DISTRIBUTION OF SNAIL INTERMEDIATE HOSTS IN SELECTED AREAS OF RIVERS STATE, NIGERIA

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Abstract: Fresh water snail vectors serve as intermediate hosts and play active role in the transmission of trematode parasites. Hence, the knowledge of their distribution becomes essential. This study assessed the distribution of snail intermediate hosts in selected areas of Rivers State. In the western part of Rivers State, freshwater snails were sampled and physico-chemical parameters of the water bodies were analysed using standard methods from April to September 2021. Snails sampled were identified morphologically and examined for infection. Out of 4672 freshwater snails recorded, *Lymnaea natalensis* was 3548 (75.94%), *Bulinus truncatus* 405 (8.67%), *Bulinus globosus* 400 (8.56%), *Oncomelania* spp. 204 (4.37%), *Biomphalaria* spp. 12 (0.26%) and *Pila ovata* 103 (2.20%). There was an observed statistical difference (P= 0.004; P<0.05) in the occurrence of the snail species. Snail abundance in relation to the location (P= 0.002) showed a significant difference. *L. natalensis* was the most abundant and widely distributed species; while *Biomphalaria* spp. was the least abundant. Only 0.13% of the snails were infected. The study revealed that the freshwater snail abundance varied monthly. Dissolved Oxygen and temperature significantly influenced snail abundance/distribution. A boom in snail reproductivity was observed by increased number of snails at the juvenile stage, suggesting a likelihood of disease resurgence in the near future if no control measure is enacted.

Keywords: Abundance, Disease transmission, distribution, Fresh water snail, Intermediate hosts.

Introduction

The intermediate host of trematode parasites of man and animals are fresh water snails (Idris and Ajanusi, 2002), some of which include: *Bulinus* spp., *Lymnaea* spp., *Physa* spp., *Aplexa waterlotti*, *Indorplanorbis exutus* (Abe *et al.*, 2012). These snail vectors are known to transmit disease such as Fascioliasis, Schistosomiasis and Amphistomosis (Sangwan *et al.*, 2016). These diseases are of great public health importance as they are widespread in different parts of Nigeria affecting man and livestock (Kenneth, 2002). Schistosomiasis is prevalent in 74 tropical countries, and over 200 million people living in the rural and agricultural areas are infected while the people at risk of the infection are approximately 500 to 600 million; and in most cases, children between the ages of 10 to 15 years are more susceptible (Kenneth, 2002).

Parasites are found in distinct environment where there are suitable environmental conditions for their hosts and vector/intermediate host. However, their distribution is not fixed in space and time and fluctuates as the host and vector fluctuates (Stengaard *et al.*, 2006). Schistosomiasis is an infection that requires freshwater snails in the course of its causative organism, *Schistosoma* spp, development to the infective larval stage for human infection. Freshwater snails such as *Bulinus* and *Biomphalaria* act as intermediate host of *S. haematobium* and *S. mansoni*, respectively, occurring in most parts of Africa. In Africa, *Bulinus globosus*, the intermediate host of *S. haematobium* is widely distributed (Joof *et al.*, 2021). These snails are found in almost all types of water-bodies such as streams, slow flowing rivers, ponds, stagnant waters, lakes and drainages (Kenneth, 2002). Although their reproductive capacity is high, the abundance and distribution of these snails show marked seasonal variation in infection rate and density with rainfall and temperature being the most determining factors.

Control of most snail borne diseases in the sub-Saharan Africa have been based on chemotherapy and use of molluscicides, but this have failed over the years as transmission continues to spread (Nagi *et al.*, 2014). Prevention of infection remains the best option and this is only achievable by snail control (Mkoji *et al.*, 2014) and snail control is best achieved when the ecology and distribution of snail vectors are known. Hence, this study is aimed at identifying areas where these vectors can be found and areas at risk of snail-borne diseases in order to target control efforts to these areas.

Materials and Methods

Study area

Rivers State is situated in the south-southern part of Nigeria and covers a land mass of 11,077 km^2 (4,276.9 square miles). The State lies between longitude 6° 49' 39 E and latitude 4° 44' 59 N. It is bordered to the South by the Atlantic Ocean, to the North by Imo, Abia and Anambra States, to the East by Akwa Ibom State and to the West by Bayelsa and Delta States. The Western Region of Rivers State lies between longitude 6° 44' E and 6° 86' E and latitude 4° 72' N and 5° 39' N in the Niger Delta Area of Nigeria and consists of seven Local Government Areas namely: Abua/Odual, Ahoada East, Ahoada West, Degema, Asari-Toru, Akuku-Toru, Ogba Egbema Ndoni (Figure 1). From each of these L.G.As, three to four communities were randomly selected for the study; Abua/Odual (3 communities), Ahoada East (4 communities), Ahoada West (4 communities), Degema (3 communities), Asari-Toru (3 communities), Akuku-Toru (4 communities), and Ogba Egbema Ndoni (4 communities). This gave a total of twenty-five communities included in the study. The inland

part of Western Region of Rivers State consists of a tropical rainforest; towards the coast it has many mangrove swamps. The region is marked with rainy and dry season. Dry season is experienced between November and April, and rainy season extends from May to October. Ponds, streams, well water and recently installed borehole pumps in the communities are sources of water for both economic and domestic uses. Some of the communities lack toilet facilities, as bushes and water bodies are used for toilet purpose (Awi-Waadu and Ezenwaka, 2009).

Water contact sites

Snail search was conducted in water bodies which include swamps, streams and drainages, and these sites are where people wash clothes or utensils, collect water for domestic purposes, bath, swim or fish, between April and September, 2021. These communities have a broad coastal plain topography with so many ponds and streams, and a tropical rainforest type of vegetation.

Collection of snail samples

Collection of snail samples at each station was carried out once in a month for six months (April to September, 2021) in the morning between the hours of 7:00 am and 10:00 am using a scoop net of about 1mm mesh size and handpicking for 45 minutes in each collection site as described by Awi-Waadu *et al.* (2020). Snails collected were transported to the laboratory of the Department of Animal and Environmental Biology, University of Port Harcourt in water-filled, perforated and labelled plastic containers where they were identified according to Brown and Kristensen (1993).

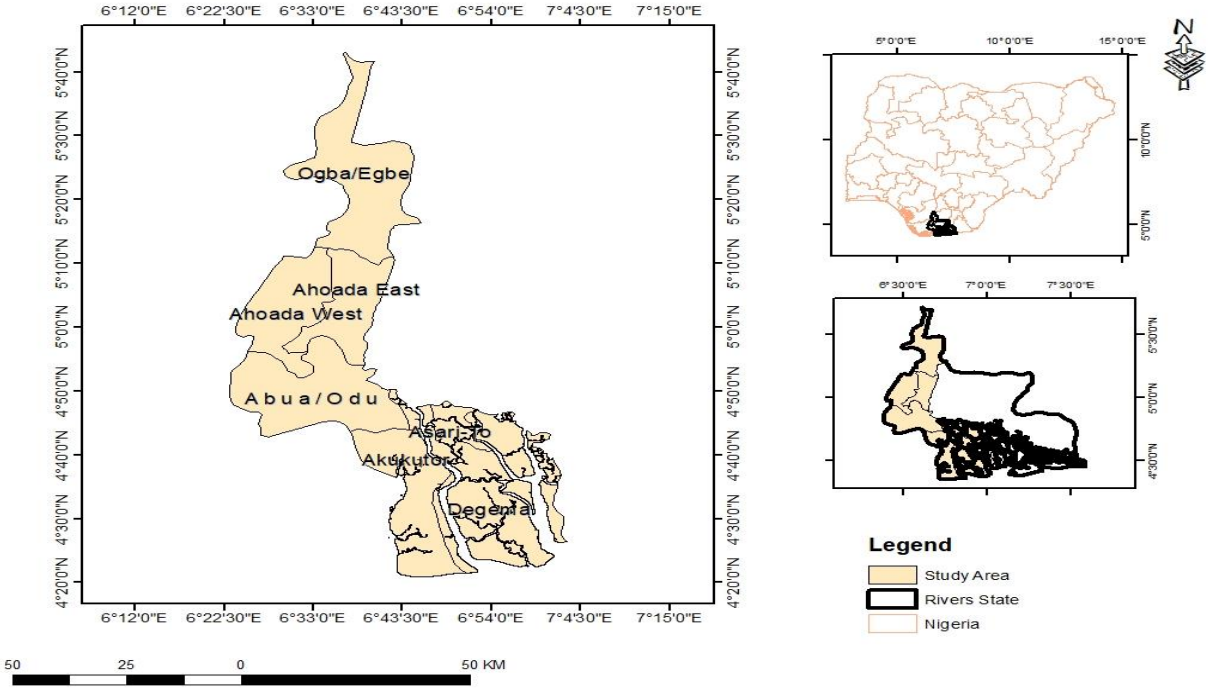

Figure 1. Map of the study area.

Morphological identification of vector snails

Identification of snails involved the characterization of snail shell according to Brown and Kristensen (1993). Snails were positioned with apex (pointed edge) pointing upward. The direction of the shell opening below the body whorl was used as a taxonomic criterion. Other shell component considered during identification include: number of whorls, shape of shell, type of apex (pointed or blunt) and shape of peristome on the aperture.

Screening for cercarial shedding

The snails were screened for cercarial shedding in the laboratory. Each snail was placed in a petri-dish containing 1ml of tap water, and exposed to sunlight for two hours to induce cercarial shedding. The water was then examined for the presence of cercariae according to Abe *et al*. (2016).

Measurement of physico-chemical parameters of water samples

Temperature, conductivity, total dissolved solid and pH were measured in-situ with a multi-meter water checker (Ultra meter 11 6PFC). The equipment was rinsed five times with the sample to ensure that there was no other substance in the water checker. The sample was introduced into the meter and the pH button was switched on. The reading was allowed to become stable before it was recorded.

Dissolved Oxygen (DO) was measured in-situ using PRO ODO Professional series YS1 dissolved oxygen meter. The probe of the meter was inserted 10-15cm into the river and the meter was switched on and the value was recorded when the reading became stable. The same was done in triplicate and the mean value was calculated.

Data analysis

The physicochemical properties of the water bodies were examined for their association with snail abundance using linear regression in SPSS (Version 24.0). Spearman rank

correlation was used for the test of association between differences in snail abundance over the months and across locations.

Results and Discussion

Overall snail vector abundance/distribution in the study area

A total of 4672 freshwater snails were recovered from 25 locations in 7 LGAs. Six species of freshwater snails were found in the study area namely; *Lymnaea natalensis*, *Bulinus truncatus*, *Bulinus globosus*, *Biomphalaria* spp., *Oncomelania* spp., and *Pila ovata*. *Lymnaea natalensis* was the most abundant snail species, 3548(75.94%), followed by *Builnus truncatus*, 405(8.67%) and *Bulinus globosus*, 400(8.56%). However, *Oncomelania* spp. had (204)4.37%, *Pila ovata* 103(2.20%); while *Biomphalaria* spp. 12(0.26%) had the least percentage abundance as shown in Table 1.

Table 1: Overall snail vector abundance/distribution in the study area

LGAs		*Lymnaea* spp.	*B. truncatus*	*B. globosus*	*Oncomelania* spp.	*Biomphalaria* spp.	*Pila ovata*	Total (%)
Ahoada East	Drainage	531(97.25)	-	-	-	-	15(2.75)	546
Ahoada West	Drainage	445(44.06)	405(40.10)	136(13.47)	4(0.40)	-	20(1.98)	1010
Onelga	Swamp/stream	573(100)	-	-	-	-	-	573
Akuku-Toru	Swamp	711(97.66)	-	-	17(2.34)	-	-	728
Asari-Toru	Swamp	307(71.56)	-	-	122(28.44)	-	-	429
Degema	Drainage	327(100)	-	-	-	-	-	327
Abua-Odual	Swamp	654(61.76)	-	264(24.93)	61(5.76)	12(1.13)	68(6.42)	1059
Total		3548(75.94)	405(8.67)	400(8.56)	204(4.37)	12(0.26)	103(2.20)	4672

Monthly distribution of snail vectors in the study area

The monthly abundance of the snails revealed that a total of 253(5.42%) were collected in April, 821(17.57%) in May, 1135(24.29%) in June, 1056(22.60%) in July, 897(19.20%) in August, and 510(10.92%) in September. Overall snail abundance was highest in June (24.29%), and lowest in April (5.42%). The snail species distribution varied across the months of collection. *Lymnaea natalensis* was the most commonly found snail species across all the months, while *Biomphalaria* spp. had the lowest distribution (Table 2).

Table 2: Monthly distribution of snail vectors in the study area

Months	*L. natalensis*	*B. truncatus*	*B. globosus*	*Oncomelania* spp.	*Biomphalaria* spp.	*P. Ovata*	Total (%)
April	188(5.30)	20(4.94)	14(3.50)	17(8.33)	2(16.67)	12(11.65)	253(5.42)
May	716(20.18)	38(9.38)	26(6.50)	31(15.20)	6(50.00)	4(3.88)	821(17.57)
June	971(27.37)	47(11.60)	41(10.25)	51(25.00)	4(33.33)	21(20.39)	1135 (24.29)
July	795(22.41)	103(25.43)	84(21.00)	41(20.10)	0(0.00)	33(32.04)	1056 (22.60)
August	594(16.74)	119(29.38)	138(34.50)	36(17.65)	0(0.00)	10(9.71)	897 (19.20)
September	284(8.00)	78(19.25)	97(24.25)	28(13.73)	0(0.00)	23(22.33)	510 (10.92)

Parasite load of snails examined in the study area

Out of 4672 snails collected from the study area, only 6(0.13%) were infected. Two of the six snail species (*L. natalensis* and *B. truncatus)* were infected with cercariae and nematodes. The *Lymnaea* spp. 3(0.06%), were infected with *Rhabditis* spp. (nematodes); while *B. truncatus* 3(0.06%) harboured cercariae of *Schistosoma haematobium* (Table 3).

Table 3: Parasite load of snails examined in the study area

Snail Spp.	No. Examined	Parasite Load (%)	
		Cercariae	Nematode
L. natalensis	3548	-	3(0.06)
B. truncatus	405	3(0.06)	-
B. globosus	400	-	-
Oncomelania spp.	204	-	-
Biomphalaria spp.	12	-	-
Pila ovata	103	-	-

(-) No parasite found in snails

Physicochemical parameters of water bodies sampled (Mean ± SD)

Table 4 shows the mean concentration of the various physicochemical parameters across the months studied. pH mean values indicated that April and May had the highest mean concentration of 7.68±0.63 and 7.51±0.63, respectively, while August had the least 7.24±0.23. Conductivity mean values indicated that July and August had the highest conductivity (279.03±183.67µs) and (271.17±185.75µs) while May had the least (224.95±81.99μs). For TDS, the highest concentration was recorded in July (199.28±129.58ppm) and least in June (115.40±70.42ppm). Highest mean temperature of water bodies sampled was observed in April (28.86±0.46 ^{o}C) and lowest in September (26.20±2.81^{o}C). For DO, highest mean value was recorded in July 3.78±2.25 mg/l and least in DO was recorded in April 2.81±1.62 mg/l (Table 4).

Table 4: Physicochemical parameters of water bodies sampled (Mean ± SD)

Months	pH	Conductivity(μs)	TDS (ppm)	Temperature (^{o}C)	DO (mg/l)
April	7.68±0.63	241.94±99.09	143.37±89.33	28.68±0.46	2.81±1.62
May	7.51±0.63	224.95±81.99	125.07±80.81	28.35±0.93	2.98±1.68
June	7.32±0.61	233.82±103.21	115.40±70.42	28.24±1.06	3.72±1.84
July	7.40±0.32	279.03±183.67	199.28±129.58	28.37±2.49	3.78±2.25
August	7.24±0.23	271.17±185.75	169.03±105.55	27.76±2.07	3.58±1.95
Sept	7.27±0.29	265.37±172.15	189.54±125.14	26.20±2.81	3.38±2.11

Relationship between physicochemical parameters and snail abundance

There was no significant relationship between overall snail abundance and pH (P>0.05). A negative correlation was recorded between snail abundance and conductivity. TDS had a negative relationship with snail abundance. The physico-chemical parameters showed that temperature of the water bodies was significant for overall snail abundance. There was a positive correlation between overall snail abundance and DO (P<0.05) (Table 5).

Table 5: Relationship between physicochemical parameters and snail abundance

Parameter	Linear Regression equation	Coefficient of Determination (R^2)	p-value
pH	Y=-124+21.82x	0.067	0.559
Conductivity(μs)	Y=43.63-0.03x	0.022	0.586
TDS (ppm)	Y=49.1-0.08x	0.105	0.564
Temperature	Y=-335+13.3x	0.652	0.028
DO (mg/l)	Y=23.5+4.1x	0.116	0.045

This study showed that within the Western Region of Rivers state, freshwater snail species were present in areas with poor drainage system and water bodies with favourable environmental conditions. In addition, areas with slow flowing water bodies have a high risk of snail occurrence than areas with water bodies of high velocity. This study recorded the presence of six freshwater snail intermediate hosts and this partially agrees with the study by Awi-Waadu and Ezenwaka (2009) who recorded *B. globosus* and *B. forskalli* in one of the communities sampled (Obedum) in this study. Present findings are in agreement with Abe *et al*. (2016) and Oloyede *et al*. (2016) which stated that species recorded in this study are the most common fresh water snail species in West Africa. Of the six species of snails found, four (*B. truncatus*, *B. globosus*, *Oncomelania* spp. and *Biomphalaria* spp.) were established to be intermediate hosts of schistosomiasis in Nigeria (Oladejo and Ofoezie, 2006), *L. natalensis;* an intermediate host of fascioliasis (Moema *et al*., 2008) and *P. ovata;* an intermediate host of a trematode, *Multicotyle purvisi* (Alves *et al.*, 2015). The presence of these snail vectors of parasites of diseases indicates the risk of emergence or re-emergence of snail-borne diseases if no control measures are enacted. It also indicates a crash of any existing functional snail control measure.

L. natalensis was found to be the most widely distributed snail species during the study. *L. natalensis* had a uniform distribution. This agrees with the study by Cuervo *et al*. (2010) who observed that *L. natalensis* is the most abundant and most widely distributed snail species due to its great adaptability and survival capacities and this enables them survive and colonize environment with diverse and extreme climatic conditions. *Oncomelania* spp. and *P. ovata* was observed to be randomly distributed in the study area. It was observed that *Bulinus* spp. distribution was affected by dissolved oxygen demand as the habitats where they were found had high dissolved oxygen. *Biomphalaria* spp. was poorly distributed. It was found in only one site. This could be due to the increased temperature in the study area where it was found. Studies by Amoah *et al*. (2017) showed that *Biomphalaria* spp. cannot survive in an environment with a slightly high temperature. The study reported that when the temperature of a snail habitat becomes higher or lower than tolerable limits, it could lead to the death of *Biomphalaria* spp. Abua/Odual L. G. A. had the highest relative snail abundance, while Degema L. G. A. had the lowest. This could be as a result of differences in the physico-chemical properties of the water bodies in both habitats.

At the beginning of this study (April 2021), the snail host abundance was lower. This was due to the reduced water and vegetation in most of the study locations as this period was preceded by the dry season (December to March). As the rain fall became intense in May to June, snail population increased. The low water current during this period, provided a stable environment for snails to survive on surfaces and not be flushed away. More so, materials like aquatic plants which served as food and oviposition

sites were now present in most water bodies and sample locations. Snail population reduced at the peak of the rainy season (July to September). The increased abundance of snails in the month of June (early rainy season) agrees with previous studies conducted by Okafor and Ngang (2004) and Ayanda (2009), but disagrees with studies by Oloyede *et al*. (2016) who found decreased number of snails at the early rainy season (May/June) and more snails at the peak of the rainy season (July/August). Reduced snail abundance between August and September had also been reported by Duwa (2016) which is in line with this study. Sturrock (2003) pointed out that intense rainfall affects water movements and temperature thereby negatively affecting the distribution and density of aquatic snails and rates of schistosomal development in the snail hosts. WHO (2005) deducted that snails do not tolerate strong currents as they could easily be flushed away. This explains the reduction in snail abundance at the peak of the rainy season as the velocity of most water bodies' increased at this time. This also explains the absence of snail vectors in rivers during this study. Snails survive only in water bodies with velocity less than 40cm/s. when the velocity is high, the snails are unable to hold and hence cannot feed nor reproduce (Rollinson *et al.*, 2001). This could also explain the reduction in snail infectivity during the period of this study.

Cercariae infectivity has been observed in various snail species, such as *Oncomeania* species, *Bulinus* species, and *Lymnaea natalensis* (Luka and Mbaya, 2015; Gboeloh and Ike-Ihunwo, 2022). The lack of infected snail vectors among some species in this study is not unusual, as Awi-Waadu *et al.* (2020) noted no infection in the snail population examined during their study. There is a possibility of snails containing mature cercariae not shedding any at the time of the study.

The low snail infection in this study may be due to the cercarial detection method used. Cercarial release, as a commonly used detection method, has been said to be inaccurate as it does not detect latent or covert infections with immature parasites, and thus underestimates the true prevalence (Studer and Poulin, 2012). Born-Torrijos *et al*. (2014) in their study demonstrated that molecular detection of trematodes in snail hosts strongly out-competes the cercarial shedding method. Therefore, a more reliable method of infection detection in snails is advocated.

The presence of other parasites (nematodes) in the snail vectors sampled showed that snails are often accidental hosts due to soil geophagy. The absence of an infection in most *Bulinus* spp. in this study is not surprising due to the stage of the snail vectors found and the parasite not being introduced to the snails. This agrees with the study of Saluwu and Odadibo (2014) and Duwa (2016). Snail infectivity in this study indicates that the western region of Rivers State is at risk of a rapid spread of Urinary Schistosomiasis and other snail-borne diseases.

On the basis of correlation analysis between physicochemical parameters and snail abundance, a negative correlation was recorded between snail abundance and conductivity. This agrees with the work by Owojori *et al*. (2006) who observed a negative correlation between snail abundance and conductivity, but disagrees with study by Oloyede *et al*. (2016) who reported a positive correlation between conductivity and snail abundance in Elele. A positive correlation was also recorded by Idowu *et al*. (2008) in the littoral region of Lake Alau in Maidugri, Borno State.

TDS had a negative relationship with snail abundance. The negative correlation between TDS and snail abundance was also recorded by Hussein *et al.* (2011) who observed a negative correlation between TDS and *Alexandrina* spp. It however, disagreed with the findings of Oloyede *et al.* (2016) which revealed a positive significant relationship between snail abundance and TDS. Cañete *et al.* (2004) reported that TDS played a significant role in the abundance of *Lymnaea* spp.

The physico-chemical parameters showed that temperature of the water bodies was significant for overall snail abundance. This corroborates the findings of Abe *et al.* (2016) but at variance with the observation of Sunday *et al*. (2023) which showed insignificant relationship between temperature and *B. globosus*. The mean temperature of water bodies sampled in this study was between 20.98 to 31.3 ^{o}C and is within range of optimum temperature for snail survival (Abdel-Hamid *et al.*, 2006)**,** which at temperatures above 30^{o}C, reduction in egg production occur. Giovanelli *et al.* (2005) opined that extreme temperatures have adverse effects on snail populations by inducing thermal stress and reduced activities.

There was no significant relationship between overall snail abundance and pH ($P>0.05$). This agrees with the report of a study conducted by Oloyede *et al.* (2016). Cañete *et al*. (2004) stated that pH is rarely a factor that limits snail abundance and distribution in their habitats. Another study recorded a non-significant relationship between pH and snail abundance (Salawu and Odaibo, 2014). However, this does not agree with an earlier work by Owojori *et al.* (2006) who recorded a positive correlation between snails' abundance and pH.

Dissolved oxygen is said to be a very important parameter that influences snail abundance. Awi-waadu *et al.* (2020) stated that low DO in water affects the feeding rate of snails and may result in death of the snails if it persists for a long time. He stated the DO range for snail survival is 0.5 to 30 mg/l. The mean range of DO in this study was between 0.45 to 10.9mg/l. There was a positive correlation between overall snail abundance and DO ($P<0.05$). An increased snail abundance which was influenced by increase in DO observed in this study has also been recorded in an earlier study (Salawu and Odaibo, 2014).

Conclusion

Various intermediate hosts of *Schistosoma* spp. were found to be distributed in the study location. The population of these vectors were observed to vary with seasons and water physicochemical properties. The prevalence of *Schistosoma*-infected snails in the study was found to be low. A boom in snail reproductivity was observed by increased number of snails at the juvenile stage which suggest a likelihood of disease resurgence in the near future if no control measure is enacted.

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Conflict of Interest

The authors declare no conflicts of interest

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