
RESEARCH**TAXONOMIC ACCOUNT OF THE GENUS *CATENELLA* GREV. (FAMILY CAULACANTHACEAE: RHODOPHYTA) IN INDIA****Sudhir Kumar Yadav****Botanical Survey of India, CGO Complex, Sector 1, Salt Lake City, Kolkata - 700064
Email: skyadavbsic@gmail.com**Received-20.11.2024, Revised-08.12.2024, Accepted-28.12.2024*

Abstract: The genus *Catenella* Grev. belongs to the family Caulacanthaceae in the order Gigartinales under the division Rhodophyta. The generic name *Catenella* is derived from a Latin word *Catena*, means 'chain'. The members of this genus are usually found in the marine and the estuarine regions. The genus is currently represented with five taxa in the world and three taxa in India. Based on the comprehensive study, a detailed taxonomic account of this genus of red seaweed in India is described.

Keywords: Indian coast, *Catenella*, Rhodophyta, Taxonomy, Marine

INTRODUCTION

India is endowed with a massive coastline of about 7500 km length, consisting of a considerable network of backwaters, estuaries, creeks, lagoons, mangroves and coral reefs, which supports a large number of marine flora and fauna. These diverse coastline harbours about 865 taxa of seaweeds or marine macro algae, including many economically important seaweeds (Rao and Gupta, 2015; Yadav *et al.*, 2015; Palanisamy *et al.*, 2017; Yadav, 2020). It usually grows on rocks, coralline beds, reefs, pebbles, shells, dead corals and also as epiphytes on other plants like sea-grasses, mangroves and also as epizoic in the intertidal shallow sub-tidal and deep sea areas. Seaweeds are the marine macro algae and ecologically play an important role in sustainability of the marine ecosystems. The marine habitat is one of the important components of the biodiversity. Considering the ecological and economic potentiality of the aquatic biodiversity, the 'Life below water' has been included as one of the seventeen goals of the Sustainable Development Goals (SDG) of the United Nations.

Taxonomically, the genus *Catenella* Grev. belongs to the family Caulacanthaceae in the order Gigartinales under the division Rhodophyta. The genus was established by Greville (1830) with *Catenella opuntia* (Gooden. & Woodw.) Grev. as type species. Derived from the Latin word *Catena*, means 'chain', the genus is characterized by the thallus of up to 5 cm length, with brownish-dark red colour, delicate, flattened to terete and with well distinct into nodes and internodes. It is adapted to grow in marine and estuarine habitats (Fig. 1). The genus is currently represented by five taxa worldwide (Guiry and

*Corresponding Author

Guiry, 2024) and three taxa in India (Rao and Gupta, 2015). In recent years, the genus has received attention globally owing to its various economic potential such as food (in the form of salad), fodder, manure, antimicrobial activity and also in industries as source of Carrageenan (Jha *et al.*, 2009; Mukherjee and Sarkar, 2015; Aung, 2018). Further, thorough exploration and proper documentation of marine flora is prerequisite for its conservation and sustainable utilization. Therefore, considering the above facts, a detailed taxonomic account of this red algal genus in India has been undertaken and discussed here.

MATERIALS AND METHODS

The present study is mainly based on the extensive botanical explorations to different coastal localities of India and a thorough study of fresh collections and herbarium specimens deposited in various herbaria. In order to study the marine macro algal flora of India, several botanical explorations were undertaken during 2011 to 2024 to different coastal localities of the Indian coast and important field observations such as habit, habitats, nature of the coast, vegetation pattern, association with other plants, GPS position (Garmin 12 channel XL) etc. were recorded and photographed using a digital camera (Nikon Coolpix L120). The collected algal samples were thoroughly washed and preserved in the form of herbarium specimens (wet and dry forms) following the standard procedure (Srinivasan, 1969; Dhargalkar and Kavlekar, 2004) and studied microscopic characters under sophisticated compound microscopes (Nikon SMZ1500 and Nikon Eclipse 50i). The samples were identified following the

standard literature (Srinivasan, 1973; Desikachary *et al.*, 1990; Silva *et al.*, 1996; Palanisamy *et al.*, 2020; Palanisamy and Yadav, 2022). The preserved specimens were deposited into different herbaria of the Botanical Survey of India such as Madras Herbarium (MH), Coimbatore, Tamil Nadu and Central National Herbarium (CAL), Howrah. Besides, the herbarium specimens at CAL, BSIS, BSI and resources of virtual herbarium at BM, K,

NY, CONN were also referred and examined. Further, all the relevant global algal databases such as Algae base (<https://www.algaebase.org>), WoRMS (<https://www.marinespecies.org>), Seaweeds (<https://www.seaweed.ie/>) and Macroalgal Herbarium Portal (<https://macroalgae.org>) etc. were referred for resolving nomenclatural ambiguities and provide the updated status of each taxon.



Fig. 1: A. Panoramic view of Mangroves forests in Sundarban Biosphere Reserves; B. Trunks, branches and pneumatophores (*inset*) of mangroves supporting algae vegetation in Sundarban.

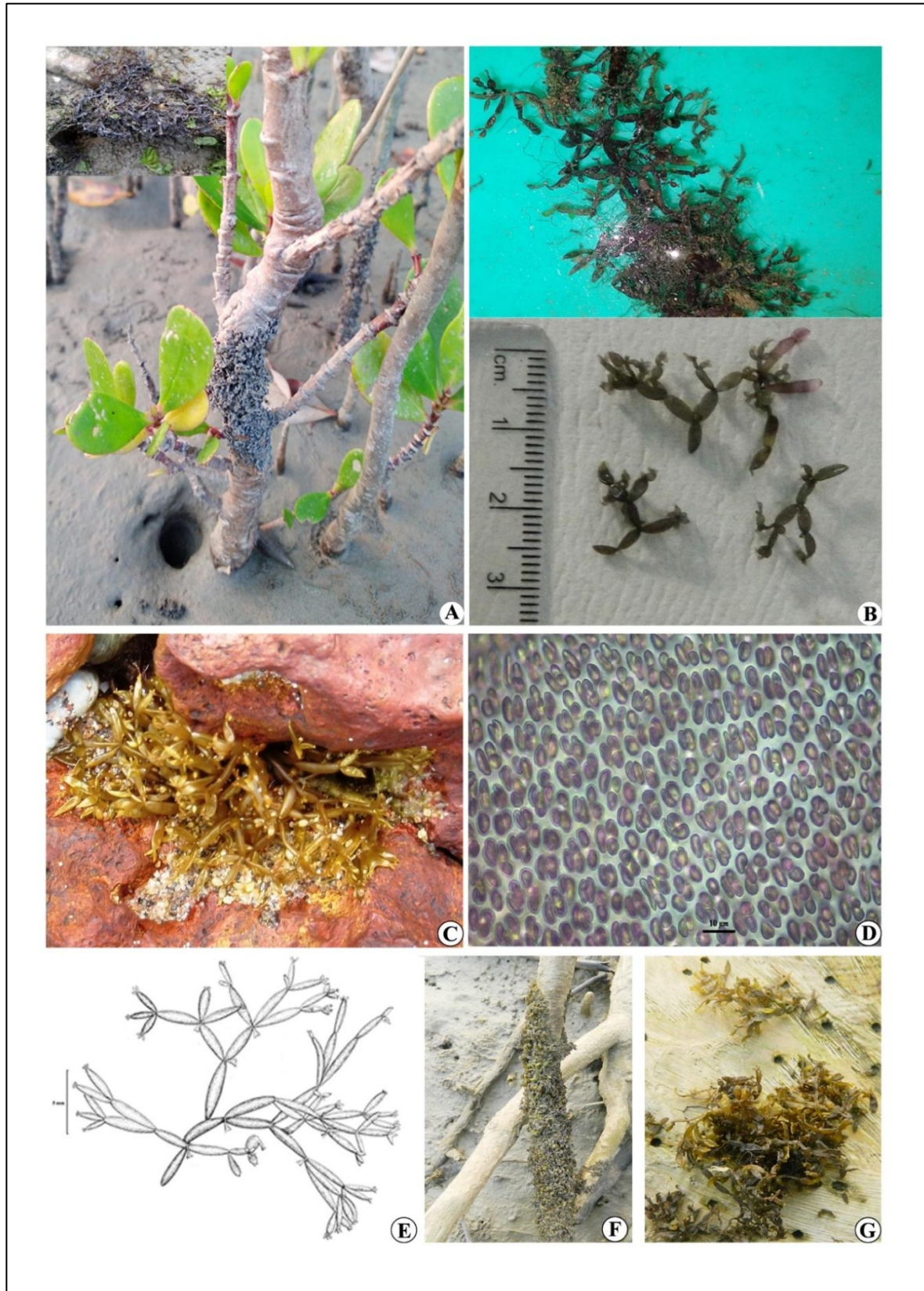


Fig. 2: A-B. *Catenella caespitosa* (With.) L. M. Irvine: A. Dense muddy patches, showing growth of *C. caespitosa* on young mangroves; B. Habit of the plant; C-E. *Catenella impudica* (Mont.) J. Agardh: C. Thallus growing in the crevices of bedrocks; D. Microscopic image showing surface cells of the thallus; E. An illustration showing habit of the thallus; F-G. *Catenella nipae* Zanardini: F. Growth of *C. nipae* on young mangroves; G. Habit of the plant.

RESULTS AND DISCUSSION

Based on the comprehensive study, a detailed taxonomic account of the genus *Catenella* Grev. in India is described in details.

Catenella Grev.

Thallus brownish-dark red in colour, flattened to terete, up to 5 cm long, erect, epilithic. Fronds compressed, segmented, differentiated into nodes and internodes, branches develop from the nodes. Spermatangia scattered over the surface; carpogonial branches usually 2-3-celled, carposporophyte produces carposporangia in chain; cystocarps without any sheath, ostiolate; tetrasporangia scattered, embedded in the outer cortical layer.

Note: The name *Catenella* is derived from a Latin word *Catena*, means chain. The genus is usually found in the marine and estuary regions (Yadav *et al.*, 2018). Its type species is *Catenella opuntia* (Gooden. & Woodw.) Grev. which is now synonym of *Catenella caespitosa* (With.) L. Irvine.

Currently, the genus is represented with 5 taxa in the world (Guiry and Guiry, 2024) and 3 taxa in India (Rao and Gupta, 2015; Palanisamy and Santhoshkumar, 2020).

Key to species

- 1a. Thallus segmented, regularly di- or trichotomously branched; segments oblong or subcylindrical **1. *C. caespitosa***
- 1b. Thallus segmented but not regularly di- or trichotomously branched; segments obovate to terete **2**
- 2a. Thallus segments obovate, ending with terete – acuminate tip **2. *C. impudica***
- 2b. Thallus segments terete – slightly compressed with rhizoidal cells at the tips, branching subapical **3. *C. nipae***

1. *Catenella caespitosa* (With.) L. M. Irvine, in Parke & P.S.Dixon, J. Mar. Biol. Assoc. United Kingdom 56: 590. 1976; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 48. 2001; P.S.N. Rao & R.K. Gupta, Algae India 3: 48. 2015; Yadav & al., NeBIO 11 (3): 202. 2020; Yadav & Majumdar, Int. J. Adv. Res. Biol. Sci. 7(12): 60. 2020; Yadav, Int. J. Bioresource Sci., 9(2): 132. 2022; Yadav & Dash, J. Plant Devel. Sci., 15 (10): 513. 2023; Guiry & Guiry, Algaebase (*e-database*), 2024. *Ulva caespitosa* With., Bot. Arr. 735. 1776. *Catenella opuntia* (Gooden. & Woodw.) Grev., Alg. Brit. lxiii, 166. 1830. *Catenella repens* (Lightf.) Batt., J. Bot. (London). 40: 69. 1902; Banerjee & al., J. Earth Syst. Sci. 118 (5): 497. 2009; Satpati & al., J. Algal Biomass Utiln. 3(4): 47. 2012. **(Fig. 2, A-B)**

Type locality: Side Rocks, Anglesey, Wales.

Thallus dark brownish - purple red in colour, foliose, 1-5 cm long, decumbent, attached by rhizoidal haptera. Holdfast fimbriate, firmly attached on substrata. Stipe small, indistinct. Fronds articulated,

up to 4 cm long, profusely branched towards apex, branching regularly di-trichotomously towards tip, differentiated into nodes and internodes; internodal segments oblong to subcylindrical, 1-6 × 0.2-2 mm, apical segments slightly curved or sickle shaped, deeply constricted at nodes. *Microscopic characters:* Cells in surface view spherical-slightly elongate, 4-16 µm across. In cross section, thallus differentiated into outer cortical layer and central hollow or loosely medullary region.

Occurrence: Usually monsoon and post-monsoon seasons. Moderate.

Distribution: INDIA: Goa, Gujarat, Maharashtra and West Bengal.

Specimens examined: INDIA: **Maharashtra:** Raigad - Alibaug 06.06.2004 *Sonali Piwalatkar* 190313 (BSI); Dapoli 14.10.2004, *Sonali Piwalatkar* 190332 (BSI); Mumbai - Colaba 27.12.2004, *Sonali Piwalatkar* 190365 (BSI); Colaba 27.06.2006, *Sonali Piwalatkar*, 192088a (BSI); Mumbai - Malad 28.06.2006, *Sonali Piwalatkar* 192094 a BSI; Mumbai-Colaba 08.12.2007, *Sonali Piwalatkar* 193083 BSI. **West Bengal:** Sundarban B.R., 12.01.2020, *S.K. Yadav & K. Majumdar* 91107 (CAL); Sundarban B.R., 29.12.2021, *S.K. Yadav* 91184 (CAL); Sundarban B.R., 30.12.2021, *S.K. Yadav* 91192, 91194 (CAL).

Notes: This species is mostly found growing in association with the pneumatophores and trunks of the mangroves (Yadav *et al.*, 2020; Yadav and Majumdar, 2020; Yadav, 2022). In field, it appears as dark muddy colour, however after preservation on herbarium sheet, it changes into brownish - purple red in colour.

Economic potential: This species is known to be used in industries as Carrageenan source (Jha *et al.*, 2009) and also used as saland in Myanmar (Aung, 2018). Further, during the field exploration, it was observed that this species is abundantly growing on mangroves in the Sundarban Biosphere Reserves, West Bengal, and therefore, it may be a potential source for its sustainable utilization in the food and other industries (Yadav, 2022; Yadav and Dash, 2023).

2. *Catenella impudica* (Mont.) J. Agardh, Spec. Gen. Ord. Alg. 2: 701. 1852; P.C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean: 281. 1996; Desikachary & al., Rhodophyta 2 (2B):146. 1998; Sahoo & al., Seaweeds Ind. Coast: 169. 2001; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg. 49. 2001; Jha & al., Seaweeds Gujarat: 138. 2009; P.S.N. Rao & R.K. Gupta, Algae India 3: 48. 2015; Yadav & al., Indian J. Mar. Sci. 1043. Fig. 3. 2018; Palanisamy & al., Seaweeds Kerala, India 135. Pl. 60. 2020; Guiry & Guiry, Algaebase (*e-database*), 2024. *Lomentaria impudica* Mont. in Ann. Sci. Nat. Bot. 2(8): 197. 1840. **(Fig. 2, C-E)**

Type locality: Cayenne, French Guiana.

Thallus blackish to dark-purple red in colour, foliose or frondose, 0.5-2.5 cm long, creeping, decumbent,

fragile, epilithic, attached by discoidal haptera at nodes. Holdfast discoid, fimbriate or branched, up to 2 mm long and 180-300 µm wide, delicate, firmly attached on calcareous substrata in the intertidal regions. Stipe minute, indistinct. Fronds articulated, irregularly di-trichotomously branched; branches usually sparse below and profuse towards apex; differentiated into nodes and internodes; internodal segments slender to slightly flattened in young stage, later become spindle, expanded or sickle shaped, 1-7 × 0.3-2 mm, deeply constricted at nodes; surface smooth; margins entire, apex irregularly forked with acute to acuminate tips, 410-1240 × 180-290 µm. *Microscopic*: Cells in surface view usually spherical, 8-15 µm across, irregularly or sparsely arranged. In cross section, thallus up to 1.3 mm thick, differentiated into outer cortical region and central hollow or loosely interwoven medullary region. Spermatangia scattered over the surface; carposporangia develop in chains; tetrasporangia zonate, scattered or embedded in cortical region.

Occurrence: Monsoon season. Moderate.

Distribution: INDIA: Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Odisha and Tamil Nadu.

Specimens examined: INDIA: **Gujarat**: Dwarka, 13.02.1955, K.S. Srinivasan s.n. (BSIS); **Karnataka**: Om Beach, 30.08.2016, M.Palanisamy & S.K. Yadav 135732 (MH); Tadri, 30.08.2016, M.Palanisamy & S.K.Yadav, 135745 (MH); Harwada-Tarangamett, 23.11.2016, Palanisamy & Yadav 135823, (MH). **Kerala**: Malappuram - Kadalundinagaram coast, 20.09.2011, M.Palanisamy & S.K.Yadav 127191; 19.06.2013, M.Palanisamy & S.K.Yadav, 128909. **Maharashtra**: Bombay - Bandra sea face, 15.02.1952, K.S. Srinivasan 1198 (BSIS); Mumbai - Colaba 27.06.2006, Sonali Piwalatkar, 192088b (BSI); Mumbai - Colaba 28.06.2006, Sonali Piwalatkar 192094 b (BSI). Ratnagiri, Dapoli 14.10.2004, Sonali Piwalatkar 192009 (BSI).

Notes: From India, this species was first recorded by Rao and Kale (1969) from Gopnath coast, Gujarat. Rao *et al.* (2008) collected this species from the Godavari estuary, Andhra Pradesh and studied its seasonal spore shedding. Piwalatkar (2010) reported this species as an addition to the seaweed flora of Maharashtra coast. It is usually found growing in small crevices and grooves on bedrocks in shallow intertidal region. It is differentiated from other two species by its irregular branching and prolonged acuminate tips. Yadav *et al.* (2018) reported this species from the Kadalundinagaram coast, Malappuram district as a new addition to the Seaweed Flora of Kerala.

Economic potential: Mukherjee and Sarkar (2015) reported the antimicrobial activity of this seaweed against a Gram negative bacterium *Aeromonas hydrophilia* and opined that it can be a potential source for the development of anti-pathogenic agents against many microbial populations.

3. *Catenella nipae* Zanardini, Mem. R. Ist. Venet. Sci., Lett. Ed Arti 17: 143, pl. VI (6): A, figs 1-7. 1872. Islam in Bangladesh J. Bot., 2 (2): pl 5, fig 1-4. 1973; Sen & Naskar, 186, pl XXII, fig 139. 2003; P.S.N. Rao & R.K. Gupta, Algae India 3: 48. 2015; Satpati & al. in J. Algal Biomass Utiln. 3(4): 47. 2012; Yadav & al., NeBIO 11 (3): 202. 2020; Yadav & Majumdar, Int. J. Adv. Res. Biol. Sci. 7(12): 60. 2020; Yadav & Dash, J. Plant Devel. Sci., 15 (10): 513. 2023; Guiry & Guiry, Algaebase (e-database), 2024. (**Fig. 2, F-G**)

Type locality: Sarawak, Borneo, Malaysia.

Thallus dark - brownish red in colour, foliose, fragile, 1-3 cm long, attached by minute rhizoidal haptera. Holdfast minute, fimbriate, loosely attached on substrata. Stipe small, indistinct. Fronds articulated, 0.8-2.5 cm long, sparsely branched below and profusely branched towards apex; branching irregularly di-trichotomously at tip, differentiated into nodes and internodes; internodal segments terete to slightly compressed, 1-4 × 0.1-3 mm, apical segments minute, dense, hairy, deeply constricted at nodes. *Microscopic*: Cells in surface view usually spherical, 3-15 µm across. In cross section, thallus differentiated into outer cortical layer and central hollow medullary region.

Occurrence: Usually monsoon and post monsoon seasons. Moderate.

Distribution: INDIA: Maharashtra and West Bengal (Sundarban BR).

Specimens examined: INDIA: **Maharashtra**: Mumbai - Colaba, 29.06.2006, Sonali Piwalatkar 192094 b (BSI). **West Bengal**: Sundarban B.R., 12.01.2020, S.K. Yadav & K. Majumdar 91108 (CAL); Sundarban B.R., (Amlamethi Ghat) 29.12.2021, S.K. Yadav 91185 (CAL); Sundarban B.R. (Jhorkhali Island) 30.12.2021, S.K. Yadav 91193 (CAL).

Notes: This species is also found growing abundantly in association with the pneumatophores and trunks of the Mangroves (Yadav *et al.*, 2020; Yadav, 2022). In field, it appears as dark muddy colour, however after preservation on herbarium sheet, it changes into dark - brownish red in colour.

Economic potential: This species has the potential to be used as food, fodder, manure and also in industries as Carrageenan source (Aung, 2018).

CONCLUSION

The marine habitat is one of the important components of the biodiversity, with potential role in mitigation of the climate change and carbon sequestration. As one of the important components of the aquatic biodiversity, and the Sustainable Development Goals (SDG) 'Life below water', proper documentation of the marine algal resources is a prerequisite for its conservation and sustainable utilization. The genus *Catenella* Grev. is a marine red algae, belonging to the family Caulacanthaceae

in the order Gigartinales under the division Rhodophyta. Out of the five species reported globally, it is represented by three species in India. It is usually adapted to grow in marine and estuarine habitats, particularly as epiphytes on pneumatophores of the mangroves and also on other flora. Besides, in the recent years, this species has got attention globally for intensive research because of its economic potential in various forms such as food, fodder, manure, antimicrobial activity and industrial values. Therefore, the detailed taxonomic account of this genus has been done, which will pave the way for further studies on various aspects of these species in the Indian coastline.

ACKNOWLEDGEMENTS

The author is thankful to Dr. A.A. Mao, Director, Botanical Survey of India, Kolkata and Dr. S.S. Dash, Scientist F & In-Charge, Technical Section, BSI, HQ, Kolkata for facilities and encouragements. Author also expresses sincere gratitude to Dr. M. Palanisamy, Scientist E, CNH, Howrah and Dr. M.U. Sharief, Scientist F & Head of Office, BSI, SRC, Coimbatore for support and encouragements.

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