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First record of *Tetraspora gelatinosa* Link ex Desvaux (Tetrasporales, Chlorophyceae) in the state of Goiás, Central-Western Brazil

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Abstract

Tetraspora gelatinosa is rare and has been recorded only in 3 Brazilian states since the 2000s. The flora of the state of Goiás is incipiently known, but there is no record of *Tetraspora* thus far. We record the occurrence of *T. gelatinosa* in Goiás and characterize this species' morphology and ecological preferences. Specimens were found in the Samambaia Reservoir, Goiânia, Goiás. Physical and chemical characteristics of the water were measured. Where *T. gelatinosa* was found, the water was shallow and characterized as ultraoligotrophic. These conditions agree with those reported for other environments in Brazil.

Key words

Algae, Meia Ponte river basin, new record, rare species, ultraoligotrophic.

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Introduction

The genus *Tetraspora* Link ex Desvaux (1818: 17) was originally proposed to include algae with spores arranged four-by-four in a thick substance ("Spores disposés quatre à quatre dans l'épaisseus de la substance"). Currently, it is included in Tetrasporaceae and encompasses representatives with green cells within a mucilaginous matrix, forming macroscopic spherical colonies; cells spherical to elliptical, arranged two-by-two or four-by-four, with 2 pseudoflagella extending beyond the mucilage; chloroplasts parietal, cupuliform, single pyrenoid, and sometimes covered by starch grains; stigma absent; contractile vacuole in the cytoplasm; asexual reproduction resulting in the formation of 2 or 4 daughter cells or biflagellate zoospores; and sexual reproduction by isogamy (Bourrely 1972, Ettl and Gartner 1988, Pentecost 2011).

Tetraspora differs from other genera of the family (i.e., *Apiocystis* Nägeli, *Paulschulzia* Skuja, *Octosporiella* Kugrens, *Polychaetochloris* Pascher, *Chaetochloris* Pascher & Korshikov, and *Chlorangiochaete* Korshikov) because the cells are free and more or less uniformly distributed throughout the mucilaginous matrix, which is macroscopic, and presents an irregular outline with irregularly demarcated shapes and edges (Ettl and Gartner 1988). *Dispora* Printz (Radiococcaceae,

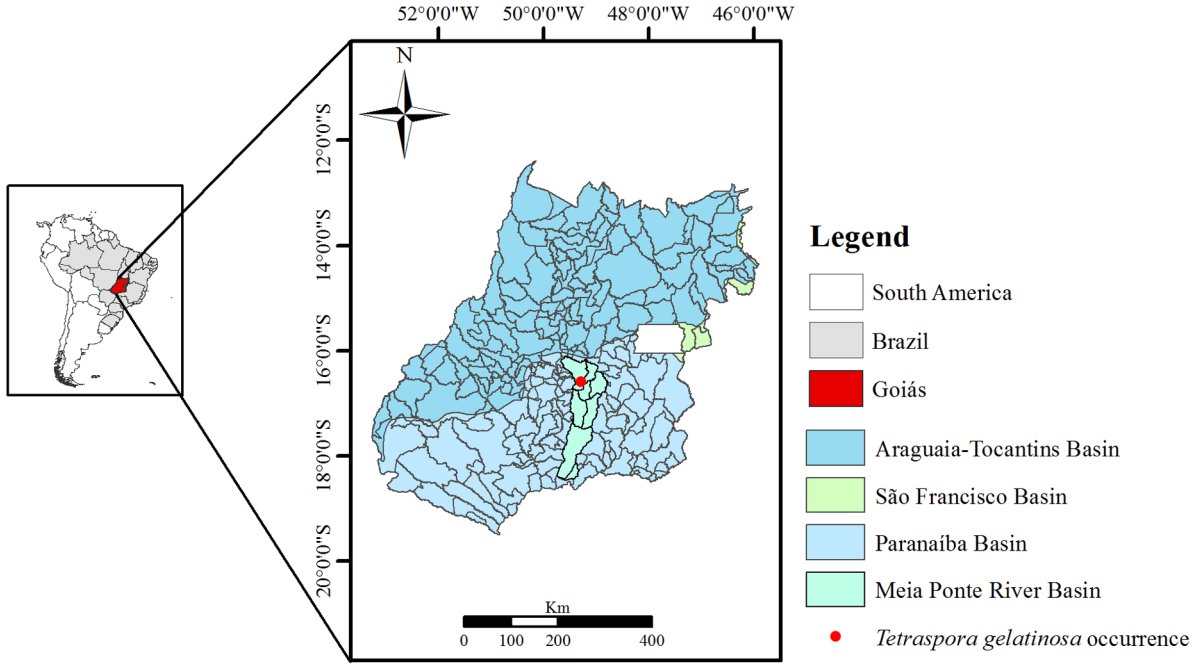

Figure 1. Occurrence of *Tetraspora gelatinosa* in the Samambaia Reservoir, Goiânia, Goiás, Brazil. Geodetic datum used: SIRGAS 2000.

Sphaeropleales) is also considered morphologically similar to the genus *Tetraspora*; however, it differs in terms of the types of reproduction, which occurs exclusively by autospores in *Dispora* (Komárek and Fott 1983).

Originally, the genus encompassed 3 species [*T. minima* (Vaucher) Desvaux, *T. intestinalis* (L.) Desvaux, and *T. gelatinosa* (Vaucher) Desvaux] and the illegitimate name *T. terrestris* (Roth) Desvaux. Later, Agardh (1824) synonymised *T. minima* with *Ulva bullosa* Roth and transferred *T. intestinalis* to the genus *Solenia* Persoon ex E. M. Fries. The only original and legitimate taxa maintained in *Tetraspora* by Agardh (1824) was *T. gelatinosa*, together with 2 new combinations made by him, *T. lubrica* (Roth) C. Agardh and *T. cylindrica* (Wahlenberg) C. Agardh. Thus, *T. gelatinosa* has become the lectotype of the genus, according to Recommendation 9A.4 of the International Code for Nomenclature of Algae, Fungi, and Plants (McNeill et al. 2012), by the exclusion of the other original taxa by Agardh (1824).

Currently, *Tetraspora* encompasses 18 species (Guiry and Guiry 2017), including *T. gelatinosa*, the type of the genus. This species is distributed in various freshwater systems across all continents, including polar, temperate, and tropical zones (Richter et al. 2014). In Brazil, *T. gelatinosa* is known in the states of São Paulo, Paraná, and Rio Grande do Sul (Branco et al. 2005, Krupek et al. 2007, 2008, Peres 2011, Tucci et al. 2015). Herein we provide the first record of *T. gelatinosa* in the state of Goiás, Central-Western Brazil.

Methods

Benthic samples were taken in a small channel constantly supplied with water from the Samambaia Reservoir in Goiânia, state of Goiás (Fig. 1). This reservoir is formed by damming the Samambaia Stream and supplies water to part of the Northern region of Goiânia. The Samambaia Stream is a tributary of the Meia Ponte river basin, whose main channel runs 491.4 km and drains an area of 12,323 km^2 in 39 municipalities (Veiga et al. 2013).

Samples were collected by scrapping the wall of the channel using a scalpel. The benthic material was placed in 100 mL glass bottles and fixed with Transeau (Bicudo and Menezes 2017) deposited in the Herbarium of the Universidade Federal de Goiás (UFG). The material was analyzed by light microscopy using a Zeiss Axioscop 40 microscope equipped with an Axiocam HRc digital camera (Carl Zeiss Microscopy GmbH, Germany). The metric characteristics were obtained using AxioVision Rel 4.8 image software (Carl Zeiss Microscopy GmbH). Identification was performed using specific literature (e.g., Bourrely 1972, Ettl and Gartner 1988). Physical and chemical variables of the water were determined according to the American Public Health Association (APHA 2017).

Results

New record. Brazil: Goiás: Samambaia Reservoir (16°35′44.35″ S, 049°16′53.46″ W [altitude ca 700 m]), Lobo, MTMPS and da Silva, WJ, 21 May 2016 (UFG 0066394)

Identification. *Tetraspora gelatinosa* (Fig. 2) is a partially floating palmelloid algae, which is characterized by macroscopic thalli, and vesicular and sac-like non-motile colonies with non-fenestrated mucilaginous matrix. The cells are almost always grouped four-by-four and rarely two-by-four or two on the periphery; cells are spherical to slightly elliptical with a diameter of 4.9–11.3 µm; each cell has 2 long pseudoflagella that extend beyond

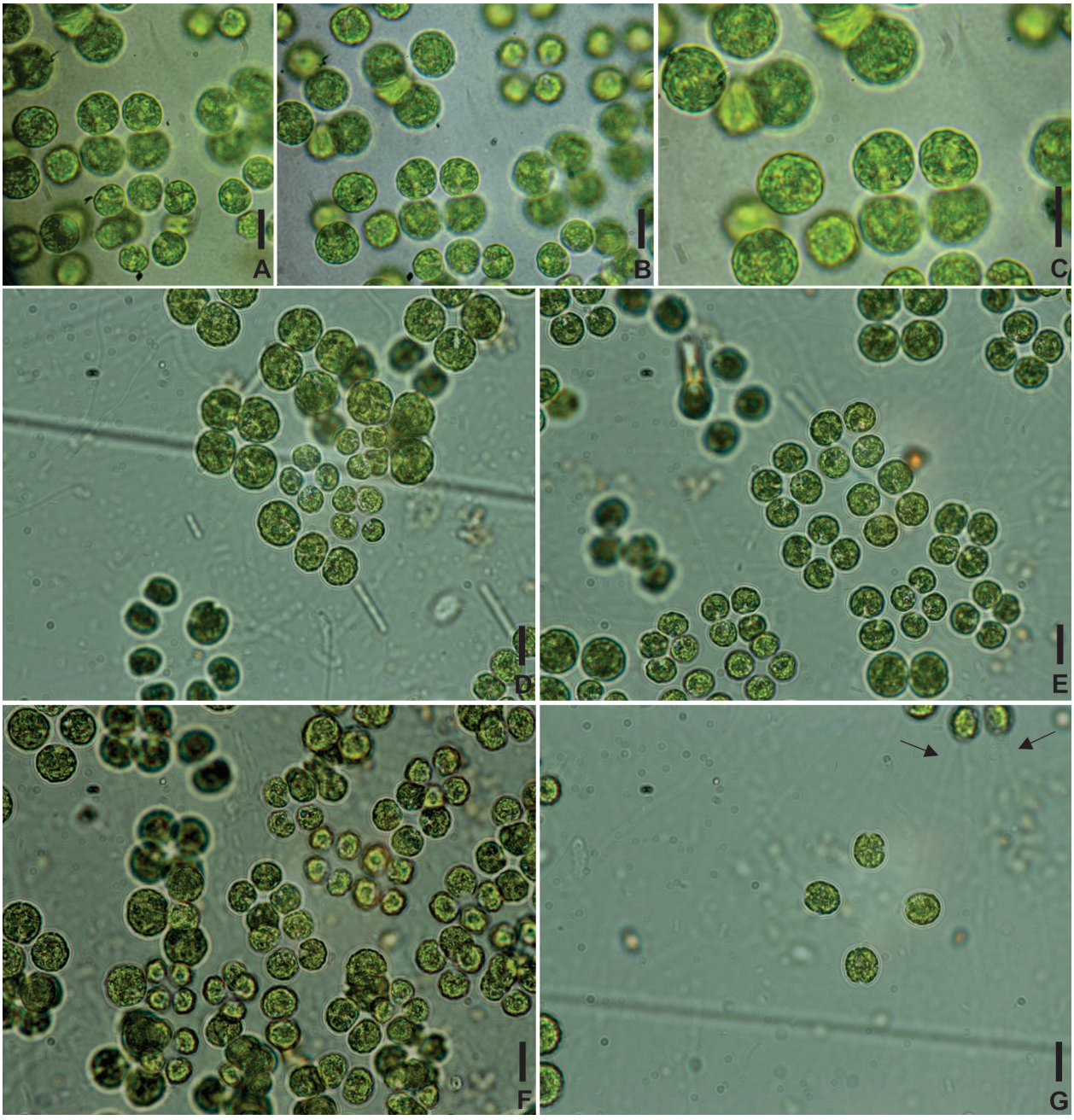

Figure 2. *Tetraspora gelatinosa* (Vaucher) Desvaux. A–F. Cells grouped four-by-four, general aspect. G. Vegetative cells bearing 2 pseudoflagella each (arrows). Scale bar = 10 µm.

the mucilage, which are occasionally absent; 2 contractile vacuoles; chloroplast single, cupuliform, or urceolate; pyrenoid single, no stigma.

Discussion

This species is similar to *T. lubrica*, but differs by the morphology of the mucilaginous matrix (whole and non-fenestrated versus tubular and fenestrated) (Pentecost 2011). Ettl and Gartner (1988) also highlighted differences in the number of starch grains, of which there are only 2 in *T. lubrica* and numerous in *T. gelatinosa*; however, we were not able to observe this characteristic. However, some authors (e.g., Pentecost 2011) suggest that these taxa could be conspecific and that the fenestrated and tubular mucilaginous matrix in *T. lubrica* could be a morphological variability of *T. gelatinosa*, or more specifically, a growth condition of this species. Indeed, these 2 species can occur in the same environment at the same time, which could support this conspecificity hypothesis (Peres 2011), but more detailed studies should be conducted to confirm this or solve other taxonomic doubts in the group, perhaps by including molecular data, as suggested by Richter et al. (2014).

Individuals of *T. gelatinosa* are normally non-motile in the vegetative phase and, similar to other Tetrasporaceae, present pseudoflagella (Ettl and Gartner 1988). These pseudoflagella differ from flagella because they

lack the 2 central microtubules (Entwisle and Skinner 2001). In some cases, the pseudoflagella do not extend beyond the mucilaginous matrix, and therefore, are difficult to observe (Entwisle and Skinner 2001). However, in zoospores and gametes, the pseudoflagella are shed and flagella are produced (Entwisle and Skinner 2001).

Tetraspora gelatinosa has been recorded in Europe (Britain, Netherlands, Romania, Spain, and Turkey), Asia (Bangladesh, India, Iraq, Pakistan, China, Russia, and Turkey), Oceania (Australia and New Zealand) (Guiry and Guiry 2017), and North America (Mexico) (Rodriguez-Flores and Carmona-Jimenez, 2018). In South America, the species has been observed in Argentina (Tell 1985; Daga et al. 2014) and Brazil, specifically in the states of São Paulo, Paraná, and Rio Grande do Sul (Branco et al. 2005, Krupek et al. 2007, 2008, Peres 2011, Tucci et al. 2015). Despite its wide distribution, the environmental condition in which it occurs appears to be specific.

Richter et al. (2014) considered *T. gelatinosa* characteristic of cold habitats and suggested that, in tropical regions, the vegetative cells tend to be smaller compared with temperate areas. Indeed, some cells of specimens found in the Samambaia Reservoir were smaller (< 6 µm) than some obtained from temperate and even tropical zones (Ettl and Gartner 1988, Entwisle and Skinner 2001, Peres 2011, Richter et al. 2014); however, dimensions close to the largest cells representative of this taxon were also observed, independently from the region of occurrence.

The channel of the Samambaia Reservoir, where *T. gelationosa* was found, is shallow with clean water, which agreed with some of the ecological conditions in which this species has been recorded (Pentecost 2011, Richter et al. 2014). Branco et al. (2005) confirmed that *T. gelatinosa* develops better in shallow environments. Moreover, longer periods of irradiance also influence the establishment of this species in Brazilian tropical streams (Branco et al. 2005). Thus, it is possible that the species exhibits a positive relationship with light in the water column, which is directly affected by irradiance, water transparency, turbidity, and depth (Margalef 1983, Kalff 2002).

The Samambaia Reservoir presented low nutrient concentrations (Table 1) and is considered ultraoligotrophic according to the levels of phosphorus and orthophosphate (Lamparelli 2004). Similarly, *T. gelatinosa* has been found in pristine environments, with oligotrophic to mesotrophic conditions and, consequently, low concentration of nutrients (Entwisle and Skinner 2001, Gutowski et al. 2004, Richter et al. 2014). Differently from the population recorded in the most disturbed sites in streams of the Mexican basin, and therefore, tolerant to high DIN concentrations (Rodríguez-Flores and Carmona-Jiménez 2018). This species appears to be sensitive to higher values of orthophosphate, as suggested by Branco et al. (2005). This occurred because the higher abundance of this species was found during rainy periods when concentrations of this nutrient were the most negatively affected. A relationship with nitrite was also verified in the analysis performed by Branco et al. (2005), although this was influenced by only one event that occurred during the sampling period.

Table 1. Physical and chemical parameters of water in the Samambaia Reservoir, Goiânia, Goiás, Brazil.

Variables	Values (mg·L^{-1})
Total nitrogen	0.48
Nitrate	0.2
Nitrite	0.01
Ammonia	< 0.6
Total phosphorus	0.01
Orthophosphate	< 0.01

Morphological characteristics of representatives of the taxon and ecological conditions of the environment where it was recorded confirm the records of *T. gelatinosa*. Although it is distributed worldwide, the species is considered rare. It appears to be dependent on pristine conditions, including in Brazil. Thus, occurrence records are important for knowing its ecology and the conservation of the environments where it is established, as the current trend, especially in Brazil, is the deterioration of environments due to extensive agricultural practices and high production of industrial and urban waste (Tundisi 2003). Future studies should focus on the population relationships of this species to verify distribution patterns and possible sites where the species occurs and the risks for its conservation.

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Authors' Contributions

WJS, ISN, and MTMPSL all shared in writing the manuscript. WJS and MTMPSL participated in the fieldwork.

References

Agardh CA (1824) Systema algarum. Litteris Berlingianus, Lundae [Lund], 312 pp. https://doi.org/10.5962/bhl.title.1829

APHA (2017) American Public Health Association. Standard Methods for Examination of Water and Wastewater. 23rd Edition. American Public Health Association, Washington DC, 1504 pp.

Bicudo CEM, Menezes M (2017) Gêneros de águas continentais do Brasil: chave para identificação e descrições. RiMa, São Carlos, 552 pp.

Bourrely P (1972) Les algues d'eau douce, initiation à la systématique, Tome I: Les algues vertes. Boubée & Cie, Paris, 572 pp.

Branco CCZ, Branco LHZ, Moura MO, Bertusso FR (2005) The succession dynamics of a macroalgal community after a flood

disturbance in a tropical stream from São Paulo State, southeastern Brazil. Brazilian Journal of Botany 28 (2): 267–275. https://doi.org/10.1590/S0100-84042005000200007

Daga C, Soteras F, Daniele GM, Dominguez, LS (2014) New records of freshwater algae and cyanobacteria from mountain streams of Córdoba (Argentina). Boletín de la Sociedad Argentina de Botánica 49 (4): 447–456.

Desvaux NA (1818) Observations sur les plantes des environs d'Angers. Angers, 188 pp. http://img.algaebase.org/pdf/5964B9370cd872CA30GU211514E0/36993.pdf. Accessed on: 2017-8-10.

Entwisle TJ, Skinner S (2001) Non-marine algae of Australia: 4. Floristic survey of some colonial green macroalgae (Chlorophyta). Telopea 9 (3): 725–739.

Ettl H, Gartner G (1988) Chlorophyta II. Tetrasporales, Chlorococcales, Gloeodendrales. In: Ettl H, Gerloff J, Heynig H, Mollenhauer D (Eds) Süssewasserflora von Mitteleurope. Gustav Fischer Verlag, Stuttgart, New York, 1–436.

Guiry M, Guiry G (2017) AlgaeBase. http://www.algaebase.org/search/genus/detail/?genus_id=44201. Accessed on: 2018-7-21.

Gutowski A, Foerster J, Schaumburg J (2004) The use of benthic algae, excluding diatoms and Charales, for the assessment of the ecological status of running fresh waters: a case history from Germany. Oceanological and Hydrobiological Studies 33 (2): 3–15.

Kalff J (2002) Limnology: Inland Water Ecosystems. Prentice Hall, Upper Saddle River, New Jersey, 592 pp.

Komárek J, Fott B (1983). Chlorophyceae (Grünalgen), O. Chlorococcales. Die Binnengewässer. Das Phytoplankton des Süβwassers, Systematik und Biologie, 7 Teil. 1. Hälfte. E. Schweizerbart′sche Verlagsbuchhandlung, Stuggart, 1044 pp.

Krupek RA, Branco CCZ, Peres CK (2008) Levantamento florístico das comunidades de macroalgas da bacia do Rio das Pedras, região centro-sul do Estado do Paraná, Sul do Brasil. Hoehnea 35 (2): 189–208. https://doi.org/10.1590/S2236-89062008000200003

Krupek RA, Branco CCZ, Peres CK (2007) Distribuição ecológica das comunidades de macroalgas da bacia de drenagem do Rio das Pedras, região Centro-Sul do Estado do Paraná, Sul do Brasil. Brazilian Journal of Botany 30 (2): 173–182. https://doi.org/10.1590/S0100-84042007000200002

Lamparelli MC (2004) Grau de trofia em corpos d'água do estado de São Paulo: avaliação dos métodos de monitoramento PhD thesis, Universidade de São Paulo, São Paulo, 235 pp.

Margalef N (1983) Limnologia. Omega, Barcelona, 1010 pp.

McNeill J, Barrie CFR, Buck WR, Demoulin V, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Marhold K, Prado J, Prud'homme Van Reine WF, Smith GF, Wiersema JH (2012) International Code of Nomenclature for algae, fungi, and plants (Melbourne Code), Melbourne, 140 pp.

Pentecost A (2011) Order Tetrasporales. In: John DM, Whitton BA, Brook AJ (Eds) The Freshwater Algal Flora of the British Isles: An Identification Guide to Freshwater and Terrestrial Algae, Second edition. Cambridge, Cambridge University Press, 376–380.

Peres CK (2011) Taxonomia, distribuição ambiental e considerações biogeográficas de algas verdes macroscópicas em ambientes lóticos de Unidades de Conservação do Sul do Brasil. PhD thesis, Universidade Estatual Paulista Júlio de Mesquita Filho, Rio Claro, 220 pp. https://repositorio.unesp.br/handle/11449/100618?show=full. Accessed on: 2017-9-5.

Richter D, Matuła J, Pietryka M (2014) The northernmost populations of *Tetraspora gelatinosa* (Chlorophyta) from Spitsbergen. Polish Polar Research 35 (3): 521–538. https://doi.org/10.2478/popore-2014-0027

Rodríguez-Flores R, Carmona-Jiménez J (2018) Ecology and distribution of macroscopic algae communities in streams from the Basin of Mexico. Botanical Sciences 96 (1): 63–75. https://doi.org/10.17129/botsci.1237

Tell G (1985) Catalogo de las algas de agua dulce de la Republica Argentina (Bibliotheca Phycologica; Bd. 70), Cramer, Vaduz, 283 pp.

Tucci A, Branco CCZ, Peres CK, Fajar A, Menezes M (2015) Chlorophyceae in Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB123978. Accessed on: 2017-9-3.

Tundisi JG (2003) Água no século XXI: enfrentando a escassez. RiMa, São Carlos, 256 pp.

Veiga AM, Santos CCP, Cardoso MRD, Lino NC (2013) Caracterização hidromorfológica da bacia do rio Meia Ponte. Revista Caminhos de Geografia 14: 126–138.