Restocking of Lake Banyoles (Girona, Catalonia, Spain) with juvenile naiad (Unionidae) born in captivity.

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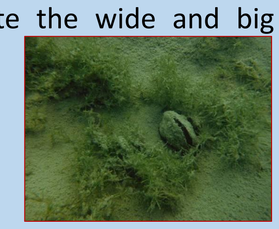
THE NAIAD BREEDING LABORATORY

The Naiad Breeding Laboratory belonging to the Consorci de l'Estany, funded by two consecutive LIFE projects (LIFE08 NAT/E/000078 and LIFE12 NAT/ES/001091), was created in 2010 as part of the project to restore populations of *Unio mancus* and U. *ravoisieri* in Lake Banyoles. Its facilities are used for semi-captive breeding of naiads. The main goal of this laboratory is to obtain juveniles for restocking suitable habitats in the basins of the rivers Ter and Fluvià, as well as Lake Banyoles.

NAIAD POPULATIONS

Less than 2000 *Unio mancus* and 200 *U. ravoisieri* remain in Banyoles Lake, despite the wide and big decline that these species have suffered during the second half of the XX century. They are located especially in draining outflow channels and in the main Lake. Banyoles Lake and irrigation channels have stable water or flow level, usually -but not ever- soft bottoms, and often absence of riparian forest.



LOCATION

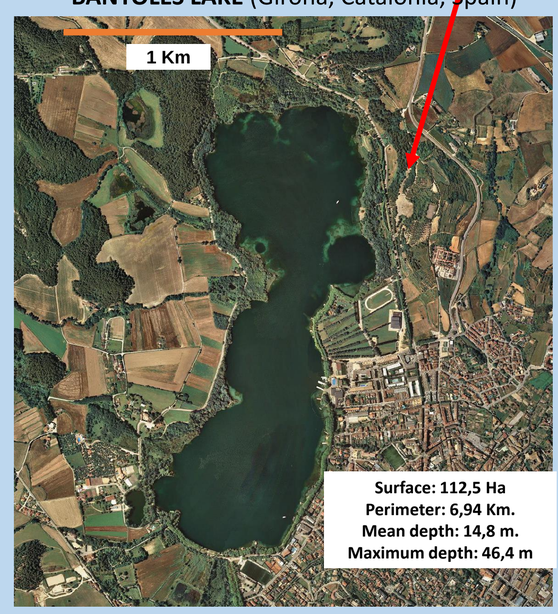
Lake Banyoles is the second largest lake in the Iberian Peninsula. The lake is part of the karstic system of Banyoles-St. Miquel de Campmajor. Its origin is to be found in the dissolution of the underlying gypsum and eocenic marl layers by the underground currents, what causes downfalls of the ground in the form of a bucket or doline. It is formed by 6 sub-buckets and 13 points of water surges in the so-called polje, producing a complex bathymetry.

Water has a high dissolved salts content, mainly sulphates and carbonates, which explains the high conductivity (0.8-1.9 mS(cm.) It arrives at a constant temperature of 19ºC and the length of residence in the lake is low (0.8 years). There is a complex stratification of the water column: the most superficial layer (*mixolimnion*) tends to separate in two during the summer (*epilimnion* and *hipolimnion*). Some of the buckets undergo *meromixis* processes. The lake is considered oligo-mesotrophic (chla a: 1-15 mg /l) Due to the bathymetric profile of the lake and the high stability of the water level, vegetal communities are configured in clearly defined concentric belts.

Draining outflow channels occuped by *Unio mancus*

Banyoles Lake, occuped by *Unio ravoisieri*

BANYOLES LAKE (Girona, Catalonia, Spain)



1 RELEASE OF SMALL JUVENILES IN 2012

Release of 6000 small juveniles (<0.3 mm) born the same year (0+ year) which were directly seeded in:

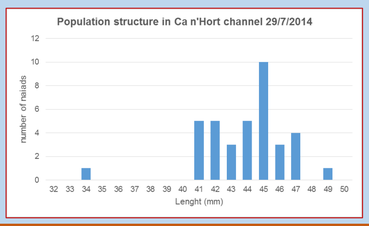
1.A. In a tray with natural sediment placed into the lake

1.B. In a tray with natural sediment placed in the outflow channel

1.C. Directly into de sediment of the lake outflow channel or inflow stream

Syst.	Location	Sector	Juveniles	Results
1A	Amaradors	Lake Banyoles	517	0 recovered
1B	Teixidor	Outflow channel	3379	Possible recoveries 100 meters down the channel
1C	Ca n'Hort	Outflow channel	1782	1 juvenile in 29/5/2013 (25.9 mm length) and 37 in 29/9/2014 (Lenght average: 44,3 mm)
1C	R. Morgat	Inflow channel	387	0 recovered

Revision results: The results were wholly negative in the lake, although some live individuals were recovered two years later (year 2+) in the outflow channels.

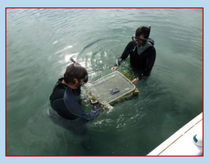


2 RESTOCKING WITH 1 YEAR JUVENILES IN 2012

One-year-old naiads (10–12 mm) born in 2011 were released into a tray with sediment into the bottom of the lake on 8/5/2012.

Revision results:

- 0 recoveries in 23/10/12 inside the tray.
- We recover a living naiad next to the tray 20/10/2012 of 28,1 mm length.
- All the naiads released using this second system were predated, probably by carp (*Cyprinus carpio*)
- We recovered shell pieces broken due to depredation. *Chara* sp. algae grow and covered the tray.

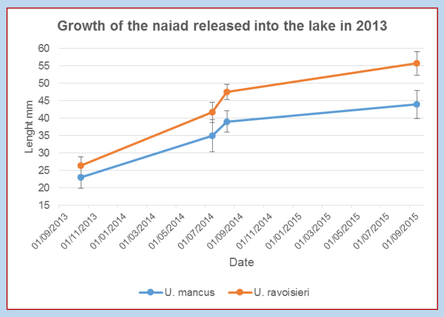


3 RESTOCKING WITH 2 YEARS JUVENILES IN 2013

Two-year-old naiads (25–30 mm average length) born in 2011 were directly seeded into the natural sediment at the bottom of the lake and its outflow channels. The two-year-old mussels were individually marked with a code, green for *U. mancus* and orange for *U. ravoisieri*.

- 502 young naiads were seeded using this system in 4 locations of the Banyoles lake, 1 located in an outflow channel and 1 more in a inflow stream to the lake.

Code	Localization	Number Juveniles 2 years	Length (mm) 2013	Release Date 2013	Naiads Number 2014	Naiads Number 2015	Survival 2 years after release
UMA1	Banys Vells - Lake	79	20.3	13/10/2013	0	0	0%
UMA2	Figuera Xo – Channel	121	23.1	13/10/2013	31	8	6,6-25,6%
UMA3	Can Morgat - Channel	78	20.6	13/10/2013	Not reviewed	Not reviewed	- %
URA1	La Cuaranya - Lake	83	26.3	13/10/2013	28	17	20,5-32,6 %
URA2	Caseta de Fusta – Lake	67	22.9	13/10/2013	1	0	0-1,5 %
URA3	La Draga - Lake	74	26.6	13/10/2013	0	0	0%

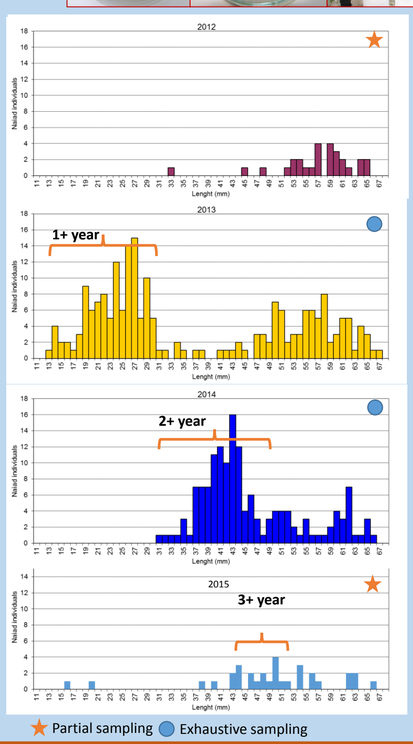


Revision results

- The two-year-old naiads had differing survival rates depending on the area in which they were released. We only recovered individuals in two out of six seeding sites – in 2015, two years after release – but they had notably increased in length. The average length increased from 23.1 to 43.9 mm in *U. mancus* and from 26.3 to 55.7 in *U. ravoisieri* at the 4rt year of their life.
- Two dead juveniles were found in the outflow channel (UMA2), with the shell broken.
- It's not easy to find the individuals released into the lake. The 2015 review of the restocked mussels allow the recapture of some individuals not recovered in the reviews of 2014.

4 RELEASE OF FISH INFECTED WITH GLOCHIDIA

Release into the lake of 3.517 parasitized fish most of them in 2012. Some fish released into the lake, moved to the output channels, where they lost mussel juveniles.



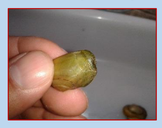
Revision results

- In the Naiad sampling of outflow channels of the lake a significant recruitment of naiad juvenile from releasing fish in 2012 have been found. In the monitoring of the Ca n'Hort-Teixidor channel in 2013, 2014 and 2015 appears the generation born in 2012.

DEPREDATION PROBLEMS

In 2014 we carried out a trial about predation of naiad juveniles by carp (*C. carpio*). In July 3 naid juveniles (2+ years, 31-33 mm long) were left in a lab pool with 3 carps. After 10 days the naiad were depredated by the carps, who broke the shell into pieces recovered from the bottom of the pool.

We can confirm the predation by other fish like pumpkinseed (*Lepomis gibbosus*) or freshwater blenny (*Salaria fluviatilis*), and by aquatic bird like mallard (*Anas platyrhynchos*).



CONCLUSIONS

- In places with a stable presence of carp or other predators, we recommend that restocking is carried out with naiads over 40 mm in length or, alternatively, that they be released into habitats with natural refuges. Given that, if they survive, juveniles grow faster whenever directly seeded into natural habitats.
- We are now experimenting with other systems like retaining mussel's juveniles temporarily in cages into the lake with protective nets.
- The release of fish infested with glochidia into the wild has been especially successful in the channels.