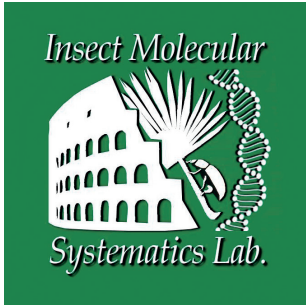




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***Calliptamus italicus* at 3050 m: a first evidence of dispersal across the Alps? (Orthoptera: Acrididae)**

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Abstract

Calliptamus italicus (Linnaeus, 1758) is a polyphagous grasshopper widely distributed from Europe to central Asia, known to perform long-range migrations during its gregarious phase, especially in the eastern part of its range. In the Alps, this species mostly occurs in dry grassland habitats in valley floors or on well-exposed slopes, usually establishing resident populations below 2000 m, but information on its dispersal patterns in this geographical area are still lacking. This short note reports an unusual observation of *C. italicus* at high elevation (3050 m) in the Cottian Alps, with a description of the associated local habitat features and short-term weather conditions. Although based on a single record, hypotheses on the possible underlying dispersal processes are provided, discussing whether this observation may represent or not a first evidence of a migration behaviour by Italian locusts across the Alpine ridge. The performance of either a local movement or a long-range migration is firstly hypothesized, due to the apparent suitability of the short-term weather conditions (i.e. no rain, increase in temperatures and wind intensity). However, since the specimen was missing the left hind leg, thus potentially compromising its dispersal capacity, a third hypothesis of an animal- or human-mediated transport is also considered. Given that the available data are not sufficient to definitely ascertain whether *C. italicus* is able to disperse in autonomy across the Alps or not, further records are needed in future to verify the hypotheses presented here and to enhance the detail of the environmental variables possibly involved.

Key words: Italian locust, local movements, migration, passive transport, weather conditions, Cottian Alps.

Introduction

Calliptamus italicus (Linnaeus 1758) (Acrididae, Calliptaminae), commonly known as Italian locust, is a univoltine polyphagous grasshopper widely distributed in southern and central Europe, Middle East and central Asia, ranging from the Iberian Peninsula to northwestern China (Cigliano et al. 2020; Hochkirch et al. 2016; Sergeev & Van’kova 2008). Within its range, this species prefers arid habitats, including dry grasslands, steppes, semi-deserts, dry clearings, pine forest edges, rocky and shrubby areas (Baur et al. 2006; Massa et al. 2012; Sergeev & Van’kova 2008), also occurring in some agricultural landscapes (e.g. Giuliano & Bogliani 2018; Nasiyev et al. 2015).

Overall, the habitat requirements of the Italian locust reflect the limited tolerance to humidity of its eggs, which appear to better develop in soils containing less than 5% in moisture (Louveaux et al. 1988). In some areas, when the environmental conditions become particularly suitable (i.e. hot and dry springs and summers), mass reproduction events can periodically occur (Aragón et al. 2013; Stolyarov 2000), even producing considerable impacts on human activities, especially when abundant locust populations move into croplands (Le Gall et al. 2019; Nasiyev et al. 2015).

In some locust species (e.g. *Schistocerca gregaria*, *Locusta migratoria*, *Dociostaurus maroccanus*), these outbreaks are associated with several morphological, physiological and behavioural changes, resulting in a transition from a solitary (sedentary) to a gregarious (swarming) phase (Le Gall et al. 2019; Massa et al. 2012). Gregarious adults can migrate hundreds of kilometres to colonize new regions, relying on wind-borne transportation and suitable migration temperatures (e.g. Yu et al. 2020). Solitary and gregarious phenotypes are known for *C. italicus* as well, even if morphological changes among phases are less pronounced than in other locust species (i.e. no clear colour distinction; Le Gall et al. 2019). However, individuals belonging to the swarming phase are usually bigger than the solitary ones, with longer forewings, hindwings and hind legs (Sergeev & Van’kova 2008; Zhang et al. 2011). Long-distance migratory behaviour has been documented for the Italian locust mainly in central Asia, where research on the relationships between physiology and flight ability has also been carried out (Cao et al. 2019).

In the Alpine region, *C. italicus* occurs in several dry open habitats, mainly in valley floors and well-exposed slopes, with resident populations mostly living below 2000 m (Baur et al. 2006; Sindaco et al. 2012). According to the available literature, mass reproduction events

have never been reported in this geographical area (e.g. in Switzerland; Baur et al. 2006), and published data on long-distance migration or dispersal behaviours involving the Alpine Italian locust populations are lacking. However, Sindaco et al. (2012) mention the possible occurrence of erratic individuals at high elevations in the Alps, but without providing any further information.

In this context, this short note reports an unusual observation of *C. italicus* at high elevation (3050 m) in the Cottian Alps, with a description of the associated local habitat features and short-term weather conditions. In addition, although based on a single record, hypotheses on the possible underlying dispersal processes are provided, discussing whether this observation may represent or not a first evidence of a migration behaviour by Italian locusts across the Alpine ridge.

Results and discussion

On 27 Aug 2020, at 10:10 (local hour), while carrying out a non-standardized orthopteran survey (visual census), the author observed and collected a single adult female of *C. italicus* on the top of Punta Losetta (3050 m; Cottian Alps; 44.68000N, 7.06261E), in the municipality of Pontechianale (Cuneo province, Piedmont, Italy), within the Monviso Natural Park. The Italian locust was on the grassy ground, likely warming at the morning sun, on a South-East-facing slope at just 100 m from the main Alpine drainage divide, i.e. between the Po and the Rhone river basins (France-Italy border) (Fig. 1). In particular, the habitat consisted of an isolated patch of Alpine grassland (area: ~1.4 ha) characterized by short grass (max 10 cm), with scattered bare ground and rocky spots (Fig. 4). No other orthopterans were found in this locality, except for a single male of *Myrmeleotettix maculatus* (Thunberg 1815).

The specimen appeared paler than usual Alpine *C. italicus* (prevailing a grey colouration, especially on pronotum and forewings) and it was missing the left hind leg (Fig. 2). The identification to species level was achieved combining several morphological traits (i.e. forewings passing the hind knee, red anal field on hindwings), according with the information provided by Baur et al. (2006), Massa et al. (2012), and Sardet et al. (2015). After measuring body length (head-cerci distance = 28.5 mm), the individual was photographed and then released.

Unfortunately, body length and colour pattern alone are not sufficient to definitely ascribe the individual either to a solitary or a gregarious phase, since a clear distinction between phases requires the calculation of the forewing length/hind femur length ratio (Zhang et al. 2011). According to the morphometric data provided by Zhang et al. (2011), central Asian females gregarious *C. italicus* are in average 25.60 ± 0.19 mm long, while mean body length in the solitary ones is 24.58 ± 0.21 , suggesting the possible belonging of the Italian locust found on Punta Losetta to a swarming phase. However, in the Alps

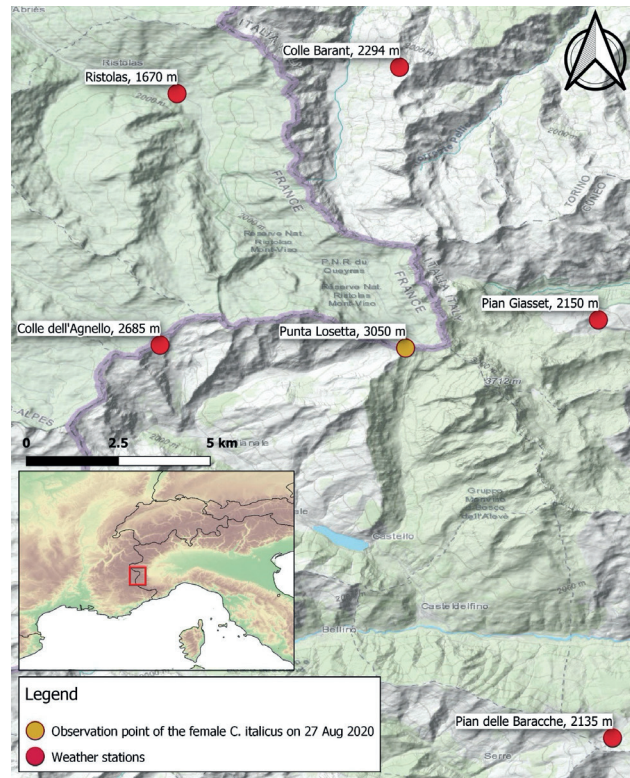


Fig. 1 – Map of the study area (Monviso massif, Cottian Alps, France-Italy border). The yellow point identifies the locality where the female *Calliptamus italicus* was observed on 27 Aug 2020 (Punta Losetta, 3050 m), while the position of the weather stations considered in this short note is reported by red dots.



Fig. 2 – The female *Calliptamus italicus* (Linnaeus, 1758) observed at Punta Losetta (3050 m, Cottian Alps) on 27 Aug 2020 (body length = 28.5 mm).

C. italicus females are reported to reach a maximum of 34 mm in head-cerci distance (Baur et al. 2006), but no distinctions are available among solitary and gregarious phases.

In order to describe the weather conditions occurred just before the observation of *C. italicus* at 3050 m, short-term (4 days: 23–27 Aug 2020) local meteorological data were gathered from the closest available weather stations from the observation point (mean distance: 9.9 ± 4.1 km), consulting the ARPA Piemonte (www.arpa.piemonte.it) and Météo France (www.infoclimat.fr) databases. In particular, air temperature, precipitations, wind intensity (average speed, gust and direction), and atmospheric pressure were considered as variables (Fig. 3; Table 1)

When considering the 23-27 Aug trend of the investigated meteorological parameters, a clear increase in air temperature, wind intensity and atmospheric pressure was observed starting from the 25 Aug afternoon, corresponding to a sudden change in the prevailing wind direction (easterly to westerly) and to an absence of precipitations. Focusing on the last 24 hours before the *C. italicus* observation, a 760.32 ± 0.95 hPa mean atmospheric pressure was recorded (Ristolas, 1670 m), while temperatures raised to an average of $11.58 \pm 2.22^\circ$ C at 2685 m (Colle dell'Agnello), and wind speed increased to a whole mean of 2.04 ± 1.21 m/s among the weather stations considered, with an average gust of 4.97 ± 2.68 m/s (Table 2).

Since acridoid orthopterans usually require warm temperatures to both initiate and maintain flight (i.e. $>20^\circ$ C; Farrow 1990), while winds often play a critical role in favouring long-distance migrations (Drake & Farrow 1988; Reynolds et al. 2009) as well as local movements (Farrow 1990), the weather conditions observed starting from the 25-26 Aug night might have supported a dispersal behaviour by the Italian locust in the surroundings of Punta Losetta.

A first hypothesis may concern the performance of a local movement. Indeed, the female Italian locust might have profited of the warm and windy weather to disperse from the resident populations occurring at low elevations around the Monviso massif. Given that gregarious females of *C. italicus* can cover up to 2 km in a single flight in laboratory conditions (Cao et al. 2019), the populations observed in the Guil valley (France, La Garcine, Abriés [Hautes-Alpes], 1560 m, 09/08/2019, Jacquier C. in www.faune-paca.org) and in the Varaita valley (Italy, Vallone di Vallanta, Pontechianale [Cuneo, Piedmont], 1930 m, 11/08/2019, Giuliano D., unpublished data) might represent a likely origin of the individual described in this short note, being distant about 16 km and 6 km from Punta Losetta respectively. The relatively high temperatures observed at both valley floors (e.g. 24.60° C the 26 Aug, 16:00, at 1670 m) and high elevations (e.g. 15.6° C the 26 Aug, 14:00, at 2685 m) might have favoured the performance of upslope movements by this single Italian locust, while wind gusts might have increased the distance covered in its flights towards the mountaintop.

On the other hand, the female *C. italicus* might have been transported by wind on Punta Losetta while performing a long-range migration. Despite descriptions of this behaviour are lacking in Europe, gregarious Italian locusts are reported to migrate up to 200-300 km in central Asia, traveling about 20-30 km per day and flying at up to 200 m in height (Sergeev & Van'kova 2008). In general, locusts usually start their migratory flights at dusk, mostly flying by night and requiring evening temperatures above 20° C, with some species even performing mass take-offs when the environmental conditions are particularly suitable (Farrow 1990; Riley & Reynolds 1979; Wang et al. 2020). By first flying upwind, each individual is able to ascend in the air at

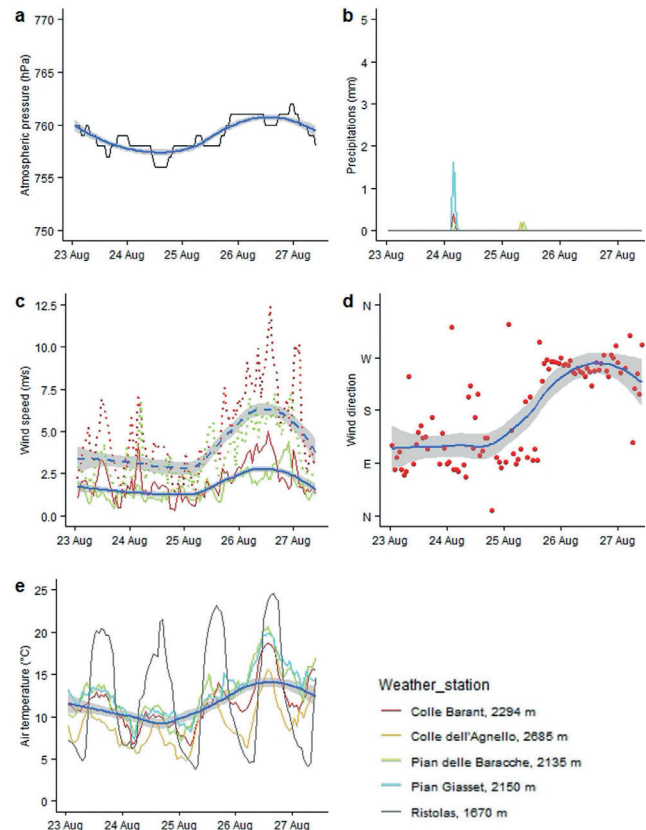


Fig. 3 – Plots representing the 23-27 Aug 2020 trends of the meteorological parameters considered in order to describe the weather conditions in the days just before the observation of the female *Calliptamus italicus* on Punta Losetta (3050 m, Cottian Alps). The trend of each parameter is better visualized with a *Loess* curve (blue line; grey area = 95% confidence interval): a, atmospheric pressure; b, precipitations; c, wind speed (solid lines) and wind gust (dotted lines); d, wind direction (origin); e, air temperature. The data collected in each weather station are reported in different colours. Sources: ARPA Piemonte and Météo France.

a steep angle for several hundred meters above the ground, then turning downwind when wind speed is sufficient to support a long-range flight (Farrow 1990). This process can even concentrate migrating locusts in horizontal layers in the atmosphere (the so-called “insect layers”), often occurring near the top of the surface temperature inversion, where warm fast-moving airflows provide good conditions for downwind flight, or in correspondence with other temperature maximums at higher elevations (Drake & Farrow 1988; Reynolds et al. 2005; Reynolds et al. 2009). Assuming that *C. italicus* behaves as other locust species, the female Italian locust might have landed on Punta Losetta after a downwind flight, profiting of the relatively strong and warm westerly wind observed in the Cottian Alps starting from the 25-26 Aug night. Accordingly, the individual might originate from *C. italicus* lowland populations of southern or central France, where outbreaks of this species are a recurring event (Louveaux et al. 1988) and climatic conditions in summer evenings are supposed to be suitable for a successful take-off behaviour at dusk.

| | | Colle Barant, 2294 m | Colle dell' Agnello, 2685 m | Pian delle Baracche, 2135 m | Pian Giasset, 2150 m | Ristolas, 1670 m |
|----------------------------------|---------|----------------------|-----------------------------|-----------------------------|----------------------|------------------|
| Distance from Punta Losetta (Km) | | 10.50 | 6.70 | 15.62 | 5.33 | 11.35 |
| Air temperature (°C) | Mean±SD | 11.45±2.72 | 9.03±2.47 | 12.68±3.09 | 12.81±2.87 | 12.39±6.53 |
| | Min | 6.50 | 4.80 | 7.10 | 7.30 | 3.80 |
| | Max | 18.70 | 15.60 | 20.60 | 19.90 | 24.60 |
| Precipitations (mm) | | 0.40 | 0.20 | 0.40 | 1.80 | 0.00 |
| Wind speed (m/s) | Mean±SD | 2.06±1.05 | - | 1.66±0.77 | - | - |
| | Min | 0.30 | - | 0.40 | - | - |
| | Max | 5.00 | - | 4.40 | - | - |
| Wind gust (m/s) | Mean±SD | 4.89±2.41 | - | 3.56±1.56 | - | - |
| | Min | 1.20 | - | 1.20 | - | - |
| | Max | 12.40 | - | 7.20 | - | - |
| Wind direction (°) | Min | 9.00 | - | - | - | - |
| | Max | 327.00 | - | - | - | - |
| Atmospheric pressure (hPa) | Mean±SD | - | - | - | - | 759.03±1.49 |
| | Min | - | - | - | - | 756.00 |
| | Max | - | - | - | - | 762.00 |

Table 1 – Summary of the meteorological parameters observed at the 5 weather stations considered in the surroundings of Punta Losetta (Cottian Alps) in the 23-27 Aug 2020 period. The distance of each station from Punta Losetta is also provided.



Fig. 4 – Landscape on the Italian slope of Punta Losetta (3050 m, Cottian Alps). The Alpine grassland in the lower part of the picture is the habitat where the female *C. italicus* was observed the 27 Aug 2020.

Despite these two hypotheses are apparently supported by short-term meteorological data, it has to be considered that the dispersal capacity of the observed individual might have been compromised by the loss of the left hind leg. Indeed, hind leg autotomy proved to significantly reduce locomotion ability in orthopterans, conditioning both walking and jumping performances (Bateman & Fleming 2006; Fleming & Bateman 2007; Norman 1995; Tsurui et al. 2014). In particular, specific studies on autotomized Acrididae highlighted a decrease of about 30% in the horizontal distance covered by jump compared with intact individuals, together with a 44% reduction in the achieved vertical height, as well as negative consequences on flight distance due to a lack of launch power and stability in take-off (Bateman & Fleming 2011; Norman 1995; Tsurui et al. 2014). Accordingly, a further hypothesis of a passive transport other than the wind-borne one (i.e. animal- or human-mediated) cannot be totally excluded to explain the occurrence of *C. italicus* on Punta Losetta, especially because the observation locality is frequented by many hikers during summer.

Regardless the possible underlying dispersal processes, the observation of an Italian locust at 3050 m on the main Alpine divide might reveal a potential dispersal capacity of

this species across the Alpine ridge, even at high elevations, perhaps profiting of periodically suitable climatic conditions: a behaviour still never described in the Alps for *C. italicus*, as well as for other orthopteran species. However, this theory must be carefully considered, since it is based on the casual observation of a single individual, without certain information on its provenance (human-mediated transport?), as well as on its survival and movements in the days following the 27 Aug. Moreover, the biometric data collected were not sufficient to unequivocally ascribe the female Italian locust either to a solitary or a gregarious phase, preventing further speculations on a possible migratory origin of the individual. Additional records are thus needed to verify the dispersal hypotheses presented in this short note, especially through an intensification of field surveys at high elevations, in order to increase the encounter probability with other possible migrating individuals, as well as to enhance the detail of the environmental, climatic and biometric variables possibly involved.

Although the information provided here cannot definitely ascertain whether *C. italicus* is able to disperse in autonomy across the Alps or not, the observation of this

species at 3050 m represents a record in elevation in Italy (see Baroni 2015), and probably in Europe (e.g. Baur et al. 2006; Sardet et al. 2015). This kind of observation is likely difficult to repeat, even with a systematic field research, due to the limited accessibility of most high elevation areas, and because of several still unpredictable factors (e.g. migration patterns, passive transport, environmental and climatic conditions, seasonality, etc.). By giving a description of the environmental and short-term meteorological conditions associated with the Italian locust record at 3050 m, this short note provides an attempt to reduce the above-mentioned unpredictability, at least concerning habitat and weather parameters, hopefully representing a useful starting point for future research.

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| | | Colle Barant, 2294 m | Colle dell' Agnello, 2685 m | Pian delle Baracche, 2135 m | Pian Giasset, 2150 m | Ristolas, 1670 m |
|----------------------------------|---------|----------------------|-----------------------------|-----------------------------|----------------------|------------------|
| Distance from Punta Losetta (Km) | | 10.50 | 6.70 | 15.62 | 5.33 | 11.35 |
| Air temperature (°C) | Mean±SD | 14.58±2.79 | 11.58±2.22 | 16.30±2.53 | 16.50±2.08 | 13.66±7.42 |
| | Min | 10.70 | 8.30 | 11.70 | 13.00 | 4.10 |
| | Max | 18.70 | 15.60 | 20.60 | 19.90 | 24.60 |
| Precipitations (mm) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wind speed (m/s) | Mean±SD | 2.63±1.17 | - | 2.38±0.94 | - | - |
| | Min | 1.30 | - | 0.90 | - | - |
| | Max | 5.00 | - | 4.40 | - | - |
| Wind gust (m/s) | Mean±SD | 6.84±2.77 | - | 4.82±1.68 | - | - |
| | Min | 2.50 | - | 1.80 | - | - |
| | Max | 12.40 | - | 7.20 | - | - |
| Wind direction (°) | Min | 125.00 | - | - | - | - |
| | Max | 307.00 | - | - | - | - |
| Atmospheric pressure (hPa) | Mean±SD | - | - | - | - | 760.32±0.94 |
| | Min | - | - | - | - | 758.00 |
| | Max | - | - | - | - | 762.00 |

Table 2 – Summary of the meteorological parameters observed at the 5 weather stations considered in the surroundings of Punta Losetta (Cottian Alps) in the last 24 hours before the observation of the female *Calliptamus italicus* (10:00, 26 Aug – 10:00, 27 Aug 2020). The distance of each station from Punta Losetta is also provided.

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