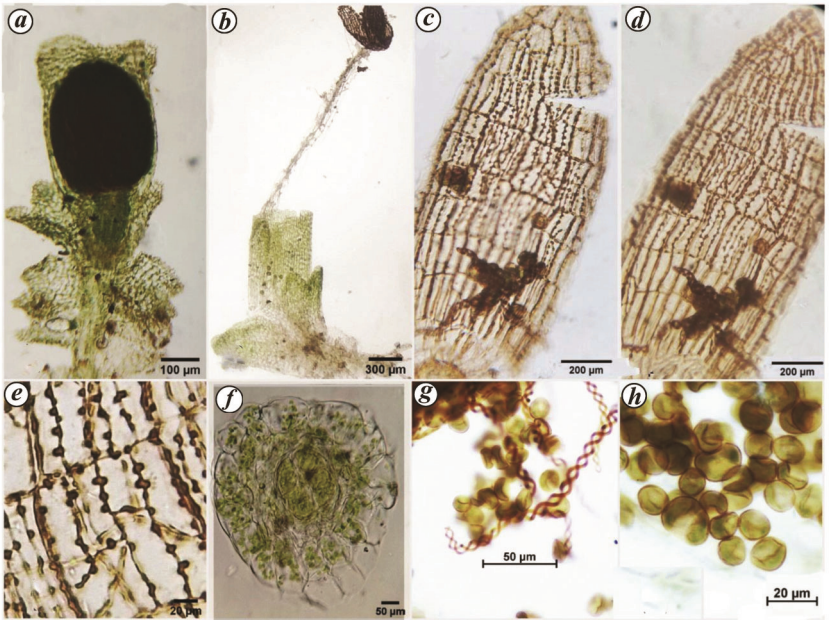

Figure 2. *G. inflata* (Huds.) Dumort. ***a***, A fertile shoot bearing gynoecium. ***b***, A mature sporophyte with elongated seta and dehisced capsule. ***c***, Outer capsule wall with nodular thickenings. ***d***, Inner capsule wall showing nodular and transverse thickenings. ***e***, Close-up of inner wall showing sinuate–nodulose thickenings. ***f***, Cross-section of seta. ***g***, Spores and elaters. ***h***, Spores.

Kathgodam–Ranibagh sal forest area, 640–800 m, 25/12/18: R.W1.23, R.W1.41, R.W1.42, R.W1.52; 26/1/19: R.W2.13, R.W2.17, R.W2.22; 12/8/2019: R.R.7, R.R.8, R.R.9, R.R.11, R.R.13, R.R.14, leg. S.D. Tewari & Richa Arya (Herbarium Department of Botany, Indira Priyadarshani Govt. P.G. Girl's College of Commerce, Haldwani; LWG).

Distribution: India (present study), Antarctica, Czech Republic, Denmark, Finland, Italy, Japan, Norway, Poland, Portugal, Russia, Sweden, Switzerland, Turkey and USA[7].

The present occurrence of *Gymnocolea* in India indicates the major range extension of this interesting leafy liverwort.

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Reproductive features of ornamental caridean shrimps under captive condition

Caridean shrimps are a large and diverse group of the order Decapoda, comprising more than 3500 valid species[1,2]. They are widely distributed from fresh to marine waters with an extensive range of habitats and reproductive features[3–6]. Many species of caridean are commercially important to fishery sector, being used for human consumption[7]. Some of them have been used in the ornamental trade as an aquarium pet, due to their attractive colours, bizarre morphology and displaying peculiar behaviour with other organisms[8,9].

Most of the decapod species have separate sexual systems. However, certain carideans have different reproductive patterns (e.g. hermaphroditism)[10]. During the copulation process in carideans, male deposits the spermatophore on the underside of the first abdominal segment of the female. The female carries the developing embryo underneath its abdomen till its maturation and releases the larva once it reaches the zoeal stage[9]. In carideans, parental care activity is similar to stenopodideans. The incubation period of carideans ranges from a week to several months, and depends on species and environmental conditions[11,12].

Generally, caridean and stenopodidean shrimps are continuous breeders under stable abiotic and ecological conditions[12]. However, some reports highlight their monogamous and polygamous activities. In carideans, the pre-mating events are

Table 1. Incubation period and fecundity of caridean shrimps in captivity

Species name and common name	Image of the specimens	Incubation period (days)	Fecundity (nos)
Gnathophyllum americanum Striped bumblebee shrimp		14–15	100–150
Periclimenella agattii Free-living shrimp		14–16	150–160
Urocaridella arabianensis Cleaner shrimp		15–16	180–185
Thor hainanensis Squat shrimp		10–11	150–200
Saron marmoratus Marbled shrimp		15–16	250–300
Lysmata hochi Hermaphroditic shrimp		15–16	400–500
Ancylocaris brevicarpalis Peacock-tail anemone shrimp		8–9	800–1000

long including contact, climb, straddle, mount, dip, pleopod beat and disengagement[9]. In females, the moulting process occurs after larval hatch out and release of larvae. Females show interest in the mating process, copulate and spawn with a new group of oocytes and continue the fertilization externally, and the process occurs repeatedly[8,9].

In the present study, we have documented spawning frequency, incubation period and fecundity of various caridean shrimps in captivity, which are commercially important in aquarium industry. The shrimps were collected from shallow-water regions of Agatti Island, Lakshadweep at a depth of 0–2.0 m, as part of an ongoing captive propagation programme. Sex was determined based on the presence of eggs and appendix masculina. After acclimatization, three pairs of

each *Lysmata hochi*, *Thor hainanensis*, *Ancylocaris brevicarpalis*, *Saron marmoratus*, *Urocaridella arabianensis*, *Periclimenella agattii* and *Gnathophyllum americanum* were accommodated separately species-wise and water parameters were provided *in situ*. Coral boulders and live rocks were given as hiding substratum. Seven of 250 l FRP tanks were used and the same were partitioned into three equal compartments, and a single pair of each species was maintained in individual partition. *Artemia* flakes, clams and commercial pellets (JBL Novo Prawn by JBL GmbH & Co, Germany) were given as feed, twice daily. The embryo development and incubation period were noted down for six months from October 2019 to March 2020. The incubation period was calculated from the observation of female moult to a subsequent hatch-out. Fecundity was calculated by counting the number of embryos brooded under the abdomen of a female, using a stereomicroscope.

It was observed that all the studied species were continuous spawners. Soon after hatch-out, within 1 to 72 h, the female shrimps were ready to undergo moulting process. Moulting occurred within 24 h after hatching and the same was observed in *P. agattii*, *A. brevicarpalis*, *U. arabianensis* and *T. hainanensis*. However, in *S. marmoratus* and *G. americanum*, this process took 48 h, whereas in *L. hochi*, it sometimes extended to 72 h. Following the moulting process, copulation began subsequently spawning and attachment of new embryos underneath the female abdomen was observed. This observation about reproductive and moulting behaviours of shrimps matched well with that of Bauer[3]. The present study shows that the incubation period was two weeks for all the species (Table 1). Variation in the tank water parameters or inadequate and balanced diet may lead to change in the spawning frequency; hence maintenance of water parameters and healthy diet was strictly followed. The results of this study on spawning frequency, incubation period and fecundity of these species may prove useful for captive propagation and scaled-up production.

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