Freshwater bryozoans in La Gamba (Costa Rica: Piedras Blancas National Park): a general introduction

Briozoos de agua dulce en La Gamba (Costa Rica: Parque Nacional Piedras Blancas): una introducción

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Abstract: Despite their common occurrence and potential ecological and economic impacts, freshwater bryozoans have received very little attention in scienctific research. These "moss animals" comprise a relatively small group, with 88 species, and are widely distributed in ponds, lakes, streams and rivers. They mostly belong to the class of phylactolaemates, which occur exclusively in freshwater, while a few species can be assigned to a predominantly marine class, the gymnolaemates. Freshwater bryozoans are sedentary, filter-feeding, colonial animals with complex life cycles. They exhibit a variety of asexual means of propagation, which is unique among freshwater invertebrates. In addition to fragmentation and fission, reproduction and dispersal takes place via resting stages such as statoblasts, in the case of phylactolaemates, and hibernaculae in the case of gymnolaemates. Freshwater moss animals are present on all continents except Antarctica, but most bryozoological research has been conducted in temperate zones. The freshwater tropics are largely unexplored, particularly the Neotropics. This pilot study on bryozoan occurrence and species diversity takes place in La Gamba (Costa Rica: Piedras Blancas National Park) and represents, together with a survey on phylactolaemate bryozoans of the Guanacaste Conservation Area, the first investigation of this animal group in Central America.

Key words: freshwater bryozoans, general characteristics, zoogeography, Plumatellidae, La Gamba, Costa Rica.

Resumen: A pesar de su frecuencia y de su potencial ecológico e impacto económico, los briozoos de agua dulce han recibido muy poca atención en la investigación científica. Los animales musgo incluyen a un grupo relativamente pequeño de 88 especies y se encuentran ampliamente distribuídos en estanques, lagunas, arroyos y ríos. La mayoría pertenece a la Clase Phylactolaemata, que se encuentra exclusivamente en agua dulce y sólo unas pocas especies pueden ser asignadas a la Clase Gymnolaemata predominantemente marina. Los briozoos de agua dulce son sedentarios, filtradores, animales coloniales con complejos ciclos de vida. Ellos exhiben una variedad de formas de propagación asexual que son únicas entre los invertebrados de agua dulce. Ademas de la fragmentación y fisión, la reproducción y dispersión ocurre a través de estados de resistencia, como los estatoblastos en el caso de Phylactolaemata e hibernáculos en el caso de Gymnolaemata. Los animales musgo de agua dulce se encuentran presentes en todos los continentes, excepto en la Antártica, sin embargo la mayoría de las investigaciones briozoológicas se han llevado a cabo en zonas templadas. El agua dulce de los trópicos son áreas no exploradas, en particular los neotrópicos. Este estudio piloto sobre la presencia de briozoos y diversidad de especies se llevo a cabo en La Gamba (Costa Rica: Parque Nacional Piedras Blancas) y representa junto con una investigación de los briozoos Phylactolaemata del área de Conservación Guanacaste, la primera investigación sobre este grupo de animales en América Central.

Palabras clave: briozoos de agua dulce, características generales, zoogeografía, Plumatellidae, La Gamba, Costa Rica.

Introduction

Freshwater bryozoans or moss animals can be commonly found in a broad range of lentic and lotic bodies of water, but they are less familiar, often overlooked and neglected in most limnological studies and faunal surveys. In many regions of the world they are one of the most poorly known faunal groups (RICCIARDI & REISWIG 1993). They are, however, among the most important suspension-feeding animals, along with sponges and mussels (WOOD 2006). Freshwater bryozoans even can dominate epibenthic and litoral communities in biomass (RADDUM & JOHNSON 1983).

In total, the invertebrate phylum Bryozoa comprises more than 8.000 extant, mostly marine species (RYLAND 2005), a number that is far exceeded by 16.000 fossil taxa. As the great majority of marine bryozoan colonies possess calcareous skeletons they are easily preserved and are among the commonest macrofossils from the Lower Ordovician onward. In contrast, the colonies of soft-bodied freshwater bryozoans have left

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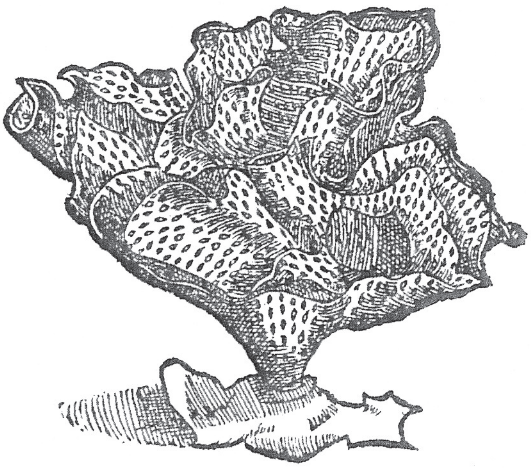

Fig. 1: First depiction of a bryozoan (RONDELET 1558): "giroflade de mer", representing a reteporid taxa.

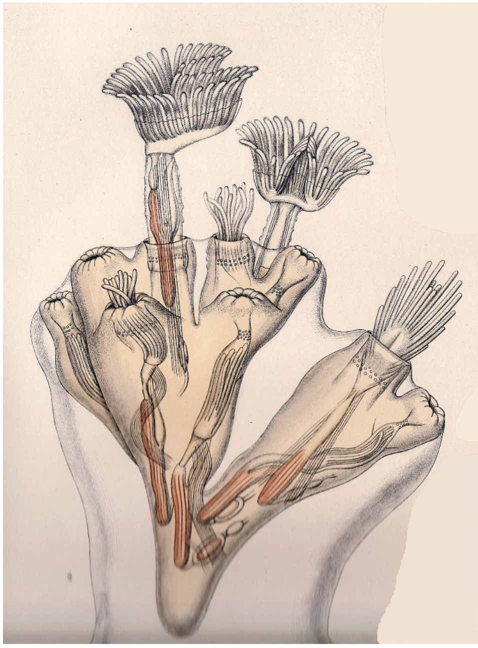

Fig. 2: First freshwater bryozoan to be described: *Lophopus crystallinus* (PALLAS 1786) or "bellflower animal" (from ALLMAN 1856).

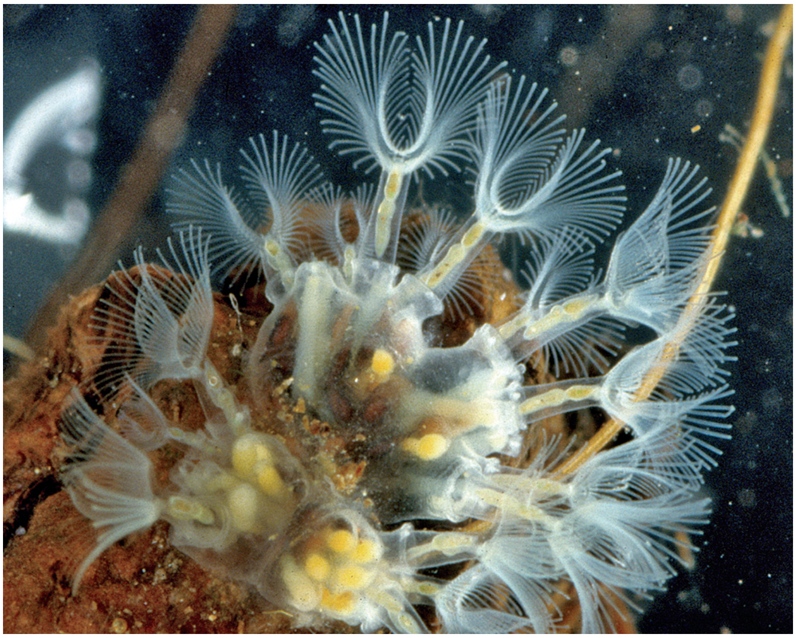

Fig. 3: *Lophopus crystallinus*: sac-like colony with protruding zooids.

no fossil record, but the chitinous resting stages manufactured for overwintering and dispersal are very occasionally found in the fossil record as far back as the Permian (TAYLOR 2005).

The first descriptions of bryozoans can be dated back to the year 1558 where RONDELET presented in his "L'Histoire entière des poisons" a figure of marine bryozoan, presumably a reteporid taxa, calling it "giroflade de mer" (Fig. 1). While Rondelet correctly classified the organisms as animals, until the mid 18th century many authors interpreted bryozoan colonies, like corals and hydroids, as plants. Tentacles of a protruded polypids of *Alcyonaria* were described as eight petals of a flower and encrusting sheets of calcareous bryozoan colonies were assigned to be a "stony plant". Generally this remains reflected both in the name of the phylum, which translates as "moss animals" and in the term "zoophyte" which was used by LINNAEUS (1758) to embraced both bryozoans and hydroids (RYLAND 2005). The first freshwater bryozoan to be described was *Lophopus crystallinus* by PALLAS in 1768, but it is believed that Trembley's depiction of a "polyp à panache" (Fig. 2) also displays that species. The name "bellflower animal" refers to its fan-shaped colonial structure. The transparent sac-like colonies possess the largest zooids of all bryozoan species reaching about 5 mm in size (Fig. 3).

The modern classification of bryozoans began in 1837 when the classes Phylactolaemata and Gymnolaemata were established, followed later on by a third class, the Stenolaemata.

The Phylactolaemata exclusively occur in freshwater while a few species of the predominantly marine group Gymnolaemata can be found in brackish water and freshwater environments as well. VINOGRADOV (2004) established the latest revision of freshwater bryozoan systematics which is still in the process of general acceptance.

Morphological and ecological characteristics

Bryozoans are sedentary, colonial animals, with colony sizes ranging from less than one millimetre in height, as in the marine genus *Monobryozoan* which consists of little more than a single feeding zooid (RYLAND 2005), to giant colony growth forms of up to 2.5 m length and 0.5 in diameter such as in the freshwater species *Pectinatella magnifica* (Fig. 4).

In the bryozoan phylum, the texture of colonies varies from strongly calcified to gelatinous. Colonies of freshwater bryozoan taxa are classified into the plumatellid and the lophopodid type (Fig. 5a, b). The plumatellid type is assigned to colonies with chitinised tubes which are relatively stiff and durable. It allows colonies to ramify over the substrate with sometimes erect branches or in a bushy shape. Large massive growth forms reach coverages metres long on submerged trunks and rocks or make colonies the size of a human head, weighing more than 1 kg (WÖSS 2005a). Colonies of the lophopodid type are gelatinous, soft and transparent. They remain either small, resembling egg masses of molluscs, or they can also aggregate to huge gelatinous bodies.

All plumatellids are strictly sessile. However, within the lophopodid type a certain motility can be observed in some species e.g. in colonies of small, lobular (*Lophopus crystallinus*) or vermiform shape (*Cristatella mucedo*).

Each colony consists of genetically identical modular units, known as zooids. In contrasts to marine species, zooids of freshwater bryozoans are monomorphic and each is provided with its own independent feeding, digestive, muscular, nervous and reproductive system. The internal living parts of the zooid constitute the moveable polypid while the surrounding walls and their associated tissues, the cystid, functions as a protective housing.

The anterior part of the polypid is the most conspicuous part of a bryozoan; a tentacular crown or lophophore, which in the case of the phylactolaemates is predominantly horseshoe-shaped, carries up to 120 tentacles. Bryozoans are active filter-feeders. The tentacles create a current of water that brings suspended particles, including living and dead organic material as well as inorganic silt, towards the mouth. Freshwater bryozoans contribute significantly to the recycling of nutrients in small lentic habitats (JOB 1976, SØRENSEN et al. 1986).

Reproduction and dispersal is highly complex and is based on a variety of propagules unique among freshwater invertebrates. Due to the instability of most freshwater environments, the occurrence of colonies is limited to a certain period of the year, e.g. colonies do not overwinter in temperate zones or they suffer from desiccation in zones with dry seasons or high water level fluctuations. Asexual propagation units are developed and constitute an obligatory component in freshwater bryozoan life cycles. This is necessary, as the sexual propagule, the larva, is highly vulnerable and can only exist and be dispersed during a short period (WÖSS 2002). Asexual reproduction can take place by fragmentation and fission of colonies and, most importantly, by the formation of resting stages. These dormant bodies consist of chitinised shells protecting the germinal mass and yolk cells. In the case of the phylactolaemates, they are categorised as statoblasts while gymnolaemates form hibernaculae. One group of statoblasts, the floatoblasts (Fig. 6a), drift on the water surface with the help of a

Fig. 4: *Pectinatella magnifica*: colony growth in massive gelatinous form.

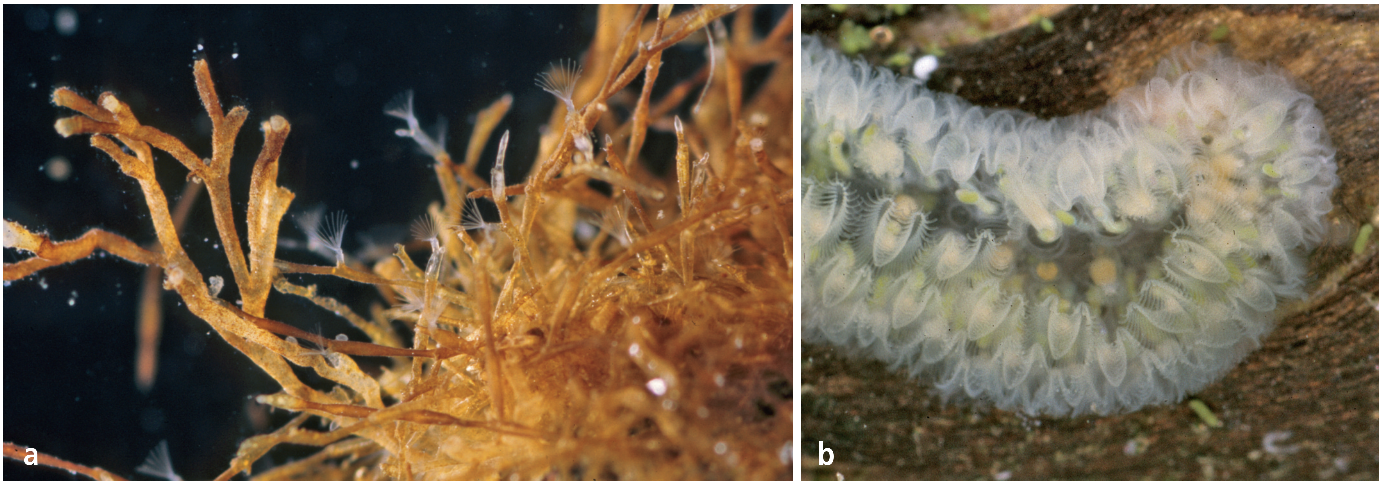

Fig 5: Classification of colonies in freshwater bryozoans. (**a**) plumatellid type (*Fredericella sultana* intermingled with *Paludicella articulata*), (**b**) lophopodid type (*Cristatella mucedo*).

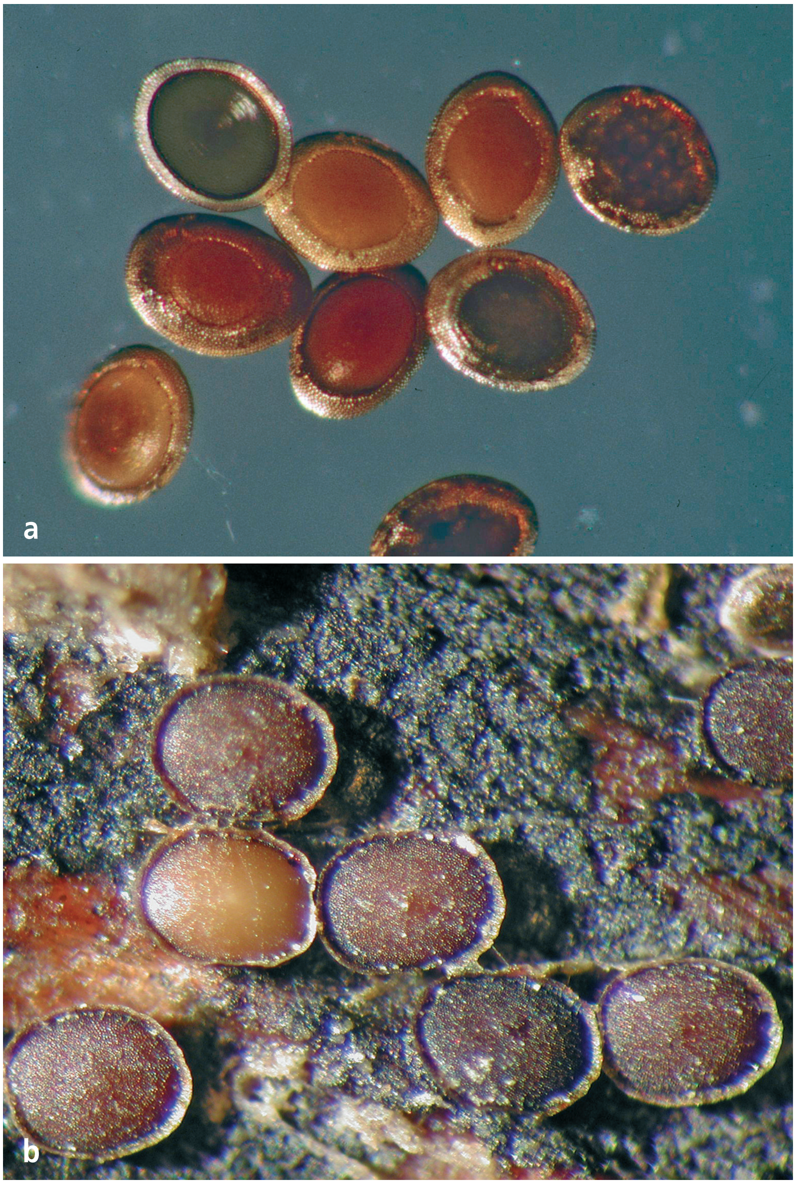

Fig. 6: Statoblasts of Plumatellidae (Phylactolaemata). (**a**) floatoblasts, (**b**) sessoblasts.

gas-filled annulus that facilitates dispersal and colonisation of new substrates. They can be disseminated by migratory waterfowl over long distances, as data on population genetics from northern European bryozoans reveal (FREELAND et al. 2000).

The second group consists of sessoblasts and piptoblasts, which both lack – as do the hibernaculae – the capability to float. Hibernaculae and sessoblasts are usually fixed to the substrate, with a special attachment apparatus located on one side of the shell in the case of the sessoblasts (Fig. 6b). Thus, these resting stages promote the local persistence of the bryozoan (KARLSON 1994).

Species diversity and zoogeographical distribution

Freshwater bryozoans occur in a broad range of freshwater habitats, such as ponds, lakes, rivers and estuaries. Colonies are attached to submerged surfaces or the underside of floating objects such as aquatic plants, wood and rocks or a wide range of other materials brought in artificially, such as plastic, glass, rubber tyres or aluminium.

Despite the small number of described species (88), freshwater bryozoans are found on all continents except Antarctica. They have been described in a range from 75° N in lakes close to Spitzbergen to 55° S in Tierra del Fuego. A total of 43 species are confined to one zoogeographical region and 22 of these 43 species are known only from a very restricted area, such as one or two sites (MASSARD & GEIMER 2008). The proportion of endemic species is specified with 45% (WOOD 2002).

The taxonomy of Phylactolaemate bryozoans has advanced considerably through the examination of statoblasts by scanning electron microscopy. Since the first discussion on zoogeography of freshwater bryozoans by BUSHNELL (1968, 1973), the number of species has more than doubled. In the taxonomically most difficult group – Plumatellidae which comprises about 78% of the phylactolaemates – species discrimination is repeatedly under revision. SEM investigations in the genus *Plumatella*, for example, has resulted in an increase of 25% in species number over the last two decades. Consequentially, the cosmopolitan status of *Plumatella repens*, *Plumatella emarginata* and *Fredricella sultana* has had to be reconsidered as former records of these species may correspond now to other, newly-described species. At present, only *Plumatella casmiana* is thought to be cosmopolitan, although it is not yet reported from South America and Australia (MASSARD & GEIMER 2008).

While progress is made in surveying bryozoans in temperate regions, mainly in Europe and Northern America, there are still large gaps in their inventories in Africa, South America, Central America, Africa and some parts of Asia. The patterns of disjunct distributions of many species are highly doubtful due to the scarcity of available data. Some of these distribution patterns can possibly be interpreted by dispersal via migrating water fowl, such as the narrow, intercontinental range of several species. In other cases, the dispersal patterns might suggest human activities as a major contributing factor (WOOD 2002).

The freshwater tropics are largely unexplored, and particularly in the Neotropics, only a few surveys on bryozoans in larger geographical areas have ever been conducted: in Brazil (WIEBACH 1967, 1970a, b, 1974,

BONETTO & CORDIVIOLA 1965, MARCUS 1941, 1942), Argentina (CAZZANIGA 1989) and Costa Rica (ROUSH 1998). The number of Central American freshwater bryozoan species is currently reckoned at six Phylactolaemata and four Gymnolaemata (WOOD http://bryo technologies.com/pages/world%20list.com), without including the Costa Rican results. Despite the paucity of data on species, the conclusion is made that freshwater bryozoans have relatively small geographic distributions in tropical regions (WOOD 2002).

Central America: Panama Canal, Guanacaste Conservation Area and La Gamba

Panama Canal

In the 1990s *Asajirella gelatinosa* (Fig. 7), a lophopodid species known previously only from eastern Asia, was recorded twice in the area of the Panama Canal system (WOOD & OKAMURA 1999). In April 1992, colonies were collected on leaves and stems of *Hydrilla verticillata* in the broad reaches of the lower Río Chagres as it enters Lake Gatun. The Lake is the 230 km^2 heart of the Panama Canal system, created in the 1890s by damming the Río Chagres. In a subsequent collection in February 1998, large colonies were found upstream of the first site on stumps and reeds in the shallow water of the Lago Alajuela impoundment (9°14.74'N, 79°35.62'W). Sporadically abundant but never common, *A. gelatinosa* has been reported from Japan, Korea, Taiwan, Burma, India, Ceylon and Indonesia. Human transport of statoblasts is a likely cause of the disjunct distribution of this species as it might have been introduced by shipping traffic with the completion of the Panama canal in early 1900.

Guanacaste Conservation Area

Surveys of freshwater bryozoans in Costa Rica started in 1996/1997 in the Guanacaste Conservation Area in north-western Costa Rica (ROUSH 1998). The Conservation Area occupies 110.000 hectares in the Guanacaste province and is designed to protect the endangered dry tropical forest biome. In this area, seventeen aquatic habitats representing tropical dry forest, cloud forest and Atlantic rainforest were investigated in the course of three field trips. In total, nine phylactolaemates could be recorded: *Fredericella browni* (ROGICK 1945, Fredericellidae) and eight species of the family Plumatellidae, seven of the genus *Plumatella* and one of *Hyalinella*. Based mainly on statoblast morphology, the eight Plumatellidae were all diagnosed as new species. The detailed description of the new species will appear in a separate publication shortly (Wood, pers. com.). *F. browni* is already known from Guatemala and also occurs in North and South America (ROUSH 1998). Species occurrence was exclusively restricted to eight shallow, seasonal streams and ponds with POC of 570-4.300 mg cm^{-3}. Four species occurred in seasonal streams (Rio Cuajiniquil, Quebrada el Duende, Quebrada Costa Rica) originating in dry tropical forest and desiccating five to six months of the year. Six species were found in seasonal lentic habitats, such as in artificial ponds (dry forest as well as rainforest), in natural seasonal marshes (dry forest) and in a small natural depression (primary moist/dry transistion forest). The permanent streams originated in cloud and rainforests and contained large volumes of fast flowing water and were characterised by POV < 560 mg cm^{-3}. They all contained no bryozoans. The nine species found in the seasonal streams and ponds showed very little overlap in distribution and all but three species were restricted to a single site.

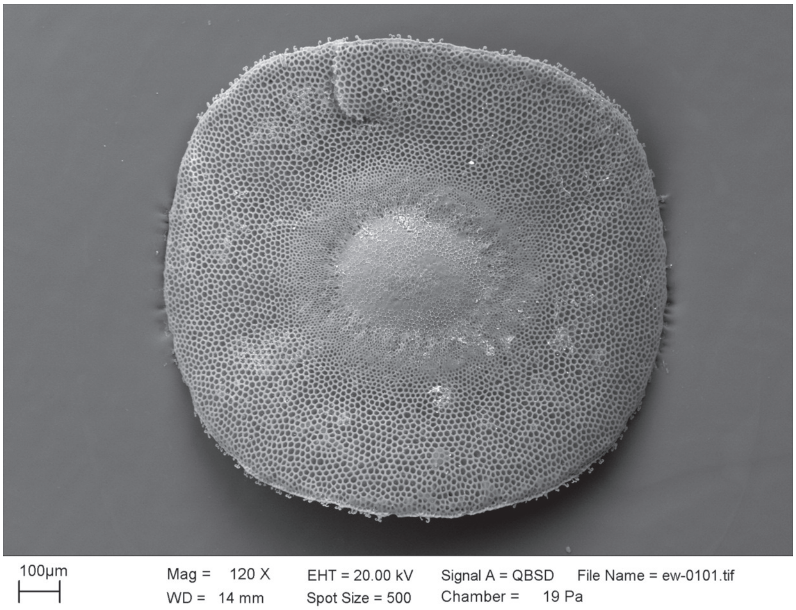

Fig. 7: *Asajirella gelatinosa*: floatoblast (spinoblast).

La Gamba

Sites and methods

This pilot study on bryozoans study was carried out from 28 January 2007 to 1 February 2007 in the surrounding area of the Research Station La Gamba (UTM 962502 N and 257756 E). As the Golfo Dulce region belongs to the most humid areas in Costa Rica, sampling in the dry season (December-April) guaranteed easier access to the water. In total, eight sites were investigated in search for bryozoans colonies or statoblasts. Aquatic plants, submerged wood and smaller rocks were pulled out with the help of a rake to analyse the aufwuchs for possible colony growth or sessoblasts

Fig. 8: La Gamba, sites with freshwater bryozoan occurrence. (**a**) "caiman pond", (**b**) "old station pond", (**c**) "forest pond", (**d**) "tilapia pond".

fixed to the substrate. Surface water was filtered and drifting detritus was sampled with a net in search for floatoblasts. Environmental parameters such as water temperature, pH and conductivity were measured with Eutech Instruments pocket testers.

Results and discussion

Five of the 8 bodies of water (Table 1) can be characterised as stagnant ("ponds"), the two streams and the river showed slow to intermediate current. The wide river bed of the Río Quebrada la Gamba had partially fallen dry with several basins nearly isolated. Water temperature ranged from 27.8°C to 30°C, pH was 6.4-7.4 and conductivity was 70-137 µS. Evidence for bryozoan presence was provided in the following four sites, all of them stagnant water bodies.

Table 1: Bryozoan survey in La Gamba (28.1.-1.2.2007): study sites and bryozoan occurrence.

date	site		bryozoans	number of species
28.1., 30.1.	1 pond	"caiman pond"	colonies, statoblasts	4
29.1.	2 pond	"old station pond"	colonies, statoblasts	3
1.2.	3 pond	"forest pond"	colonies, statoblasts	1
1.2.	4 pond	"tilapia pond"	colony	1
28.1., 30.1.	5 pond	"swimming pond"	—	
29.1.	6 stream	riverbed trail	—	
1.2.	7 stream	"forest stream"	—	
31.1.	8 river	Río Quebrada la Gamba	—	

Site 1: "caiman pond", situated on the road between Research Station La Gamba and Esquinas Rainforest Lodge (Fig. 8a).

Colonies: submerged branch (ø 2.5 cm) with several young colonies. Colonies growing in "runners" (Wöss 1996), cystid texture hyaline to weakly chitinised. All zooids attached to the substrate, one colony with about 30 extruded zooids, tentacles 45-56 and delicate. Floatoblasts were in formation and ripened in the largest colony to be successfully reared for a weak in the laboratory. Statoblasts: high number of floatoblasts drifting close to the shore. Floatoblasts of four different *Plumatella* species: two types of floatoblasts of broad oval shape (similarities with European *P. repens*, *P. rugosa*), two types floatoblasts of long oval shape (similarities with European *P. emarginata*, Asian *P. bombayensis*).

Site 2: "old station pond", situated within the area of the former research station and present guest house (Fig. 8b).

Colonies: floating branch (ø 1 cm) with several very small colonies. Colony growth dense and fully adherent to the substrate, cystid transparent. Tentacles long, delicate and mostly 50 in number; colony tubes with small elongate floatoblasts (a few similarities with European *P. casmiana*).

Statoblasts: floatoblasts sticking on a floating branch (ø 1.8 cm) and drifting on the water surface: three different *Plumatella* species (floatoblasts broad oval, Fig. 9, long oval and small elongate)

Site 3: "forest pond", eastern part of the flood plain area of the Rio Quebrada la bolsa: a depression within the forest, north-east of Señor Mundo's finca (Fig. 8 c)

Colonies: several colonies on few thick branches (ø 4 cm). Colonies fully adherent to the substrate, cystid chitinised with long oval, mature floatoblasts inside.

Site 4: "tilapia pond", eastern part of the flood plain area of the Rio Quebrada la bolsa: a depression at the edge of the forest, south of Señor Mundo's finca (Fig. 8d)

Colonies: one very small colony on a plant stem, with statoblasts in formation, presumably sessoblasts.

The fifth stagnant water body, the "swimming pond", is situated within the garden of the present research station. The rich aquatic vegetation would provide enough substrate for littoral aufwuchs communities, but bryozoans are absent. This may be explained by the young age of the pond; it was created in 2002, in contrast to the "caiman pond" which has been in existence since 1994 (Weissenhofer, pers. com.).

It can be assumed that water bodies in the flood plain area of the Rio Quebrada la bolsa are interconnected during the rainy season. This may especially be the case for the "forest pond" and the "forest stream" and would affect the dispersal of resting stages and colony fragments. Furthermore, dispersal of statoblasts – often assigned to waterfowl – could also be accomplished by caimans. The reptiles were hiding in emersed vegetation or accumulations of detritus in all of the stagnant water bodies except the "tilapia pond". They were even temporarily found in the "swimming pond", although they were repeatedly moved from there.

In summary, despite the preliminary character of the survey, the result is promising: freshwater bryozoans seem to frequently colonise the ponds in immediate vicinity of the research station La Gamba. Species diversity per site turned out to be even higher than it was in Guanacaste in two of the four sites. In La Gamba, up to five species will be documented by floatoblasts. Sessoblasts were very rare; WOOD (2000) mentions that sessoblasts are unknown in a number of plumatellid phylactolaemates and refers to 70% of all neotropical species. By contrast, sessoblasts do occur in 91% of plumatellid holarctic species and in all of those from Australia. However, material from the tropics is extremely

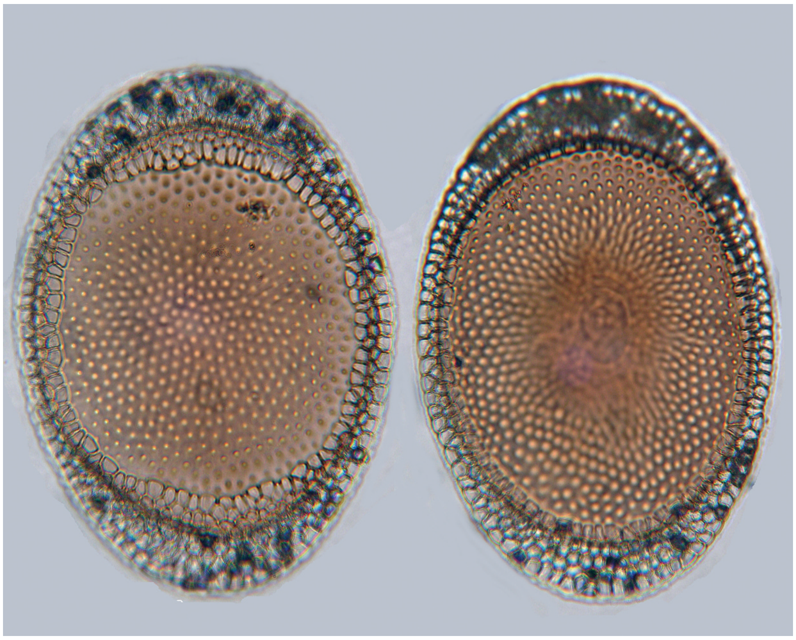

Fig. 9: *Plumatella sp.* ("old station pond"): floatoblast, the two valves separated after treatment with KOH.

Fig. 10: Prolific growth of plumatellid colonies on artificial substrates.

Fig. 11: Bryozoan fouling in a fish farm in Demmin, Germany: (**a**) colonies of *Plumatella fungosa*, (**b**) dead colony tubes with remaining floatoblasts.

sparse and further sampling might dispute the hypothesys that sessoblasts evolved as overwintering structures mainly in temperate regions.

As in Guanacaste, no gelatinous species of the lophopodid type were detected in La Gamba. All findings can be assigned to the Plumatellidae, a result that resembles the study of ROUSH (1998). Additionally, ROUSH emphasized that "bryozoans in the GCA prefer seasonal habitats with slow to no current and high POC content" which also agrees with the present results from La Gamba. Although nutrient content was not measured during collecting in the ponds, a food chain from phytoplankton to fish seemed to provide an optimal environment for the presence of bryozoans. The fact that they were absent in lotic water bodies is not unknown from studies in the temperate zone, although freshwater bryozoans do occur in streams and rivers. In general, the structure of the habitat, such as the availability of suitable substrates which was greater in the ponds, play a crucial role for bryozoan presence and absence.

It might turn out that all of the sampled species of La Gamba could not be classified in existing species lists of Central America or from elsewhere. However, they might be already represented in the findings of the Guanacaste area which are now in process. Therefore the detailed description of the La Gamba material will be synchronised by comparing SEM pictures of statoblasts or by exchanging material. Besides, further sampling in the La Gamba area would be advantageous to acquire complete information (colonies and all kind of resting stages) in the case of describing holotypes and to get an insight into the life histories of freshwater bryozoans in the tropics (colony versus statoblast occurrence in the course of the year).

Human related issues

"In the whole animal kingdom there are few groups less frequently associated with the activities of men than the Polyzoa" (ANNANDALE 1922, still using the term Polyzoa for the phylum Bryozoa). The following examples will outline the potential of bryozoans: causing damage as well as offering beneficial qualities – all from an anthropocentric point of view.

Biofouling

Moss animals are probably the most common among the fouling organisms. Before the widespread use of sand filtration, freshwater bryozoans were a frequent nuisance in water supply systems of large cities like London and Hamburg where KRAEPELIN (1885) called them "Leitungsmoos" (pipeline moss). Nowadays, economical loss is noteworthy as they are still responsible for blocking conduits or clogging filters in water reservoirs, municipal water supplies, waste water treatment systems and irrigation systems (SMITH 2005, WOOD 2005). The rapid and widespread growth of attached colonies (Fig. 10) reduces water exchange and fish growth in fish farms (JONASSON 1963, pers. obs.) and causes operating problems in thermal and nuclear power stations (APROSI 1988). For instance, the Chinon power station on the River Loire had to be shut down due to prolific bryozoan settlement in the cooling circuits which were supplied by river water. In addition, biofouling by bryozoans is persistent, since statoblasts and hibernaculae are very resistant to physical and chemical treatment and can act as seed banks (Fig. 11a, b).

Prokiferate kidney disease

A number of freshwater bryozoans are already known to be the hosts of the myxozoan parasite *Tetracapsuloides bryosalmonae*, the causative agent of the proliferate kidney disease (PKD, ANDERSON et.al. 1999). Proliferate kidney disease is a serious infection of wild and farmed salmonids, affecting mainly the kidney and spleen of the fish hosts. The infection causes the fishes' immune cells to multiply out of control, destroying the infected organs and resulting in anaemia, bloating, discolouration and death. In intensive farming situations, entire stocks can be wiped out. Due to the great economic losses to aquaculture industries, PKD has been identified as one of the most economically important diseases affecting cultured salmonid fisheries (TOPS & OKAMURA 2005).

Although PKD was recognised as a serious salmonid fish disease in the early 20th century, the etiological agent remained unidentified until in the 1980s when evidence was provided that the parasite organism belongs to a group known as Myxozoa. As the parasite does not develop into its final form in fish, it was not possible to identify it further until 1999, when identical genetic material of this parasite was demonstrated in bryozoans as well as in rainbow trout, thus identifying bryozoans as the mystery hosts harbouring the infective stages of this myxozoan. The parasite was named *Tetracapsula bryosalmonae* (later renamed to *Tetracapsuloides bryosalmonae*), reflecting the names of the bryozoan and salmon hosts. The discovery has far-reaching implications for fish farming. For the first time, the natural source of infection has been identified, raising hopes that infection in fish can be lowered or even prevented by controlling the occurrence of bryozoan species in the water body.

Neurotoxins and chemotherapeutic substances

Lophopodella carteri, a gelatinous freshwater bryozoan species, synthesises a non-protein neurotoxin, a substance responsible for killing fish, probable through inhibition or neurotransmission (MASSARD & GEIMER 2008). Bryostatin is another bioactive component produced by the marine bryozoan *Bugula neritina* (Gymnolaemata: Cheilostomatida) and its specific symbiont *Endobugula sertula*. It has been used as anti-cancer treatment for patients suffering from leukaemia, lymphoma, melanoma, ovarian cancer and breast cancer. In 1968, bryostatin 1 was detected in populations of *Bugula neritina*, the dominant element of the fouling communities on oil platforms in the Gulf of Mexico in California. For many years, synthetic production was too time-consuming and complex. As 38 tons of the bryozoan were necessary to harvest just 18 g of the substance, the original population of *Bugula* declined dramatically. Furthermore, investigations revealed that a bacterial symbiont of *Bugula*, *Endobugula sertula*, was responsible for producing bryostatin and *E. bugula* could not be cultivated. As *Bugula* samples from other sites did not contain the identical pharmaceutical active substance, the situation turned out to be critical until at the end of the 1990s, bryostatin 2, a synthetic form of bryostatin 1, could be produced. Currently, 15 variants of bryostatin are known and progress in molecular biology facilitates economically efficient production of the anti-cancer drug (WÖSS 2005b).

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