



Ground Flora Species Richness and Diversity in Traditional Forests of Southwest, Nigeria

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ABSTRACT: Diversity indices of tree species in tropical rainforest have been studied, but less effort has been devoted to the ground flora studies especially in sacred groves of tropical rainforest, Nigeria, as it plays a critical role in nutrient cycling and energy flow within the forest ecosystem. This study was carried out to determine the ground flora species diversity, richness and density in five traditional forests (Igbo-Ile, Igbo-Oba, Igbo-Olua, Igbo-Olodumare Igbo-Gbopo) of southwestern Nigeria. The ground flora enumeration of 5 x 10m was laid at the centre of 50 x 50m laid in each of the sacred grove. All plants with dbh \leq 10cm were identified and the frequency of occurrence recorded. In all the Sacred Groves, a total of 14064 plants/ha individual were recorded with 80 species distributed among 36 families. Igbo-Oba had highest diversity index of 3.21, followed by Igbo-Olodumare (2.80), Igbo-Ile (2.42). The least diversity index was recorded in Igbo-Gbopo (1.97). Among the 36 families, maximum species was recorded in Sterculiaceae (10), followed by Euphorbiaceae (5), Apocynaceae (4), Combretaceae (4) and Sapindaceae (4). Among the families with lowest frequencies (1) recorded are: Acanthaceae, Araceae, Rutaceae, Sapotaceae, Solanaceae. The study concludes that anthropogenic disturbances observed, e.g. farming, spiritual engagements etc. around Igbo-Olua and Igbo-Gbopo might have contributed to low diversity index compared to Igbo-Ile, Igbo-Oba and Igbo-Olodumare where high diversity index was recorded. It is recommended that to maintain high diversity index in the scared groves, buffer zones should be created around the sacred groves.

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The significance of ground flora in forest ecosystem cannot be over emphasized, although biodiversity studies in tropical forests have been concentrated on existing woody species, with less concern on other important part of the forest ecosystem e.g. ground flora. It includes the woody and herbaceous plants which occupy the lowest forest stratum (Gilliam and Roberts, 2003). Current information on ground flora species is needed because of its potential usefulness in understanding the relative extent of plant biodiversity and its implication for conservation and management (Kadavul and Jagatheeswari, 2005). The plants are typically more sensitive than tree species to disturbance (Barnes *et al.*, 1998; Small and McCarthy, 2002). Diversity indices have been computed for various forest types by various workers, but less effort has been devoted to the description of patterns of diversity in these conspicuous strata of vegetation as this may reveal ecological processes responsible for plant community structure Mansoor *et al.*, (2011). According to Polykov *et al.*, (2008), diversity is one of the major factor that defines stability and efficient functioning of forest ecosystem so as to

maintain biodiversity for forest management. Tropical forests that represent some of the most species-rich ecosystems on the planet constitutes the most biologically diverse terrestrial ecosystem and are under continuing pressure from habitat loss and fragmentation, driven by deforestation for agricultural expansion (Taubert *et al.*, 2018). Sacred groves which is a form of *in-situ* conservation are the tracts of virgin forest that were left untouched by the local inhabitants, harbour rich biodiversity, and are protected by the local people due to their cultural and religious beliefs and taboos that the deities reside in them (Khan *et al.*, 2008). They manifest the spiritual and ecological ethos of local indigenous communities. Some authors have identified the importance of ground flora in sacred groves. The ground flora in the sacred groves often harbors wild turmeric (*Curcuma* spp.), wild ginger (*Zingiber* spp.) and cardamom (*Elettaria cardamomum*). Water reservoirs and ponds closer to sacred groves supports wide variety of flora and fauna, often have wild crop relatives and endemic and endangered species (Swamy, 1997).

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Ground flora/herb are therefore likely to be more sensitive to desiccation and the condition which may be found to be critical for their distribution, will only be important for trees when seedlings establish (Poulsen, 1996). The relationship between canopy trees and ground flora in a tropical rain forest in Singapore have been studied (Turner *et al.*, 1996). The density of crop plants and ground flora plays a crucial role in the outcome of competition between them. It has been reported that dense crop has a something effect on ground flora (Sen, 1979). Although understory vegetation often contributes relatively a small portion to the biomass of overall forest ecosystems, it plays a critical role in nutrient cycling and energy flow due to the high turnover rates of understory vegetation (Hubau, *et al.*, 2019, Powers, *et al.*, 2005, Kumar, *et al.*, 2018). The ground flora life form is subordinate to trees and shrubs and the conditions on the ground in a closed-canopy forest are characterized by low light intensities and high humidity (Poulsen, 1996). Vegetative spread is important in ground flora reproduction (Burt 1977) resulting in regenerative capabilities and mobility not found in trees. In some cases ground flora depend on gaps to promote seed production (Smith 1987). Not surprisingly, ground herbs are often found to have a patchy distribution and large areas of the forest floor are often devoid of herbaceous cover (Poulsen and Balslev, 1991). The objective of the study is to determine the ground flora species diversity, richness and density in five traditional forests of southwestern Nigeria.

MATERIALS AND METHODS

Location: The study area is located in the rainforest of southwest Nigeria which extends from Lat. 24°S and 24°N and Long. 10°E and 20°W. This humid tropical region has bimodal rainfall with the dry periods typically occurring in August and between October and March (Okusami *et al.*, 1997). The tropical rainforest begins a few kilometers in land along the coastal vegetation for the derived and Guinea savanna vegetation. It is 300km wide in its widest area (Okojie, 1994). There is a distinct dry and rainy seasons, having an average annual rainfall and temperature of 1489mm and 26.5°C respectively. The zone has a high density of human population with agriculture as primary occupation of the people (Sowunmi and Akintola, 2010).

Relief and Soils: The geology is a mixture of sedimentary and crystalline rock of the basement complex rocks especially granite gneisses (Fasina *et al.*, 2015). These soils vary in physical and chemical properties but they exhibit some common characteristics, most of them are well – drained by

several rivers, bright red or brown in colours and dominated by the kaoline type of clay. Their humus content tends to be low and is mostly confined to the uppermost horizons. Soils are predominantly ferruginous tropical, typical of the variety found in intensively weathered areas of basement complex formations in the rainforest zone of south-western Nigeria (Onyekwelu *et al.*, 2008).

Vegetation: The national report of FEPA (1992) recorded 5, 018 plant species in Nigeria lowland rainforest ecosystem of which 205 are endemic. There are also 247 species of mammals. The physiognomy of trees is usually uniform i.e. with straight boles and almost cylindrical. The reason for its richness is due to the favorable climatic conditions existing and availability of fertile soil. Examples of the species found in the area as reported by Oyelowo (2019) are *Celtis whitii*, *Celtis zenkeri*, *Cola gigantean*, *Hildegardia barteri*, *Sterculia rhinopetala*, *Sterculia tragacantha*, *Triplochiton scleroxylon*, *Diospyros monbuttensis*, *Ficus exasperata*, *Milicia excelsa*, *Trilepisium madagascarlensis*, *Lecaniodiscus cupanioides* etc.

Selection of Study Areas:

Five sacred groves were purposely selected from South-West states. They are:

Igbo-Ile Sacred Grove, Ibere, Ogo-Oluwa Local Government, Oyo State, Nigeria

Igbo-Oba Sacred Grove, Oba Ile, Olorunda Local Government, Osun State, Nigeria

Igbo-Olua Sacred Grove, Igbara Oke, Ifedore Local Government, Ondo State, Nigeria

Igbo-Olodumare Sacred Grove, Oke Igbo, Oke Igbo Local Government, Ondo State, Nigeria

Igbo-Gbopo Sacred Grove, Aye, Ejigbo, Local Government, Osun State, Nigeria



Fig 1: Map of South-western states, Nigeria, showing the location of the sacred groves with maps of Africa and Nigeria in inset (Oyelowo, 2014).

Diversity index and plant species classification: The plant species encountered were classified into families and frequency. Their frequencies of occurrence were obtained to ascertain species abundance/richness of flora composition on and species evenness. The ground flora enumeration of 5 x 10m was laid at the centre of 50 x 50m laid in each of the sacred grove. The following biodiversity indices were used to obtain the diversity, evenness within the forest in each sacred grove. All plants with dbh ≤ 10cm were identified and the frequency of occurrence recorded.

Diversity index: Species diversity is a measure of heterogeneity of a site taking into consideration the number and the density of individual species. Each sacred grove was assessed using the Simpson (1949)

$$I = \frac{\sum \{ni (ni - 1)\}}{N(N - 1)}$$

Where I = Simpson's diversity index; n_i = Number of individuals of i th species enumerated; N = Total number of species enumerated

The value in the original Simpson diversity index ranges from 0 to 1, implying that the lower the value calculated, the higher the diversity. With the inverse form, the higher the value, the higher the diversity. The inversed Simpson diversity index is given as follows

$$I = \frac{N(N - 1)}{\sum \{n_i(n_i - 1)\}}$$

Table 1: Summary of Ground flora Diversity indices in all the Sacred Groves

	Igbo Ile	Igbo Oba	Igbo Olua	Igbo Olodumare	Igbo Gbopo
No of Plants/Plot	408	721	425	1715	247
No of Species/ha	56	152	48	72	48
No of family	8	20	11	12	9
Density/ha	1892	2884	1700	6860	988
Diversity index	2.42	3.21	1.35	2.80	1.97
Species evenness	0.81	0.65	0.32	0.72	0.60

Among the species recorded in Igbo-Ile, *Culcasia saxalis* had the highest frequency of 83, followed by *Trichilia monadelpha* (67), *Cola gigantea* (47), *Sterculia rhinopetala* (34), and *Cnestis ferruginea* (32). *Cola millenii* (2) was recorded as the least occurring species (Table 2).

In Igbo-Oba, *Commelina benghalensis* had the highest frequency of 76, followed by *Thaumatococcus daniellii* (73), *Combretum hispidum* (51) *Combretum racemosum* (47), *Culcasia scandens* (43), and *Combretum zenkeri* (43). Among the least species identified were *Newboldia laevis* (4), *Mucuna sloanei* (4), *Cola nitida* (2) and *Irvingia wombolu* (1). Species with low frequencies identified in Igbo-Olua were; *Myrianthus arboreus* (3), *Capsicum frutescens* (3) and

Species evenness (E) in each ecosystem will be calculated by adopting Shannon's equitability (E_H) as stated by Kent and Coker (1992):

$$EH = \frac{\sum \ln P_i (P_i)}{\ln(s)}$$

Where: S = the total number of species in the habitat;
 P_i = proportion S (species in the family) made up of the i th species; Ln = natural logarithm

RESULT AND DISCUSSION

Ground Flora Composition and Structure: In all the Sacred Groves, a total of 14064 plants/ha individual were recorded. 80 species were distributed among 36 families. Among these, Igbo-Oba had the highest number of 152spp/ha. Igbo-Olodumare had 72spp/ha followed by Igbo-Ile, Igbo-Olua and Igbo-Gbopo with 56spp/ha, 48spp/ha, 36spp/ha and 12spp/ha respectively. Igbo-Oba had highest diversity index of 3.21, followed by Igbo-Olodumare (2.80), Igbo-Ile (2.42). The least diversity index was recorded in Igbo-Gbopo (1.97) (Table 1). Among the 36 families, maximum species was recorded in Sterculiaceae (10), followed by Euphorbiaceae (5), Apocynaceae (4), Combretaceae (4) and Sapindaceae (4). Among the families with lowest frequencies (1) recorded are: Acanthaceae, Araceae, Rutaceae, Sapotaceae, Solanaceae. (Figure 2).

Cola gigantea (4). *Chromolaena odorata* had the higher frequency (280), followed by *Acacia tragacantha* (34), *Acanthus montanus* (31) and *Holarrhena floribunda* (21). In Igbo-Olodumare, 23 ground flora species were identified.

Hildegardia barteri had the highest frequency of 210, followed by *Hunteria umbellata* (198), *Diospyros dendo* (195), *Milicia regia* was identified as the least frequency (9). The total of 12 ground flora species were identified in Igbo-Gbopo. *Zanthoxylum gillettii* had the highest frequency of 90, followed by *Acanthus montanus* (48), *Combretum collinum* (21), and *Alchornea laxiflora* (21). The least species recorded were *Cnestis ferruginea* (4), *Albizia zygia* (4) and *Myrianthus arboreus* (4).

Table 2: Ground flora of the Five Sacred Groves.

SPECIES	Igbo-Ile Sacred Groves	Igbo-Oba	Igbo-Olua	Igbo-Olodumare	Igbo-Gbopo
<i>Acacia triagacantha</i>	0	0	34	0	0
<i>Acanthus montanus</i>	0	0	31	0	48
<i>Achyranthes aspera</i>	0	0	19	0	0
<i>Azelia africana</i>	0	0	0	10	0
<i>Albizia ferruginea</i>	0	6	0	0	17
<i>Albizia zygia</i>	0	0	0	45	4
<i>Alchornea laxiflora</i>	0	0	0	0	21
<i>Blighia sapida</i>	0	8	0	0	0
<i>Bridelia micrantha</i>	0	0	0	59	0
<i>Buchholzia coriacea</i>	0	0	5	0	0
<i>Canthium vulgare</i>	0	24	0	0	0
<i>Capsicum frutescens</i>	0	0	3	0	0
<i>Ceiba pentandra</i>	0	0	0	35	0
<i>Celtis brownii</i>	0	4	0	0	0
<i>Celtis whittii</i>	0	5	0	0	0
<i>Celtis zenkeri</i>	0	21	0	0	0
<i>Chromolaena odorata</i>	0	0	280	0	0
<i>Chrysophyllum albidum</i>	0	13	0	0	0
<i>Cleistopholis patens</i>	0	0	0	10	0
<i>Cnestis ferruginea</i>	32	0	0	0	4
<i>Cola acuminata</i>	0	9	0	0	0
<i>Cola gigantea</i>	47	0	4	0	0
<i>Cola millenii</i>	2	4	0	0	0
<i>Cola nitida</i>	0	2	0	0	0
<i>Combretum collinum</i>	21	0	0	0	21
<i>Combretum hispidum</i>	0	51	0	0	0
<i>Combretum racemosum</i>	0	47	0	0	0
<i>Combretum zenkeri</i>	0	43	0	0	0
<i>Comelina benghalensis</i>	0	76	0	0	0
<i>Culcasia saxatilis</i>	83	0	0	0	0
<i>Culcasia scandens</i>	0	43	0	0	0
<i>Cyathula prostrata</i>	0	21	0	0	0
<i>Deinboilia pinnata</i>	0	6	0	0	0
<i>Dialium guineense</i>	0	7	7	0	0
<i>Dioscorea bulbifera</i>	0	16	0	0	0
<i>Dioscorea dumetorum</i>	0	27	0	0	0
<i>Diospyros crassiflora</i>	0	0	0	112	0
<i>Diospyros dendo</i>	0	0	0	195	0
<i>Diospyros monbuttensis</i>	0	21	0	0	0
<i>Elaeis guineensis</i>	0	8	0	0	0
<i>Glyphaea brevis</i>	17	0	0	0	0
<i>Hildegardia barteri</i>	21	0	0	210	0
<i>Holarrhena floribunda</i>	0	0	21	110	0
<i>Hunteria umbellata</i>	0	0	0	198	0
<i>Iringia wombolu</i>	0	1	0	0	0
<i>Landolphia owariensis</i>	14	0	0	0	0
<i>Leucanodiscus cupanioides</i>	22	0	0	0	0
<i>Maesopsis eminii</i>	29	0	0	0	0
<i>Mallotus oppositifolius</i>	0	0	0	96	0
<i>Manihot utilisima</i>	0	0	0	46	15
<i>Memecylon umbellatum</i>	0	4	0	0	0
<i>Milicia excelsa</i>	0	0	0	0	2
<i>Milicia regia</i>	0	0	0	9	0
<i>Millettia thonningii</i>	0	0	0	54	0
<i>Morus mesozygia</i>	0	21	0	0	0
<i>Mucuna pruriens</i>	0	31	0	0	0
<i>Mucuna sloanei</i>	0	4	0	0	0
<i>Myrianthus arboreus</i>	0	12	3	0	4
<i>Newboldia laevis</i>	0	4	0	19	0
<i>Olax subscorpioidea</i>	19	5	14	0	0
<i>Parkia biglobosa</i>	0	0	0	0	12
<i>Picralima nitida</i>	0	0	0	15	0
<i>Rauvolfia vomitoria</i>	0	0	0	161	0
<i>Ricinodendron heudelotii</i>	0	0	0	40	0
<i>Rothmannia hispida</i>	0	6	0	0	0
<i>Spondias mombin</i>	0	2	0	95	0
<i>Sterculia rhinopetala</i>	34	0	0	43	0
<i>Sterculia tragacantha</i>	0	4	0	50	9
<i>Stronbosia postulata</i>	0	0	4	0	0
<i>Strophanthus gratus</i>	0	7	0	0	0
<i>Tabernaemontana pachysiphon</i>	0	31	0	0	0
<i>Thaumatococcus daniellii</i>	0	73	0	0	0
<i>Tithonia diversifolia</i>	0	23	0	0	0
<i>Tragia benthami</i>	0	31	0	0	0
<i>Trichilia monadelpha</i>	67	0	0	0	0
<i>Voacanga africana</i>	0	0	0	13	0
<i>Zanthoxylum gillettii</i>	0	0	0	90	90

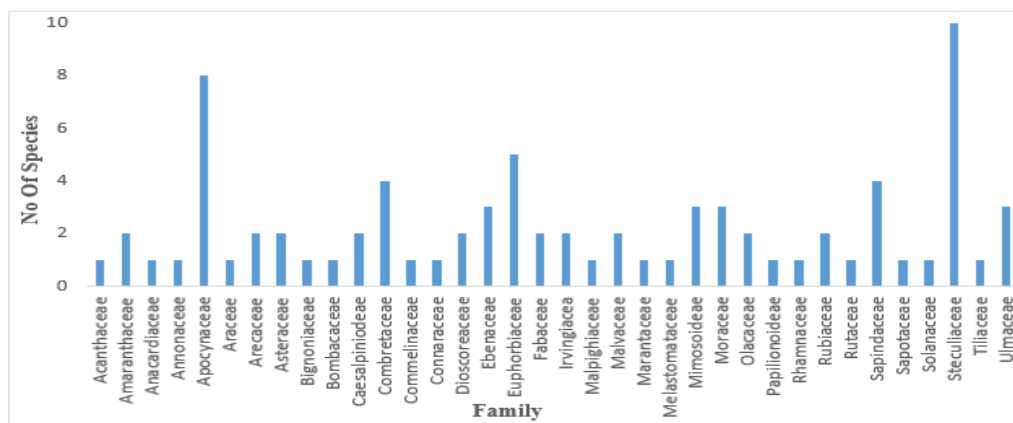


Fig. 2: Family Composition in all the Sacred Grove.

Table 3: Similarity Indices of Ground flora in all the Five Sacred Groves

Sacred grove	Igbo Ile	Igbo Oba	Igbo-Olua	Igbo Olodumare	Igbo-Gbopo
Igbo Ile	1				
Igbo Oba	0.4379	1			
Igbo Olua	0.8039	0.8700	1		
Igbo Olodumare	0.9137	0.9173	0.6019	1	
Igbo-Gbopo	0.9123	0.7860	0.6341	0.9824	1

Among the 5 Sacred Groves, Table 3 shows the Simpson Similarity between the groves. High similarity value was recorded between Igbo-Olodumare and Igbo-Gbopo (0.9824), followed by Igbo-Olodumare and Igbo-Oba (0.9173), between Igbo-Olodumare and Igbo-Ile (0.9137), between Igbo-Gbopo and Igbo-Ile (0.9123). However, low similarity value was recorded between Igbo-Oba and Igbo-Ile (0.4379), between Igbo-Olodumare and Igbo-Olua (0.6019), between Igbo-Gbopo and Igbo-Olua (0.6341).

The density of ground flora in the sacred groves varies from each other. The high ground flora density was recorded in Igbo-Olodumare (6860 plants/ha). This could be attributed to natural gaps existing within the groves. The process of canopy gap formation has a profound influence on the diversity and dynamics of forest (Dirzo *et al.*, 1992; Beckage *et al.*, 2000). Gap formation is often viewed as inherently beneficial for plants, primarily because growth and flowering are enhanced when light is no longer a limiting resource (Denslow *et al.*, 1990). The least ground flora density recorded in Igbo-Gbopo (988 plants/ha) could be attributed to the topography and close canopy of the grove. Igbo-Gbopo serves as watershed to river Yemo. The topography accelerates the washing of the top soil and seeds into the river. However, studies investigating how canopy, topographic conditions and damage interact to influence plant growth and physiology remain limited (Sipe and Bazzaz, 2001). Low density of the saplings of the dominant or emergent tree species at the floor of the forest is a

result of canopy cover which prevents light from reaching the floor. The diversity index which is the measure of species diversity in a community provides information about rarity and commonness of species in a community. The diversity index ranged from 1.35 – 3.21. The obtained diversity of the under storey plants of Varagalair, Western Ghats, India (H¹ 2.43) Annaselvam and Parthasarathy (1999) fall within that of this study. The diversity could be attributed to the ability of the species to grow under shade. Rackhan, 1975 and Peterken, 1981 reported that there are a number of ways in which the ground flora can survive the shade phase. In general, species show habitat preferences based on the suitable conditions for their survival. But some sites at certain periods are unsuitable for certain species due to the incompetence of species in the local abiotic habitat, or local predators (Janzen, 1970; Connell, 1971). Among the 36 families, maximum species of 10 was recorded in Sterculiaceae. This is different from the study by Kadavul and Jagatheeswari (2005), where Poaceae was represented to be the highest species (16 species) among the 42 families in this region.

Invasion of exotic weeds into sacred groves has become a serious problem in the ecological functioning of some sacred groves. Local biodiversity of the sacred groves are being depleted and further threatened by the domination of exotic weeds such as *Eupatorium Odoratum*, *Lantana camara*, *Prosopis juliflora* and *Hiptis suaveolens* (Swamy *et al.*, 2003). The most dominance species recorded in all the

locations is weed; *Chromolaena odorata*. The presence of the species showed that the forest canopy of Igbo-Oba is relatively closed compared to other sacred groves. Species with high frequencies identified in Igbo-Olua was *Chromolaena odorata* had the higher frequency (280). *Chromolaena odorata* is considered invasive weed of field crops in its introduced range, and has been reported to be the most problematic invasive species within protected rainforests in Africa (Struhsaker *et al.*, 2005). *Chromolaena odorata* can easily invade open spaces and heavily disturbed environments such as croplands and neglected pastures, forest margins and disturbed rainforests (Uyi, *et al.*, 2014). This supports the invasion of the species in Igbo-Olua sacred grove. *Chromolaena odorata* in Nigeria by different researchers strongly regards *Chromolaena odorata* as a serious threat to agriculture and biodiversity conservation. Although *Chromolaena odorata* is considered a good fallow plant by several authors in Nigeria partly because of the speculative decrease in natural fallow lengths (Tian *et al.*, 1999; Akobundu and Ekeleme 2002; Aweto and Iyanda 2003). In Igbo-Olodumare, *Hildegardia barteri* had the highest frequency of 210, Igbo-Oba recorded *Commelina benghalensis* as the highest frequency of 76 followed by *Thaumatococcus daniellii* (73). The abundance of *Commelina benghalensis* could be linked to farmland existing close to the sacred grove. *Commelina benghalensis* often found on disturbed sites, forest edges, road sides, agricultural sites, and home gardens (van der Burg, 2004; Webster *et al.*, 2005). *Commelina benghalensis* acts as a herbaceous perennial in its native range and as an annual weed in the southeastern United States (Prostko *et al.*, 2005). However, *Thaumatococcus daniellii*, is a rhizome understory ground flora, found in the Tropical rainforest. The *Zanthoxylum gillettii* seedlings (90) was found in Igbo-Gbopo. *Zanthoxylum gillettii* are light-demanding and natural regeneration may be abundant in large gaps in the forest and in regrowth of old farmland. In Liberia seedlings are commonly present in such localities, but reportedly never gregarious (<http://www.prota.org>). High similarity value recorded between Igbo-Olodumare and Igbo-Gbopo (0.9824). However, low similarity value was recorded between Igbo-Oba and Igbo-Ile (0.4379),

Conclusion: The study concludes that the sacred groves of Igbo-Ile, Igbo-Oba, Igbo-Olodumare were rich in ground flora species than Igbo-Olua and Igbo-Gbopo, Anthropogenic disturbances observed like farming, spiritual engagements etc. around Igbo-Olua and Igbo-Gbopo might have contributed to low diversity index.

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