are several cages in the reservoir for trout farming. Also, amateur fishing activities are carried out in the reservoir. Akdeğirmen Reservoir (Afyon), which has an area of 5.60 km² area is used for irrigation and drinking water.

Sampling was carried out in October, 2020 in Akdeğirmen reservoir and in November, 2020 in Atabey Reservoir. Fishing nets ranging from 5 to 55 mm mesh size and small hand nets are used for sampling. Jellyfish individuals were measured and preserved in a plastic jar in Atabey Reservoir.

Figure 1. Locations of the sampling reservoirs in Turkey (1. Akdeğirmen Reservoir, Afyon, 2. Atabey Reservoir, Isparta).

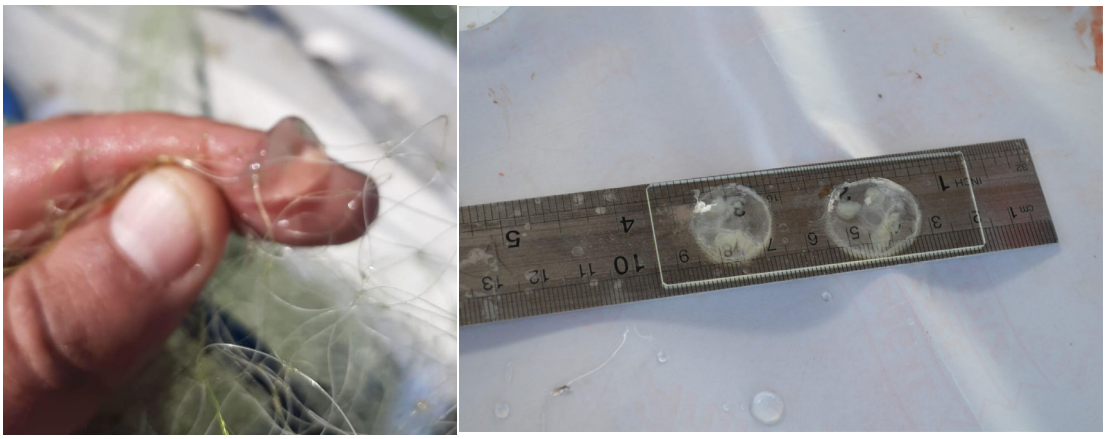

Figure 2. *Craspedacusta sowerbii* samples from Akdeğirmen Reservoir.

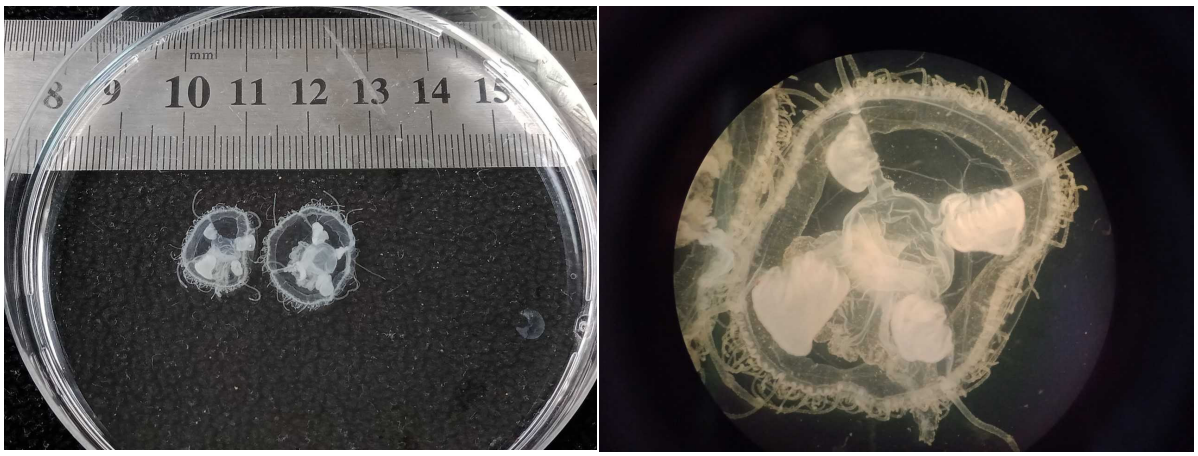

Figure 3. *Craspedacusta sowerbii* samples from Atabey Reservoir.

Results and Discussion

This study provides additional records of *Craspedacusta sowerbii* from Turkish freshwaters with some evidence of its establishment. The first record of *C. sowerbii* was from Akdeğirmen Reservoir in October, 2020 (Fig. 2). Twelve individuals were sampled, measured and preserved in a plastic jar. Bell diameters of the individuals were between 1.3 and 2.4 cm. Temperature, pH and dissolved oxygen values of the sampling area were 18.7ºC, 7.9 and 6.34 mg/l, respectively.

The second record was from Atabey Reservoir in November, 2020. Temperature, pH and dissolved oxygen values of the reservoir were 10.9ºC, 7.94 and 9.36 mg/l, respectively. Four *C. sowerbii* individuals were observed and two of them were sampled from the reservoir (Fig. 3). Bell diameters of the individuals were measured as 2.3 cm and 1.4 cm, respectively.

Some physicochemical parameters of the previous sampling sites in both Europe and Anatolia were presented in Table 1 and Table 2, respectively. According to McClary (1959) and Acker (1976), optimum temperature ranges for this species were 19-25°C. It was reported that medusae occur at temperature of 15-30°C (Milne, 1938) and also could not survive under the temperature 15°C (Dunham, 1941). However, in this study, we found that medusae survived at 10.9°C in Atabey Reservoir. In parallel, previous studies showed that this species could tolerate a wide range of temperature from 10°C to 28°C. Further, *C. sowerbii* was found in European and Turkish lakes between March and November that indicated high environmental tolerance of this species (Table 1-2). Fritz *et al*. (2007) noted that *C. sowerbii* spread rapidly after 1990's in Germany. In Turkey, this species has been recorded since 1983 - this is probably because this tiny jellyfish could not be realized before that time. Balık *et al.* (2001) and Bekleyen *et al*. (2011) suggested that fast spread of this species may have been facilitated by fish stocking activities in Turkish inland waters. Some records of *C. sowerbii* in Turkey revealed that the first appearance of this species was after fish stocking activities (Gülşahin, 2017).

In the Akdeğirmen Reservoir, we found *C. sowerbii* on the fish nets. It has been widely reported that jellyfish

Table 1. Reports of *Craspedacusta sowerbii* from Europe and some physicochemical parameters of the sampling areas.

Locality	Season/year	Temperature (°C)	pH	DO (mg/l)	Secchi depth (m)	Maximum depth (m)	Literature
Iris Pond (Israel) (Natural pool)	September/2011	25	-	8.6	0.84	3	Gasith *et al*., 2011
Germany, 97 lakes, ponds, quarry ponds, gravel pits	1923-2006	-	-	-	-	-	Fritz *et al.*, 2007
Lake Malpaga (Italy) (artificial lake)	July 2009	10.1-28.03	7.2-8.1	2.9-14.4	4	10	Stefani *et al.,* 2010
Water-filled gravel pit located near the Nemunas River (Lithuania)	August 2002	20.3°C	-	-	-	4-5	Arbačiauskas & Lesutienė, 2005
Monte da Rocha Reservoir (Spain)	October 2012	25.3°C	-	-	-	-	Gomes-Pereira & Dionísio, 2013
Pool near Velika Morava river, (Natural shallow pools), Serbia	1958-2004 from July to September	20-26°C	-	-	-	-	Grozdanić & Manojlović, 1958
Sava Lake (Man-made impoundment), Serbia	1958-2004 from July to September	20-26°C					Kalafatić, 1983
Lake Velika Peščara (Artificial water basin), Serbia	1958-2004 from July to September	20-26°C					Kalafatić *et al.,* 1999
Lake Miloševo (Reservoir), Serbia	1958-2004 from July to September	20-26°C					Ludoški *et al.*, 2004
Lake Šumarice (Artificial reservoir), Serbia	1958-2004 from July to September	20-26°C					Jakovčev-Todorović *et al*., 2010
Lake Marathon reservoir, Greece	September 2014	15.6	7.91	7.87	-	54	Karaouzas *et al*., 2015
Cingi-Lingi Lake, Croatia	March 2004	-	-	-	-	19	Stankovi´c & Ternjej 2010
Drenovets Reservoir, Bulgaria	July 2007	26.5	-	9.2	1.2	28	Kozuharov *et al*., 2017
Iskar Reservoir, Bulgaria	August 2011	25.0	-	-	-	76	Kozuharov *et al*., 2017
Studen Kladenets Reservoir, Bulgaria	July 2016	29.0	9.09	7.6	8.5	40	Kozuharov *et al.*, 2017

aggregations cause clogging the fish nets and become a problem for fishermen and fishing activities (Purcell *et al*., 2007). In this reservoir, fishermen admitted that this jellyfish lead to similar problems and become highly nuisance. Also, it has been observed that the density of this species was high in both reservoirs, which would suggest their successful establishment. For instance, *C. sowerbii* is observed every year in Ula Pond (Muğla) since it was recorded for the first time in 2016 (Gülşahin 2017). These records and observations suggested that this species formed established populations in some reservoirs of Anatolia.

The most common foods in stomach contents of sampled individuals from Malpaga Lake (Italy) were copepods and cladocerans (Stefani *et al*., 2010) especially *Bosmina spp*. (Dunham 1941). Cladoceran abundances increase in summer and autumn by parthenogenetic reproduction and

Table 2. Reports of *Craspedacusta sowerbii* from Turkey and some physicochemical parameters of the sampling areas.

Locality	Season/year	Temperature (°C)	pH	DO (mg/l)	Secchi depth (m)	Maximum depth (m)	Literatures
Topçam Reservoir-Aydın	September, October 1999	26-21	-	7.6-5.4	1.6-1.4	-	Balık *et al.*, 2001
Keban Reservoir, Elazığ	-	-	-	-	-	-	Dumont, 1994
Sapanca Lake, Kocaeli	August, September 2009	24.3	-	7.4	5.6	55	Akçaalan, 2011
Kozan Reservoir, Adana	-	-	-	-	-	-	Bozkurt, 2004
Kıralkızı Reservoir, Diyarbakır	August 2008	26.9	8.57	7.3	-	-	Bekleyen *et al.*, 2011
Ula Pond, Muğla	Eylül, 2016	25.5-25.9	-	-	-	20	Gülşahin, 2017
Uzunçayır Reservoir, Tunceli	September 2018	20.3	8.8	8.8	3.6	-	Kutlu, 2020
Ürkmez Reservoir and Küçük Menderes River, İzmir	August and September, 2014	28.7-22.0	8.36-8.45	7.63-8.44	0.3	17	Özbek & Sömek, 2020

it was determined *Daphnia spp.* and *Bosmina spp.* were found with high numbers in the plankton samples from Akdeğirmen Reservoir (unpublished data).

Polyps of *C. sowerbii* become constricted and form dormant podocysts in winter and podocysts transform into new polyps. These podocysts are dispersed by animals, commonly birds that are especially migratory such as cormorants (Sarkar & Mude, 2010). This vector might be important for dispersal of this species in Turkey. Also, it may have been possible for *C. sowerbii* to be introduced to Akdeğirmen reservoir where there are many cormorants distributed.

According to the risk identification tool of non-native aquatic species so called AS-ISK (Aquatic Species Invasiveness Screening Kit) *C. sowerbii* yielded high scores to be potential invasive species (Killi *et al*., 2020) and records from Europe and Turkey (Table 1 and Table 2) support the spreading and establishment potential of this species. Moreover, species distribution models can help understanding the potential distribution of the species under projected climate conditions and this should be taken into consideration against the possibility of the spread of this species in the future.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declare that they have no conflicts of interest.

Author Contributions: Conception/Design of study: N.K., A.S.T., S.B., S.Ö.K., Ö.E., I.K., P.Ö.V., S.A., A.S.T.; Data Acquisition: N.K., S.A., S.Ö.K., Ö.E., I.K., P.Ö.V., S.A., A.S.T.; Data Analysis/ Interpretation: N.K., A.S.T., S.Ö.K., S.A.; Drafting Manuscript: N.K., A.S.T., P.Ö.V., Ö.E.; Critical Revision of Manuscript: N.K., A.S.T.; Final Approval and Accountability: N.K., S.A., S.B., S.Ö.K., Ö.E., I.K., P.Ö.V., S.A., A.S.T.

References

Acker, T.S. & Muscat, A.M. (1976). The ecology of *Craspedacusta sowerbii* Lankester, a freshwater hydrozoan. *American Midland Naturalist*, 95(2), 323-336.

Akçaalan, R., Isinibilir, M., Gürevin, C. & Sümer, A. (2011). A new contribution of biodiversity of Sapanca lake: *Craspedacusta sowerbyi* Lankester, 1880 (Cnidaria: Hydrozoa). *Journal of FisheriesSciences.com*, 5(1), 43-46.

Allman G.J. (1880). The freshwater medusa. *Nature*, 22: 218.

Arbaèiauskas K & Lesutienë J. (2005). The freshwater jellyfish (*Craspedacusta sowerbii*) in lithuanian waters. *Acta zoologica Lituanica,* 15(1):54–57.

Balık, S., Ustaoğlu, M.R. & Özbek, M. (2001). A new locality for the freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1880 in Turkey. *Zoology in the Middle East*, 22(1), 133-134.

Beckett, D.C. & Turanchik, E.J. (1980). Occurrence of the freshwater jellyfish *Craspedacusta sowerbyi* Lankester in the Ohio River. *The Ohio Journal of Science*, 32: 323-324.

Bekleyen, A., Varol, M. & Gokot, B. (2011). A new record of the freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1880 (Hydrozoa) in Southeastern Anatolia (Turkey), *Chinese Journal of Oceanology and Limnology*, 29 (2011) 366-368.

Bozkurt, A. (2004). First Observations on Zooplankton Fauna of Some Dams and Ponds in the Eastern Mediterranean Region, *Turkish Journal of Fisheries and Aquatic Sciences*, 2, 71-76.

Deevey, E.S., Jr. & Brooks, J.L. (1943). *Craspedacusta* in open water, Lake Quassapaug, Conneticut. *Ecology*, 24: 266-267.

Dexter, R.W., T.C. Surrarrer & Davis, C.W. (1949). Some recent records of the freshwater jellyfish *Craspedacusta sowerbyi* from Ohio and Pennsylvania. *The Ohio Journal of Science*, 49: 235-241. Dumont, H.J. (1994). The distribution and ecology of the fresh- and brackish-water medusa of the world. *Hydrobiologia*, 272, 1- 12.

Dunham, D.W. (1941). *Studies on the ecology and physiology of the freshwater jellyfish, Craspedacusta sowerbii* (Doctoral dissertation). The Ohio State University.

Fritz G., Schill R., Pfannkuchen M. & Brümmer F. 2007. The freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1880 (Limnomedusa: Olindiidae) in Germany, with a brief note on its nomenclature. *Journal of Limnology,* 66 (1): 54-59.

Gasith, A., Gafny, S., Hershkovitz, Y., Goldstein, H., & Galil, B. S. (2011). The invasive freshwater medusa *Craspedacusta sowerbii* lankester, 1880 (Hydrozoa: Olindiidae) in Israel. *Aquatic Invasions*, 6 (Suppl 1), S147-S152.

Gomes-Pereira, J. N., & Dionísio, G. (2013). *Craspedacusta sowerbii* Lankester, 1880 in southern Portugal. *BioInvasions Records*, *2*(2), 133-136.

Grozdanić, S., & Manojlović, J. (1958). Nekoliko momenata iz života slatkovodnih meduza *Craspedacusa sowerbyi* Lank. Zaštita prirode 14, 1-4, Beograd.

Gülşahin, N. (2017). Muğla İli Ula Göleti'nde Bır Tatlısu Denizanası: *Craspedacusta sowerbii* Lankester, 1880, *Journal of Aquaculture Engineering and Fisheries Research,* 3 (2017) 82-86.

Jakovčev-Todorović D., Đikanović V., Skorić S. & Cakić P. (2010). Freshwater jellyfish *Craspedacusta sowerbyi* Lankester, 1880 (Hydrozoa, Onindiidae) – 50 years' observation in Serbia. *Archive of Biological Sciences*, Belgrade 62: 123-127.

Jankowski, T. (2000). Chemical composition and biomass parameters of a population of *Craspedacusta sowerbii* Lank 1880 (Cnidaria: Limnomedusa). *Journal Plankton Research*, 22: 1329-1340.

Kalafatić, V. (1983). New find of the species *Craspedacusta sowerbyi* Lankester in fauna of Yugoslavia. *Archives of Biological Sciences*, 35 (1-2), 1P-2P, Beograd.

Kalafatić, V., Martinović-Vitanović, V., & Tanaskovic, M. (1999). The freshwater medusa *Craspedacusta sowerbii* (Lankester, 1880) in FR. Yugoslavia. *Contribution to the Zoogeography and Ecology of the Eastern Mediterranean Region,* 1, 343-349.

Karaouzas, I., Zogaris, S., Lopes-Lima, M., Froufe, E., Varandas, S., Teixeira, A., & Sousa, R. (2015). First record of the freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1880 in Greece suggests distinct European invasion events. *Limnology*, 16 (3), 171-177.

Killi, N., Tarkan, A. S., Kozic, S., Copp, G. H., Davison, P. I., & Vilizzi, L. (2020). Risk screening of the potential invasiveness of non-native jellyfishes in the Mediterranean Sea. *Marine Pollution Bulletin*, *150*, 110728.

Kozuharov D., Kalchev R., Beshkova M. , Stanachkova M. , Kenderov L. , Vasilev V. & Trichkova T. (2017). Occurrence of the Alien Freshwater Jellyfish *Craspedacusta sowerbii* Lankester, 1880 (Cnidaria: Hydrozoa) in some Bulgarian Reservoirs. *Acta Zoologica Bulgarica*, Suppl. 9, 2017: 67-72.

Kramp, P. L. (1950). Freshwater medusae in China. In *Proceedings of the Zoological Society of London* (Vol. 120, No. 1, pp. 165-184). Oxford, UK: Blackwell Publishing Ltd, 1950.

Kutlu, B. (2020). Occurrence of the freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1800 from Uzunçayır dam lake (Tunceli), Turkey. *Indian Journal of Geo Marine Sciences*, 49 (05): 908-910.

Lankester, E.R. (1880a). On a new jellyfish of the order Trachomedusae, living in freshwater. *Science*, 1:34.

Lankester, E.R. (1880b). On *Limnocodium (Craspedacusta) sowerbyi*, a new Trachomedusa inhabiting freshwater. *The Quarterly journal of microscopical science*, 20:351-371.

Ludoški, J. L., Milankov, V. R., & Radišić, P. K. (2004). Allozyme pattern for new record of Craspedacusta sowerbii in Serbia. *Zbornik Matice srpske za prirodne nauke*, (106), 15-19.

Lundberg, S. & Svensson, J.E. (2003). Medusae invasions in Swedish lakes. Fauna Och Flora, 98: 18-28.

Marchessaux, G. & Bejean, M. (2020). Growth and ingestion rates of the freshwater jellyfish Craspedacusta sowerbii. *Journal of Plankton Research*, 42(6), 783-786.

McClary, A. (1959). The effect of temperature on growth and reproduction in Craspedacusta sowerbii. *Ecology*, 40(1), 158-162.

Milne, L.J. (1938). Some Aspects of the Behavior of the Fresh-Water Jellyfish, Craspedacusta sp. *The American naturalist*, 72(742), 464-472.

Özbek, M., & Sömek, H. (2020). Invasive freshwater jellyfish *Craspedacusta sowerbii* (Lankester, 1880) in Turkey: New locality record and habitat limnoecology, with an overview of distributional data in the Middle East and Balkans. *Acta Aquatica Turcica*, *16* (4), 487-497.

Purcell, J. E., Uye, S. I., & Lo, W. T. (2007). Anthropogenic causes of jellyfish blooms and their direct consequences for humans: a review. *Marine Ecology Progress Series*, 350, 153-174.

Rayner, N.A. & Appleton, C. C. (1992). *Craspedacusta sowerbii*, new record (Cnidaria: Limnomedusae) from southern Africa. *South African Journal of Zoology*, 27: 143-145.

Reisinger, E. (1957). Zur Entwicklungsgeschichte und Entwicklungsmechanik von Craspedacusta (Hydrozoa, Limnotrachylina). *Zeitschrift für Morphologie und Ökologie der Tiere*, 45, 656-698.

Sarkar, P. K., & Mude, S. N. (2010). A new site for the freshwater jellyfish *Craspedacusta sowerbii*. *Current Science*, *99*(9), 1165.

Stefani, F., Leoni, B., Marieni, A., & Garibaldi, L. (2010). A new record of *Craspedacusta sowerbii*, Lankester 1880 (Cnidaria, Limnomedusae) in northern Italy. *Journal of Limnology*, *69* (1), 189.

Stanković, I., & Ternjej, I. (2010). New ecological insight on two invasive species: *Craspedacusta sowerbii* (Coelenterata: Limnomedusae) and *Dreissenia polymorpha* (Bivalvia: Dreissenidae). *Journal of Natural History*, 44 (45): 2707-2713.