



High abundance of *Trochospongilla horrida* (Porifera, Spongillidae) in the Rhine (Germany) 1992–1995

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Abstract

Trochospongilla horrida (Porifera, Spongillidae) was the dominant freshwater sponge in the Rhine between Karlsruhe and Bonn between 1992 and 1995 are reported. It showed an annual life cycle, with an inactive phase during winter. The life cycle was controlled by temperature. Gemmules were produced in high numbers, and played a significant role as resting bodies. Their role as distribution units was negligible because they were tightly fixed to the substratum. *Trochospongilla horrida* preferred relatively stable habitats, not affected by fluctuations in water level; it was restricted to habitats with a slightly alkaline pH. Laboratory experiments showed a delayed germination of the gemmules, which explains why the highest abundance of the species occurred considerably after the first hatching colonies.

Introduction

The freshwater sponge *Trochospongilla horrida* Welter, 1893, occurs throughout the holarctic region, but in spite of its wide distribution, it is always rare (Richelle-Maurer et al., 1994; Wittling & Mauch, 1993).

In Germany it is mainly known from big rivers and their tributaries: the Elbe (Dorschner et al, 1993), Danube (Wittling & Mauch, 1993), and the Rhine.

From the Rhine it was mentioned first by Lauterborn (1905) between Ludwigshafen and Speyer. In 1928 the species was recorded again near St. Goar (Arndt, 1928), and in 1951 from a blind river arm of a tributary to Lake Constance by Simon (1951). Simon (1952) mentions old reports by Schröder of *T. horrida* in Lake Constance. Since the 1980s the reports from the Rhine have become more abundant: Neubert & Eppler (1992) gave a listing of several new records, and Saller (1990a–c) obtained sponges near Bonn.

Outside Germany, *T. horrida* has been recorded in Belgium (Richelle-Maurer et al., 1994), France (Arndt, 1928), Italy (Pronzato & Manconi, 1989), Poland (Konopacka, 1983–84), the Czech Republic (Dorschner et al., 1993; Elbe: Fric & Vavra, 1901), Slovakia (Kosel, 1972), Romania (Arndt, 1937, Ru-

descu, 1975), Lithuania (Dybowski, 1886), Latvia, Russia (Arndt, 1926) and Ukraine (Dniepr: Grimailowskaja, 1928), Uzbekistan (Rezvoj, 1928), China (Gee, 1926) and Egypt (Nile: Gugel, 1993).

Trochospongilla horrida has also been found in the USA (Pennak, 1953), eastern Canada (Ricciardi & Reiswig, 1993) and in Panama (Poirrier, 1990). One record in Argentina (Bonetto & Ezcurra de Drago, 1965) was considered synonymous with the South American *Trochospongilla minuta* (Potts, 1887) by Volkmer-Ribeiro & de Rosa-Barbosa (1985).

Biotope-wise, these records originated from

- rivers: Rhine, Lahn (Ehmann, 1995), Elbe and Danube (Wittling & Mauch, 1993), Neman (Dybowski, 1886), Pilica (Konopacka, 1983–84), Dniepr, Nile;
- deltas of rivers: Danube delta (Rudescu, 1970), Amu-Darja delta (Rezvoj, 1928), Mississippi delta (Cooper, 1988);
- channels and blind river arms: Richelle-Maurer et al. (1994), Simon (1951);
- lakes: Poirrier (1990), Arndt (1937), Sebestyén (1942).

The goal of the present investigation was to document a mass occurrence of a species, which hitherto

was believed to be rare, and to investigate some aspects of its ecology.

Material and methods

For synonyms and taxonomy of *T. horrida* see Weltner (1893) and Penney & Racek (1968).

Collecting sites

The sites shown in Figure 1 were visited between January 1993 and October 1995 (Table 1).

Procedure

Collections were made from the banks, by wading and removing the substrate by hand, except on the dates indicated by an asterisk in Table 1, when collections were made with a grab from the research ship 'Argus' of the federal state Hesse.

The sponges were removed from the rocky substrate with a knife and preserved in 70% ethanol. From each individual sponge, one microscope slide was prepared following Arndt (1928).

The individual sponges on approximately 1.3 m² (five rocks about 40 × 15 × 15 cm, randomly chosen in an area of about 10 m²) of substrate at each collecting site were counted (Figure 5), and the average number of individual sponges per m² available substrate was calculated. Only active colonies and their number was considered, not their size of area.

Evaluation of the period of flooding before collection

At each collection, water depth was recorded. Daily water levels on the stations at Worms and Mainz were available (Figure 2). For each site, the period of flooding before collection was calculated.

Evaluation of abundance from 1992 to 1995

Size classes (1–7), based on area of coverage, were defined according to Dorschner et al. (1993): (1) small single colonies, (2) several small colonies, (3) single robust colonies, (4) several robust colonies, (5) coverage was more than 25%, (6) coverage was more than 50%, (7) coverage was more than 75%

From collection trips on 22/23.01.1993, 08/11.05.1993, 10/11.08.1994 and 12/14.10.1995 (Table 1) the distribution of the species from 1992–1995 was evaluated. In January 1993 and October 1995 only gemmule crusts were obtained.

Because *T. horrida* always leaves gemmule crusts from the summer before (here: summers of 1992, evaluated at 22/23.01.1993 and 1995 evaluated at 12/14.10.1995), the maximum area covered by colonies could be evaluated even when active colonies were absent.

In 1994 the samples were taken in August, at a time when the coverage of the species reached its maximum (Figure 5). The quantitative estimate for 1993 might be underestimated, as samples were taken in May, before the species reached its maximum (Figure 5).

Laboratory experiments to estimate the germination rates of gemmule crusts

The gemmules used were collected from Gernsheim on 24.08.1993, 2 years prior to the experiments, and were stored in a refrigerator at 278.15 K (5°C) in water taken from the habitat. They were put in aquaria with 20 l of tapwater at a constant temperature of 273.15 K (20°C) and a photoperiod of 12 h. The germination experiments were conducted in October 1995. Experiments without prior storage of the gemmules in the cold (about 278 K (5° C)) for at least several weeks always failed.

For the germination experiments 15 gemmule-crusts consisting of five gemmules each were placed in the aquaria.

Results

The organism

Trochospongilla horrida formed thin encrustations (never thicker than 5 mm); color in life whitish to light grayish-brown; surface velvet-like; no outgrowths; larger colonies with irregular outline, smaller ones (<3 cm in diameter) more or less circular.

Gemmuloscleres: amphidiscs with entire margins of the rotules (Figure 1e–g), in one layer within the gemmule wall; rotules regularly overlapping; for development of the gemmuloscleres (see Figure 3). According to figures given by Richelle-Maurer et al. (1994) and Simon (1951), a stage with serrated margins of the rotules sometimes present. During normal gemmulosclere development, this is not the case, but rotules such as in Figure 3h, showing many radial orientated central canals, might have a serrated state during their development.

Table 1. Collecting sites (compare with Figure 1) and dates.

Locality	22/23.1. 1993	08/11.5. 1993	24/26.8. 1993*	7/8.9. 1993*	25/26.9. 1993	67.11. 1993	22.2. 1994	11.5. 1994*	8.6. 1994*	30.6. 1994*	15/26.7. 1994*	10/11.8. 1994	14/15.10. 1994	15.3. 1995	3.8. 1995	8.10. 1995	12/14.10. 1995
Iffezheim																	X
Neuburg	X	X										X					X
Leimersheim	X	X										X					X
Sondernheim	X	X										X					X
Altrip	X	X										X					X
Ludwigshafen ¹	X	X										X					X
Lampertheim-Rosen-																	
Garten					X	X	X				X		X	X			X
Worms				X													
Biblis, nuclear power plant						X	X					X		X	X		X
Biblis, downstream n.p.pl.						X					X						
Worms-Rheinduerk-																	
Heim	X	X										X					X
Gross-Rohrheim													X	X			
Gross-Rohrheim, 2km downstream					X	X					X	X	X	X			X
Gernsheim			X	X			X				X		X	X			
Kornsand			X	X			X	X			X		X	X			
Nierstein	X	X	X				X	X		X	X	X					X
Oxbow of Ginsheim																	
Mainz-Laubenheim	X	X	X	X	X	X	X	X	X	X	X	X	X				X
Mainz			X	X				X	X	X							
Heidenfahrt																	
Bingen	X	X						X	X	X		X					X
Bacharach	X	X										X					X
Boppard	X	X										X					X
Urnitz/Kaltenenger	X	X										X					X
Bad Breisig	X	X										X					X
Remagen																	X
Bonn-Bad Godesberg																	X

¹ Near the facilities of the BASF AG.

² Outflow of the cooling water circuit of the power plant. The temperature here is up to 10 K higher than the surrounding river.

³ Slightly polluted stagnant water.

* Collection was done with a grab dredger on board of the research ship 'Argus'.

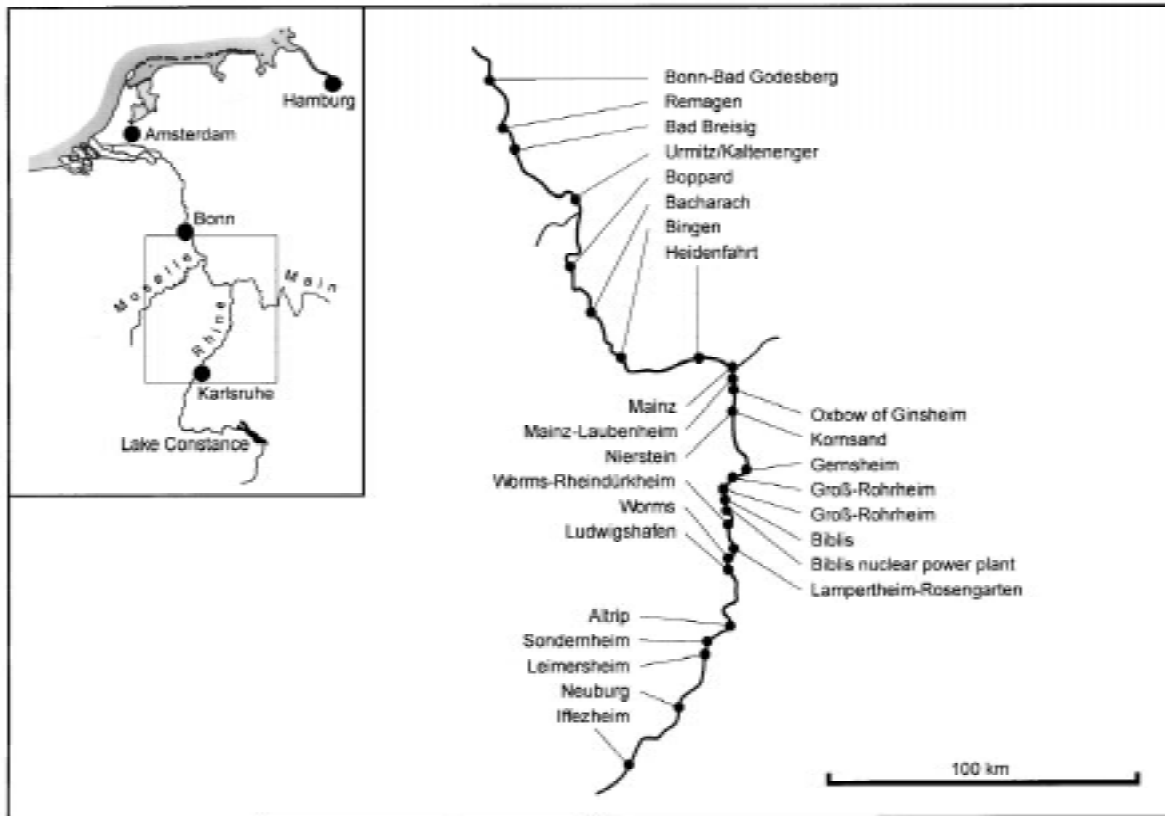


Figure 1. The collecting sites

Physical chemical properties of the habitat

The data summarized in Table 2 originate from the station for water examination of the Rhine (Landesamt für Wasserwirtschaft in Rhineland-Palatinate).

*Abundance of *T. horrida* from 1992 to 1995*

In 1994 and 1995 *T. horrida* was the most abundant sponge species in the Rhine between Karlsruhe and Bonn; in some places it was the dominant benthic organism. It was also the most abundant sponge species in the river Lahn (Germany, Hesse) in 1993 and 1994 (Ehmann, 1995; pers. comm.).

In 1992 the species occurred mainly in the southern part of the area. It appeared sporadically, but in high abundance (Figure 4). In 1993 its abundance was equal to that observed in 1992, but its distribution was more regular. In 1994 the species was the dominant freshwater sponge in the investigated area. Its lowered abundance between Ludwigshafen and Worms-Rheindürkheim was probably due to the

waste from the purification plant of BASF AG. In 1995 it was again the most abundant sponge species, but was not observed south of Neuburg nor north of Bad Breisig. Probably the lowered abundance at Ludwigshafen was due to the influence of the purification plant of the BASF AG (as 1994); the samples from Lampertheim-Rosengarten to Kornsand were taken from the opposite bank of the Rhine.

Ecological strategies

The first colonies of *T. horrida* were observed in April (spring). In July (summer) the abundance of the species rose again distinctly (Figure 5). During summer the colonies grew to more than 20 cm in diameter. The growing colonies fused after coming into contact with each other. From October on (autumn) only exceptionally active colonies were observed. After the colonies died, they dissociated rapidly and left gemmule crusts on the substrate. The onset of the gemmulation pro-

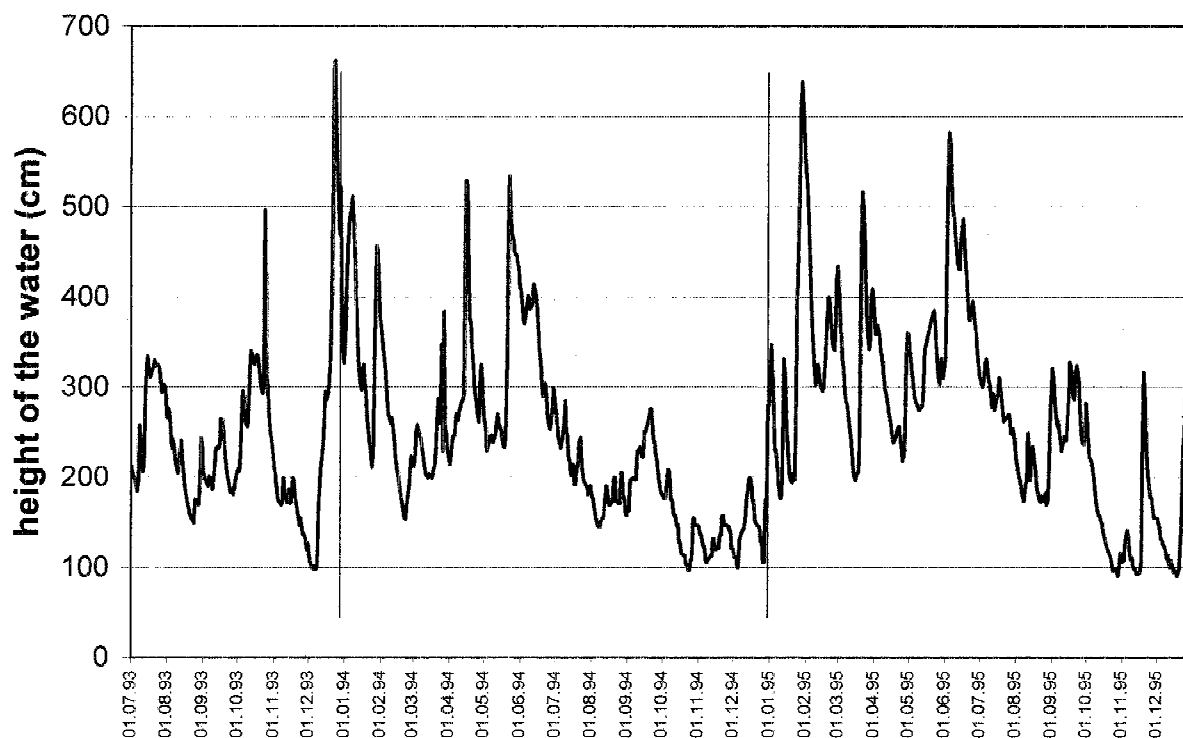


Figure 2. Water levels in Worms from June 1993–December 1995. Vertical lines indicate the change of the years (the scale is a relative one without a defined zero point.)

cess began in July or earlier, after the colonies reached approximately 2.5 cm in diameter.

Colonies with signs of sexual reproduction were never observed, nor were bright green colonies due to symbiotic zoochlorellae found.

Trochospongia horrida preferred to settle in habitats, which were flooded more than 6 months and not affected by water fluctuations. Places, flooded not more than 9 weeks and regularly drying out were avoided. At places flooded more than 6 months 16.9 single colonies (regardless of their size) were found per m², at places flooded for only 9 weeks only 5.7 colonies per m² were found.

Laboratory experiments to estimate the germination rate of gemmule crusts from *T. horrida*

In half of the crusts (seven crusts) single gemmules germinated after 7–12 days. Within the next 18 days in the rest of the crusts single gemmules germinated. In each crust, single gemmules germinated within 4 weeks.

Discussion

Physical–chemical demands

Trochospongia horrida shows a preference for slightly alkaline pH values. According to the data presented in Table 2 and those of Simon (1951), Ricciardi & Reisinger (1993) and Richelle-Maurer et al. (1994), the species occurs in water with pH values between 7.4 and 8.4; never in waters with a pH lower than 7 (Ricciardi, in litt.). Harrison (1974) reported the species at pH values between 5.5 and 8.7, but part of his records may refer to the North American species *Trochospongia pennsylvanica* (Potts, 1882); the author himself admitted this possibility. *T. pennsylvanica* indeed prefers slightly acidic conditions at pH between 5.0 and 7.2 (Ricciardi, in litt.).

Competitive ability

T. horrida formed large colonies, in spite of the presence of the pontocaspian amphipod *Corophium curvispinum* Sars, 1895, which invaded the Rhine recently and became the dominant benthic animal (Wittmann, 1994). Its tubes formed thick layers (>3 cm) on all

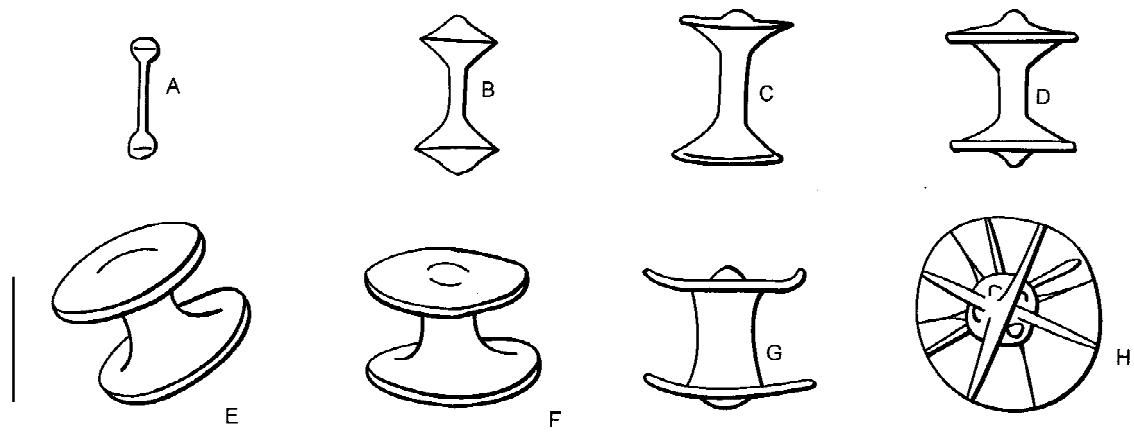


Figure 3. (a–d) Proposed development of the gemmuloscleres, as seen in a preparation from 03.08.1995 from Lampertheim-Rosengarten; (e–f): Grown-up gemmuloscleres in different views (the same preparation); (h): rotule with lots of central canals, from the same preparation. Scale bar, 10 μ m.

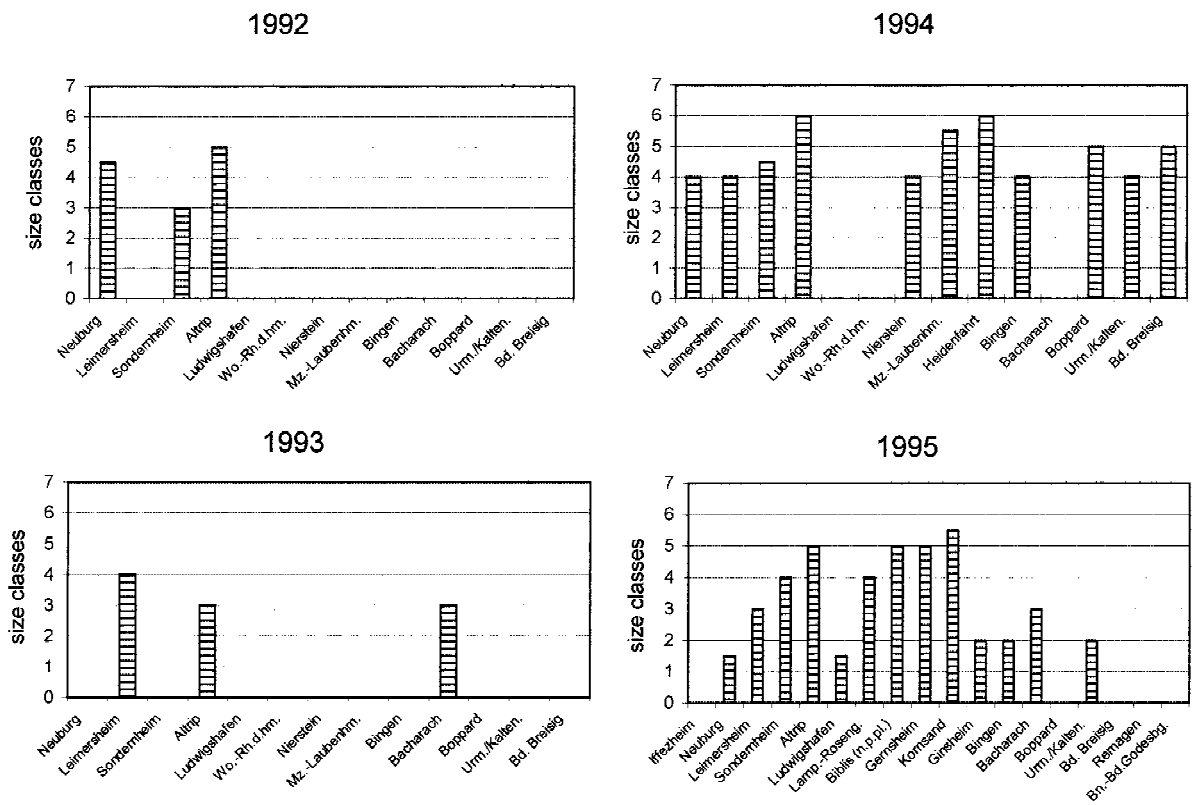


Figure 4. Occurrence of *Trochospongilla horrida* in the investigated area in 1992, 1993, 1994 and 1995.

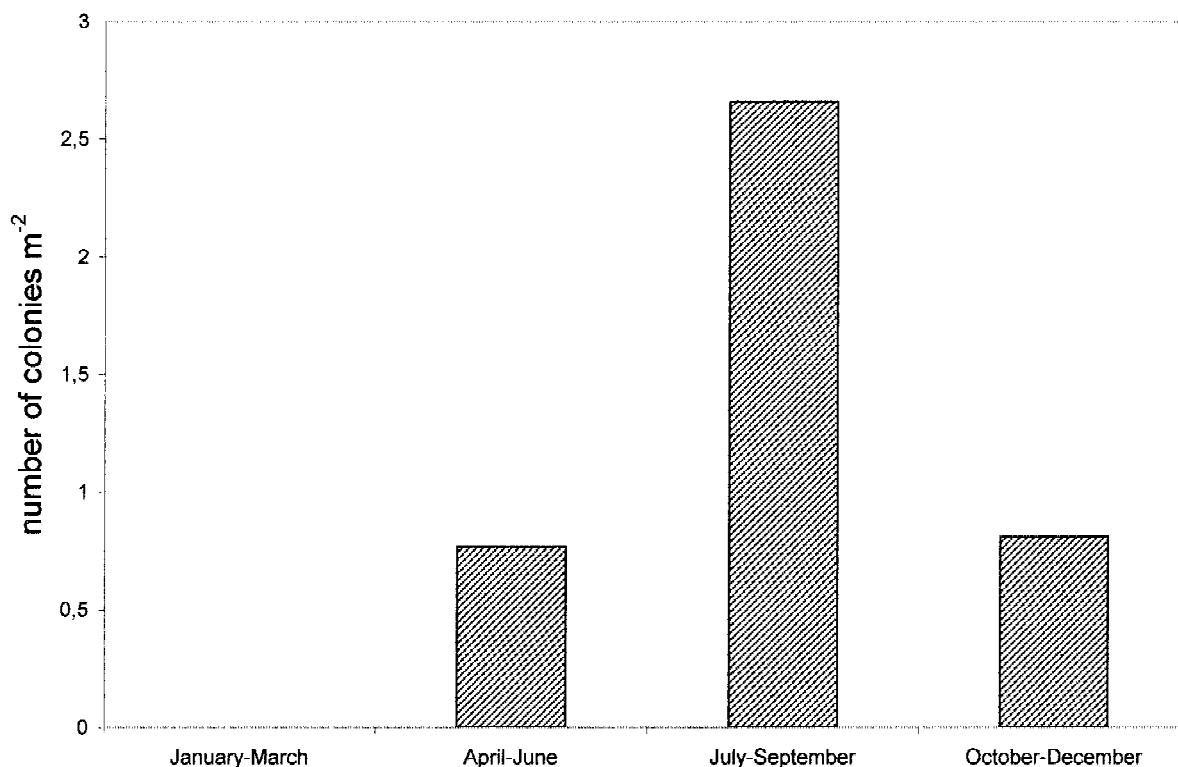


Figure 5. Seasonal appearance of *Trochospongilla horrida* 1993–1995 in the investigated area.

available hard substrates, and it was the major space competitor in the Rhine. For other sessile animals, the occurrence of *C. curvispinum* is a major threat (Schöll et al., 1995), many of which almost vanished.

Reproduction strategies

Trochospongilla horrida ensures its presence in the following spring through the production of gemmules during the active period. These gemmules form a tightly attached pavement-like crust on the substrate. In this way the species ensures resettlement of a substrate, which had proved to be suitable in the preceding year. Due to the absence of free-swimming larvae and movable free gemmules it remains unclear how *T. horrida* ensures its dispersal within the habitat. Occasionally, single gemmules without a 'layer of small boxes' were found drifting in the water column (Epler, pers. com.). Perhaps the gemmules were not immediately fixed to the substrate after their formation with their 'layer of small boxes' (Saller, 1990a).

Larvae are very rare. In fact, there is only one published record: Simon (1951) described and presented illustrations of larvae of *T. horrida* from a blind

river arm of a tributary to Lake Constance. The species reaches its highest abundance (Figure 5) in July/August (summer) after hatching in April (spring). In laboratory conditions it took four weeks for young sponges to hatch from all gemmule crusts.

Temperature dependence

The colonies seemed to die mainly due to lower temperatures in autumn. On 06.11.1993 some flourishing colonies could be observed in the outflow of the cooling water circuit of the nuclear power plant in Biblis, where the water temperature was about 291.15 K (18°C), whereas at a water temperature of about 283.15 K (10°C) within the surrounding Rhine, no active colonies could be observed (see Gugel, 1995). Factors like food supply probably played a minor role.

Germination experiments

In each gemmule crust only single gemmules germinated, apparently inhibiting germination of neighboring gemmules. The inhibition of the germination of additional gemmules in the presence of an active sponge is

Table 2. Physical and chemical data from the Rhine in Mainz from 1993–1995. Mean values are given for March–October (the period in which active sponge colonies were found) are given; if outside this period different values appeared, the range for the whole year is given in parentheses

Parameter	1993	1994	1995
Temperature (°C)	6.6–24.1 (3.4–24.1)	9.0–27.1 (5.5–27.1)	5.2–25.2 (4.9–25.2)
Temperature (K)	279.75–297.25 (276.55–297.25)	282.15–300.25 (278.65–300.25)	278.35–298.35 (278.05–298.35)
O ₂ (mg l ⁻¹)	6.1–11.6 (6.1–12.0)	6.0–10.6 (6.0–11.7)	6.6–11.4 (6.6–11.8)
PH	7.7–8.4	7.6–8.1	7.7–8.2
Conductivity (μS cm ⁻¹ at x ₂₀)	360–1070	383–811 (333–917)	355–889 (351–889)
Chloride (mg l ⁻¹)	32–239 (31–239)	29–152	31–196
Calcium (mg l ⁻¹)	58–82	59–67 (59–71)	58–70 (58–79)
Magnesium (mg l ⁻¹)	8.4–11.0	8.8–9.7 (8.8–10.0)8.3–10.0	(8.3–11.0)

probably due to the presence of gemmulastasin, produced by many freshwater sponges (Bergquist, 1978; Brien, 1973).

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References

Arndt, W., 1926. Die Spongillidenfauna Europas. Arch. Hydrobiol. 17: 337–365.
 Arndt, W., 1928. Porifera, Schwämme, Spongien. In F. Dahl (ed.) Die Tierwelt Deutschlands und der angrenzenden Meeresteile nach ihren Merkmalen und ihrer Lebensweise 4 (Porifera – Hydrozoa – Coelenterata – Echinodermata), Leipzig: 1–94.
 Arndt, W., 1937. *Ochridaspongia rotunda* n.g. n.sp., ein neuer Süßwasserschwamm aus dem Ochridsee. Arch. Hydrobiol. 31: 636–677, plates 10 and 11.
 Bergquist, P.R., 1978. Sponges. Hutchinson & Co, London, 268 pp.
 Bonetto, A.A. & I. Ezcurra de Drago, 1965. El género *Trochospongia* Vejdowski en el alto Paraná argentino (Porifera, Spongillidae). Physis 25: 95–98.
 Brien, P., 1973. Les Démosponges: morphologie et reproduction. In P. Brien, C. Lévi, M. Sará, O. Tuzet & J. Vacelet (eds), Traité de Zoologie, tome III: spongiaires Masson, Paris: 133–461.
 Cheatham, E.P. & J.P. Harris Jr., 1953. Ecological observations upon the fresh-water sponges in Dallas County, Texas. Field Lab. 21 (3): 97–103.

Cooper, C.M., 1988. The toxicity of suspended sediments on selected freshwater invertebrates. Verh. int. Ver. Limnol. 23: 1619–1625.
 Dorschner, J., U. Dreyer, J. Gugel, H. Guhr, R. Kinzelbach, A. Meister & P. Seel, 1993. Der Gewässerzustand der Elbe 1991. Ergebnisse einer Bereisung mit dem hessischen Meß- und Laborschiff 'Argus' zwischen Veletov und Geesthacht. Umweltplanung, Arbeits- und Umweltschutz, 153, 99 pp.
 Dybowski, W., 1886. Mittheilung über die aus dem Flusse Niemen stammende *Trochospongia erinaceus*. Dorpater Naturforschergesellschaft: Sitzungsberichte 7: 295–298.
 Ehmman, H.-J., 1995. Faunistische Erhebungen an der Lahn. Makrozoobenthos. In charge of the Bundesanstalt für Gewässerkunde Koblenz, 113 pp. + annex.
 Fric, A. & V. Vavra, 1901. Untersuchungen über die Fauna Böhmens. Untersuchung des Elbflusses und seiner Altwässer. (Schwämme). Arch. Naturwiss. Landesdurchforsch. Böhmen 11: 86–89.
 Gee, N.G., 1926. Chinese freshwater sponges. J. r. asiatic Soc. Great Britain Ireland/China Branch 57: 110–112.
 Gee, N.G., 1931–32. Genus *Trochospongia* of fresh-water sponges. Peking Nat. Hist. Bull. 6: 1–32.
 Grimailowskaja, M., 1928. Zur Spongilliden-Fauna der Dnjepere-Expedition. Trav. Stat. Dnjepre 10: 215–223.
 Gugel, J., 1993. Sessile invertebrates from the Nile. Zool. Middle East 8: 103–120.
 Gugel, J., 1995. Erstnachweis von *Eunapius carteri* (Bowerbank 1863) (Porifera, Spongillidae) für Mitteleuropa. Lauterbornia 20: 103–110.
 Harrison, F.W., 1974. Sponges (Porifera: Spongillidae). In Hart, C.W. Jr. & S.L.H. Fuller (eds), Pollution Ecology of Freshwater Invertebrates, Academic Press, New York, London: 29–66.
 Konopacka, A., 1983–84. Morphological analysis of skeleton elements in freshwater sponges. Acta Hydrobiol. 2: 157–164.
 Kosel, V., 1972. Neue Funde von Süßwasserschwämmen. Biologica 27: 433–436.
 Lauterborn, R., 1905. Die Ergebnisse einer biologischen Probeuntersuchung des Rheins. Arbeiten Kaiserlichen Gesundheitsamte 22: 630–652.
 Neubert, E. & G. Eppler, 1992. *Trochospongia horrida* (Weltner 1893) — Neufunde aus dem Rhein. Lauterbornia 9: 59–63.
 Pennak, R.W., 1953. Porifera (sponges). In Pennak, R.W. (ed.), Fresh-Water Invertebrates of the United States. Ronald Press Company, New York: 77–97.

- Penney, J.T. & A.A. Racek, 1968. Comprehensive revision of a worldwide collection of freshwater sponges (Porifera: Spongillidae). U. S. Nat. Mus. Bull. 272: 1–184.
- Poirrier, M.A., 1990. Freshwater sponges (Porifera: Spongillidae) from Panama. *Hydrobiologia* 194: 203–205.
- Pronzato, R. & R. Manconi, 1989. Chiave dicotomica per il riconoscimento delle spugne d'acqua dolce italiane. *Boll. Mus. Ist. Biol. Univ. Genova* 53: 81–99.
- Rezvoj, P., 1928. Die Spongillidenfauna Rußlands. *Zool. Anz.* 76: 219–232.
- Ricciardi, A. & H.M. Reiswig, 1993. Freshwater sponges (Porifera, Spongillidae) of eastern Canada: taxonomy, distribution, and ecology. *Can. J. Zool.* 71: 665–682.
- Richelle-Maurer, E., Y. Degoudenne, G. van de Vyver & L. Dejonghe, 1994. Some aspects of the ecology of Belgian freshwater sponges. In R.W.M. van Soest, T.M.G. van Kempen & J.-C. Braekman (eds), *Sponges in Time and Space. Biology, Chemistry, Paleontology*. A.A. Balkema, Rotterdam Brookfield: 341–350.
- Rudescu, L., 1970. Contributii la cunoasterea faunei spongilidelor din delta Dunarii. *Hydrobiologia* 11: 89–104.
- Rudescu, L., 1975. Porifera. Potamospongiae. *Fauna republicii socialiste Romania* 2, 115 pp.
- Saller, U., 1990a. A redescription of the freshwater sponge *Trochospongilla horrida* (Porifera, Spongillidae). *Abhandlu. Ver. naturwiss. Ver. Hamburg (NF)* 31/32: 163–174.
- Saller, U., 1990b. The formation of the gemmule shells in the freshwater sponge *Trochospongilla horrida* (Porifera, Spongillidae). *Zool. Jb. Anat. Ontog. Tiere* 120: 239–250.
- Saller, U., 1990c. Vergleichende Darstellung der Skelet-Elemente und der Gemmula-Schalen von Süßwasser-Schwämmen (Porifera, Spongillidae). *Abhandlu. Ver. naturwiss. Ver. Hamburg (NF)* 31/32: 175–183.
- Schöll, F., C. Becker & T. Tittizer, 1995. Das Makrozoobenthos des schiffbaren Rheins von Basel bis Emmerich 1986–1995. *Lauterbornia* 21: 115–137.
- Schön, A., 1957. Massenentwicklung von Schwämmen in Rheinkraftwerken. *Zeitschrift für Fischerei N.F.* 1 (6): 85–86.
- Sebestyén, C., 1942. The freshwater sponges of Hungary. *Fragmenta Faunistica Hungarica* 5: 91–94.
- Simon, L., 1951. Ein neuer Fundort von *Trochospongilla horrida* Weltner. *Zool. Anz.* 146: 133–135.
- Simon, L., 1952. Die Spongillidenfauna des Bodensees (Obersee). Ein Überblick über die bisher gefundenen Süßwasserschwämme. *Zool. Anz.* 149: 79–82.
- Volkmer-Ribeiro, C. & R. de Rosa-Barbosa, 1985. Redescription of the freshwater sponge *Tochospongilla repens* (Hinde, 1988) and *Trochospongilla amazonica* (Weltner, 1895) with an account of the South American species of *Trochospongilla* (Porifera, Spongillidae). *Iheringia Sér. Zool.* 65: 77–93.
- Weltner, W., 1893. Über die Autorenbezeichnung von *Spongilla erinaceus*. *Sitzungsber. Gesell. naturforsch. Freunde Berlin*: 7–13.
- Weltner, W., 1909. Spongillidae. In Brauer, A. (ed.), *Die Süßwasserfauna Deutschlands* 19: 177–190.
- Wittling, T. & E. Mauch, 1993. *Trochospongilla horrida* Weltner 1893 in der oberen Donau bei Donauwörth (Schwaben, Bayern). *Lauterbornia* 13: 36.
- Wittmann, J., 1994. Der Schlickkrebs *Corophium curvispinum* G. O. Sars, 1895 im nördlichen Oberrhein im Frühjahr 1994. *Diplomthesis at the TH Darmstadt, Institut für Zoologie*, 54 pp. + annex.