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Occurrence and Composition of Fish Species in Three Different Locations of the Ganga River

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Authors' contributions

This work was carried out in collaboration among all authors. Author SK collected the data, contributed in data analysis, performed the analysis and wrote the paper. Author AS helped in designing the research and guidance in writing. Author NNP helped in paper correction and applying of statistical operation where needed. Authors DA and Toshibaa helped in sample analysis during the study period. All authors read and approved the final manuscript.

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ABSTRACT

The freshwater ecosystem's health and fish diversity depend on natural and human interventions. The present investigation was carried out for one year to observe the present physicochemical parameters, fish composition, and abundance with diversity at three selected locations, i.e., A1, A2,

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and A3. Physico-chemical parameters were exceptionally suitable, and the limnological conditions were favorable for the growth and survival of biodiversity. 39 fish species belonging to 8 orders and 16 families were recorded, and cypriniformes was the most predominant order, followed by siluriformes. Simpson's Diversity Index (D) at site A1 was D=0.73, site A2 D=0.82, and site A3 D=0.87. The highest diversity was found at site A3 and the lowest at site A1. The second most dominant catch of exotics in the landing has adversely impacted the Indian major carps. There should be proper regulations and guidelines for the production and disposal of effluents as well as excessive fishing of indigenous aquatic fisheries.

Keywords: Ganga river; physico-chemical; diversity; cypriniformes.

1. INTRODUCTION

“In tropical areas, riverine fisheries sustain millions of people's food and way of life. Numerous freshwater fish species have become critically endangered due to severe human interference that has caused habitat loss and degradation in India's riverine environment, especially true in the Ganges basin, where there is a high demand for freshwater. Designated as a national river due to its distinctive geographical, historical, social, and economic characteristics, it holds a special place in the history and civilization of the Indian subcontinent” [1]. The rivers, seas, and oceans that make up our natural inheritance have been abused, misused, and poisoned. Nowadays, our drinking water is far from pure-it contains over 200 harmful industrial additives. The world's fifth-largest Ganges basin drains an area of approximately 1,060,000 km^2 and holds significant cultural, historical, and religious value [2]. “Ganga originates from the Himalayas after the confluence of 6 rivers: Alaknanda meets Dhauliganga at Vishnuprayag, Nandakini at Nandprayag, Pindar at Karnaprayag, Mandakini at Rudraprayag and finally Bhagirathi at Devprayag. From here onwards, it is known as Ganga in the Indian state of Uttarakhand. All of the Ganges' tributaries in India are managed by barrages that restrict water flow for agriculture; as a result, fish catches have decreased, and reports of a loss of species diversity have followed” [3,4]. With around 260 fish species recorded for Indian waters, the River Ganges is home to a varied fish fauna [5]. Over the last few decades, India has imported over 300 foreign fish species for leisure fishing, experimental aquaculture, and mosquito control [6]. According to recent estimates, 20% of freshwater species globally are considered vulnerable, endangered, or extinct [7]. The loss of biodiversity, mainly due to human activities [8], is of particular concern to aquatic ecosystems [9,10,11]. Due to their high sensitivity to the quantitative and qualitative alterations of aquatic habitats [12], as well as the morphology and life history of species associated with environmental constraints [13,14], freshwater fish are one of the most threatened taxonomic groups [15,16,17]. The uncontrolled transfer of aquatic creatures, mainly fish, has raised worldwide concerns, including the loss of native species [18,19]. Fish native to the area compete with exotics for food and habitat. They may consume indigenous fish, introduce new diseases and parasites, produce hybrids, destroy the genetic composition of native species, and change the physiochemical makeup of aquatic ecosystems. Globally, changes in riparian vegetation and impoundments [20,21], as well as pollution and sedimentation [22], have affected water quality and caused disturbances to physical habitat that have led to fish assemblage shifts, a decrease in the diversity of native species, community homogenization, range reduction, and extinction. Humans often introduced exotic species into natural habitats to suit their nutritional needs or for less essential uses like fishing, hunting, or gardening [23]. Considerable studies on fish fauna from different freshwater bodies of India have been carried out. However, significantly less work has been done on fish composition at District Haridwar, Bijnor, and Muzzafarnagar. As a result, the current effort aimed to generate extensive data on the biodiversity of freshwater fish in the Ganga River from three different locations.

2. MATERIALS AND METHODS

2.1 Sampling Sites

The study lasted from March 2019 to February 2020. The flexibility of the river stretch, considering changes in pollution, biodiversity, and hydrological regimes, served as the foundation for selecting sample sites. Based on the current investigation's survey, three sample locations were chosen from the Ganga River: Haridwar (Bhadrabad) site A1, Bijnor (Balawali) site A2, and Muzaffarnagar (Bairaj Ganga bridge) site A3 which are presented in Fig. 1.

Table 1. Geographical locations of the sampling sites

Ganga river	A1	A2	A3
	Bhadrabad	Balawali	Bairaj Ganga bridge
Map Location	29°55'15.1"N 78°04'42.2"E	29°38'07.0"N 78°06'21.7"E	29°22'26.1"N 78°02'03.5"E

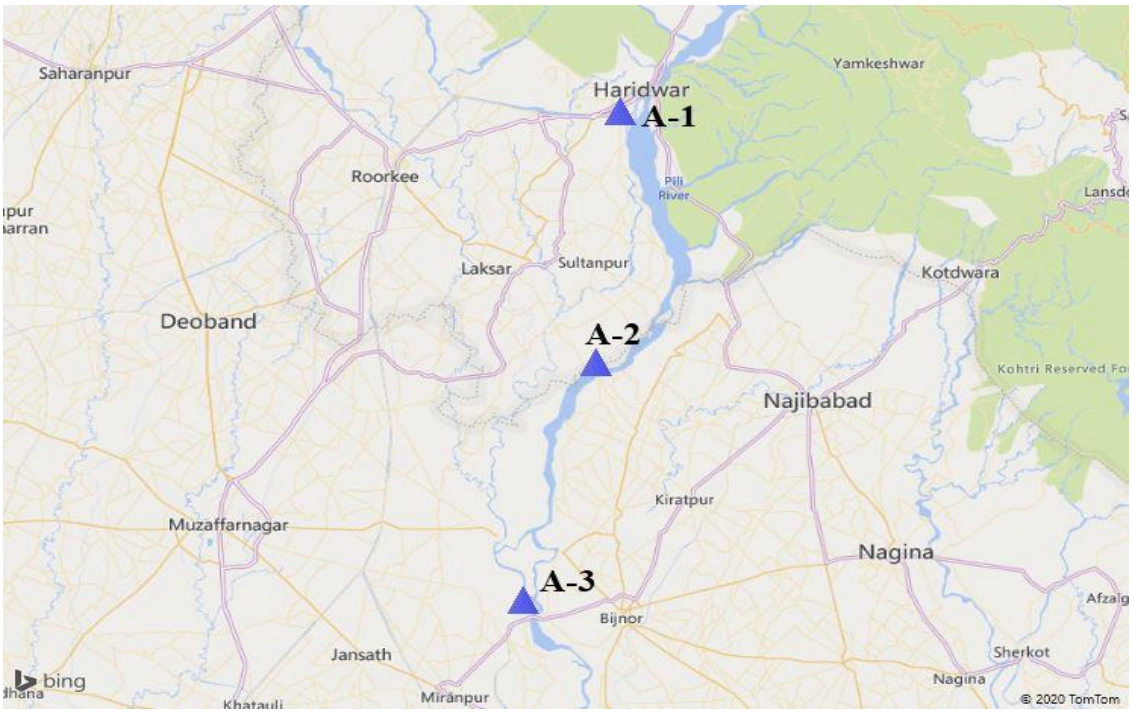

Fig. 1. Sampling location in the Ganga river

2.2 Sampling and Data Analysis

Between March 2019 and February 2020, the fish were harvested from the Ganga River with the help of local fishermen. The fish were kept and transported in a 10% formaldehyde solution for taxonomic research. Freshwater Fishes of the Indian Region [24] and Inland Fishes of India and Adjacent Countries [25] are considered classics in fish identification literature. Water samples were collected monthly from each sampling site to examine water quality parameters. pH, electrical conductivity, free CO_2, dissolved oxygen, and water temperature were measured at the sample site. A mercury thermometer (Borosil) measured the water's temperature. The pH of the water samples was measured using a portable digital pH meter known as the HANNA. A portable "HANNA" digital conductivity meter was used to measure electronic conductivity. Free CO_2 and dissolved oxygen were measured using the methodology provided by [26]. Statistical analysis must play a significant role in both sampling strategy and conclusion-making.

Simpson's Diversity Index (D) measures diversity by considering the number of species present and each species' relative abundance.

The formula to calculate Simpson's Diversity Index (D) is

$$D = 1 - \left[\frac{\sum n\,(n-1)}{N\,(N-1)}\right]$$

Where
n = the total number of organisms of a particular species
N = the total number of organisms of all species

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Parameters

"Physico–chemical water parameters at the three sampling sites markedly differ; this seems to be caused by variations in the amount and duration of rainfall" [27]. In the Ganga River at site A1, the minimum value of DO (mg/l) was 8.4 in July, and

the maximum was observed at 10.4 in January. The average value of 9.42 with SD± 0.69 was observed at site A1. Site A2's minimum value was 7.6 in June, and the maximum was 8.9 in February. The average value of 8.30 with SD± 0.45 was observed at sites A2 and A3; the minimum value was 7.4 in June, and the maximum was 9.2 in March. The average value of 8.17 with SD± 0.49 was observed at site A3. The increased concentration in winter might be due to the increased rate of photosynthesis activity and the decrease in water temperature. The minimum might be due to the high metabolic rate of organisms in the water body [28] also observed a similar trend in the Ganga River at Haridwar [29] reported dissolved oxygen from 8.0 mg/l to 10.0 mg/1 at Rishikesh. Free CO_2 (mg/l) in the Ganga River at site A1, the minimum value was 1.3 in January, and the maximum was 3.6 in September. The average value of 2.33 with SD± 0.80 was observed at site A1. Site A2's minimum value was 1.8 in January and April, and the maximum was 4.5 in October. The average value of 2.82 with SD± 0.88 was observed at site A2. Site A3's minimum value was 1.9 in March and January, and the maximum was 4.4 in October. The average value of 2.91 with SD± 0.93 was observed at site A3. A similar result of free CO_2 was reported by [30] from Kali River in Pithoragarh, Uttarakhand. According to [31], the maximum values of free CO_2 in the rainy season in the Alaknanda River were observed due to its utilization by negligible phytoplankton population and less availability of sunlight. [32] noted in their study that free carbon dioxide fluctuated from 1.69 to 3.62 mg/L in the Basanter River at Jammu. At site A1, the minimum water temperature (ºC) was 13.1 in January, and the maximum was 18.9 in September. The average value of 16.14 with SD± 2.16 was observed at site A1. Site A2's minimum value was 15.2 in January, and the maximum was 19.4 in October. The average value of 17.85 with SD± 1.51 was observed at site A2. Site A3's minimum value was 14.8 in January, and the maximum was 20.1 in October. The average value of 17.93 with SD± 1.65 was observed at site A3. [33] investigated the temperature range of 10.8°C to 23°C in the western Ganga canal at Haridwar. The maximum temperature in the river at all sampling sites was observed during the monsoon season, which is generally due to suspended particles as they absorb and scatter sunlight in the water column and lower in winter due to rare rainfall and cold, which is supported by the results observed by [34]. In the Ganga River at site A1, the minimum pH value was 7.6 in May, and the maximum was 8.1 in November, February, and July. The average value of 7.90 with SD± 0.16 was observed at site A1. Site A2's minimum value was 7.3 in April, and the maximum was 7.9 in February. The average value of 7.60 with SD± 0.19 was observed at site A2. Site A3's minimum value was 7.2 in May, and the maximum was 7.8 in March. The average value of 7.51 with SD± 0.18 was observed at site A3. [35] in their study on the Ganga River, found higher pH values during the monsoon season, which might be due to the increasing chemical load in the river and the minimum in the winter season. Similar results were made by [36] in the Subarnarekha River, [37] in the Betwa River, and [38] in the Ganga River. The electrical conductivity (µS/cm) in the Ganga River at site A1 minimum value was 122 in January, and the maximum was 245 in September. The average value of 186.33 with SD± 42.58 was observed at site A1. Site A2's minimum value was 149 in January, and the maximum was 289 in October. The average value of 211.75 with SD± 43.66 was observed at site A2. At site A3, the minimum value was 165 in January, and the maximum was 302 in September. The average value of 229.33 with SD± 42.69 was observed at site A3. [35] also noted a similar conductivity trend in the River Ganga at Bulandshahar and River Panvdhoi at Saharanpur, respectively. Higher values during monsoon season may be due to a large number of salts, silts, and greater ionic concentration inlet flow carried by the river [39].

3.2 Occurrence, Composition, and Biodiversity of the Ganga River

39 fish species belonging to 8 orders and 16 families were recorded from three sampling sites during the study period, presented in Table 1 and Fig. 2. Cypriniformes was the most predominant order with 3 families (Cyprinidae, Botidae & Nemacheilidae) and 18 fish species (*Catla catla, Cyprinus carpio, Puntius sarana, Puntius ticto, Salmostoma bacaila, Esomus danricus, Schizothorax richardsonii, Labeo rohita, Labeo calbasu, Tor tor, Rasbora daniconius, Puntius chola, Cirrhinus migala, Tor putitora, Crossochielus latius latius, Schizothoax niger, Botia dario* and *Noemacheilus botia*) followed by Siluriformes contributing 7 family (Bagridae. Siluridae, Claridae, Sisoridae, Schilbeidae, Heteropneustidae & Ailiidae) with 13 fish species (*Sperata seenghala, Sperata oar, Mystus vittatus, Mystus tengra, Mystus bleekeri, Mystus seenghala, Wallago attu, Clarius batrachus, Clarius gariepinus, Bagarius bagarius,*

Eutropiichthys vacha, Heteropneustes fossilis and *Clupisoma garua*), Osteoglossiformes with 1 family (Notopteridae) and 2 fish species (*Chitala chitala* and *Notopterus notopterus*), Ophiocephaliformes with 1 family (Channidae) and 2 fish species (*Channa striatus* and *Channa punctatus*), and Anabantiformes with 1 family (Osphronemidae) and 1 fish species (*Tricchogaster faciata*), Perciformes with 1 family (Nandidae) and 1 fish species (*Nandus nandus*), Beloniformes with 1 family (Belonidae) and 1 fish species (*Xenentodon cancila*) and Synbranchiformes with 1 family (Mastacembelidae) and 1 fish species (*Mastacembelus armatus*).

At site A1, 30 species from 10 families were recorded which is presented in Fig. 3. Cyprinidae is the most abundant family, contributing 52% of species, followed by the family Bagridae 21% species, Nemacheilidae, Botidae, Claridae 4% species each, Sisoridae, Schilbeidae, Channidae, Osphronemidae, and Nandidae 3% species each. At site A2, 29 species from 12 families were recorded which is presented in Fig. 4. Cyprinidae is the most abundant family contributing 38% of species, followed by the family Bagridae 21% of species, Notopteridae and Channidae 7% of species each, Siluridae, Claridae, Sisoridae 4% of species each, Heteropneustidae, Ailiidae, Nandidae, Belonidae, Mastacembelidae (3%) species each. At site A3, 24 species belonging to 13 families were recorded which is presented in Fig. 5. Cyprinidae is the most abundant family contributing 27% of species, followed by the family Bagridae 23% of species, Notopteridae and Channidae 7% of species each, Nemacheilidae, Siluridae, Claridae, Sisoridae, Heteropneustidae, Ailiidae, Nandidae, Belonidae, Mastacembelidae 4% species each respectively. Simpson's Diversity Index (D) at site A1 was D=0.73, site A2 D=0.82, and site A3 D=0.87 was calculated. The highest diversity was found at site A3 and lowest at site A1. The present investigation reveals that Cyprinid fishes are found to be the more dominant group in the Ganga River than others, which is supported by other studies by [40]. The abiotic factors, such as current velocity, temperature, and substrate, can determine the distribution and abundance of individual species [41]. In the Ganga river, the second most dominant catch of exotics in the landing has adversely impacted the Indian major carps (IMC), i.e., *Labeo rohita, Catla catla*, and *Cirrhinus mrigala* [42,43]. The greatest diversity in cypriniformes and siluriformes has also been reported by [44] in the Western Himalayan Hill Stream. [45] studied the fish fauna of Mahananda reservoir, Near Siliguri Town, and recorded 49 species of fish. [46] reported 21 species of fishes from Darjeeling uplands. Resilient exotic fishes have been established in river Sone due to low discharge-driven altered river habitats [47]. The invasion and establishment of hardy, resilient exotic fishes could be attributed to their greater adaptability to polluted and stagnant waters.

Table 2. Fish occurrence and composition were found in the Ganga River at three locations

S.No.	Fish species	A1	A2	A3
Family-	**Cyprinidae**			
1	*Catla catla* (Hamilton, 1822)	**+**	**+**	**-**
2	*Cyprinus carpio* (Linnaeus, 1758)	**++**	**++**	**++**
3	*Puntius sarana* (Hamilton, 1822)	**++**	**++**	**+**
4	*Puntius ticto* (Hamilton, 1822)	**++**	**+**	**+**
5	*Salmostoma bacaila* (Hamilton, 1822)	**-**	**+**	**-**
6	*Esomus danricus* (Hamilton, 1822)	**+**	**++**	**+**
7	*Schizothorax richardsonii* (Gray, 1832)	**+**	**-**	**-**
8	*Labeo rohita* (Hamilton, 1822)	**++**	**+**	**-**
9	*Labeo calbasu* (Hamilton, 1822)	**++**	**++**	**+**
10	*Tor tor* (Hamilton, 1822)	**+**	**-**	**-**
11	*Rasbora daniconius* (Hamilton, 1822)	**+**	**-**	**-**
12	*Puntius chola* (Hamilton, 1822)	**++**	**++**	**+**
13	*Cirrhinus migala* (Hamilton, 1822)	**++**	**+**	**+**
14	*Tor putitora* (Hamilton, 1822)	**+**	**-**	**-**
15	*Crossochielus latius latius* (Hamilton, 1822)	**++**	**+**	**-**
16	*Schizothoax niger* (Heckel, 1838)	**+**	**-**	**-**
Family-	**Botidae**			
17	*Botia Dario* (Hamilton, 1822)	**+**	**-**	**-**

S.No.	Fish species	A1	A2	A3
Family-	**Nemacheilidae**			
18	*Noemacheilus botia* (Hamilton, 1822)	+	-	+
Family-	**Bagridae**			
19	*Sperata seenghala* (Sykes, 1839)	+	+	++
20	*Sperata oar* (Hamilton, 1822)	++	++	+
21	*Mystus vittatus* (Bloch, 1794)	+	+	++
22	*Mystus tengra* (Hamilton, 1822)	+	++	+
23	*Mystus bleekeri* (Day, 1877)	++	+	++
24	*Mystus seenghala* (Hamilton, 1822)	+	++	++
Family-	**Siluridae**			
25	*Wallago attu* (Bloch & Schneider, 1801)	-	++	++
Family-	**Claridae**			
26	*Clarius batrachus* (Linnaeus, 1758)	++	+	-
27	*Clarius gariepinus* (Burchell, 1822)	-	-	+
Family-	**Sisoridae**			
28	*Bagarius bagarius* (Hamilton, 1822)	++	++	++
Family-	**Schilbeidae**			
29	*Eutropiichthys vacha* (Hamilton, 1822)	+	-	-
Family-	**Heteropneustidae**			
30	*Heteropneustes fossilis* (Bloch, 1794)	-	++	+
Family-	**Ailiidae**			
31	*Clupisoma garua* (Hamilton, 1822)	-	+	+
Family-	**Notopteridae**			
32	*Chitala chitala* (Hamilton, 1822)	-	+	+
33	*Notopterus notopterus* (Pillas, 1789)	-	+	++
Family-	**Channidae**			
34	*Channa striatus* (Bloch, 1793)	-	++	+
35	*Channa punctatus* (Bloch, 1793)	++	+	+
Family-	**Osphronemidae**			
36	*Tricchogaster faciata* (Bloch & Schneider, 1801)	+	-	+
Family-	**Nandidae**			
37	*Nandus nandus* (Hamilton, 1822)	+	+	-
Family-	**Belonidae**			
38	*Xenentodon cancila* (Hamilton, 1822)	-	++	+
Family-	**Mastacembelidae**			
39	*Mastacembelus armatus* (Lacepe`de 1800)	-	+	-
	Total	**30**	**29**	**24**

Note: - (Absence); + (Presence); ++ (Abundance)

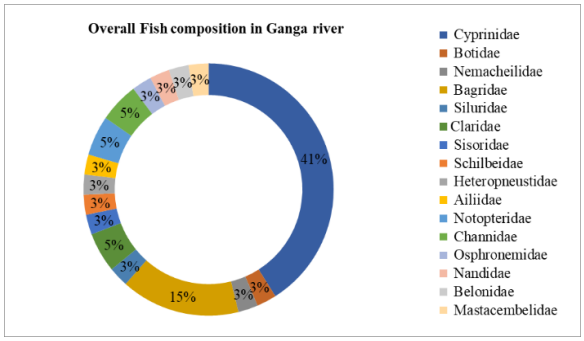

Fig. 2. Overall Fish composition in Ganga river

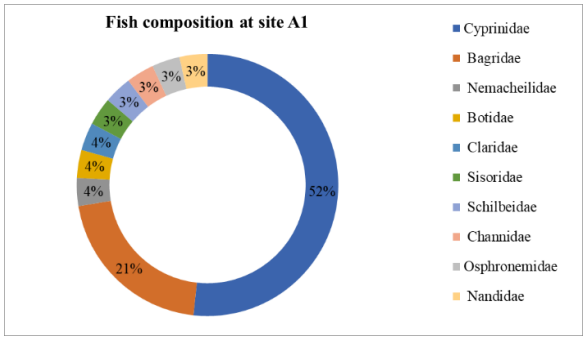

Fig. 3. Fish composition at site A1 in Ganga river

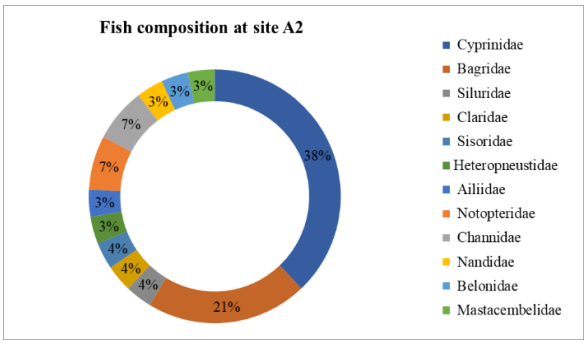

Fig. 4. Fish composition at site A2 in Ganga river

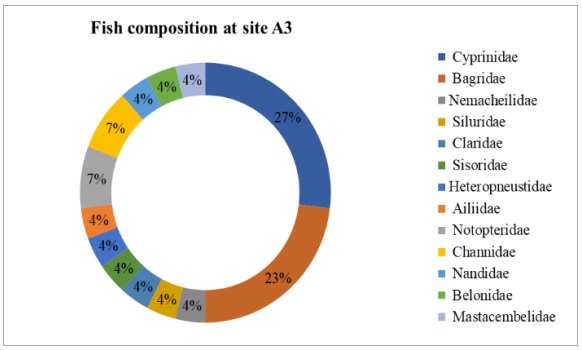

Fig. 5. Fish composition at site A5 in Ganga river

4. CONCLUSION

This investigation shows that the river's water is not substantially contaminated except during the summer when multiple wastewater sources congregate. Cypriniformes order is the more dominant group, followed by siluriformes, generally catfishes. The highest diversity was found at site A3 and the lowest at site A1 which means there is lot of human intervention at site A1 and less at site A3. Moreover, at site A1 the flow of river is very fast and temperature become a limiting factor. The Ganga River's biodiversity and water quality must be protected, necessitating collaboration among scientists, conservationists, aquarists and communities. The inventory of fish composition will form a baseline for further studies, providing information on families, genera, species as also on endemism, rare and threatened taxa. The present data may be used as a baseline for future study since it allows administrators and fisheries professionals to assess the effects of different natural and artificial activities on the river's water quality and fishery.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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