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Note brève - Short note

First record of *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya et Subba Raju (Cyanobacteria) in a lotic system in France

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Keywords : potentially toxic cyanobacteria, *Cylindrospermopsis raciborskii*, River Seine, lotic system, France.

Cylindrospermopsis raciborskii (Woloszynska) Seenayya et Subba Raju, a potentially toxic bloom forming cyanobacteria (Nostocales), was recorded in the River Seine in August 2001. The cyanobacterium was previously observed in some French ponds but this is the first report of this reputedly tropical species in a river in France.

Première récolte de *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya et Subba Raju (Cyanobactérie) dans une rivière française

Mots-clés : cyanobactérie potentiellement toxique, *Cylindrospermopsis raciborskii*, Seine, milieu lotique, France.

Une cyanobactérie potentiellement toxique et capable de proliférations massives («blooms»), *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya et Subba Raju (Nostocales), a été récoltée dans la Seine en août 2001. Bien que cette cyanobactérie ait déjà été signalée dans quelques étangs en France, c'est la première observation de cette espèce décrite comme tropicale dans une rivière française.

Phytoplankton is regularly monitored in the River Seine at Ivry (10 km south of Paris) by S.A.G.E.P. (Société Anonyme de Gestion des Eaux de Paris). Raw water is collected monthly and fixed with Lugol's iodine. Observation and enumeration of the fixed samples was done using a ZEISS Axiovert 135 light microscope. Since the beginning of the survey in 1996 (Druart 1996), *C. raciborskii* has never been observed. However, on 8 August 2001, trichomes of *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya and Subba Raju were identified in samples collected from a location situated just upstream of a pumping site for drinking water. Its density reached 80 trichomes/ml. *C. raciborskii* was not the main phytoplankton species in the sample, which was characterised by a great diversity of classes and species typical of a temperate river such as the Seine (Table 1). Among them, typical temperate cyanobacteria as *Planktothrix agardhii* and *Limnothrix redekei* were also identified at low densities.

The *C. raciborskii* observed in the River Seine had straight trichomes, bearing terminal drop-shaped heterocytes with pointed ends (Fig. 1). Coiled trichomes were never observed. Trichome length was 150 ± 50 µm (mean ± standard deviation) (n=15) and breadth was 2.5 ± 0.2 µm. Heterocytes were observed at one or both ends of the trichomes. There was little or no constriction at the crosswalls of the vegetative cells, which contained gas vesicles. No akinetes were observed on the trichomes.

Cylindrospermopsis raciborskii was described for the first time as *Anabaenopsis raciborskii* in 1912 in Java. The genus *Cylindrospermopsis*, with *C. raciborskii* as type species, was established in 1972 (Seenayya et Subba Raju 1972). The cyanobacterium has been identified not only in tropical or sub-tropical

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Table 1. Phytoplankton population in the River Seine on August 8th 2001.
Tableau 1. Populations phytoplanctoniques dans la Seine le 8 août 2001.

Others Taxons identified	Abundance (cells/ml)
Cyanobacteria	
Aphanizomenon flos aquae (L.) Ralfs	80
Limnothrix redeckei (Van Goor) Meffert 1988	80
Oscillatoria sp	880
Pannus sp	80
Raphidiopsis sp	80
Romeria sp	80
Diatomophyceae	
Amphora ovalis (Kützing) Kützing	80
Aulacoseira granulata (Her.) Ralfs	
Aulacoseira granulata var. *angustissima* O.M. Simonsen	80
Cyclostephanos invisitatus (Horn & hellermann) Theriot, Stoermer & Hakansson	240
Cyclotella stelligera Cleve & Grunow	80
Cymatopleura solea Brébisson	80
Fragilaria crotonensis Kitton	400
Gyrosigma attenuatum (Kützing) Clève	80
Navicula spp	80
Navicula menisculus Schumann	80
Navicula tripunctata (O.F.M.) Bory	80
Nitzschia acicularis (Kützing) W.M. Smith	240
Nitzschia levidensis (W. Smith) Grun. in W.H.	80
Nitzschia sigmoidea (Nitzsch) W.M.Smith	80
Nitzschia sp	240
Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot	80
Skeletonema subsalsum (Cleve-Euler) Berthge	160
Stephanodiscus hantzschii Grunow in Clève	800
Chlorophyceae	
Ankistrodesmus gracilis (Reinsch) Kors.	80
Pediastrum boryanum (Turp.) Menegh.	80
Pediastrum simplex Meyen	80
Scenedesmus acuminatus (Lagerh.) Chodat	160
Scenedesmus quadricauda (Turpin)	80
Schroederia setigera (Schroëder) Lemmermann	
Cryptophyceae	
Cryptomonas sp	240
Rhodomonas minuta var. *nannoplanctica* Skuja	80
Desmidiaceae	
Closterium sp	80

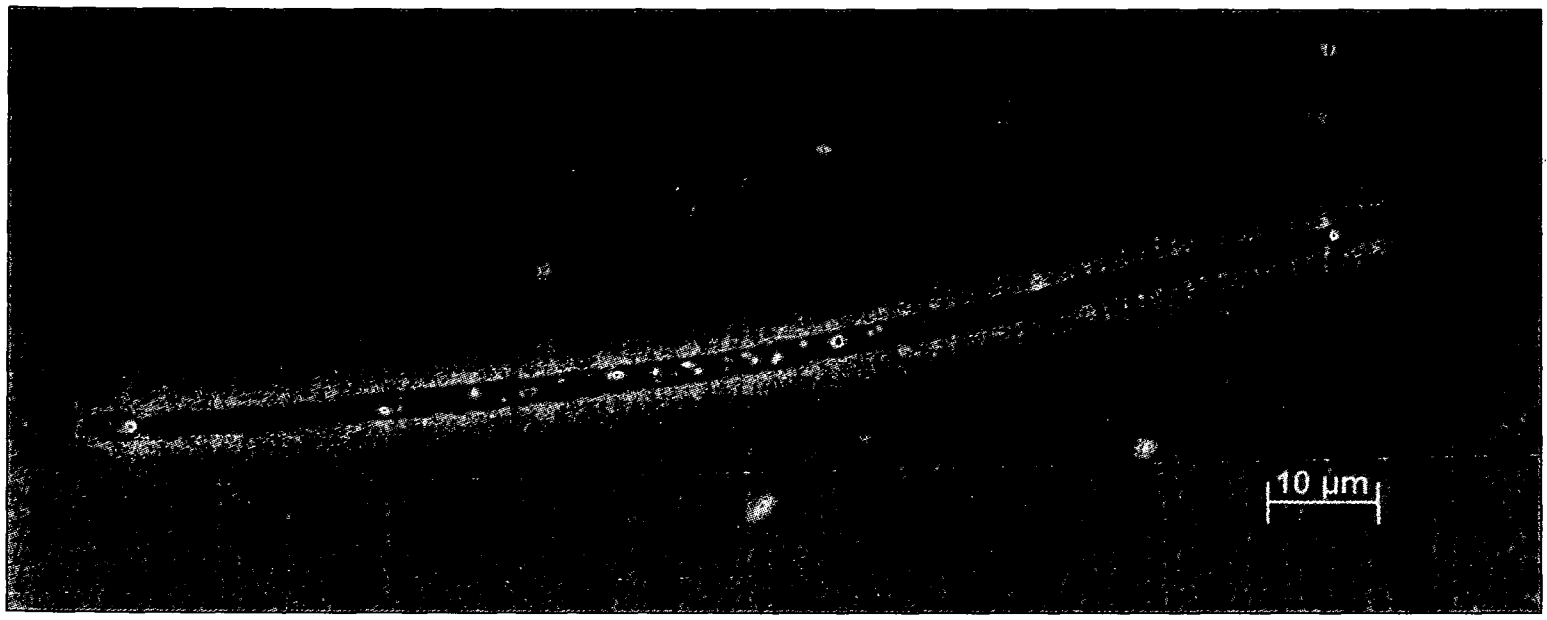

Fig. 1. *Cylindrospermopsis raciborskii* : trichome with two terminal heterocysts, isolated from the River Seine on August 8th 2001.
Fig. 1. *Cylindrospermopsis raciborskii* : un trichome avec deux hétérocystes en position terminale dans la Seine le 8 août 2001.

areas, as first reported, but across a wide range of latitudes (Padisák 1997). In Europe, *C. raciborskii* was first observed in Lake Kastoria in Greece in 1938, and in a lotic system, only in the Danube (Padisák 1997). In France, up to now, *C. raciborskii* has only been observed in two ponds in the Paris area (Couté et al.1997, Briand 2001). The *C. raciborskii* described here from the Seine looks like the trichomes previously isolated from French ponds : only straight trichomes, bearing at least one heterocyst with a pointed end, and in a similar range of length (cf. 119 ± 20 µm in «Francs-Pêcheurs» (FP) pond, Briand et al. 2002). Trichomes appeared to be wider in the River Seine isolates (*cf.* 1.5 ± 0.3 µm in FP pond). Such variation in length and width of trichomes may depend on the physiological state of the cyanobacterium.

In temperate countries (for example, Austria, Dolukil & Mayer 1996, France, Couté et al. 1997, and Hungary, Padisák 1997), *C. raciborskii* proliferations are limited to warmer periods as temperature seem to be a key factor for the development of the cyanobacterium (Briand et al. 2002). The occurrence of the cyanobacterium in the River Seine in August is consistent with this requirement. The temperature (22°C, Table 2) was within the optimal range for the germination of akinetes (22-23°C, Padisák 1997). Furthermore, *C. raciborskii* has previously been reported in such temperatures in temperate areas (Alte Donau, Austria, Dolukil & Mayer 1996, FP pond, France, Briand et al. 2002). *C. raciborskii* proliferates every year in tropical rivers like the River Fitzroy (Queensland, Australia, Fabbro & Duivenvoorden 1996) after periods of stable stratification and no flow. However, due to the relatively high flow in the River Seine (Briand 2001), such blooms do not appear to be possible here. In addition, high ammonium and nitrogen concentrations were measured

Table 2. Water temperature, pH, dissolved oxygen and nutrients concentrations in the River Seine on August 8th 2001.
Tableau 2. température de l'eau, concentrations en oxygène dissous et en nutriments dans la Seine le 8 août 2001.

Temp. (°C)	pH	Dissolved oxygen (mg/l)	Total Phosphorus (mg/l)	Orthophosphate (mg/l)	Nitrogen (Kjeldahl) (mg/l)	NH_4^+ (mg/l)
22	7.9	8.3	0.15	0.34	0.43	0.07

(Table 2) which would not favour a nitrogen-fixing cyanobacterium such as *C. raciborskii*. Finally, our data corroborate the hypothesis that *C. raciborskii* is not a characteristic species of eutrophic waters (Table 2, Padisák 1997, Briand et al. 2002). Thus, the presence of *C. raciborskii* in the river could be due to the entrance into the Seine water of contaminated pond water. Stratified conditions and higher temperatures can occur in these water bodies, allowing the germination of akinetes present in sediments, as previously observed in the FP pond. Even if a high biomass of the cyanobacterium entered the Seine water, the high flow of the river would then lead to the dilution of the trichomes, which could explain the relatively low density reported in the Seine the 8 August. The FP pond could not have been involved because of the absence of a link to the Seine. Therefore, research should be undertaken to localise the potential source(s) of contamination upstream of the Ivry sampling point.

The occurrence of *C. raciborskii* in the River Seine, as well as in two ponds in the Paris area (Couté et al. 1997, Briand 2001), raises the question of the actual geographic distribution of the species in France and, consequently, of the reason why such a tropical species can seemingly invade a temperate area. *C. raciborskii* is a well known bloom forming cyanobacteria in tropical Australian or Brazilian water-bodies, but blooms of this cyanobacterium have only been reported relatively recently in Hungary, Austria, Germany and France (Padisák 1997). A past misidentification of *C. raciborskii* in some cases can not be completely excluded, but in the case of the Alte Donau in Austria, for example, phytoplankton data are available for 5 years before the appearance of *C. raciborskii* (Dolukil & Mayer 1996). This new occurrence may indicate the selection of clones adapted to temperate conditions or a large physiological tolerance to environmental parameters in this species. Further ecophysiological experiments are in progress to try to answer this question.

Finally, as *C. raciborskii* is known to produce cylindrospermopsin and paralytic shellfish poisons (Codd et al. 1999), and was responsible for the intoxication of 141 people in Palm Island (Australia) (Hawkins et al. 1985), the toxicity of French *C. raciborskii* strains should be determined. Furthermore, the risk of contamination of water used for drinking purposes, by *C. raciborskii* or other potentially toxic cyanobacteria, should be assessed.

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