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Effects of surface runoffs on the species diversity and abundance of the fishes of Ibiekuma Stream, Ekpoma, Edo State, Nigeria

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ABSTRACT: This study examined the effects of surface runoffs on the fish abundance, diversity and distribution, at three selected stations of Ibiekuma stream, Ekpoma, Nigeria between July and December 2003. The physico-chemical properties of the water were also monitored during the period. The results showed that the water chemistry, the fish species diversity and distribution were different among the stations. The species diversity and abundance as well as the condition factor of the fishes were significantly lower at Station 2, which received surface runoffs impact, than at Stations 1 and 3. It was also shown that the fishes at Station 2, fed mainly on nematodes and *Chironomid* larvae and pupae, which are known bio-indicators of organic pollution. The observation of improved water chemistry, fish species diversity and abundance at Station 3, which is downstream of the runoffs-receiving Station 2, showed the temporary and non-residual nature of the pollution and indicated organic pollution from surface runoffs. The ability of the stream to purify itself after pollution was demonstrated. It was also demonstrated that apart from diversity indices and water quality parameters, food and feeding habits of fish could be used in assessing organic pollution impacts.

Key words: Nigeria, Stream, Surface Runoff, Fish Fauna.

Introduction

Surface water degradation has become a matter of increasing national and global concern as the impact of contaminants continue to render vital water resources marginal or unsuitable for their intended uses (Dean *et al*, 1972; CIFA, 1991). The aquatic ecosystem has had the lion share of man's degrading onslaught. Increase in industrialization, technological development, human population, oil exploration and exploitation and agricultural advancement have introduced many synthetic and organic wastes into the environment. These wastes finally end up in aquatic ecosystems as allochthonous inputs from surface run-offs or through direct discharge from the waste-generating plants (Ogbeibu and Ezeunara, 2002). Some identified effects of runoff water on natural water bodies are nutrient enrichment, deterioration of water qualities, destruction of spawning grounds for aquatic and marine life and fish kills (Martin *et al*, 1992).

The Ibiekuma stream is a typical example of a stream receiving surface run-offs from adjoining agricultural farm lands, forest areas and waste dumps. These run-offs contain significant spectrum of organic and inorganic pollutants capable of producing adverse effects on the physical, chemical and biological components of the stream.

This paper reports on the effects of surface run-offs on the fish population of Ibiekuma stream, with emphasis on the changes in species distribution, abundance, diversity, condition factor, food and feeding habits.

Materials and Methods

Study Area

This study was conducted in a transect of Ibiekuma Stream, a perennial first order rain forest stream in Ekpoma (Fig.1). The stream takes its source within the Ambrose Alli University permanent site and meanders over the 4km stretch study area before joining the Oriri stream further downstream (Edokpayi and Osimen, 2001). The area is characterized by flat land surface with sandy loam soil. Farming is the major human activity in the study area. The crops cultivated are mainly cassava, yam, rice, corn and pineapples.

For the purpose of this study, three stations were established within a 4.0km stretch of the upper reaches of the stream (Fig. 1). Station 1 is close to the source of the stream at about 800m upstream of the hydrological Dam established on the stream by the Ambrose Alli University. The depth of water at this site is about 0.5m, while the width is about 7m. The vegetation consists of shrubs mainly *Phoenix* palm and *Sagitaria sagittifolia* (Edokpayi and Osimen, 2001). The soil is mainly coarse sand mixed with clay. Human activities at the site are minimal and include occasional fishing and idol worshipping.

Station 2 is located about 1.0km from Station 1. It is about 200m downstream of the Dam. The depth of the stream at this station is about 0.25m, while the width is about 3.0m. The substratum is mainly sand mixed with clay. The station receives large quantities of allochthonous matter from surface run-offs. Human activities at the station include occasional fishing, bathing and washing of rubber tapping implements.

Station 3 is further downstream at a distance of about 1.5km from Station 1. The stream at the station is 0.35m deep and about 4.5m wide. The stream channel is shaded with trees (*Hevea brazilensis, Eleasis guinensis, Alstonia boonei* etc) and shrubs (*Sagittaria sagisttifolia*, *Similax krussiana* and *Phoenix* palm). The substratum is coarse sand mixed with decaying leaves. Human activities are mainly fishing and farming.

Water and fish samples were collected monthly from July to December 2003. On each sampling occasion, samples were collected in three replicate spots at each station. The water samples were treated using concentrated nitric acid and stored frozen (Ademoroti, 1996; APHA, 1989). Fish samples were collected using a combination of traps, gill nets of various mesh sizes and baited hooks and lines. The fish samples were ice-packed after capture, kept chilled under ice-blocks in a plastic Cooler and immediately transported to the laboratory. In the laboratory, the fish specimens were identified to species level using keys and descriptions of Boulenger, (1909 – 1916); Daget and Iltis (1965); Reed *et al* (1967); Holden and Reed (1972) and Teugels *et al* (1992).

The physico-chemical properties of the water were determined according to APHA (1989) and Ademoroti (1996). Statistical procedures were according to Zar (1984) and SPSS 6.5 windows application.

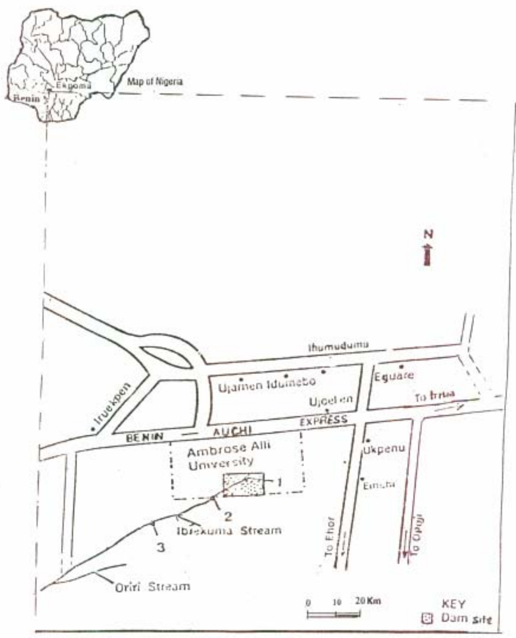

Fig.1 Map of Ekpoma showing the location of the study stations

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Results

Physico-Chemical Properties

The physico–chemical parameters of the water at the sample stations are shown in Table 1. Most parameters (Temperature, Turbidity, Flow velocity, Total Dissolved Solids, Conductivity, Biological Oxygen Demand (BOD), Chloride, Chloride, Calcium, Magnesium, Nitrates and Phosphates) were highest at Station 2. The pH, Dissolved Oxygen (DO) and Alkalinity were least at Station 2, but highest at Station 1. Nitrates and Phosphates were highest at Station 1. Statistical analysis, showed significant differences ($P<0.05$) in the levels of TDS, Turbidity, Flow Velocity, Conductivity, pH, DO, BOD, Alkalinity and Chloride, but for Water temperature, Calcium, Magnesium, Nitrates and Phosphates, there were no significant differences ($P>0.05$) among the study stations.

Fish species Diversity and Abundance

A checklist of the fish species and the number of individuals per species caught at the stations during the study period are presented in Table 2. A total of 230 fishes classified into 9 families, 13 genera and 15 species were caught. Station 1 recorded the highest number (129) of individuals belonging to 9 families, 13 genera and 15 species. Station 3 followed with 87 individuals belonging to 9 families, 11 genera and13 species. Station 2 was least with 14 individuals belonging to 4 families, 4 genera and 5 species.

In terms of abundance, the family Cichlidae dominated the collection with a total of 131 individuals classified into 4 genera and 5 species. Other major families were Mormyridae with 18 individuals classified into 2 genera and 2 species; Clariidae also with 18 individuals classified into a single genus and 2 species; Notopteridae with 15 individuals in a single genus and single species. Five families (Anabantidae, Bagridae, Channidae, Characidae, and Malapteruridae) recorded between 6 and 12 individuals in a single genus and single species each (Table 2).

The most dominant species in terms of number of individuals was *Tilapia zilli* (Cichlidae), which recorded a total of 55 individuals with 21 and 14 individuals at Stations 1 and 3. Next was *Tilapia mariae* with a total of 46 individuals with 30 and 16 at Stations 1 and 3 also. Ten species namely *Ctenopoma kingsleyae, Auchenoglanis biscutatus, Parachanna obscura, Brycinus nurse, Hemichromis fasciatus, Oreochromis niloticus, Clarias anguillaris, Malapterurus electricus, Mormyrus rume and Papyrocranus afer,* recorded between 8 and 15 individuals (Table 2). Three other species namely *Brycinus nurse* (Channidae), *Chromidotilapia guentheri* (Cichlidae) and *Mormyrops deliciosus* (Mormyridae) recorded the least with 6 individuals each. Statistical analysis (ANOVA) showed significant differences (P<0.05) in species abundance and diversity among the study stations.

Stomach Content Analysis

Examination of the stomach contents of the fishes revealed a wide variety of fish food items such as diatoms, algal filaments, insect larvae and pupae, other insect parts, nematodes, fish scales, desmids, detritus, plant parts and sand particles. The fullness method (Table 3) showed that the feeding status of the fishes at the study stations were not significantly different (P>0.05). The frequency of occurrence method showed that the fishes at Station 2 fed almost exclusively on Chironomid insects (*Chironomus sp, Chryptochrinomus sp. Polypedolum sp*) larvae and pupae. Nematodes (*Tubificidae* and *Naididae spp*.) were next in rank in the fishes at Station 2. Plant materials were the major food items at Stations 1 and 3.

Condition factor

The calculated condition factor of the fishes at the three study stations varied between a minimum value of 0.8 computed for *C. macromystax* at Station 2 to a maximum of 6.2 recorded for *P.afer* at Station 1 (Fig. 2). The condition factor of 7 out of the 15 species were higher at Station 1. These were *C. guentheri, A. biscutatus, B. nurse, H. fasciatus, O. niloticus, M. electricus* and *P.afer*. 5 species namely *P. obscura, T. mariae, T. zilli, C.anguillaris* and *C. macromystax* had higher condition factor at Station 3. The remaining 3 species (*C. guentheri, M. rume and M. deliciosus*) were recorded only at Station 1. Of these three species, *M. rume* had the highest condition factor, followed by *M. deliciosus* and *C. guentheri* in descending order. Statistical analysis showed that there were significant differences (P<0.05) in the condition of the fishes at the study stations as reflected by their condition factors.

Discussion

Physico-Chemical Properties

The physical and chemical properties as well as the biological contents, determine the quality of water. The range of mean water temperature (27.10-27.20^oC), recorded in Ibiekuma stream in this study, is high and typical of tropical climates. The high Total Dissolved Solids (TDS), Turbidity and Conductivity recorded at the runoffs-receiving Station 2 in comparison to Stations 1 and 3 could have arisen from the large volume of runoffs influx into the station. Oguzie (2003) attributed similar results in Ikpoba River in Benin City to the effects of surface runoffs.

The low mean values of pH (3.64-5.61) and DO (1.54-3.77*mg/l*) recorded at the sample stations (Table 1) especially at Station 2, which received the largest amount of runoffs showed the impact of the runoffs. According to CIFA (1993) and Idodo–Umeh (2002), runoffs from farm and forest areas reduce DO and pH of water bodies and attributed this to organic pollution, increased pesticides and fertilizers use and bush burning. The high BOD at the Station in comparison to Stations 1 and 3 indicated the large volume of organic matter undergoing decomposition and showed that the pollution is principally organic. The low DO and pH values recorded in this study fall below the 6.92mg/l DO recommended value (WHO, 1984) and pH optimum range (6.5 – 9.0) required for healthy fish growth (Boyd, 1979) and could have adversely affected the fish community of the stream, especially at Station 2. The higher values of the DO and pH and the general improvement in water quality at Station 3, in comparison to Station 2, showed the non-residual nature of the pollution effects as well as the ability of the river to purify itself after organic pollution. Similar results have been reported for Ikpoba River (Ogbeibu and Ezeunara, 2002) and Ogba River (Obasohan, 2003) in Benin City, Nigeria

Table 1: Summary of the physical and chemical conditions at the Ibiekuma Stream study stations (January-June, 2003).

PARAMETERS	STATION 1			STATION 2			STATION 3			Probability
	Min.	**Max.**	**Mean**	**Min**	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**	
Air Temperature (°*C*)	27.00	36.00	**31.00**	27.00	36.10	**30.50**	26.80	36.00	**30.00**	P>0.05
Water Temperature (°*C*)	26.00	28.00	**27.10**	26.10	28.10	**27.20**	26.10	28.00	**27.00**	P>0.05
Total Dissolved Solids (*mg/l*)	8.30	8.40	**8.35**	8.68	22.62	**15.62**	8.28	10.20	**9.26**	P<0.05
Turbidity (*FTU*)	0.58	7.54	**4.46**	7.84	12.22	**10.01**	4.00	8.20	**6.10**	P<0.05
Flow Velocity (*cm/s*)	0.00	0.00	**0.00**	0.02	0.38	**0.35**	0.35	0.09	**0.05**	P<0.05
Conductivity (s/cm)	10.42	58.20	**30.43**	48.88	150.12	**99.36**	36.46	72.54	**56.22**	P<0.05
pH	4.60	6.62	**5.61**	3.40	4.20	**3.64**	4.20	6.60	**5.28**	P<0.05
Dissolved Oxygen (DO) *mg/l*	2.80	4.80	**3.77**	1.00	2.20	**1.54**	2.80	4.65	**3.70**	P<0.05
Biological Oxygen Demand (BOD) *mg/l*	0.60	2.64	**1.22**	1.20	3.20	**2.52**	0.82	2.84	**1.60**	P<0.05
Alkalinity (*mg/l*)	12.20	36.60	**21.40**	6.200	18.12	**12.02**	9.32	32.24	**20.72**	P<0.05
Chloride (*mg/l*)	14.17	17.75	**15.53**	16.20	30.86	**23.53**	14.20	17.58	**16.25**	P<0.05
Calcium (*mg/l*)	0.80	6.42	**2.03**	0.80	6.83	**2.60**	0.82	6.82	**2.31**	P>0.05
Magnesium (*mg/l*)	0.49	3.40	**1.94**	0.97	4.37	**2.22**	0.49	4.41	**2.20**	P>0.05
Nitrate (*mg/l*)	0.19	3.56	**0.94**	0.96	1.68	**1.32**	0.25	3.56	**0.92**	P>0.05
Phosphate (*mg/l*)	1.07	2.31	**1.89**	0.81	2.24	**1.99**	1.09	2.24	**1.90**	P>0.05

Table 2: Fish Species Diversity, Distribution and Abundance at the Sample Stations (January – June, 2003)

S/NO	FISH	STATIONS 1	2	3	TOTAL
1.	FAMILY: **ANABANTIDAE** Genus: Ctenopoma (Peters, 1844) Species: *Ctenopoma Kingsleyae* (Gunther, 1865)	6	–	5	11
2.	FAMILY: **BAGRIDAE** Genus: Auchenoglanis (Gunther, 1865) Species: *Auchenoglanis biscutatus* (Geoffrey St. Halaire 1827)	5	3	3	11
3.	FAMILY: **CHANNIDAE** Genus: Parachanna (Teugels and Daget 1984) Species: *Parachanna obscura* (Gunther, 1861)	8	-	4	12
4.	FAMILY: **CHARACIDAE** Genus: Brycinus (Valenciennes, 1849) Species: *Brycinus nurse* (Ruppel, 1832)	4	-	2	6
5.	FAMILY: **CICHLIDAE** Genus: Chromidotilapia (Boulenger, 1898) Species: *Chromidotilapia guentheri* (Sauvage, 1882)	6	-	–	6
	Genus: Hemichromis (Peters, 1857) Species: *Hemichromis fasciatus* (Peters, 1857)	5	6	4	15
	Genus: Oreochromis (Trewavas, 1980) Species: *Oreochromis niloticus* (Trewavas, 1980)	4	–	5	9

S/NO	FISH	STATIONS 1	2	3	TOTAL
	Genus: Tilapia (Smith, 1849) Species: *Tilapia mariae* (Boulenger, 1899) Species: *Tilapia zilli* (Gervais, 1848)	 30 21	 - -	 16 34	 46 55
6.	FAMILY: **CLARIIDAE** Genus: Clarias (Scopoli, 1777) Species: *Clarias anguillaris* (Linnaeus, 1756) Species: *Claria macromystax* (Gunther, 1864)	 3 4	 2 2	 5 2	 10 8
7.	FAMILY: **MALAPTERURIDAE** Genus: Malapterurus (Lacepede, 1803) Species: *Malapterurus electricus* (Gmelin, 1789)	 5	 -	 3	 8
8.	FAMILY: **MORMYRIDAE** Genus: Mormyrus (Linnaeus, 1758) Species: *Mormyrus rume* (Cuvier and valencienne, 1846) Genus: Mormyrops (Muller, 1843) Species: *Mormyrops deliciosus* (Leach	 10 6	 – –	 2 -	 12 6
S/NO	**FISH**	**STATIONS 1**	**2**	**3**	**TOTAL**
9.	FAMILY: **NOTOPTERIDAE** Genus: Papyrocranus (Greenwoor, 1963) Species: *Papyrocranus afer* (Gunther, 1868)	 12	 1	 2	 15
	Total No. of individuals per Station Total Families per Station Total Genus per Station Total No. of Species per Station	129 9 13 15	14 4 4 5	879 11 13	230
	Total for the stations: Families = 9; Genera = 13; Species = 15				

Table 3: Stomach contents analysis using fullness method

STOMACH FULLNESS						
Station	Full (%)	¾ (%)	½ (%)	¼ (%)	Empty(%)	No of fish examined
1	11	25	25	35	4	129
2	16	20	26	30	8	14
3	15	20	25	30	10	87

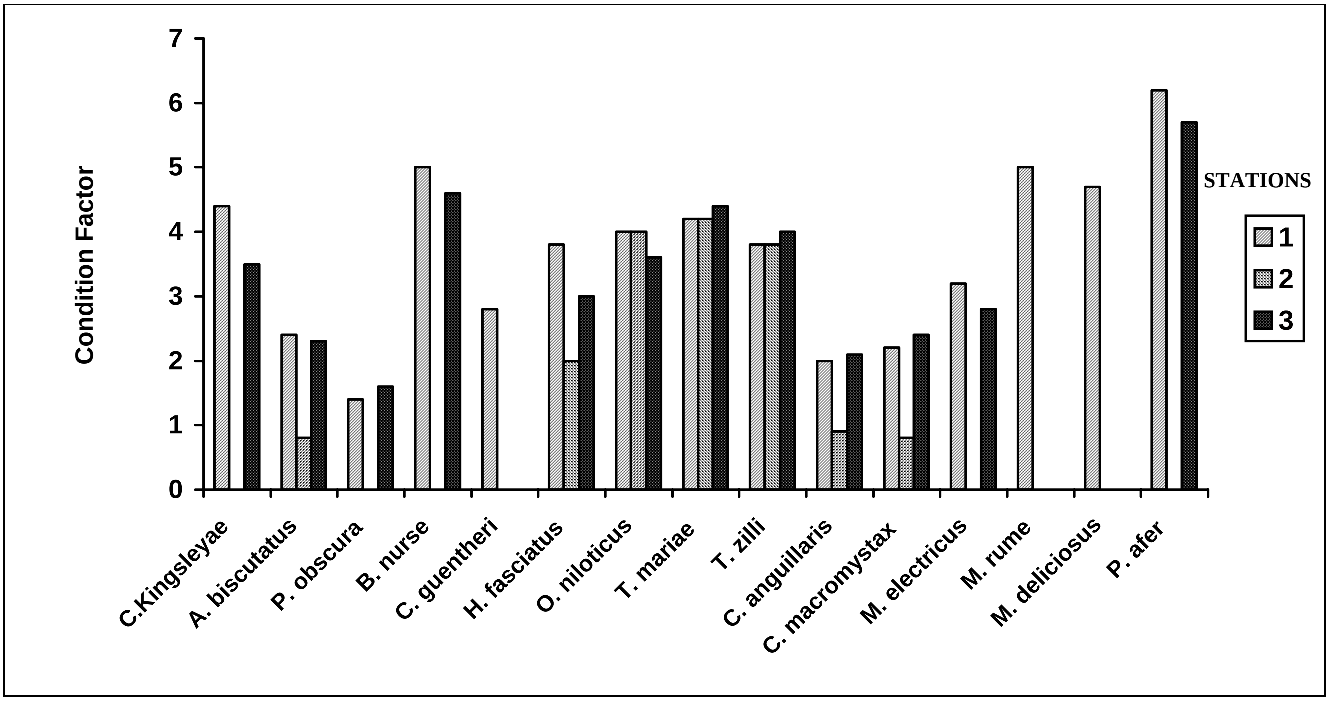

Fig 2: Comparison of the condition factor of fish species of the study stations of Ibiekuma stream

Fish Species Diversity and Abundance

Changes in water quality caused by agricultural land use are known to affect fish and other benthic communities (Cross and Brascho; 1969; Ogbeibu and Ezeunare, 2002). The overall number of fish species (15) recorded at the sampling stations in this study was low when compared with other tropical water bodies (Banks *et al*, 1965; Welcomme, 1979; Ita, 1993).

In comparison to specific rivers, the 15 species was also lower than the 58 species reported for Ikpoba River (Victor and Tetteh, 1988); the 26 species for Ogba River (Obasohan, 2003) and the 39 species each for Cross Rivers (Moses, 1979) and Olomoro water bodies (Idodo-Umeh, 2002).

The low fish species diversity recorded in this study could be due to ecosystem instability resulting from large influx of surface water runoffs from surrounding agricultural fields. Ikhuoria (1993) and Edosomwan and Aigbe (2004) observed that the forest cover in the study area was being depleted at an annual average rate of 435.2ha (2.8%) resulting in increased volumes of uncontrolled runoffs, which assault the stability of the environment. There were no available records of which fish species are native or introduced to the stream as at the time of this study. The contribution of possible fish introductions if any, to the disturbed environment, could not be assessed.

Species diversity and abundance were higher at Station 1, when compared to Stations 2 and 3. This could be due to impoundment, as the station was located in the upper stream end of the Dam. Station 1 also received less surface run-offs and hence was probably more stable environment for fish. The low fish population in terms of number of individuals and species at Station 2 could be due to the higher influx of runoffs laden with allochthonous matter, resulting in organic pollution, deposition of silt and water volume reduction at the station. These, together with the more human activities at the station, could lead to adverse ecological conditions, which probably caused fish movement away from the station. Fish are mobile and they can quickly respond to environmental changes by swimming away from unfavorable conditions (Hortwitz, 1978; Idodo-Umeh, 2002). The improvement in fish species diversity and abundance at Station 3 in comparison to Station 2, also supported the fact that the water quality improved downstream of the runoffs-receiving Station 2.This showed that the pollution effects were local and non-residual and thus indicated organic pollution.

Feeding Interrelationships

Fish consume a wide variety of food items. The feeding habits of fish species have been used to classify them into categories ranging from predators through plankton to detritus feeders. The faunal and floral composition of any water body is determined by the physical and chemical characteristics of the water. The principal food items found in the stomachs of many of the fishes caught at Station 2 were Chironomid insects (*Chryptochironomus and Polypedolum spp.*) larvae and pupae, nematodes and some oligochaetes. Other food items found included plant materials and detritus. These major food items, especially the larvae and pupae of the *Chironomid spp.* and the nematodes, are known bio-indicators of organic pollution and other forms of environmental stress (CIFA, 1991; Ogbeibu and Ezeunara,2001). It is conceivable that these food items were readily available in high density at Station 2 due to the high degree of organic pollution at the station, caused by the large volume of runoffs influx.

Condition Factor

The condition factor provides information on the fatness, relative robustness and general well being of a fish. Nikolsky (1963) reported that a heavier fish of a given length is in better condition than a lighter fish of the same length. The condition factor of the fishes of Station 2 were low (< 1.0) in comparison to those of the fishes of Stations 1 and 3, which were all higher than 1 (> 1.0). The above finding showed that whereas the fishes of Stations 1 and 3 were in good condition, those at Station 2 were not, and supported the reported presence of stress inducing factors especially at Station 2.

Conclusion

The results of this study showed that the species diversity and abundance of the fishes of Ibiekuma stream have been adversely affected by surface runoffs from the surrounding agricultural fields. The ability of the stream to purify itself after pollution was also demonstrated. The study also showed that apart from diversity indices and water quality parameters, food and feeding habits can also be used in assessing organic pollution impacts. However, in view of the short period of the study, further sampling of the river for a longer period is strongly recommended.

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