REPTILES & AMPHIBIANS

Extended Breeding of the Marsh Frog, *Pelophylax ridibundus* (Pallas 1771)

Mykola Drohvalenko

Zoology and Animal Ecology Department, V.N. Karazin Kharkiv National University, Svobody Square 4, Kharkiv, Ukraine (m.drohvalenko@karazin.ua)

In temperate climates, most anurans, triggered by rainfall and rising temperatures, breed in the spring (e.g., Duellman and Trueb 1986); this allows larvae to develop and metamorphose before the onset of cooler temperatures in autumn. The Marsh Frog (*Pelophylax ridibundus*), one of the most widely distributed Eurasian amphibians, is known to breed with some minor variation from the beginning of April through the beginning of June. Development begins roughly a week after fertilization and normally requires two to three months (Pysanets 2014). Herein, we report some unusual observations made during the 2020 breeding season.

From 6–8 August 2020, along the shore and floodplains of Khortytsia Island in the Dnipro River, Zaporizhzhia, Ukraine (47.829°N, 35.061°E – 47.795°N, 35.125°E), we observed Marsh Frogs in both early and late stages of larval development (Fig. 1). We simultaneously observed froglets that had almost completed metamorphosis, metamorphs in various stages of tail resorption, tadpoles in the middle stages of hindlimb development (about stage 37; Gosner 1960), and small larvae lacking hindlimb buds. Given the 2–3-month time period required for development of waterfrogs, these observations are indicative of an exceptionally long breed-

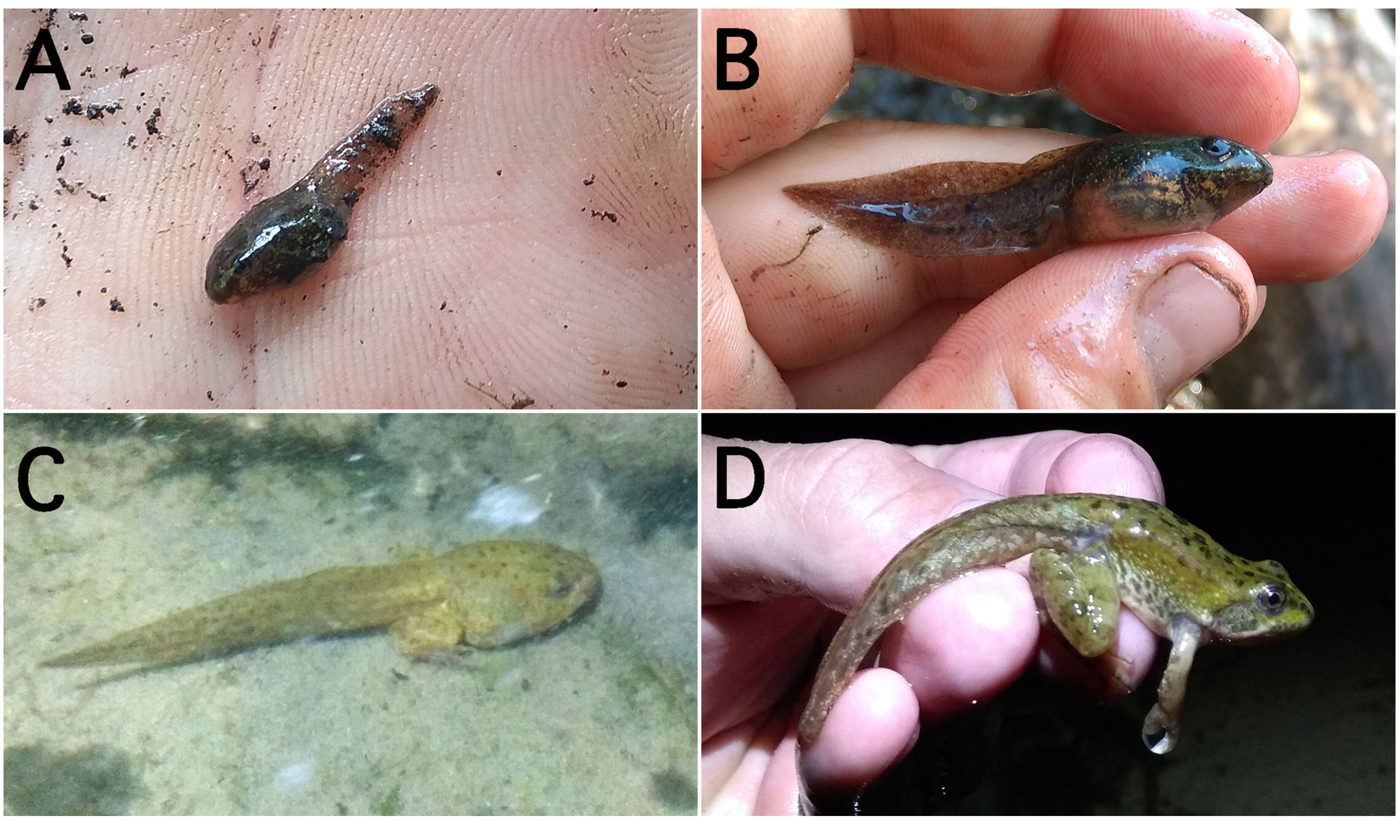

Fig. 1. Larval Marsh Frogs (*Pelophylax ridibundus*) at various stages of development found during a two-day period on Khortytsia Island, Zaporizhzhia, Ukraine: early-stage tadpole (A), mid-stage tadpole with hindlimbs (B), tadpole in early stage of metamorphosis (C), and metamorph (D). Photographs by Mykola Drohvalenko.

Reptiles & Amphibians ISSN 2332-4961

ing period lasting from May (for the largest tadpoles and metamorphs) until late July (for the smallest larvae without hindlimb buds). We found additional indirect evidence for an abnormally long 2020 breeding season in a pond with a hybridogenetic population system of both *Pelophylax esculentus* (hemiclonal hybrids known as "Edible Frogs") and *P. ridibundus* (Meleshko et al. 2014) in the Kharkiv Region of eastern Ukraine, where we found a female *P. esculentus* on 3 July 2020 still full of eggs, which subsequently were discharged in the laboratory. Also, on 28 September 2020, we found quite young and very small froglets with unresorbed tail remnants in a pond at the periphery of Kharkiv in the Zhychorets River Valley. Also in Kharkiv, we had found the first already quite large waterfrog tadpole of the 2020 season on 17 June 2020.

Any hypothesis attempting to explain such an unusually long breeding season raises even more questions. Slowing tadpole growth can lead to the desynchronization of development and can be driven by overcrowding within a relatively small environment (Berger 2008). However, all of the observations reported herein occurred in a major river (Dnipro) and its connecting floodplain channels. An examination of climatic conditions seems to provide more plausible answers. May 2020 was relatively cold and humid (Fig. 2) with periods of cool rain. Such conditions could affect frog breeding behavior. Add relatively low water temperatures (near 15 °C), which are at the lower limit of breeding preferences for these frogs (Pysanets 2014), and behavioral and temporal shifts are hardly surprising. However, the smallest larvae, products of the latest breeding activity, were found in floodplain channels south of Khortytsia Island, where the water should be warmest. Late breeding seems to be relatively common and even winter activity has been reported in artificially heated water, such as that close to power stations (Bogdan et al. 2011; Fominykh and Lyapkov 2012). However, late breeding in natural bodies of water can lead to mortality of larvae that have not completed metamorphosis. Another climate-related hypothesis looks at warm winters (Fig. 3). If too hot and too dry, frogs are unable to hibernate properly and require more of the subsequent spring to attain the necessary reproductive fitness to breed successfully (Carey and Alexander 2003). In the case of the abnormally long breeding season in 2020, the driving force remains unclear and might be a combination of these and other factors.

The adaptive capacity of waterfrogs to withstand climatic changes has been investigated in only a few isolated ponds (e.g., Llorente et al. 2006) and in drought conditions (Todd et al. 2011; Walls et al. 2013), neither of which is applicable to our study. As an invader in parts of Europe, the Marsh Frog has had an alarming impact on native amphibian populations, disrupting native waterfrog communities and, in some regions, disturbing natural hybridogenetic population systems (Leuenberger et al. 2014; Litvinchuk et al. 2020). The capacity of *P. ridibundus* to adjust its reproductive phenology could facilitate its invasion of new habitats and disruption of native anuran communities and, as such, deserves further investigation by the scientific community.

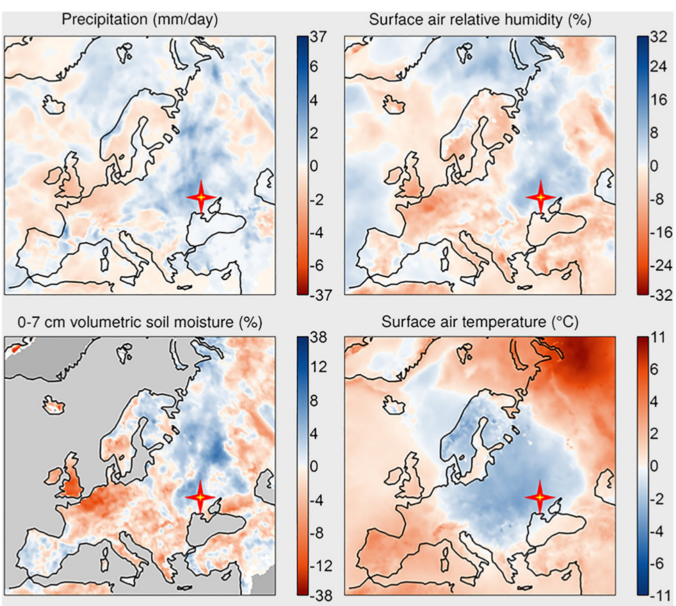

Fig. 2. Climatic conditions during May 2020. The color scale at the right of each map is based on the climatic index for May 2020 for reference period 1981–2010 (data ERA5). Stars mark the approximate location of Khortytsia Island, Zaporizhzhia, Ukraine. Copernicus Climate Change Service C3S/ECMWF.

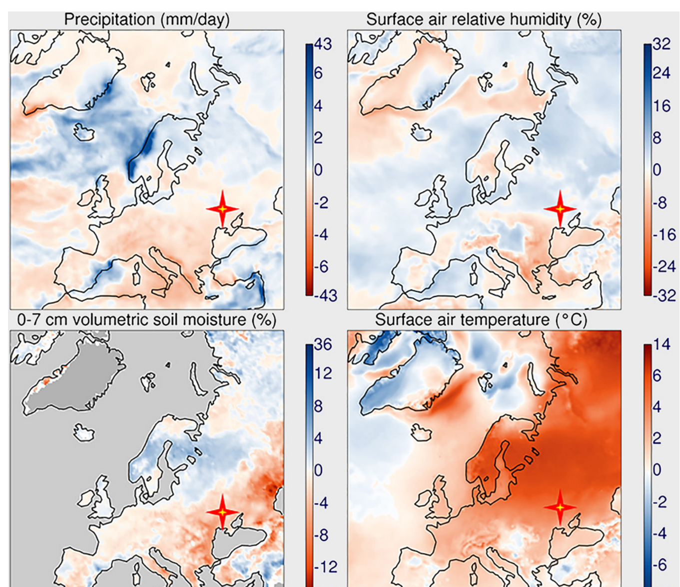

Fig. 3. Climatic conditions during January 2020. The color scale at the right of each map is based on the climatic index for January 2020 for reference period 1981–2010 (data ERA5). Stars mark the approximate location of Khortytsia Island, Zaporizhzhia, Ukraine. Copernicus Climate Change Service C3S/ECMWF.

Acknowledgements

I thank O. Korshunov and D. Shabanov for research consultation and A. Fedorova for accompanying me in the field.

Literature Cited

Berger, L. 2008. *European Green Frogs and Their Protection*. Fundacja Biblioteka Ekologiczna, Prodruk, Poznań, Poland.

Bogdan, H.-V., S.-D. Covaciu-Marcov, C. Antal, A.-Ş. Cicort-Lucaciu, and I. Sas. 2011. New cases of winter-active amphibians in the thermal waters of Banat, Romania. *Archives of Biological Sciences* 63: 1219–1224. https://doi.org/10.2298/ABS1104219B.

Carey, C. and M.A. Alexander. 2003. Climate change and amphibian declines: Is there a link? *Diversity and Distributions* 9: 111–121. https://doi.org/10.1046/j.1472-4642.2003.00011.x.

Duellman, W.E. and L. Trueb. 1986. *Biology of Amphibians*. McGraw-Hill, Inc., New York, New York, USA.

Fominykh, A.S. and S.M. Lyapkov. 2012. The formation of new characteristics in the life cycle of the Marsh Frog (*Rana ridibunda*) in thermal ponds. *Biology Bulletin Reviews* 2: 211–225. https://doi.org/10.1134/S2079086412030036.

Gosner, K.L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica* 16: 183–90.

Leuenberger, J., A. Gander, B.R. Schmidt, and N. Perrin. 2014. Are invasive Marsh Frogs (*Pelophylax ridibundus*) replacing the native *P. lessonae*/*P. esculentus* hybridogenetic complex in western Europe? Genetic evidence from a field study. *Conservation Genetics* 15: 869–878. https://doi.org/10.1007/s10592-014-0585-0.

Litvinchuk, S.N, A.Y. Ivanov, S.A. Lukonina, and O.A. Ermakov. 2020. A record of alien *Pelophylax* species and widespread mitochondrial DNA transfer in Kaliningradskaya Oblast' (the Baltic coast, Russia). *BioInvasions Records* 9: 599–617. https://doi.org/10.3391/bir.2020.9.3.16.

Llorente, G., A. Montori, and A. Richter-Boix. 2006. Breeding phenology of an amphibian community in a Mediterranean area. *Amphibia-Reptilia* 27: 549–559. https://doi.org/10.1163/156853806778877149.

Meleshko, O.V., O.V. Korshunov, and D.A. Shabanov. 2014. The study of three hemiclonal population systems of *Pelophylax esculentus* Complex from the Seversko-Donetskiy center of green frogs' diversity. *The Journal of V.N. Karazin Kharkiv National University*, *Biology* 20: 153–158.

Pysanets, Y. 2014. *Amphibians of Eastern Europe. Part II. Order Ecaudata*. Zoological Museum, National Museum of Natural History, National Academy of Sciences of Ukraine, Kyiv, Ukraine (in Ukrainian and English).

Todd, B.D., D.E. Scott, J.H.K. Pechmann, and J.W. Gibbons. 2011. Climate change correlates with rapid delays and advancements in reproductive timing in an amphibian community. *Proceedings of the Royal Society B: Biological Sciences* 278: 2191–2197. https://doi.org/10.1098/rspb.2010.1768.

Walls, S., W. Barichivich, and M. Brown. 2013. Drought, deluge and declines: The impact of precipitation extremes on amphibians in a changing climate. *Biology* 2: 399–418. https://doi.org/10.3390/biology2010399.