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Rapid Communication

First record of a ctenophore in lakes: the comb-jelly *Mnemiopsis leidyi* A. Agassiz, 1865 invades the Fayum, Egypt

Gamal El-Shabrawy[1] and Henri J. Dumont[2]

[1]*National Institute of Oceanography and Fisheries, Fish Research Station, El Kanater El Kharia, Cairo, Egypt*
[2]*Department of Biology, Ghent University, Belgium, and Department of Hydrobiology, Jinan University, Guangzhou, China*
E-mail: Elshabrawy_gamal@yahoo.com (GES), henri.dumont@ugent.be (HJD)

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Abstract

In 2013, the invasive marine ctenophore *Mnemiopsis leidyi* was first recorded in a true lake, Birket Qarun in the Fayum, Egyptian Desert. In 2014, it expanded in numbers and was also recorded in lake El Rayan II, south of Birket Qarun. Both lakes are saline, with Birket Qarun currently more concentrated than seawater. In the hot summer of 2015, a huge mortality was recorded, with only few larvae surviving. Whereas previous invasions were made possible by transportation in ship ballast water, trucks transporting mullet fry from aquaculture facilities in the Nile Delta to Birket Qarun and Lake Rayan II triggered the Fayum invasion. This is the first ever record of a ctenophore in an inland environment. We do not expect this invasion to be permanent, but it may damage the lake fisheries in the years ahead.

Key words: invasive species, Birket Qarun, aquaculture

Introduction

The 'modern' Fayum lakes (for a detailed discussion, see El Shabrawy and Dumont 2009) are fed by Nile water, first pumped to the agricultural areas surrounding them, and then drained to the lake(s). They are situated in the desert, at c. 100 km South-West of Cairo, in a depression below sea level (El Rayan, for example, is at -60m). The depression was created by wind deflation around 1.8 my y ago, and intermittently contained natural lakes until the mid-Holocene (Ball 1939). After the Holocene humid period, the lakes fell dry until the Middle Kingdom, when Pharaoh Amenehat I (1980–1970 BC) ordered a canal to be cut across the c. 25 km that separate Birket Qarun from the Nile. This became known as the Bahr Yusuf canal throughout antiquity, and the lake that became filled with Nile water was known as Lake Moeris. It covered a much larger surface (c 725 km^2) than the present Lake Qarun (235 km^2), and was of freshwater until the canal silted up. During the 19th century, water flow through the canal gradually stopped and the hydrological balance turned more and more negative. At present, average depth is only 4m., and maximum depth is 8m.

Ctenophores (comb-jellies) are exclusive marine animals, although several species show a preference for brackish waters and live in estuaries and coastal lagoons in open connection with the sea. One species, *Mnemiopsis leidyi* A. Agassiz, 1865, native of the east coast of the Americas, has gained notoriety after it invaded the Black and Caspian Seas in the 1980s and 1990s (Ivanov et al. 2000), causing great ecological damage to these quasi-closed saline-water ecosystems, including a collapse of their pelagic fisheries. *Mnemiopsis* is correctly considered one of the world's worst invaders. The vector that explains the success of its transatlantic travels is believed to have been ship ballast water; and the origin of the invader is situated in some estuary in North or South America.

The Caspian is a giant brackish-water lake, with a gradient in salinity from the freshwater north to the south, where salinity reaches 12–13 psu. It is the endorheic end-point of the Volga

River, but its size (about 400,000 km^2) is so large that it is usually referred to as a sea (Dumont 1998). Soon after *Mnemiopsis* invaded the south and central basins (Ivanov et al. 2000), it depleted the zooplankton and pelagic fish larvae and eggs, and made a flourishing sardine fishery collapse. It has remained a dominant element of the pelagic zone ever since, in contrast to the Black Sea, which recovered after *Beroe* (also a comb jelly), and a natural predator of *Mnemiopsis*, arrived on the scene (Kideys 2002).

Around 2005, a second wave of ballast-water driven invasions struck the North Sea coasts from France to the Baltic (Antayan et al. 2014). At that same time, *Mnemiopsis* expanded across the Mediterranean Sea, which it had so far largely avoided because of its supra-optimal salinity. This expansion required an adaptation to a higher salinity, and may have happened in the Black Sea, or by a new ballast-water mediated invasion directly to the Mediterranean (Ghabooli et al. 2011). Here, we report that the strain involved has now crossed yet another barrier, that between the sea and two true land-locked lakes, Birket Qarun and Lake El Rayan II.

Material and methods

Jelly samples were collected in 2014, on a transect of Birket Qarun (twelve stations) once per season, using a 75 cm mouth and 0.5 mm mesh size plankton net equipped with a flow meter to quantify the volume of water filtered. The net was hauled horizontally at a ship speed of 1–1.5 knots for up to 3 minutes. Because ctenophores are notoriously difficult to preserve, no fixation was attempted. Animals were therefore transferred to a flat-bottom tray and counted alive. From Wadi El Rayan only qualitative records are available, mainly by fishermen. In 2015, the only sightings were done by members of the research team of the Fish Research Station of El Kanater.

Results

The first observations of jellies, in Birket Qarun, were in March 2013, by fishermen detecting jelly accumulations in their nets. Because the original inoculum must have been small, this pushes the likely date of the introduction back to around 2010 or earlier. In spring 2014, there was an outburst. On a transect of 12 stations, two stations had no jellies, but two had up to 40 m^{-3}, sized on average 30–40 mm, with few specimens

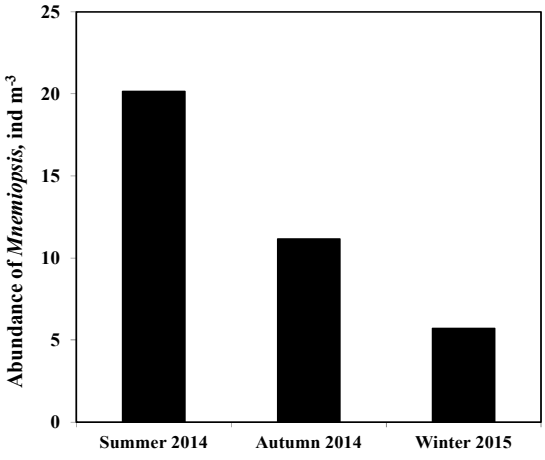

Figure 1. Average surface water abundance of *Mnemiopsis leidyi* in Birket Qarun in summer and autumn 2014 and in winter 2015.

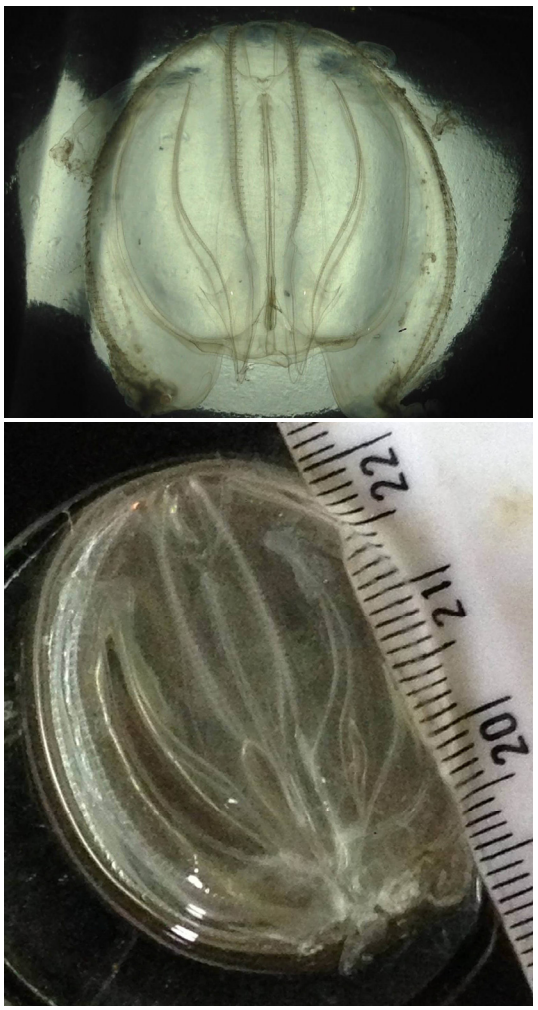

Figure 2. *Mnemiopsis leidyi* captured in Birket Qarun on October 30, 2015. Photographs by Safaa, S. A. El-Gelani.

up to 6 cm. Mediterranean specimens reach over 10 cm, with the Fayum animals smaller, more like those of the Caspian Sea. In summer, abundance remained around 20 per cubic meter, dropping to 10 in autumn and below 5 in winter (Figure 1). It occurs as well in Birket Qarun as in Lake Rayan II (50.9 km^2, current salinity c. 20 psu), suggesting two independent introduction events. It does not occur in Lake Rayan I (62 km^2, salinity c. 2 psu).

In summer 2015, an extended heat-wave hit northern Egypt, and the surface water of the Birket became heated to temperatures around 40 degrees. Under these circumstances the comb jellies perished, the water was replete with jelly fragments, and only some small larvae survived.

The plum-shaped animals were identified on sight from their shape and the fact that their oral lobes arise at the level of the infundibulum, which is typical of *Mnemiopsis* (Figure 2) and rules out *Bolinopsis,* the one genus with which confusion might be possible.

Discussion

As the Bahr Yusuf canal lost its function, salinity in Birket Qarun started rising. Around the beginning of the 20th century, the lake became mesohaline. Around 1970, it became equivalent to seawater. At present it is hypersaline and fluctuates at 40–45 psu. The current water supply entirely results from the pumping back of drained Nile water used for agricultural irrigation. Since the 1970s, an overflow of drainage water from the Birket has been allowed to flow into the formerly dry beds of the two El Rayan lakes situated further south. Birket Qarun, and currently also the Rayan lakes, are exploited lakes. Qarun has been an important regional source of fish protein throughout history, but the catch gradually shifted with salinity, from Nilotic (*Tilapia*-based) to marine (*Mugil* and *Liza*-based) species. The current Mugil landings are estimated at around 4,000 t per year.

While all previous invasions by *Mnemiopsis* have been attributed to ballast water, this was not the case in the Fayum waters where co-transportation with marine fish fry is believed to be the introduction pathway. Mullet is the main harvested species, but it does not reproduce to a measurable extent in the lake(s). Year-class I provides the main catch, and thus yearly re-introductions are needed to maintain an exploitable population (El-Serafy et al. 2014). Fry (around 2 cm in size, with about 10 million released per lake per year) are trucked in aerated fiberglass tanks (2 m^3 volume, 3 tanks per truck, c. 50,000 fry per tank) from Mediterranean aquaculture facilities in Alexandria, Damietta and Suez to the lakes, a trip of c. 5 hours duration. The fish-culturing facilities are at least in part consisting of nets hung up in the estuaries of the Nile delta lakes with a free circulation of Mediterranean water inside. *Mnemiopsis* almost certainly was attracted to the fry, and ended up in transportation tanks. In spite of being a fragile jelly organism, it clearly proved capable of surviving the five hours trip to the Fayum.

Ctenophores are non-selective pelagic carnivores that will not find a wide array of food items in the Fayum lakes. In fact, only the calanoid copepod, *Paracartia setosa,* at a maximum of about 100 specimens per liter in summer 2013 (N.K.S. Ahmed, unpublished data), is a reliable food source. But by winter 2014–2015, copepod numbers had dropped to nil and showed no sign of recovery by March 2015 (N.K.S. Ahmed, unpublished data). No official change in fish landings has been reported in 2014 but fishermen complained about decreasing catches. We expected a collapse or at least an effect of the invader on the fish landings in 2015, but exceptional climatic conditions prevented this. It remains to be seen whether the *Mnemiopsis* population will survive to 2016, and potentially any subsequent impacts on the fisheries need to be identified in the case of a sustainable population in the Fayum lakes.

Conclusions

The invasion of two out of three Fayum lakes proves that ctenophores can live in saline limnic environments not connected to the ocean, if introduced there by humans. In the present case, they were capable of surviving transport in a relatively small volume of water, with high densities of fish fry. Their chances of survival in lakes with a suitable salinity will primarily depend on the availability of food, although, rather unexpectedly, high water temperature also turned out to be important. Only one species of calanoid copepod is available in Birket Qarun, which may ultimately prove fatal to a predator that, in nature, relies heavily on a varied diet of plankton, planktonic fish eggs, and fish larvae. (Purcell et al. 2001) In the long-term, the survival of the ctenophore is therefore not probable, and the combined effects of food scarcity and suboptimal

physical environmental factors (notably temperature) may drive it to extinction. Of course, repeated introductions remain a possibility, and may occur as long as the Birket needs to be replenished with fish.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records *Mnemiopsis leidyi* in Birket Qarun in 2014–2015

Appendix 1. Video of *Mnemiopsis leidyi* captured in Birket Qarun on October 30, 2015

This material is available as part of online article from:
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