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Citizen science reveals a rapid range expansion of a Mediterranean hoverfly under climate warming (Diptera: Syrphidae)

Umberto MARITANO

Independent Researcher, Condove (TO), Italy – umberto.maritano@gmail.com

Abstract
The big-headed lagoon fly, *Eristalinus megacephalus* (Rossi, 1794), is a Mediterranean hoverfly historically restricted in Italy to a handful of coastal regions. Recently, numerous observations uploaded to the iNaturalist citizen-science platform show a rapid northward and inland expansion, with new regional records from Piemonte, Lombardia, Veneto, Friuli-Venezia Giulia, Marche, Umbria, Puglia and Calabria. Here we compile Italian literature records and recent citizen-science observations and map the current occurrence of the species in the country. The density of recent records in the Po Valley and in other inland areas suggests that *E. megacephalus* is no longer limited to coastal Mediterranean climates. We discuss the value of citizen-science data for fast-moving biogeographic updates. Targeted surveys are now needed to test whether newly observed clusters represent transient dispersers or established populations.

Key words: Distribution shift; *Eristalinus megacephalus*; Syrphidae; iNaturalist; Climate Change

Introduction

Eristalinus megacephalus (Diptera: Syrphidae) is readily recognisable by its punctate eye pattern and the pale abdominal bands and has a wide distribution from the circum-Mediterranean region into the Afrotropical region, reaching South Africa (Speight 2020). Within Europe its distribution is centred in the Mediterranean belt. In Italy, historical and regional literature reports the species from Toscana (Rossi 1794), Lazio (Tuccimei 1908; Paparatti 1997; Paniccia 2024), Campania (Paniccia 2024), Sardegna (Costa 1886; Belcari et al. 1995; Daccordi & Sommaggio2002; Paniccia 2024), Sicilia (Belcari et al. 1995; Daccordi & Sommaggio 2002) and more recently, a northward expansion into Emilia-Romagna (Corazza & Baretje 2023). Several intensive surveys conducted in recent decades did not detect the species in northern Italy (Birtele et al. 2002; Sommaggio 2017; Maritano 2020, 2021). During the last few years, surprisingly, several new records have appeared in northern Italy on iNaturalist. The main aim of this paper is to document the expansion of the distribution of *E. megacephalus* in Italy by integrating literature data with new citizen-science records.

Materials and Methods

We compiled all regional records for Italy from the published literature (Rossi 1794; Costa, 1886; Tuccimei 1908; Belcari et al. 1995; Paparatti 1997; Daccordi & Sommaggio 2002; Corazza & Baretje 2023; Paniccia 2024) and retrieved all national occurrence records from iNaturalist (www.inaturalist.org). For iNaturalist records, we considered only those with photographs clearly showing the diagnostic eye pattern and pale abdominal bands. For each observation we assigned it to the corresponding Italian administrative region, and then generated an updated distribution map that shaded regions according to whether the species was previously known from the literature (blue) or represented a new regional record (orange).

Results

Citizen-science observations from the last few years document a marked expansion of *Eristalinus megacephalus* across Italy (Fig. 1) relative to earlier literature records, which were restricted to Toscana, Lazio, Campania,

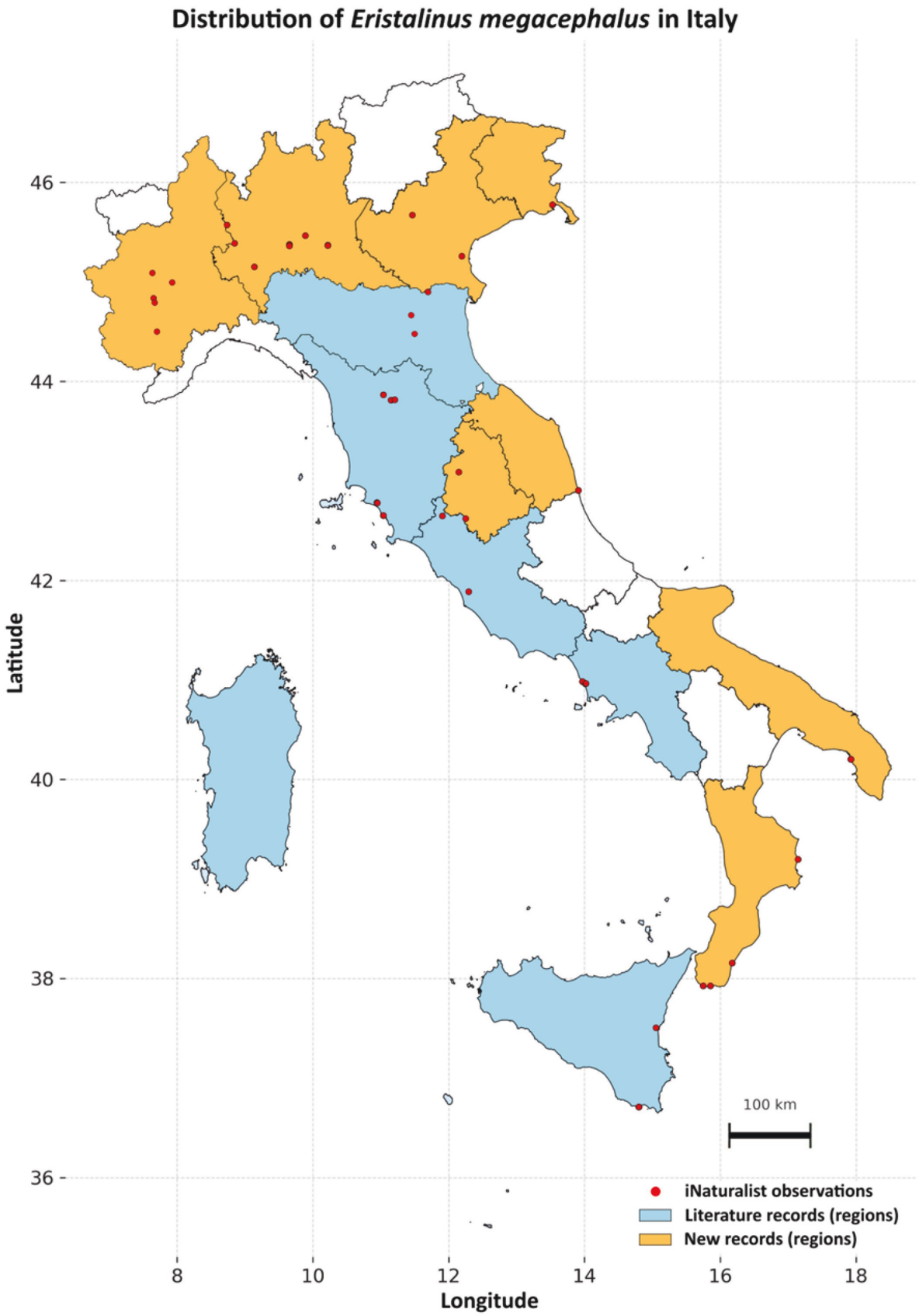

Fig. 1 – Distribution of *Eristalinus megacephalus* (Rossi, 1794) in Italy. Red dots: iNaturalist observations. Blue regions: literature records. Orange regions: new regional records based on citizen-science observations.

Emilia-Romagna, Sardegna and Sicilia. New regional records based on iNaturalist data include Piemonte, Lombardia, Veneto, Friuli-Venezia Giulia, Marche, Umbria, Puglia and Calabria. Numerous observations cluster in the Po Plain and foothill areas of northern Italy. These findings stand in contrast to the species' absence in recent faunistic surveys in the north even at site where new records were obtained only a few km from intensively monitored professional survey sites (Birtele et al. 2002; Sommaggio 2017; Maritano 2020, 2021).

Discussion

The pattern emerging from citizen science observations indicates that the species has rapidly shifted from a strictly coastal distribution and is now frequent in the warm lowlands of northern and central Italy. This result is supported by a recent study that documented *Eristalinus megacephalus* well outside the classic Mediterranean range in Serbia (Vujić & Šćiban 2024), highlighting its recent capacity to occur in continental settings. Ongoing climate warming plausibly facilitates this expansion by reducing winter constraints and extending the period suitable for adult activity. Alternative, non-mutually exclusive explanations include increased observer effort, improved recognition of this readily diagnosable species, and occasional long-distance dispersal. However, the high spatial density of recent records in several northern regions is more consistent with newly established populations rather than sporadic vagrants.

To test this hypothesis, we recommend: (i) targeted surveys from late spring to autumn in sites with potential larval habitats, such as organically enriched slow-flowing waters including coastal lagoons; and (ii) ongoing validation of citizen-science identifications. This contribution also illustrates the power of citizen science for rapidly updating distributional knowledge of conspicuous insects, while emphasizing the need to critically evaluate such data and integrate them with structured fieldwork.

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