

# First record of the spirobolid *Eucarlia hoffmani* Golovatch & Korsós, 1992 (Diplopoda: Spirobolida: Pachybolidae) from the Maldives, Indian Ocean

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**Abstract.** The remote Maldivian archipelago in the Indian Ocean has a diverse invertebrate fauna both underwater and on land. While some terrestrial classes, e.g. spiders, orthopterans, or decapods, have thoroughly been investigated and described on these coralline islands, others have been completely neglected. Although millipedes (Diplopoda) are important detritivores in almost all terrestrial ecosystems, they have until now never been reported from the Maldivian islands. Here, we report the finding of *Eucarlia hoffmani* Golovatch & Korsós, 1992 on one atoll of the Maldivian archipelago. This species has so far only been recorded from a single atoll between Madagascar and the Seychelles (Farquhar atoll) and therefore be considered as “endangered” by the IUCN red list. Our record of *E. hoffmani* on the Maldives suggests that the distribution of *E. hoffmani* is larger than previously known and that this species might, therefore, be less susceptible to possible extinction than considered.

**Keywords.** Archipelago, millipede, tropical island

## 1. Introduction

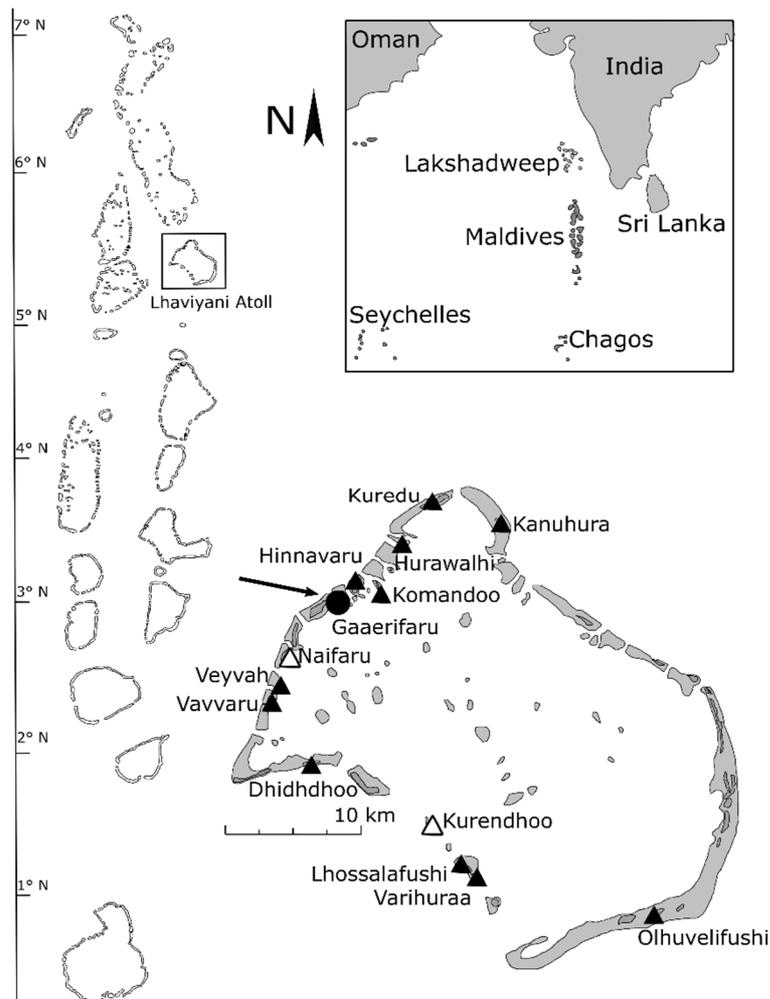
The Maldivian archipelago lies in the Indian Ocean, south of the Indian subcontinent, and the adjacent island of Sri Lanka. It consists of more than 1,100 small coralline islands that form a double chain of 26 atolls, spanning from latitudes of 8° North over the equator up to 1° South. The islands are mostly made up of sand, lack freshwater, and are on average not bigger than one square kilometre. The dominant habitat type on the islands is tropical moist forest, a forest type that is considered to be among the rarest and least protected of the world (GILLESPIE et al. 2012). Due to these moist forests and the overall tropical environment, the Maldivian islands have a diverse terrestrial invertebrate community (KEVAN & KEVAN 1995, HOGARTH et al. 1998, SUNIL 2012, TAITI 2014). While the occurrence and diversity of some terrestrial invertebrate groups on the Maldives have been thoroughly reported (e.g. spiders, orthopterans, isopods), others have never been investigated.

Millipedes (Diplopoda) are the third-largest class of terrestrial arthropods (following insects and arachnids) with more than 12,000 described species that have a relevant function as detritivores in most terrestrial ecosystems (GOLOVATCH & KIME 2009). Despite their key role as detritivores, they have never been

investigated and reported from the Maldivian archipelago. Here, we report for the first time the record of a millipede (Diplopoda: Spirobolida) species found on Maldivian islands.

## 2. Material and Methods

We visited and investigated 14 coralline islands within the Lhaviyani (Faadhippolhu) Atoll, Republic of Maldives, between February to April 2019 (Fig. 1). The sampled islands were either pristine uninhabited islands, islands used for touristic purposes, or islands inhabited by the local Maldivian population. Millipedes were searched for by removing detritus and deadwood underneath shrub and tree vegetation on random locations on each investigated island. For microscopic investigations and identification, five millipedes from one island (Gaaerifaru) were hand-collected using forceps, fixated in 98 % ethanol and stored at 8° C in a freezer. The millipedes were identified based on the gonopods using given literature (GOLOVATCH & KORSÓS 1992) and are stored at the Bavarian State Collection of Zoology.



**Figure 1:** Study area. The Maldivian islands lie south of the Indian Subcontinent (top right). The Lhaviyani Atoll (left) with 14 investigated islands (bottom right) lies in the centre of the archipelago. *Spirobolida* spec. (observations on 11 islands) – black triangles; no millipedes (Naifaruru and Kurendhoo) – white triangles; *Eucarlia hoffmani* Golovatch & Korsós, 1992 (1 male, 4 females on Gaaerifaru) – black circle and arrow.

### 3. Results and Discussion

On 11 islands of the 14 investigated (Fig. 1), Spirobolida spec. were observed, while only on two islands, Naifaru and Kurendhoo, no millipedes were found. On one island, Gaaerifaru, *Eucarlia hoffmani* Golovatch & Korsós, 1992 (1 male, Fig. 2; 4 females, Fig. 3) was found.

#### *Eucarlia hoffmani* Golovatch & Korsós, 1992

##### Material examined (Fig. 1, black circle):

1 ♂ (ZSM-A20200002, 4 ♀♀ (ZSM-A20200001, ZSM-A20200003, ZSM-A20200004, ZSM-A20200005): Maldives, Lhaviyani (Faadhippolhu) Atoll, Gaaerifaru island, underneath detritus and deadwood in shrub and tree vegetation (5.4863°N, 73.4031°E), 26.II.2019.

##### Spirobolida spec.

**Material observed (Fig. 1, black triangles):** Unidentified spirobolids underneath detritus and deadwood in shrub and tree vegetation: Maldives, Lhaviyani (Faadhipoolhu) Atoll, Kanuhura island (5.5338°N, 73.5058°E) 25.III.2019; Kuredu island (5.5474°N, 73.4608°E) 14.III.2019; Hurawalhí island (5.5225°N, 73.4417°E) 18.III.2019; Komandoo island (5.4917°N, 73.4250°E) 26.III.2019; Hinnavaru island (5.4961°N, 37.4147°E) 05.III.2019; Vavvaru island (5.4181°N, 73.3544°E) 25.II.2019; Veyvah island (5.4255°N, 73.3608°E) 21.II.2019; Dhidhdhoo island (5.3755°N, 73.3792°E) 16.III.2019; Lhossalafushi island (5.3088°N, 73.4853°E) 07.IV.2019; Varihuraa island (5.3034°N, 73.4883°E) 11.IV.2019; Olhuvelifushi island (5.2779°N, 73.6047°E) 11.III.2019.

**Identification:** A detailed description of the morphology is given by GOLOVATCH & KORSÓS (1992). An exact identification of most millipede species, especially in the tropics, is only possible with adult males, as the gonopod is the decisive identification criteria. However, adult males are often extremely rare or occur only during a limited time. For example, the type series of *E. hoffmani* consists of a single 1 adult male, 6 females, and 56 juveniles.

In *E. hoffmani* we face another problem already mentioned by GOLOVATCH & KORSÓS (1992): Adult males in Spirobolida are often hardly recognizable externally, thus every specimen has to be checked carefully under a dissecting microscope for being an adult male with developed gonopods. Fortunately, there was one adult male among the collected material from the Maldivian Lhaviyani atoll that allowed the identification to species level based on the unique structure of the phallopod telopodite (Fig. 2). Because the other collected animals could not be identified to species level and specimens from the other investigated islands were not collected for microscopic analysis, we cannot exclude with certainty whether or not *E. hoffmani* is the only diplopod species, or if more than one Spirobolid species is present on the investigated islands.

The entire classification of the family Pachybolidae is still under discussion (GOLOVATCH & KORSÓS 1992). With the alternative to unite all species from the East Indies in the genus *Trigoniulus*, GOLOVATCH & KORSÓS (1992) decided to broaden the concept of the genus *Eucarlia* to incorporate several Seychellean pachybolids. However, the allocation of the Seychellean species of *Eucarlia* to this genus is only provisional until a thorough revision of the whole family (GOLOVATCH & KORSÓS 1992).

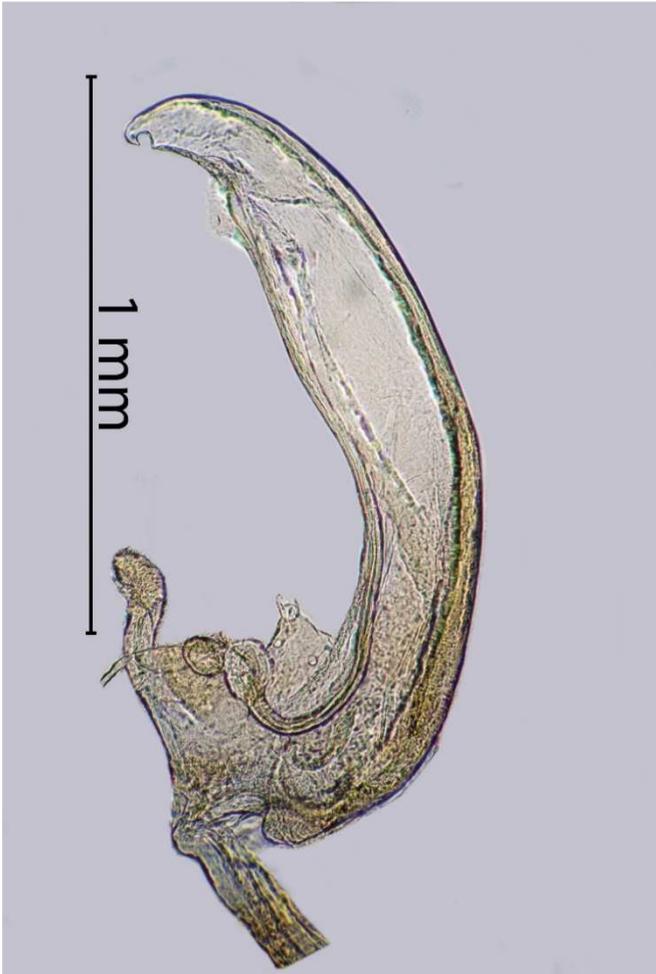


Figure 2: The phallopod telopodite of the collected male of *Eucarla hoffmani*.



Figure 3: A female of *Eucarla hoffmani*.

**Ecology:** The collected species aggregated under deadwood or leaf litter in the tropical moist forests of the coralline islands. The two islands, Naifaru and Kurendhoo (Fig. 1), where no spirobolids were found, are larger islands inhabited by the local population, where most of the pristine forest habitat has been removed.

**Distribution:** The species has previously only been recorded from the Farquhar atoll lying between Madagascar and the Seychelles (GOLOVATCH & KORSÓS 1992). Due to this very restricted distribution, it is listed as “Endangered” in the IUCN red list (GERLACH 2014). However, GOLOVATCH & KORSÓS (1992) already expressed their doubts about *Eucarlia hoffmanni* being a local endemic. The main evidence was the fact that all other millipede species recorded from Farquhar atoll are common species widespread due to human introduction. They supposed it to be an obvious introduced species and noted that “the source area of *E. hoffmani* sp. n. is still to be discovered” (GOLOVATCH & KORSÓS 1992). The records from the Maldives show that *E. hoffmani* has a much larger distribution than previously considered, and we suggest that its area might span over more island groups in the Indian Ocean. Nevertheless, all these young islands could not be the area of origin of this species. The family Pachybolidae is species-rich in the Indo-Australian region (ATTEMS 1914, CHAMBERLIN 1920). Considering the direction of sea currents together with our confirmation from the Maldives, *E. hoffmani* probably originates from one of the larger Indo-Australian islands, continental Asia or even Australia.

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