CYTOTAXONOMIC STUDIES IN THE GENUS *URGINEA* STEIN IN WEST AFRICA. III. THE CASE OF *URGINEA INDICA* (ROXB.) KUNTH IN NIGERIA[1]

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ABSTRACT

Urginea indica (Roxb.) Kunth is a morphologically variable species of wide distribution in the Old World. In West Tropical Africa, it has been considered to consist of a large form and a dwarf form. The large form was investigated morphologically in the field and in the laboratory, as well as karyotypically. Four morphological variants were encountered in the field. They differ in both vegetative and floral morphology, were found in different populations, and showed differences in ecological preferences. Biometrical analysis of vegetative and floral morphology showed that the four variants are distinct and separate but not immediately recognizable taxa. Preliminary karyotype analysis showed that they are similar but not identical in karyomorphology. Artificial crosses between them failed to produce viable seeds. It is concluded that *U. indica* is an incipient polyspecies or species complex.

Urginea indica (Roxb.) Kunth is one of the four species of *Urginea* recognized in the latest revision of Liliaceae in Flora of West Tropical Africa (Hepper, 1968). It is distinguished from the other species by its globose capsule. It is widespread in the Old World tropics, inhabiting savanna vegetation of tropical and subtropical areas of Africa, southern India and further east (Thiselton-Dyer, 1898). In Nigeria, it is widespread in the central segment of the country, occurring between latitudes 7°N and 10°N. It occurs in open, heavy soil with a top layer of humus or in clay soil of seasonally flooded plains.

It occurs in different ecological niches in various soil types within the savanna region and shows a variety of morphological forms. Hepper (1968) observed this morphological variation and contended that there are at least two different forms of this variable species: a large form and a dwarf form. These two are easily distinguishable in the field. The large form has light green leaves whose undersurface, immediately out of the bulb, is pinkish; the reproductive shoot is also pinkish, 45–150 cm tall, with not less than 15 flowers in the lax, racemose inflorescence. The tepal is also pinkish with a greenish keel. Leaves and flowers are never borne together. The dwarf form, on the other hand, has dark green leaves; the reproductive shoot is green, generally less than 40 cm tall, with flowers usually ranging between one and 12; the tepals are yellowish green with a green keel. Leaves and flowers are never borne together. Field studies of this taxon during vegetative growth and flowering revealed that Hepper's contention was a rather conservative estimate. The present paper therefore aims at establishing the taxonomic status of *U. indica* through morphological studies, starting with the large form.

MATERIALS AND METHODS

Natural populations of the large form were studied morphologically during several field trips. Representative samples were collected and brought into cultivation in nurseries first at the University of Ibadan (southwestern Nigeria), then at Ahmadu Bello University, Zaria (northcentral Nigeria) and later at the University of Ilorin (westcentral Nigeria). Each collection site was visited at least twice—during the vegetative growth period (May to August) and during the flowering and fruiting period (November to March). Altogether about 200 bulbs were brought into cultivation. Four morphological variants were identified from different populations during collection. Titled A–D, they were grown on adjacent nursery beds. No intermediate forms were encountered, even where the variants grew together or in contiguous sites. Records of morphological features were kept and carefully followed in order to identify any environmentally induced features. These collections have been in cultivation since 1972/73.

Each bulb is normally not more than 3–4 inches

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deep in the soil. Soil samples were usually taken along with each bulb, and both texture and composition of the soil were determined later in the laboratory. The type of vegetation in which the population was found was also noted.

Morphological characteristics were divided into qualitative and quantitative features. The qualitative features are bulb shape, shoot color, inflorescence color, leaf form, perianth color, ovary shape, ovary color, filament, style, and anther color. These were assessed visually. The quantitative features are shoot and inflorescence height, number of flowers in the inflorescence, pedicel length, tepal length and width, length of ovary, style and stigma, anther, filament, and leaf, and leaf width. The leaf length-to-width ratio, called leaf ratio (l/w), was calculated for each leaf measured. Measurements were taken with a meter-rule graduated in millimeters and centimeters or with millimeter graph paper. The shoot was measured from its base at bulb surface to its tip, while the inflorescence height was taken from the base of the first flower to the tip of the shoot. Both measurements were taken after the last (youngest and apical) flower had either opened or withered to ensure that the reproductive shoot had stopped elongating. Floral parts from newly opened flowers were dissected out for measurements.

Transverse sections of mature leaves were made in order to investigate leaf cuticular surface pattern, leaf margin, number of veins, structure of veins, stomatal structure, and the general pattern of tissue distribution in the leaf.

Chromosome number and karyomorphology were studied using root tip squashes. Root tips were harvested at about 8 A.M., pretreated for one hour in saturated aqueous solution of p-dichlorobenzene, fixed in fresh 1 : 3 acetic alcohol (glacial acetic acid and absolute ethanol) and stored for at least 30 minutes at about −4°C before hydrolysis. Hydrolyzed root tips were squashed in 2% acetic orcein.

RESULTS

The major collection areas are indicated in Figure 1. Except for Groups B and D, which were found growing together in a wide expanse of land, different groups were found in different populations and in different ecological niches. All the populations encountered were found growing either in large numbers or as a few individuals dispersed in open savanna, with very light grass and forb cover and a few short, scattered trees and shrubs. The soil was heavy clay with or without stones and/or pebbles. The top layer was dark humus. All the populations were found in flood plains with little organic topsoil during the rains. In the dry season, the soil was hot, dry, hard and cakey.

Figure 2 illustrates the vegetative morphology of the four groups, while Table 1 contains a summary of all the morphological features investigated. Leaves are produced from the onset of the rains, and the plants remain vegetative for most of the rainy season. The leaves dry up towards the end of the rains. The early annual savanna fire of October to November burns the dry leaves, and reproductive shoots may be produced any time from two weeks after the burning. The mature flower opens into a bell shape; the pedicel curves back to carry the flower face downwards at anthesis and until after pollination, after which the pedicel straightens up. The flower withers if not fertilized. When fertilization occurs, however, the young fruit enlarges while the fading tepals close over it and shrivel into a little cap on top of the fruit by the time of maturation.

Groups B and D are most similar, being distinguished by shoot and inflorescence height, leaf length and form, and number of flowers per inflorescence only. D is distinguished from C by the lengths of tepal, style and stigma, filament and anther, filament color, bulb shape, shoot and inflorescence color, and ovary shape and color. B differs from A in shoot height and color, inflorescence height, lengths of pedicel, style and stigma, filament, anther, ovary shape, and filament color. A and C are distinguished by shoot height, inflorescence height and color, number of flowers, lengths of pedicel, tepal, anther and leaf, leaf width, and ovary shape. A and D differ in shoot and inflorescence height, number of flowers, lengths of tepal, style and stigma, filament and leaf, filament color, leaf form and width, ovary shape, and bulb shape.

Figure 3 illustrates variations in leaf surface patterns, leaf margin, vein structure, and the pattern of distribution of palisade and spongy tissues of the leaf mesophyll. Each of the groups is distinctly different from the others in each of the features exhibited.

The leaf surface pattern is similar in all, showing minute crenation, which is most noticeable in variant D but less so in variants C, A, and B, respectively (see Fig. 3: A_1, B_1, C_1, and D_1). A and D have similar epidermal cell size, type, and arrangement as well as palisade cell size, form,

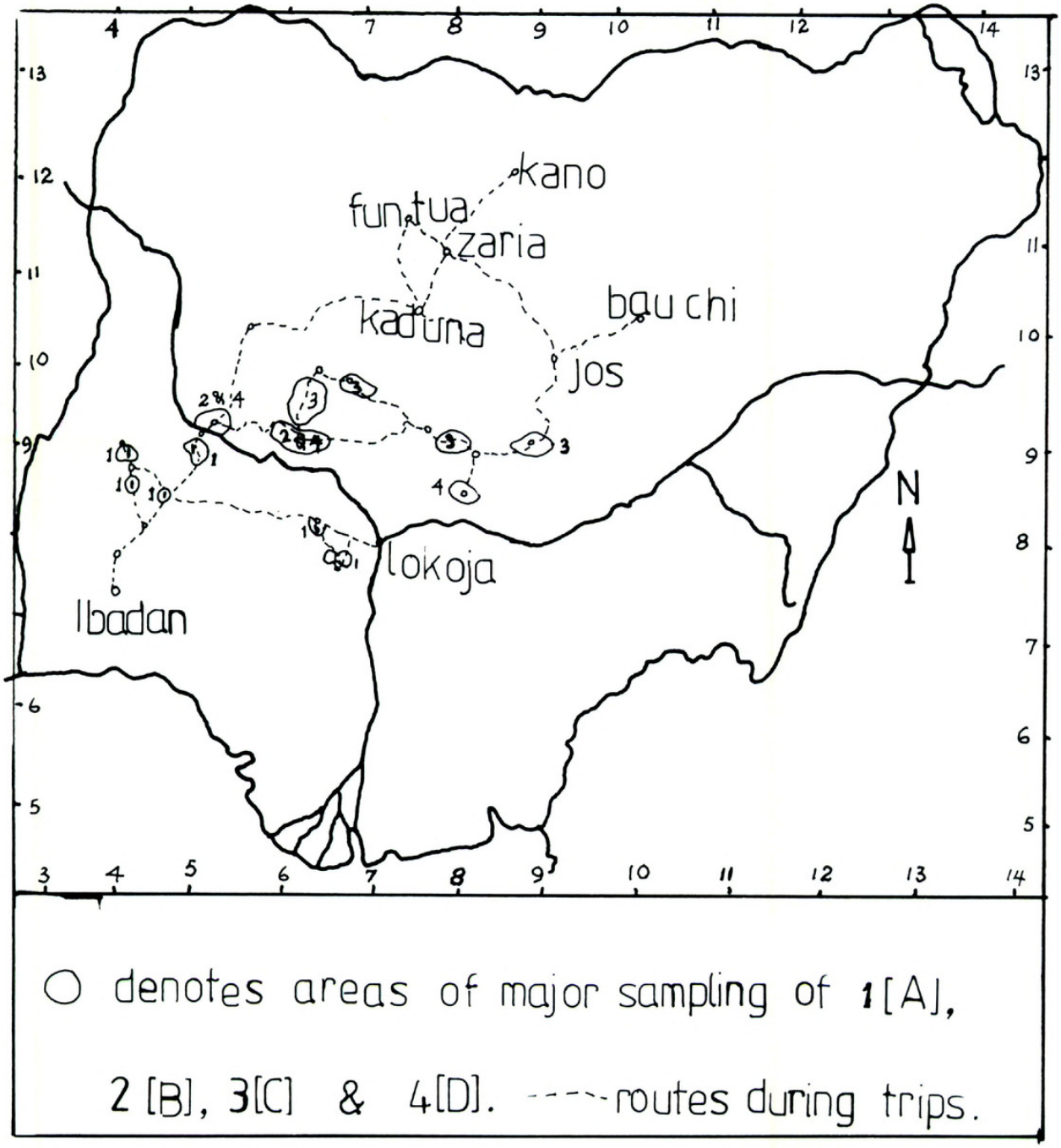


FIGURE 1. Map of Nigeria showing areas of major sampling of the large form of *U. indica*.

and arrangement. They differ in leaf margin, being short and acute in A, the adaxial and abaxial epidermal layers being separated to the margin by the palisade, which aborts on a marginal epidermal cell, while leaf margin in D is projected with both epidermal layers coming together outside the palisade and terminating with a marginal epidermal cell. They also differ in the distribution of phloem tissue in the vein, being bicollateral in A but only collateral in D. In B and C, the epidermal cells are short and isodiametrical, the palisade cells are also short and less tightly arranged, and the veins have large xylem vessels with conspicuous bicollateral phloem tissue. The leaf margin shows progressive elongation, being long and more acute in B than in A. In B, both epidermal layers do not close completely beyond the palisade before terminating in a marginal epidermal cell; in C, leaf margin is projected with rounded tip as in D and the epidermal layers barely close up beyond the palisade before terminating in a single marginal cell. Finally, the arrangement of the large metaxylem vessels is similar in A, B and D but differs in C.

TABLE 1. Data on morphological features.

Characters	Taxa			
	A	B	C	D
Bulb shape	Small, spherical	Medium, spherical	Medium, ovoid	Large, spherical
Shoot color	Green	Pink	Light green	Pink
Inflorescence color	Pink	Pink	Yellowish cream	Pink
Leaf form	Short, coiled	Short, reflexed	Long, coiled	Long, straight
Perianth color	Pinkish brown with green keel	Pink with yellowish green keel	Pinkish brown with green keel	Pink with yellowish keel
Ovary shape	Pyramidal	Globose	Pyramidal	Globose
Ovary color	Green	Green	Green	Light green
Filament color	Pink	Yellowish	Pinkish	Yellowish
Style color	Pink	Pink	Pink	Pink
Undehisced anther color	Dirty white	Dirty white	Dirty cream	Creamy white
Shoot height (cm)	45–60; 52.9	70–90; 76.9	100–140; 123.8	100–140; 119.9
Inflorescence height (cm)	15–20; 17.6	24–30; 27.0	50–60; 54.7	50–70; 59.5
Number of flowers	15–20; 17	15–20; 17	20–30; 24	20–30; 25
Pedicel length (mm)	22–23; 22.6	35–40; 37.1	30–40; 33.9	*(30–) 50–70; 60.3
Tepal length (mm)	12–14; 12.8	12–13; 12.6	15–16; 15.5	11–13; 12.1
Tepal width (mm)	4–4.5; 4.2	4–6; 5.2	3.5–4.5; 4.0	4.5; 4.5
Ovary length (mm)	4.5–5.5; 4.9	5–6; 5.3	4.5–5.0; 4.9	5–6; 5.5
Style + stigma (mm)	6.5–7.5; 7.0	5–6; 5.3	*(6.5–)7.0; 7.0	5–6; 5.5
Filament length (mm)	8.5–9.5; 9.0	5; 5.0	*(8.5–)9.0; 9.0	5–6; 5.6
Anther length (mm)	2; 2.0	2.5–3.5; 3.0	2.5; 2.5	3; 3.0
Leaf length (cm)	20–25; 22.7	25–35; 31.2	50–80; 67.3	50–70; 61.1
Leaf width (cm)	0.8–1.3; 1.0	0.8–1.3; 1.1	1.4–2.6; 2.1	1.0–2.4; 1.6
Leaf index (l/w)	17–31; 23.6	24–43; 29.8	22–52; 32.6	26–56; 39.5

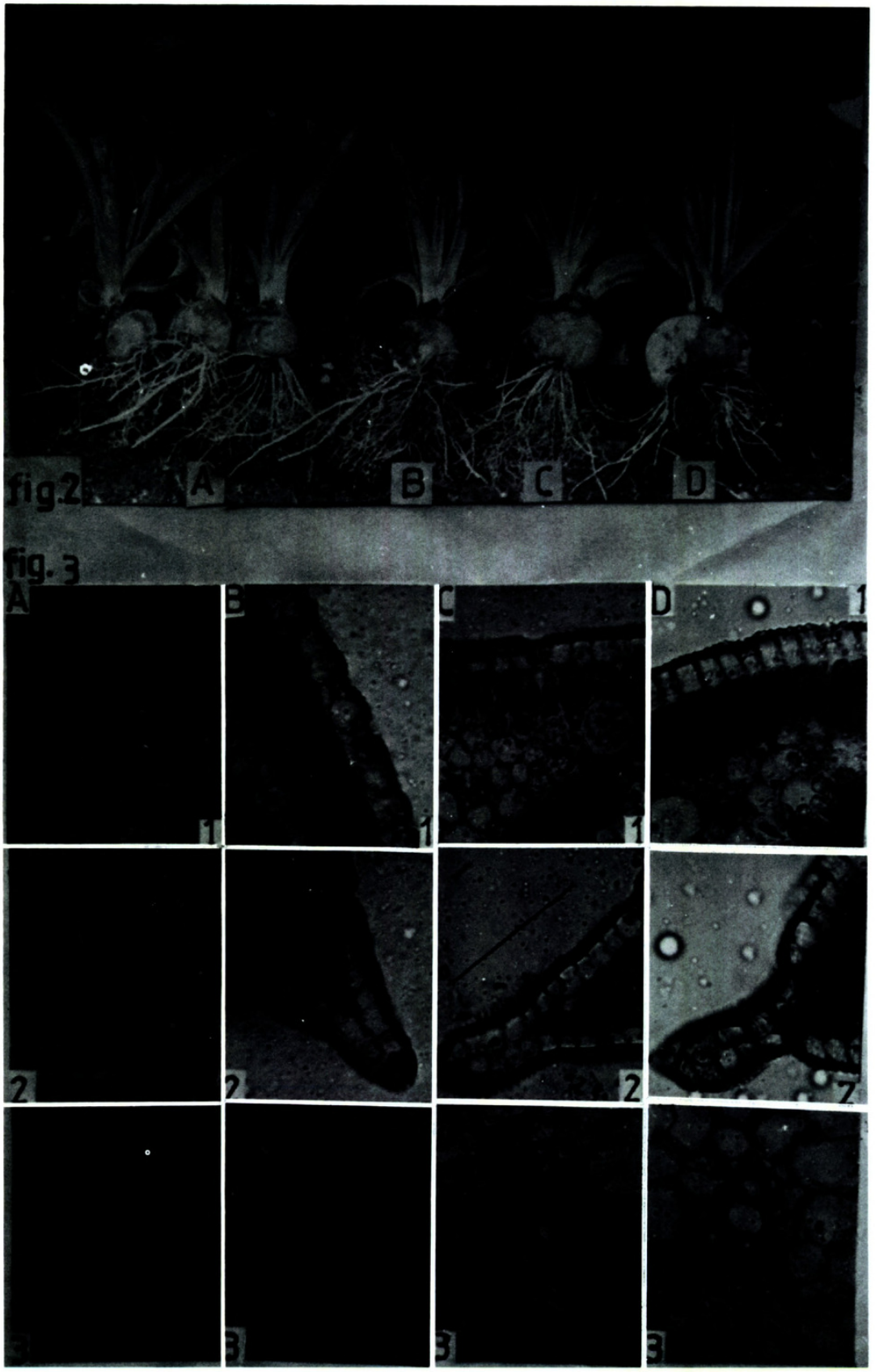
* Indicates infrequent deviating measurements.

All four groups have a somatic chromosome number of $2n = 20$. They have similar but not identical karyomorphology. An analysis of the karyotypes is the subject matter of a separate report (Oyewole, 1986). Artificial crossing between the four groups failed to produce any hybrid fruits.

DISCUSSION

Urginea indica has been described as a variable species (Hepper, 1968; Morton, 1961). Morphological variation was maintained even under uniform cultivation, suggesting that the variation is genetically based. Furthermore, morphological variations are correlated within the variants and with ecological preference rather than being ubiquitous in all populations, as would be expected if the variations were due to polygenic effects (Dobzhansky, 1951; Huxley, 1942; Mather, 1943). In *U. indica,* two distinct forms, B and D, were found together in the same population area without intermediates, indicating that the differences between them are not environmentally induced, while each group has a distinct karyotype (Oyewole, 1986). Hence variation in this case is not just a case of polymorphism.

The correlation between the external morphological variations and the leaf epidermal and mesophyll features strongly supports the idea that this taxon is not just a single species. These anatomical features are genetically controlled and, under the same environmental conditions, still maintain their differences. The importance of such anatomical features in species delimitation has been amply emphasized by Carlquist (1959) and Metcalfe (1963) and exhaustively demonstrated in many other works (for example, Prat, 1932; Church, 1949; Sørensen, 1953; Borrill, 1959, 1961; Oyewole, 1971; Adeyemi, 1981).



FIGURES 2, 3.—2. Vegetative morphology of the four groups (A–D) of the large form of *U. indica*. Horizontal bar represents 4 cm.—3. Leaf surface patterns: 1—Leaf surface, epidermal cell structure and the palisade layer; 2—leaf margin; and 3—Leaf vein structure. Diagonal bar represents 25 μm.

Speciation, in the words of Dobzhansky (1951), is "that stage of evolutionary process at which the once actually or potentially interbreeding array of forms becomes segregated in two or more separate arrays which are physiologically incapable of interbreeding." Recent views on speciation emphasize the relationship of the organism and the environment as the controlling factor (Hutchinson, 1959; Lewis, 1969). Thus adaptive radiations often occur when a species enters an unoccupied habitat with diverse open niches or when a population acquires a new complex of adaptive characters that enables it to exploit available environment more efficiently (Stebbins, 1971), as recorded for the *Axonopus compressus* complex (Gledhill, 1966). Hence it is clear that *U. indica,* in which there are four morphologically distinct, genetically isolated forms even within the so-called large form, is not simply one phenotypically plastic genotype. It is significant that these forms exist side-by-side in nature or at least within the same geographical location and climatic condition while maintaining their identity both reproductively and morphologically. Obviously their karyotypes resemble one another. However, they are biological entities. It is untenable to regard the hitherto *U. indica* as a single species (Lewis, 1969); rather it must be recognized as a species complex. The evolutionary history of *U. indica* may possibly be similar to that of *Albuca nigritana* and the *U. altissima* complex in the same family (Gledhill & Oyewole, 1972; Oyewole, 1975, respectively).

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