FIRST OBSERVATION OF FILIAL CANNIBALISM IN *SCOLOPENDRA CINGULATA* LATREILLE, 1829 (CHILOPODA: SCOLOPENDROMORPHA: SCOLOPENDRIDAE)

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ABSTRACT

Filial cannibalism is recorded for the first time in *Scolopendra cingulata* Latreille, 1829 in a natural environment in Almería (Andalusia, Southern Spain). A female was found exhibiting parental care of 2nd stadia juveniles and after checking possible ways of escape from the brood-chamber, she started to devour her brood and a total of five juveniles were consumed. A detailed description of filial cannibalism in *S. cingulata* is given and a new account of this phenomenon is documented. In addition, comparisons with filial cannibalism among other taxa are given and possible factors causing this in *S. cingulata* are discussed.

KEYWORDS: Filial cannibalism, *Scolopendra cingulata*, breeding behaviour, recording, Andalusia, Spain.

INTRODUCTION

Filial cannibalism (*sensu* Klug & Bonsall, 2007) consists of the consumption of offspring by the parental generation. In recent years, this behaviour has been considered an adaptive trade-off between current and future reproductive success (Manica, 2004; Miller & Zink, 2012). The predominant hypothesis about filial cannibalism claims that it is an adaptive strategy in which the parental generation obtains energy by ingesting its brood, thus ensuring their own reproductive success (Trivers, 1972; Rohwer, 1978; Sargent, 1992). On the other hand, it has also been suggested that filial cannibalism may be a mechanism to ensure the survival of a greater number of descendants. Hence, this behaviour is likely to appear when the filial generation is too numerous and parents do not have the capacity to provide them with full protection (Manica, 2002; Payne *et al*., 2002; Klug *et al*., 2006). It has also been proposed that filial cannibalism would be a result of avoiding fierce competition when food availability is low and may endanger either the survival of the filial or parental generation (O'Connor, 1978; Thomas & Manica 2003). In other circumstances parents may turn to filial cannibalism to make the breeding period shorter, for hygienic reasons when either non-viable eggs are produced or juveniles have been infected or parasitised (Thomas & Manica 2003; Miller & Zink, 2012; Lehtonen & Kvarnemo, 2015; Vallon *et al*., 2016a). Nevertheless, filial cannibalism occurs when environmental conditions are adverse due to a lack of resources leading to a compromise between the viability of

parents and their brood (Klug & Bonsall, 2007) or due to a stress response caused by an anthropogenic disturbance (Chardine & Morris 1983, Gilbert *et al*., 2005).

Infanticide is a common behaviour pattern among many animals but filial cannibalism has been documented less frequently and it often occurs amongst those with parental care (Elgar & Crespi, 1992). In vertebrates, this phenomenon has been observed among birds (Gilbert *et al*., 2005; Solaro & Sarasola, 2012), rodents (Elwood, 1992; Klemme *et al*., 2006), primates (Dellatore *et al*., 2009; Fowler & Hohmann, 2010), marsupials (Pires *et al*., 2010), reptiles (Lourdais *et al*., 2005; Cooper Jr. *et al*., 2015) and amphibians (Solano, 1987), although most researchers focus on many fish groups (Smith & Reay, 1992; Manica, 2002; Mehlis *et al*., 2009; Vallon *et al*., 2016b). In invertebrates, some cases are known among cephalopods (Ibáñez & Keyl, 2009), but this behaviour has been documented to a greater extent in arthropods such as insects (Bartlett, 1987, Thomas & Manica 2003, Miller & Zink, 2012, Takata *et al*., 2013), arachnids (Anthony, 2003; Wise, 2006) or myriapods (Lawrence, 1984). In chilopods, records of filial cannibalism are scarce and restricted to the order Scolopendromorpha and the family Scolopendridae, more specifically to the species *Cormocephalus westwoodi anceps* Porat, 1871 (Brunhuber, 1970), *Otostigmus (Otostigmus) spinosus* Porat, 1876 (Siriwut *et al*., 2014) and *Otostigmus (Parotostigmus) scabricauda* (Humbert & Saussure, 1870) (Machado, 2000). The results obtained by Siriwut *et al*. (2014) in the breeding behaviour of a female of *O. spinosus* are worth noting. After mating and building the brood chamber, a female deposits her eggs and takes care of her brood after hatching. The researchers observed a particular behaviour pattern among this species when the mother suffered disturbance, generally by predators or other external agents. If a mother is apparently calm when observed and finds a way to escape and to return to the brood chamber, she rejoins her offspring and parental care proceeds normally. On the other hand, when the mother is apparently disturbed, she leaves the brood chamber and abandons her brood indefinitely. However, there is an additional possibility when a stressed mother cannot find a way to escape. In this scenario, filial cannibalism occurs.

Although *O. spinosus* has been studied in depth, there is still much to know about breeding behaviour in other species and thus increase current ethological knowledge in the class Chilopoda. Hence the main aim of this report is to describe the first observation of filial cannibalism in *Scolopendra cingulata* Latreille, 1829 in a natural environment located in Almería (Southern Spain) and to compare the observed behaviour with the results obtained by Siriwut *et al*. (2014). In addition, possible causes and external factors underlying the phenomenon of filial cannibalism are discussed.

MATERIAL AND METHODS

Studied species

S. cingulata is a species of the order Scolopendromorpha, family Scolopendridae and it is widely distributed in the Mediterranean region of Europe, North Africa and East Asia (Bonato *et al*., 2016) (Fig. 1A). In Spain, *S. cingulata* occurs abundantly in almost the whole of the Iberian Peninsula, except for the Eurosiberian region, where it is restricted (Fig. 1B). *S. cingulata* is a thermophilic, anthropophilic, silvicolous and praticolous species (García-Ruiz, 1997), in which female uni-parental care has been registered (Heymonds, 1901; Radl, 1992). Parental care in general maximises reproductive success by increasing the chances of the brood success but this behaviour may sometimes put the survival of the mother or her brood in jeopardy (Thomas & Manica 2003; Klug *et al*., 2006). Once females have reached sexual maturity (it takes at least 3 years), they look for a mate during the spring months. After mating, they then seek a well-conditioned breeding chamber and lay between 10 and 49 eggs (Fig 2B). This takes place between May and June. Approximately 20 days after egg-laying, the 1st stadium adolescents hatch and remain motionless with the mother curled around them. After

approximately 17 days, the 2nd adolescent stadium is reached and juveniles are able to move but cannot feed (Fig. 2C-D). 10 days later, the juveniles reach the 3rd adolescent stadium and are able to feed themselves. A few days later, the mother leaves the chamber and finally abandons her brood.

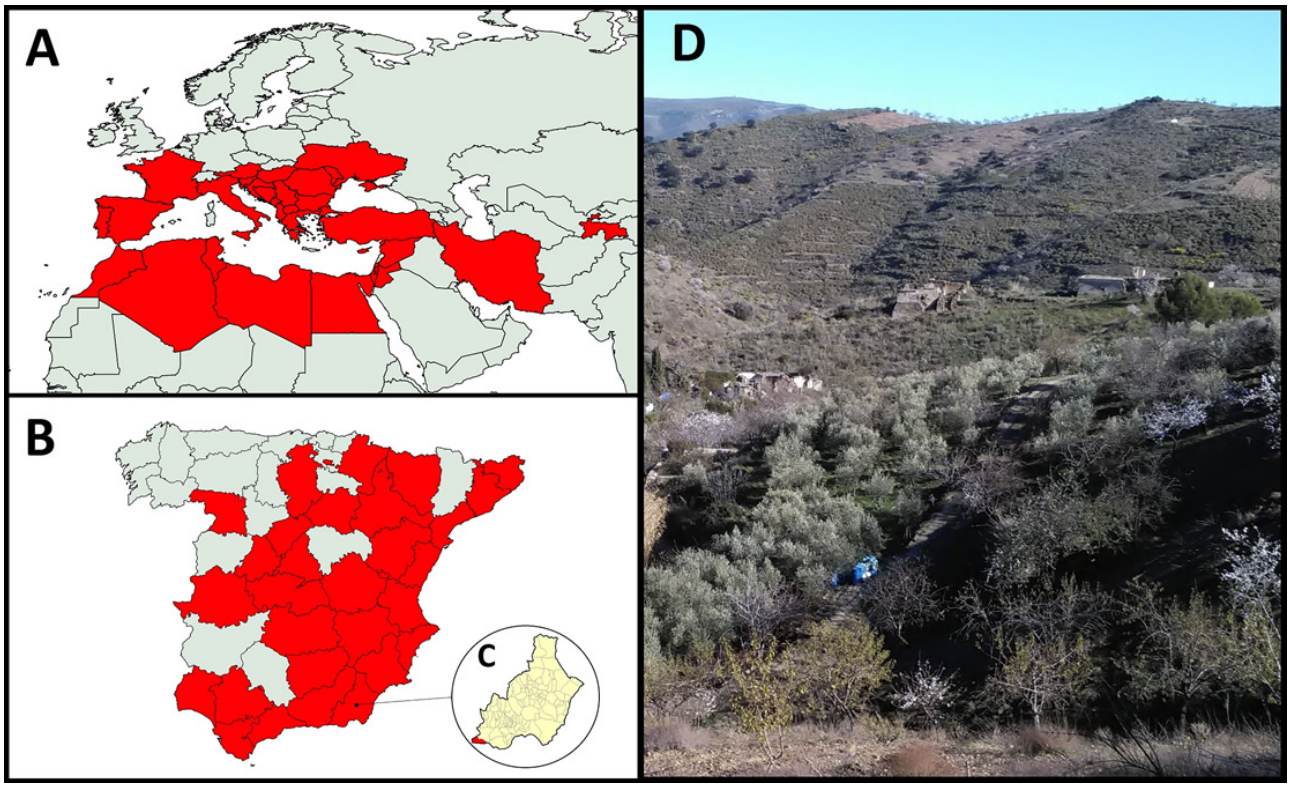

Figure 1: Distribution and area of breeding of *Scolopendra cingulata*.
A) Worldwide distribution; B) Distribution in mainland Spain; C) Municipality of Adra in Almería province (Andalucía); D) Mediterranean habitat and fields of cultivation of *Olea europea* and *Prunus dulcis*.

Area of the study

Observations took place in the municipality of Adra, in the province of Almería, located near the Mediterranean coast of southern Spain (Fig 1C). The area is located in the vicinity of fields of cultivation of *Olea europea* L. and *Prunus dulcis* (M.), in a terrain dominated by Mediterranean scrubland and the dispersed presence of *Quercus ilex* L. (Fig. 1D). The zone is characterised by the absence of precipitation during the warmer season and daytime maxima temperatures in September oscillate between 28 and 30ºC, which confers xeric properties to the land.

Characteristics of the brood chamber

Initially, the brood chamber was discovered during maintenance work under a heavy rainwater collection tank (Fig. 2A). The inside of the chamber comprised a compact rocky substratum without galleries or apparent cavities on the sides although possible ways to escape above were seen. Parental care in *S. cingulata* had already been noted in this site about 3 years ago (Fig. 2B). Hence, this environment must have formed a microhabitat that undoubtedly offered good conditions for breeding as the animals had found a humid, sheltered and undisturbed place to settle in. Unfortunately, the water tank had to be moved and from then on was replaced by a large stone to properly cover the brood chamber.

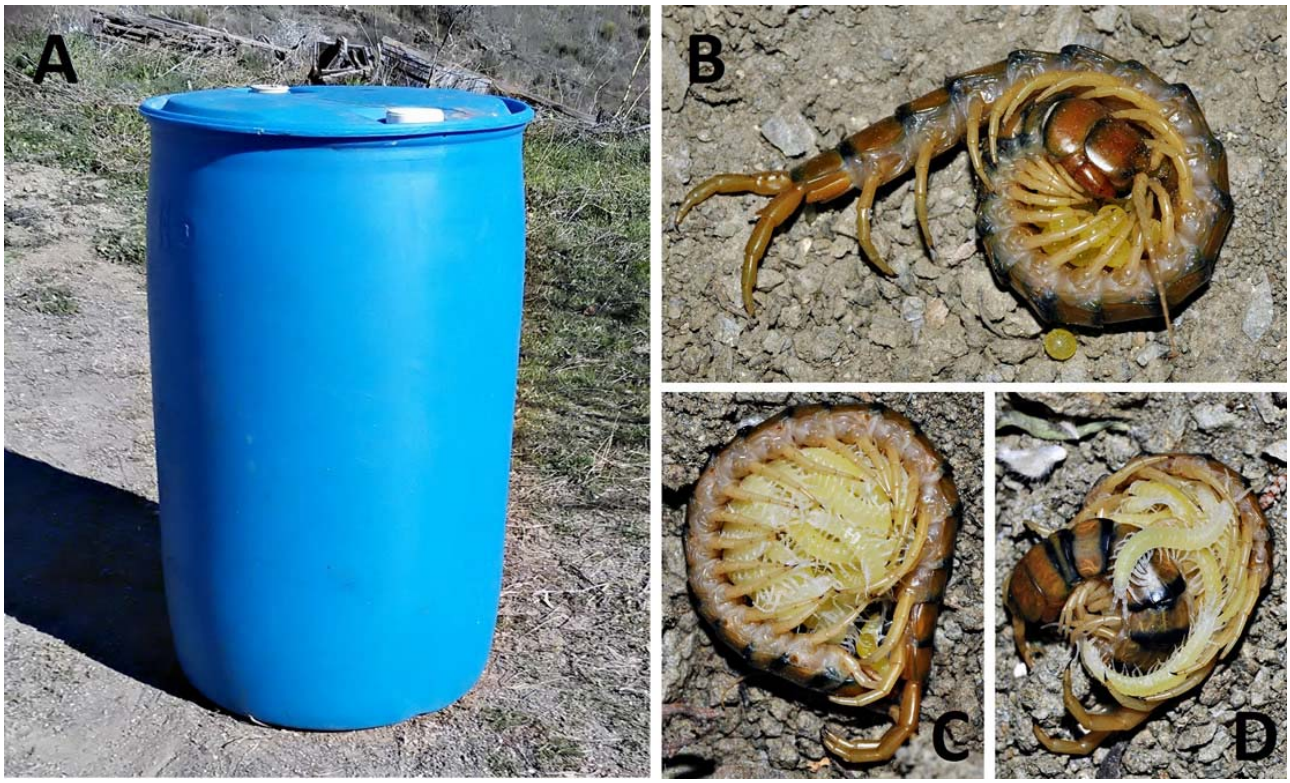

Figure 2: Parental care in *Scolopendra cingulata*.
A) Rainwater collection tank that initially covered the brood chamber; B) View of female uni-parental care underneath the collection tank in 2015; C) First observation of parental care in 2018; D) Second observation of parental care in 2018, prior to filial cannibalism.

RESULTS AND SHORT DISCUSSION

Filial cannibalism

The first observation of the female caring for 2nd stadium juveniles was on 19th September 2018. When the rainwater collector tank was removed, the mother and her offspring were found to be there in a manner characteristic of scolopendrid species (Siriwut *et al*., 2014): she was curled up around her brood, forming the typical protective position for the juveniles who were moving around each other (Fig. 2C-D). The second observation took place on 28th September 2018 and a few minutes after uncovering the stone, filial cannibalism was seen. At the start of both the first and second periods of observation their behaviour was apparently normal. In the daylight, while photographs were being taken and video recordings were being made (Rodríguez-Luque, 2018), the mother started to move in a disturbed manner several times (Fig. 3A). When so disturbed, she released the brood, possibly trying to find a way to escape from the brood chamber (Fig. 3B), from which several possible escape routes had been noted by the authors but despite this the mother remained in the brood chamber and then circled around the young a few times. Then she grasped the juveniles again, which were still mostly assembled in a group, by leaning on them and finally started to eat some of them (Fig. 3C). Three of the juveniles were devoured during recording (Fig. 3C-F) and none of them attempted to escape; only the third victim slightly increased its speed. Furthermore, the members of the brood who were not attacked behaved as normal, apparently indifferent to the filial cannibalism. After the recording, the mother was observed eating two more juveniles before cannibalism came to an end. 10 days after this, neither the mother nor her offspring were found in the brood chamber.

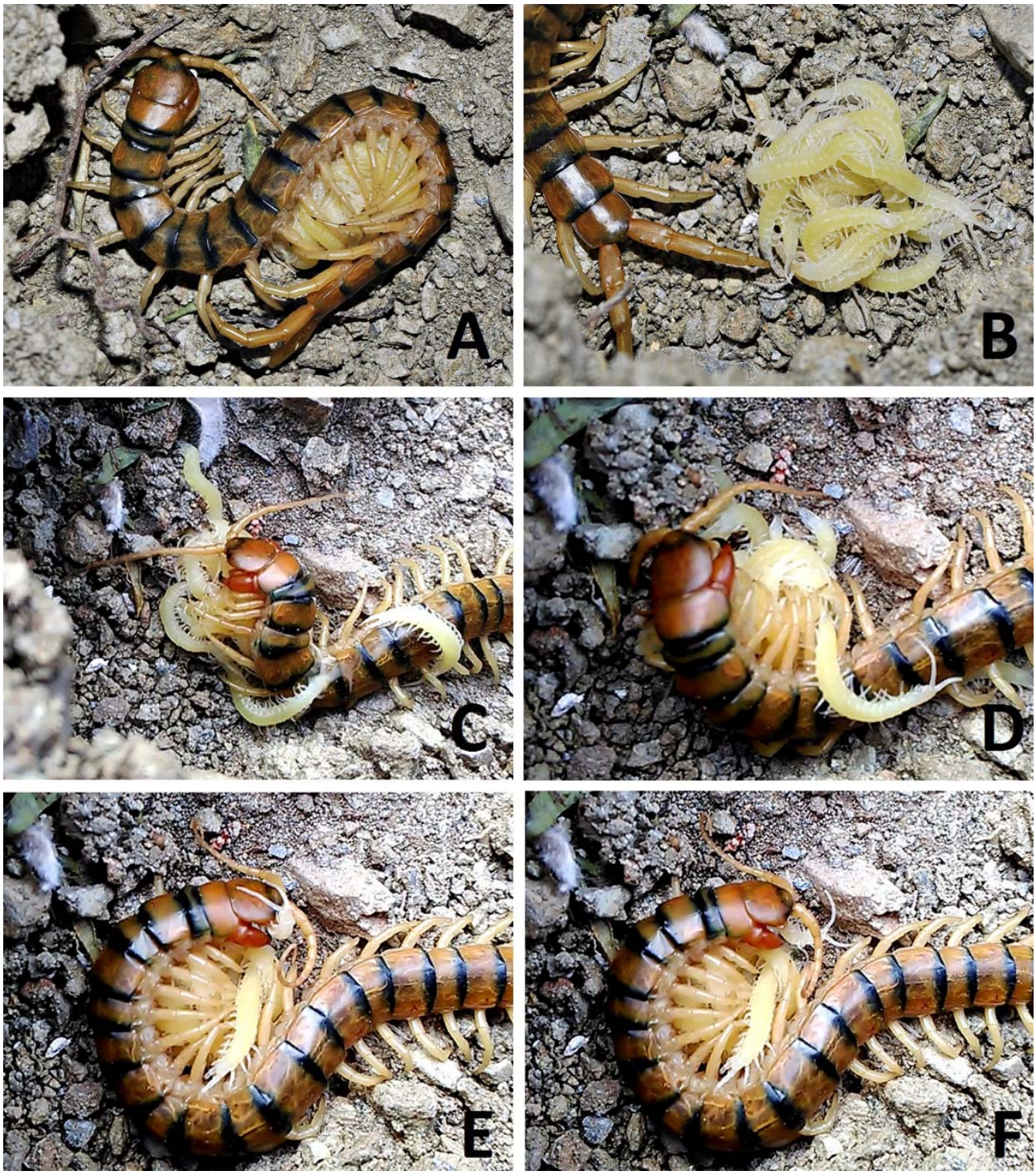

Figure 3: Filial cannibalism in *Scolopendra cingulata*.
A) Mother starting to feel "nervous" and exposed; B) Mother abandoning her brood; C) Beginning of filial cannibalism and first juvenile consumed; D) Second juvenile ingested by the mother; E-F) Consumption of the third juvenile.

This sequence follows the pattern described for *O. spinosus* breeding behaviour (Siriwut *et al.*, 2014) with the difference that possible ways to escape were available but not used. That circumstance drove the subject into the cannibalistic behaviour predicted in this model, which could have several possible explanations. One of these could be that the female had not detected possible ways of escape, which would imply a low level of perception, since there were several cases of juveniles moving in different

directions. Further studies should be oriented towards how these observations relate to normal perceptive capacity in *S. cingulata* and whether high levels of stress have implications for its ability to assess its surroundings. However, this could be contrasted with the female's apparent tranquility whilst devouring her offspring. Another relevant idea to test is if the stress level gradually decreased after the initial shock she had when the rock was lifted up. Abruptness of movements could be good stress indicators in these animals and contrary to the initial behaviour of releasing the offspring and fast circling around them, after grasping them back her movements became less violent again. The offsprings' reaction was similar to that of their undisturbed mother, even though some of their siblings were eaten alive. This may support the idea of low perception in analysing the surroundings, at least among young individuals. As has seen in other animals such as rodents (Elwood, 1992), bonobos (Fowler & Hohmann, 2010) and spiders (Anthony, 2003), filial cannibalism could represent a sacrifice of a part to save the whole. Eliminating five members of the clutch of offspring would relieve the female's responsibility for taking care of a large brood and, moreover, using them as an energy resource rather than leaving them to possible predators would increase her own chances of survival (Rohwer, 1978). Consequently, the remainder of the brood would have better chances of survival and, in an extreme case of sacrificing the whole brood, the healthy mother could survive to produce a new set of offspring (Klug & Bonsall, 2007).

In general terms, filial cannibalism behaviour in *S. cingulata* concurs with the results presented by Siriwut *et al.* (2014) for *O. spinosus*. The fact that the mother was clearly disoriented at the beginning may suggest that stress was too severe for her to find a way to escape and filial cannibalism in this scenario could take place with a stressed mother who could not find an escape route from the brood chamber when being observed and so, innately driven to consume her brood, as in *O. spinosus*. However, further ethological studies are needed to investigate the trigger for filial cannibalism in *S. cingulata*.

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