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First record of two hymenopteran species, *Brachymeria excarinata* Gahan (Chalcididae) and *Pteromalus* sp. (Pteromalidae), as hyperparasitoids of *Diadegma insulare* in Senegal

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ABSTRACT

After being recorded as a parasitoid of larvae of the pest *Plutella xylostella* (L.) in April 2016, the species *Brachymeria excarinata* Gahan (Chalcidoidea) was subsequently identified among individuals emerging from cocoons of the parasitoid *Diadegma insulare* (Cresson). Later in the same study, individuals of *Pteromalus* sp. (Pteromalidae) also emerged from cocoons of *D. insulare*. Specimens of both hymenopteran species were collected from cabbage (*Brassica oleracea* L., Brassicaceae) fields at Lac Rose (14°49′52.93″ N, 17°09′20.94″ W), Senegal. This study represents the first simultaneous record of these parasitoids as hyperparasitoids of *D. insulare* in Senegal and in West Africa. Both species parasitized the cocoons of the primary parasitoid from which they subsequently emerged during laboratory monitoring. Specimens were identified by Gérard Delvare, an international taxonomist and specialist of Chalcidoidea (Hymenoptera). At Lac Rose, the mean minimum annual temperature during the sampling period was 23 °C. The occurrence of these two species as secondary parasitoids may play an important role in shaping the parasitoid complex associated with the pest *P. xylostella*.

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INTRODUCTION

Chalcididae are generally primary parasitoids, although some species may act as hyperparasitoids. The genus *Brachymeria* Westwood comprises numerous species (Gibson *et al.*, 1996), most of which are solitary endoparasitoids of Lepidoptera (Labou *et al.*, 2025) and Diptera, while a few species exhibit gregarious behaviour (Hanson *et al.*, 1995).

Within the genus *Pteromalus*, several species are known to be endoparasitoids of larval and pupal stages. This is notably the case for *Pteromalus briani* sp. n., an endoparasitoid of the pupae of *Vanessa atalanta* (L.) and *Aglais urticae* (L.), two common butterfly species (Lepidoptera: Nymphalidae) in Europe (Baur, 2015). Most hyperparasitoids are either facultative or obligate (Delvare, 2025).

The species *Brachymeria excarinata* Gahan is an endoparasitoid of the pupae of *Earias insulana* (Boisduval) (Lepidoptera: Noctuidae) in North Africa, particularly in Egypt (Mohammed *et al.*, 2020). Other species of hymenopteran parasitoids attack the larvae and pupae of *Pieris brassicae* (L.) (Lepidoptera: Pieridae) in various agroecosystems. *B. excarinata* has also been reported as a hyperparasitoid of *Cotesia plutellae* (Hymenoptera: Braconidae) (Khaliq *et al.*, 2016), as well as of certain families of Diptera and Hymenoptera (Joseph *et al.*, 1973).

The genus *Brachymeria* is widely distributed worldwide and comprises approximately 200 species, of which 42 have been reported from the Neotropical region (Biever *et al.*, 1994; Mitchell *et al.*, 1997; Munir *et al.*, 2015), compared with 71 species recorded from the Oriental region (Joseph *et al.*, 1973). In other regions of the world, species of this genus have also been reported, including 27 species in North America (Khaliq *et al.*, 2016), 25 species in Vietnam (Narendran *et al.*, 2016), 11 species in Brazil (De Santis *et al.*, 1980), and three species in the British and Irish fauna (Dale-Skey *et al.*, 2016).

The genus *Pteromalus*, by contrast, comprises approximately 485 species worldwide, with the majority (371 species) having been described from Europe (Noyes, 2015), making it the most species-rich genus within the family Pteromalidae. All species are parasitoids of the larvae and pupae of various holometabolous insects, including Lepidoptera, Coleoptera, gall-forming Hymenoptera (Cynipidae, Tenthredinidae), and Diptera (Tephritidae). Although no recent studies have defined the genus *Pteromalus* based on phylogenetic principles, it can be readily recognised based on a combination of morphological characters (Graham, 1969; Bouček and Heydon, 1997).

Hymenoptera are well known for their economic importance, as several of their families parasitise insect pests of agricultural importance. The present study therefore contributes to the enrichment of knowledge on the entomofauna of beneficial insects in Senegal and, more broadly, in West Africa.

MATERIALS AND METHODS

Study area

The study was conducted at two sites located in the peri-urban area of Dakar, Senegal: Gorom and Lac Rose. This area is relatively isolated in terms of cropping systems and is characterised by a distinctive microclimate influenced by Lac Rose and its proximity to the Atlantic Ocean. Some plots situated within larger horticultural zones may occasionally be more exposed to wind, resulting in locally higher or lower temperatures.

Sampling procedure

The study was carried out over two cropping seasons: the hot dry season (HDS), from February to May, and the rainy season (RS), also referred to as the “winter” season, from June to September. At each study site, twenty (20) cabbage plants per plot were sampled weekly from transplanting until harvest. Larval and pupal stages of *Plutella xylostella* were collected from randomly selected plants.

Collected larvae were reared individually under laboratory conditions in 12-well culture plates (Thermo Fisher Scientific, France) and supplied with fresh cabbage leaf fragments. Following pupation,

pupae and parasitoid cocoons were transferred individually into small emergence boxes (2 × 2 cm compartments) and maintained until adult emergence. Emerged parasitoids were identified, and parasitism rates were calculated.

To characterise local climatic conditions, the mean minimum annual temperature was estimated using the "ClimaPlots" extension in QGIS, based on GPS coordinates of plots where the species were recorded at Lac Rose.

RESULTS AND DISCUSSION

Individuals of both species, *Brachymeria excarinata* Gahan and *Pteromalus* sp., were recovered from cocoons of the parasitoid *Diadegma insulare* (Cresson), which parasitises larvae of the cabbage moth *Plutella xylostella* (L.), in cabbage (*Brassica oleracea* L.) plots at Lac Rose (14°49′52.93″ N, 17°09′20.94″ W). In a previous study, *B. excarinata* was recorded for the first time in West Africa as a larval endoparasitoid of *P. xylostella* (Labou *et al.*, 2025). During that same study conducted in April 2016, both hymenopteran species were subsequently recorded as hyperparasitoids of *D. insulare* (Fig. 1&2).

His represents the first record of *B. excarinata* and *Pteromalus* sp. as hyperparasitoids of *D. insulare* in Senegal and, more broadly, in West Africa. Specimens were identified by Gérard Delvare, an international taxonomist and specialist in Chalcidoidea (Hymenoptera) at CIRAD (France). This identification complements earlier taxonomic work that recognised *B. excarinata* as an endoparasitoid of *P. xylostella*. Species identification was based on morphological characters supported by recent molecular phylogenetic data, allowing reliable recognition of the families Chalcididae and Pteromalidae (Delvare, 2025).

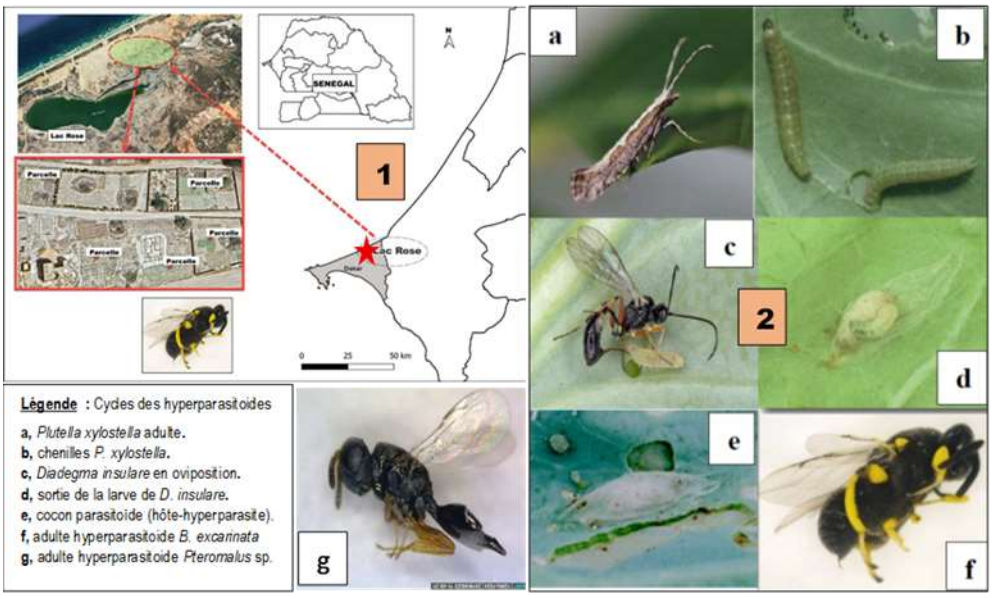

Fig. 1&2. (1) Collection site (Lac Rose). (2) Biological cycles of the hyperparasitoids

As in previous studies, voucher specimens were deposited at the entomology laboratory of the Institut Fondamental pour la Recherche Africaine (IFAN, Dakar, Senegal). Additional specimens were retained in the Department of Animal Biology, Laboratory of Integrated Protection and Production in Agroecosystems, Cheikh Anta Diop University of Dakar (UCAD).

Despite the wide host range of these hymenopteran species among phytophagous insects, in Senegal they have so far been recorded only in association with the parasitoid *D. insulare*, with *B. excarinata* also attacking *P. xylostella*. This is the first report of *B. excarinata* and *Pteromalus* sp. acting as hyperparasitoids of an ichneumonid parasitoid. These

species are generally better adapted to temperate and subtropical climates, and their occurrence in Senegal is most likely linked to accidental introductions through international trade (Sanae, 2013).

Senegal imports large quantities of agricultural products from North Africa, including onions, cabbages, carrots, potatoes, and other vegetables (Gueye, 2013). *B. excarinata* is known to occur in North Africa, particularly in Egypt, where females parasitise several lepidopteran species (Mohammed *et al.*, 2020). It is therefore likely that these species were introduced via infested cabbage and/or potato consignments imported from this region (Labou *et al.*, 2016b).

Notably, *D. insulare*, the host of these two hyperparasitoids, was first reported in Senegal in 2014 in nearby locations (Labou *et al.*, 2016b), and its introduction was similarly attributed to imports from northern countries.

Two years after its introduction, *D. insulare*, a highly efficient parasitoid of *P. xylostella*, was itself parasitised by two different hymenopteran species. This unprecedented situation within the parasitoid community associated with the cabbage moth appears to be linked to the population dynamics of *P. xylostella* prior to the establishment of *D. insulare*. This cosmopolitan pest poses a major threat to cabbage production in Senegal, to the extent that some growers have been forced to abandon their fields (Labou *et al.*, 2016a). The arrival of *D. insulare* initially raised considerable hope, as it significantly reduced moth populations, with average parasitism rates exceeding 70% (Labou *et al.*, 2026).

Laboratory studies subsequently demonstrated the high performance of *D. insulare*, with parasitism rates reaching up to 93% of *P. xylostella* larvae (Labou *et al.*, 2026).

However, this strong impact was accompanied by a marked decline in populations of other native parasitoids, including *Apanteles litae*, *Cotesia vestalis*, and *Oomyzus sokolowskii*, in the Niayes region of Senegal. The emergence of *B. excarinata* and *Pteromalus* sp. as hyperparasitoids may thus represent a regulatory mechanism contributing to the restoration of ecological balance within this trophic system.

Beyond ecological interactions, the introduction of these species is likely linked to agricultural trade. In addition to North Africa, Senegal imports cereals from countries such as India and Pakistan, regions close to Iran, where several species of *Brachymeria* have been reported (Husain *et al.*, 1982; Roodi *et al.*, 2016). In southern Sindh, pupae of *Earias* spp. have been parasitised by *Brachymeria bicolorata* in cotton and cereal crops (Ishrat *et al.*, 1987). In Karachi, unidentified species of *Brachymeria* have been reported parasitising fruit fly pupae (Samad *et al.*, 1971; Ahmed *et al.*, 1987), as well as capsule worm pupae (Sheikh *et al.*, 1987). Despite these records, the genus *Brachymeria* remains poorly studied (Khokhar *et al.*, 1971).

A similar introduction scenario has been documented for *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), which was introduced into Senegal through tomato imports from North Africa and has since become established throughout the Dakar region and the Niayes coastal zone (Brévault *et al.*, 2014).

Cropping systems may also play a significant role in the establishment of non-native insects (Idris and Grafius, 2001). Parasitoid hymenopterans are often attracted to host crops, as adults require continuous nectar sources for survival and longevity. Habitats offering abundant food resources enhance fecundity and lifespan (Lee and Heimpel, 2008). Parasitoid performance varies depending on host plant genotype (Sarfraz *et al.*, 2008) and is improved when host larvae feed on nitrogen- and sulphur-rich plants (Ulmer *et al.*, 2005; Sarfraz and Keddie, 2009; Sarfraz *et al.*, 2010; Dosdall *et al.*, 2011).

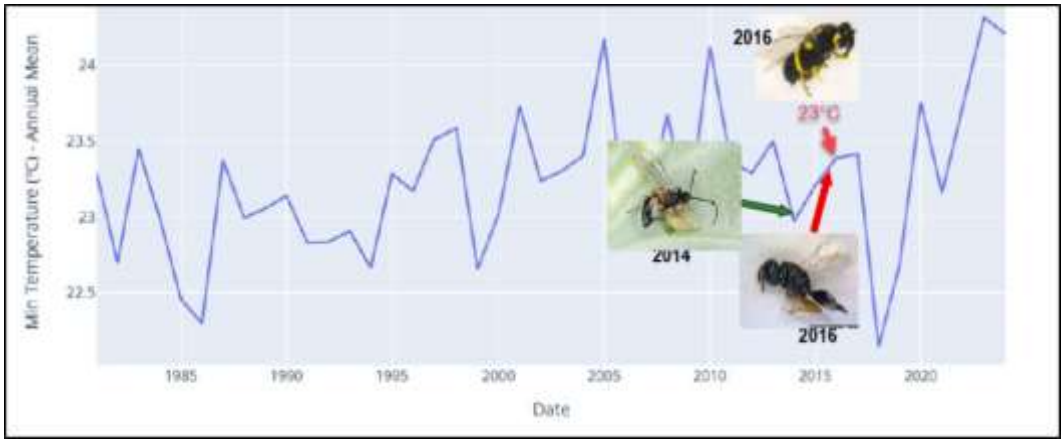

Fig. 3. Mean annual minimum temperatures at sampling plots where hymenopterans were recorded at Lac Rose (QGIS "ClimaPlots")

Climatic factors are also critical determinants of insect distribution. Temperature fluctuations can disrupt synchronisation between pests and their parasitoids (Hance *et al.*, 2007), while biological control agent capable of adapting to climatic variation are more likely to persist (Golizadeh *et al.*, 2008). At Lac Rose, specimens were collected under climatic conditions characterised by a mean minimum annual temperature of 23 °C, estimated using the QGIS "ClimaPlots" extension based on GPS coordinates of sampling plots (Fig. 3). Bahar *et al.* (2012) reported that these hymenopterans are well adapted to temperatures ranging from 15 to 28 °C, with an optimum around 22 °C.

The first record of *B. excarinata* as a parasitoid of *P. xylostella* occurred at a mean temperature of 23 °C, and the present record of *B. excarinata* and *Pteromalus* sp. as hyperparasitoids of *D. insulare* was made under similar thermal conditions. These results suggest that the local environment provides suitable temperatures for the long-term establishment and proliferation of these parasitoid species. Indeed, mean annual temperatures at Lac Rose declined from 24.12 °C to 23.38 °C between January 2010 and January 2016, creating favourable conditions for their persistence and effectiveness (Bolter and Laing, 1993; Bahar *et al.*, 2012). There is therefore a strong likelihood that these species will become established, contributing to increased diversity of beneficial insect fauna in Senegal.

CONCLUSION

Hymenoptera constitute a highly important group of beneficial parasitoids, as many species within this order have been successfully employed as biological control agents. Contrary to common assumptions regarding hyperparasitoids and their role in pest regulation, these species contribute significantly to maintaining parasitoid biodiversity by controlling the most aggressive parasitoids that could otherwise overexploit host resources. Consequently, hyperparasitoids play a critical role in both natural and agricultural ecosystems by regulating not only pest population densities but also the abundance and diversity of primary parasitoids.

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