Short Communication

Citizen scientist in action: first evidence of the non-native spiny-cheek crayfish *Faxonius limosus* (Rafinesque, 1817) as a trophic source for water-related birds

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Abstract - We report the first European record of five shorebirds (*Anas platyrhynchos*, *Fulica atra*, *Larus michahellis*, *Melanitta fusca,* and *Podiceps cristatus*) preying on the non-native spiny-cheek crayfish (*Faxonius limosus*) in Lombardy (Northern Italy). This crayfish is considered an invasive alien species, rapidly spreading all over the country, primarily in northern regions. These first observations of predation by bird species evidenced the availability of *F. limosus* as a new trophic resource, even for mostly herbivorous species, such as *F. atra* and *A. platyrhynchos*. In this note, we would also highlight the role of citizens in providing further records of new interactions among native and non-native species.

Key words: allochthonous species, predation, riverine habitats, citizen science, Italy.

Riassunto - La scienza partecipata in azione: prime evidenze del gambero non autoctono *Faxonius limosus* (Rafinesque, 1817) come fonte trofica per gli uccelli acquatici.

Riportiamo le osservazioni di predazione del gambero americano (*Faxonius limosus*) in Lombardia (nord Italia), da parte di cinque specie di uccelli acquatici (*Anas platyrhynchos*, *Fulica atra*, *Larus michahellis*, *Melanitta fusca* e *Podiceps cristatus*). Il gambero americano, classificato come IAS (*Invasive Alien Species*) a livello europeo, risulta essere in espansione su tutto il territorio italiano, in particolare nelle regioni settentrionali. Le osservazioni di predazione evidenziano la disponibilità di *F. limosus* come nuova risorsa trofica per determinate specie di uccelli. In questa nota sottolineiamo l'importanza della scienza partecipata (*citizen-science*) per la raccolta di dati, supportati da foto/video, per lo studio delle interazioni tra specie autoctone ed alloctone.

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Parole chiave: specie alloctone, predazione, habitat fluviali, citizen-science, Italia.

Social media and photographic online databases can represent a fundamental source of information and data for scientific approaches (Silvertown, 2009). Citizens can collect a large amount of data useful to researchers, often obtaining data for new species on unexpected sites or specific ecological relationships (Foster-Smith & Evans, 2003; Lepczyk, 2005). In this regard, citizens may also be useful to record data about non-native (allochthonous) species (Battisti & Cerfolli, 2021).

Invasive species are considered among the main drivers of the loss of biodiversity worldwide (MEA, 2005). Several definitions of invasive species have been provided in scientific literature (Colautti & MacIsaac, 2004). The International Union for Conservation of Nature (2024) classifies as "invasive" all alien species that have a harmful effect on the economy, environment, or human health. The impacts of invasive alien species (IAS) are estimated at all the biodiversity levels: genetic (e.g., interspecific hybridization) (Haynes *et al.,* 2012), extinction of animal and plant population and species (Blackburn *et al.,* 2019) and changes at ecosystem/landscape levels (Pejchar & Mooney, 2009). IAS can also cause economic damage to infrastructures and spread animal diseases (Pejchar & Mooney, 2009; Chinchio *et al.,* 2020)

Due to their biological characteristics, such as their ability to spread without apparent natural controls (e.g., natural predators and diseases), several IAS can rapidly colonize new sites, leading to a growth of population level unchecked and over-control (e.g., Graebner *et al.,* 2012). In this regard, the management of IAS is still challenging worldwide (Gentili *et al.,* 2021), and the direct human interventions to control or remove IAS are often difficult (e.g., Sharp *et al*, 2011; Bonanno, 2016). However, the study and identification of IAS predators could represent an important step towards the correct management of these species, especially for the control of population growth. Indeed, the predation of IAS can potentially impact their population dynamics, reducing their numbers and

mitigating their ecological impact. Understanding these interactions can lead to the development of new conservation strategies for native species, as well as strategic management plans for controlling and managing IAS populations.

Considering the latest Implementing Regulation 2022/1203 EU to update the list of IAS, six crayfish species are considered as IAS in Europe: *Procambarus clarkii* (Girard, 1852), *Orconectes virilis* (Hagen, 1870), *Pacifastacus leniusculus* (Dana, 1852), *Procambarus fallax f. virginalis* (Hagen, 1870), *Faxonius rusticus* (Girard, 1852), and *Faxonius limosus* (Rafinesque, 1817). Several studies highlighted the negative effects of these species on entire ecosystems, primarily in susceptible environments, such as wetlands and inland waters (e.g., Arce & Diéguez-Uribeondo, 2015).

The spiny-cheek crayfish (*Faxonius limosus*) is a North American native species (United States and Canada) (Momot, 1988), and is considered the first alien crayfish introduced in Europe (Todorov *et al.,* 2020). Due to the intentional release of mature individuals for fish farming activities, it has now become invasive worldwide, deeply impacting the colonized environments (Invasive Species Compendium, 2022). In Europe, the species was first observed in 1890 in Poland, spreading all over several other countries (Holdich & Black, 2007; Souty-Grosset *et al*., 2006; Todorov *et al.,* 2020).

In Italy, the presence of spiny-cheek crayfish was documented for the first time in 1991, in Lake Iseo (Lombardy, Northern Italy), and nowadays can be regularly observed in several Italian regions (Aquiloni *et al.,* 2010). The European distribution and the ecological traits of *F. limosus* are exhaustively studied in several studies (e.g., Kozák *et al.,* 2006; Holdich *et al.,* 2009; Aquiloni *et al.,* 2010; Kaldre *et al.,* 2020), but less information is known about predators of this invasive crayfish species, both in Europe and Italy.

In this note, we report records of five water-related bird species preying on the spiny-cheek crayfish: i.e., *Fulica atra*, *Anas platyrhynchos Larus michahellis*, *Melanitta fusca*, and *Podiceps cristatus*. To the best of our knowledge, these records represent the first photographic evidence of predation of *F. limosus* by bird species in Europe. Each record consists of documentative photos, date, and location of the observation. These records were obtained during a review conducted between December 2023 and June 2024, focusing on freshwater crayfish preyed by water-related species: we analyzed all the scientific literature available on the main web search engine (Google Scholar and Web of Science), and in the platform iNaturalist, using the English and the corresponding Italian keywords: “crayfish”, “crawfish”, “predation”, “bird species”, “Italy” and several word combinations. The spread of invasive species is often complex to study (Arim *et al.,* 2005), and high-quality updated data about IAS are needed for a better knowledge of their current distributions and their ecological impacts at small and large scales. In this regard, data provided by citizens is welcome.

All six observations were made in the Lombardy region (Northern Italy) (Tab. 1). A *F. atra* juvenile and a *P. cristatus* adult were observed preying on *F. limosus* in Paratico, near Lake Iseo and River Oglio (Fig. 1). In the River Adda, in Pescate, a *F. atra* and a *A. platyrhynchos* adult female were observed with similar predator behavior (Fig. 2). The *M. fusca* observation was made in Lake Garlicate, while for the last record, the identification of the crayfish species was based on a photo of a *L. michahellis* pellet found in Angera, near Lake Maggiore (Fig. 3).

Bird species, such as *P. cristatus*, *L. michahellis,* and *M. fusca,* are well-known for their carnivorous diet, mainly consisting of fishes, crustaceans, and gastropods (e.g., Stempniewicz, 1986; Gwiazda, 1997; Durinck *et al.,* 1993), and *F. limosus* can potentially become an important food resource of the species, especially in Lombardy lakes and rivers. Instead, *F. atra* and *A. platyrhynchos* have a food spectrum primarily consisting of plant species (e.g., Perrow *et al.,* 1997; Metna *et al.,* 2015; English *et al.,* 2017). Observation of these mainly herbivorous species preying on *F. limosus* can possibly represent an act of defense or a change in the diet due to the new availability of the crayfish as a trophic resource.

As already documented for the red-swamp crayfish, introduced crayfish species can represent a food resource for many native taxa in Europe (Correia, 2001) and Italy (e.g., Fasola & Caldarelli, 2015; Delmastro, 2017).

The presence of *F. limosus* in the Lombardy region is well documented for the provinces of Bergamo, Brescia, Como, Lodi, Milano, Pavia, and Varese (Fea *et al.,* 2006). such as the Lakes of Varese (Pilotto *et al.,* 2008), Garda (Aquiloni *et al.,* 2010), and Maggiore (Garzoli *et al.,* 2020; Boggero *et al*., 2023). The collected records confirm the presence of the species in lakes and small rivers (River Adda) in the provinces of Brescia, Lecco, and Varese.

Tab. 1 – First records of the water-related birds preying on non-native Spiny-cheek crayfish *Faxonius limosus* in Italy. / Prime segnalazioni di uccelli acquatici che predano il gambero non autoctono *Faxonius limosus* in Italia.

Species	Date	Location	Coordinates	Region	Observer
Anas platyrhynchos	3 March 2021	Pescate (Lecco)	45°50’ N 9°24’ E	Lombardy	Chiara Bresciani
Fulica atra	3 March 2021	Pescate (Lecco)	45°50’ N 9°24’ E	Lombardy	Chiara Bresciani
Fulica atra	June 2021	Paratico (Brescia)	45°39’ N 9°57’ E	Lombardy	Primo Bonacina
Larus michahellis	25 August 2023	Angera (Lake Maggiore, Varese)	45°46’ N 8°35’ E	Lombardy	Milo Manica
Melanitta fusca	2019	Lake Garlate (Lecco)	45°48’ N 9°24’ E	Lombardy	Antonio Perego
Podiceps cristatus	July 2021	Paratico (Brescia)	45°39’ N 9°57’ E	Lombardy	Primo Bonacina

Fig. 1 – Photo of *Podiceps cristatus* (left) and juvenile *Fulica atra* (right) preying on the spiny-cheek crayfish in Paratico (Lombardy; ©Primo Bonacina). / Foto di *Podiceps cristatus* (a sinistra) e di un giovane esemplare di *Fulica atra* (a destra) che predano il gambero *Faxonius limosus* a Paratico Fig. 1 (Lombardia; ©Primo Bonacina). Source /Fonti: https://www.facebook.com/photo/?fbid=290374203093609&set=a.213412154123148; https://www.facebook.com/photo/?fbid=594881442642882&set=a.213412154123148.

Fig. 2 – Photo of *Fulica atra* (left) and *Anas platyrhynchos* adult female (right) in the River Adda (Pescate, Lombardy, ©Chiara Bresciani). / Foto di *Fulica atra* (a sinistra) e femmina adulta di *Anas platyrhynchos* (a destra) nel fiume Adda (Pescate, Lombardia, ©Chiara Bresciani).

Fig. 3 – Photo of *Larus michahellis* pellet (left) collected in Angera (Lake Maggiore) and the *Melanitta fusca* (right) in Garlicate Lake. Left photo: ©Milo Manica; right photo: ©Perego Antonio / Foto di borra di *Larus michahellis* (a sinistra) raccolta ad Angera (Lago Maggiore) e di un adulto di *Melanitta fusca* (a destra) nel Lago di Garlicate. Foto a sinistra: ©Milo Manica; foto a destra: ©Perego Antonio. Source /Fonte: https://www.facebook.com/photo/?fbid=10222278956714119&set=pcb.1524246497774680.

Due to the non-native species trade globalization and the difficulties in the IAS management (e.g., Sharp *et al.,* 2011; Bonanno, 2016), a further expansion of *F. limosus* in Italy and more generally Europe seems inevitable.

In this note, we highlight the importance of raw data directly collected by citizens (i.e., wildlife photographers and naturalists). Social media and photographic online databases can represent a fundamental source of information and data for scientific approaches (Gallitelli *et al.,* 2023), especially in citizen science projects. However, a high-quality photo is fundamental for a correct identification of the species, while the exact location is necessary for a better understanding of the expansion of the IAS.

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