NEST SITE SELECTION AND THE TIME OF BREEDING BY SLAVONIAN GREBES *PODICEPS AURITUS* IN SCOTLAND

R W SUMMERS and R A MAVOR

Royal Society for the Protection of Birds, Etive House, Beechwood Park, Inverness, IV2 3BW, Scotland

Bottle Sedge Carex rostrata provided the main nesting habitat of Slavonian Grebes in Scotland. In the sedge beds, the sedge density decreased and water depth increased from land to open water. The grebes preferred to nest in dense sedges growing at a medium water depth. Thus, there was an optimum mid-band of suitable sedges which provided sufficient cover, security from predators and shelter from wave action. Sedge beds did not provide good cover until early June. The observation of early nests in stands of dead reeds (mean first egg date 14 May) and in the semi-submerged branches of willows (29 May), compared with nests in sedges (6 June), suggests that the late growth of sedges limited the timing of breeding of the grebes. The average dates of first eggs for initial clutches in all nests were 5 June in 1992 and 3 June in 1993.

Keywords: Slavonian Grebe, Nest selection

The Slavonian Grebe *Podiceps auritus* has a Holarctic distribution but the subspecies *P.a. arcticus* is restricted to Norway, Iceland, the Faeroe Islands and Scotland (Fjeldså 1973a). This sub-species started to breed in Scotland in 1909 (McGhie 1994) and, since then, has bred in Highland, Grampian and Tayside Regions (Thom 1986). There have been detailed studies of the breeding biology of this subspecies in Norway and Iceland (Clase *et al.* 1960, Fjeldså 1973b, 1973c), but not in Scotland.

Slavonian Grebes generally build their nests from fresh and dead water plants which are accumulated to form semi-floating mats anchored within growing emergent vegetation at the shallow margins of lakes (Cramp & Simmons 1977). Slavonian Grebes usually nest in beds of Bottle Sedge *Carex rostrata* in Scotland (Thom 1986). Beds of dense sedge occupy a relatively small area so availability of nest sites might limit the number of nesting pairs (Summers & Mavor 1995). Hence, this study set out to describe the characteristics of sedge beds, investigate nest site selection within sedge beds and determine the relationship between time of breeding and spring growth of sedges.

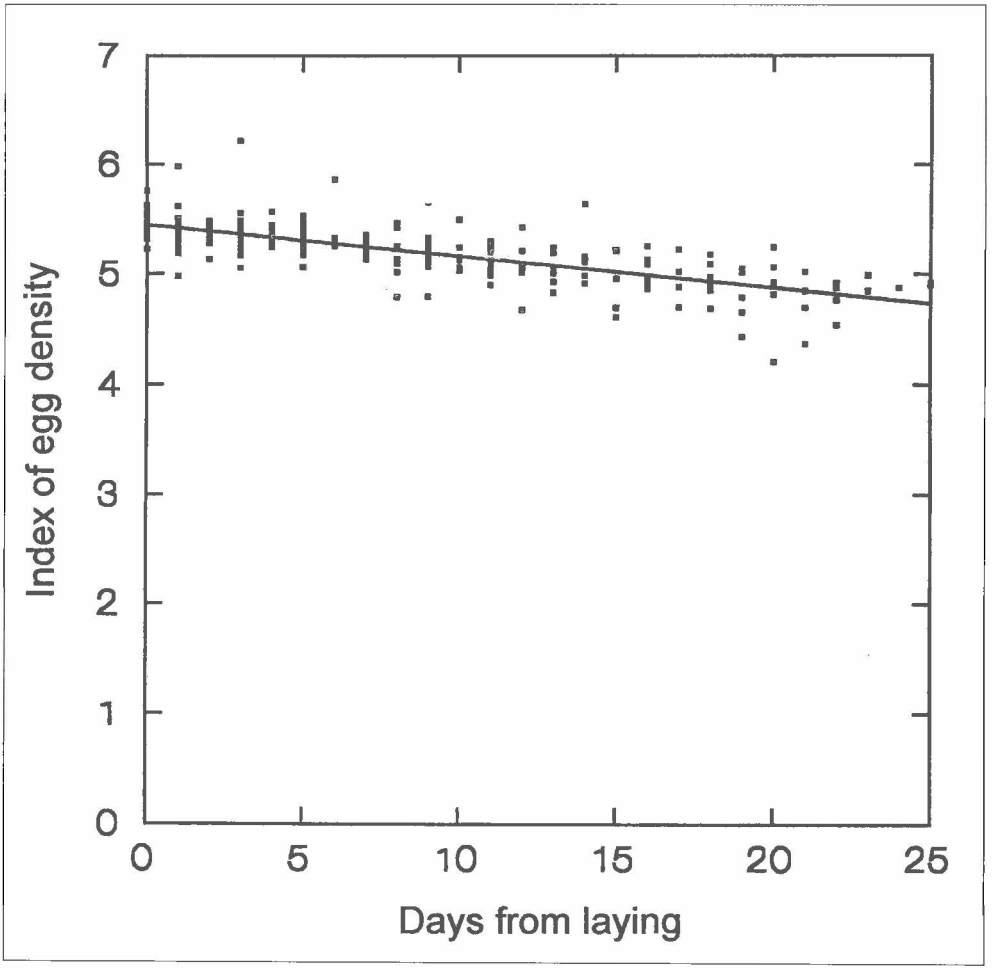
Method

In Scotland, 40 lakes were used by 72 and 73 pairs of breeding Slavonian Grebes in 1992 and 1993 respectively. Twenty-five of these lakes were selected for detailed observations; these had 54 and 65 pairs of nesting grebes in the two years. Thus, a high percentage of the Scottish breeding population was studied on a wide variety of the breeding lakes. Detailed work on sedge beds was carried out at Loch Ruthven, the main nesting site in Scotland (Summers & Mavor 1995).

The fieldwork was carried out from 1 May to 31 October 1992 and from 1 April to 31 October 1993. Lakes were visited at least twice per week in order to search for and re-visit nests. Nests were searched for where pairs were present close to suitable habitat early in the season. The behaviour of the birds also alerted us to the location of nests; eg swimming into and carrying nest material into

sedge beds. Most nests (74 out of 125) were found during egg-laying and the date of laying the first egg (if more than one egg was present at the first visit) was based on eggs being laid every second day. Two-day laying intervals were determined from daily observations at one nest and this pattern was consistent at five other nests visited at 2-3 day intervals during egg-laying. If the clutch was complete, the date of the laying of the first egg was estimated from the relationship between days from laying and an index of egg density (mass x 10,000/length x breadth^2), derived from the regression equation of egg density on days from laying (**Figure 1**). Egg mass was measured to 0.1 g with a Pesola balance and length and breadth measured with dial callipers to 0.1 mm. Laying dates at 15 nests were based on the observed hatching dates of chicks and subtracting the incubation period (24 days) (Cramp & Simmons 1977).

Figure 1. Changes in the index of density (mass (g) x 10000)/(length (mm) x breadth^2 (mm)) of Slavonian Grebe eggs during incubation. The regression equation was fitted: Index of density = 5.45 (± 0.017) - 0.029 (± 0.002) Days from laying (r = -0.74, P <0.001). This equation was re-arranged to give the relationship between days from laying and density: Days from laying = 187.9 - 34.5 Index of density.



When a nest was found in a sedge bed, its distance to land and open water were measured. Also, an index of visibility of a nest was measured using a chequered board (30 cm x 30 cm) with 100 alternating brown and white squares (each 3 x 3 cm), set vertically in the sedge bed so that the base of the board was at water level. The number of white squares that could be seen fully or partially was counted separately, when the top of the board was viewed at an angle of 20° (measured by a clinometer) and at a distance of *c.* 5 m. A model, based on 30 such samples, was then computed which combined the numbers of fully and partially seen squares (to give a single visibility index) and related them to sedge densities and leaf lengths. Sedge densities at the sample points were obtained by cutting the sedges within three 25 x 25 cm quadrats set at 25 cm around each point, and averaging the values. Only the central stems were counted and not the leaves. The average leaf length above the water was measured by taking the lengths of the 15 longest leaves, five from each quadrat, from the lake bottom to leaf tips, and subtracting the depth of the water. The numbers of fully and partially seen squares were combined by multiplying the fully seen squares by an increasing factor and adding them to the number of partially seen squares until the best fit (maximum adjusted r^2) with a combination of sedge density and leaf length was obtained. This was achieved by doubling the number of fully seen squares ($r^2 = 0.873$).

The changes in sedge density and water depth within sedge beds were described from transects through each of three sedge beds (A, B and C) from land to water at Loch Ruthven in August when the sedges were fully grown. At each 2 m interval, the sedges within a 25 x 25 cm quadrat were cut and the stems counted, and the water depth was measured to the nearest 1 cm.

The growth of sedges was described from 10 plants a metre apart and marked with plastic rings round the stem. Each week, the maximum leaf lengths from lake bottom to tips were measured. The development of cover (the inverse of visibility) was also measured at five sites, 2 m apart, using the chequered board. Stakes were driven into the lake bottom and the water level marked so that readings of visibility could be taken at the same height on each occasion.

The placement of nests in sedge beds was examined by expressing the distance from the land to a nest as a percentage of the total width of the bed. Nests were then grouped into four bands; 0-25%, 26-50%, 51-75% and 76-100%, the first being closest to the land and the last closest to the water. The distribution of nests was then tested against the expected numbers in a Chi-squared test.

In order to determine whether the grebes were selecting nest sites in particular parts of sedge beds, visibility scores and water depths were recorded at nest sites and compared with random sites paired with each nest in a given bed. Random sites were selected using random numbers, from 0 to 99, which provided percentage co-ordinates for the lengths and breadths of beds. The water depths of both nest and random sites were adjusted to the time of the first egg using the twice-weekly data collected from water gauges set in each lake. The data on visibilities and water depths were used to construct a logistic regression model where the y variable took the values 1 (for nests) and 0 (for random points) (Francis *et al.* 1993).

Results

Nesting habitat

The range of plant species within a 1 m radius of nesting Slavonian Grebes is shown in **Table 1**. All emergent plants were single-species stands and by far the most important was Bottle Sedge. Generally, only one pair of grebes was found per sedge bed, though a bed at Loch Ruthven held four pairs in 1992. Less important species used as nesting habitats included lake-side willows *Salix* sp. where the branches trailed in the water, and Common Reed *Phragmites australis*. Unusual nest sites included a half-submerged bale of Barley *Hordeum vulgare* straw and the top of a half-submerged tree stump on which the grebes had gathered dead stems of Rose-bay Willow-herb *Chamaenerion angustifolium*.

Table 1. The species of emergent plants and other situations providing nesting habitat or sites for Slavonian Grebes in Scotland.

	Number of nests			Percent of nests
	1992	1993	Both years	
Carex rostrata	35	51	86	69.9
Semi-submerged branches of Salix sp.	5	11	16	13.0
Phragmites australis	3	4	7	5.7
Nymphaea alba	1	2	3	2.4
Equisetum fluviatile	2	0	2	1.7
Juncus sp.	1	1	2	1.7
Grasses	0	1	1	0.8
Typha latifolia	0	1	1	0.8
Rumex hydrolapathum	0	1	1	0.8
Glyceria fluitans	0	1	1	0.8
Tree stump	1	0	1	0.8
Scirpus lacustris	1	0	1	0.8
Straw bale	1	0	1	0.8

Sedge beds were not uniform. There was a tendency for sedge density to decrease and water depth to increase from the land to open water (**Figure 2**).

Visibility indices were recorded from 30 locations where the sedge density and leaf lengths varied. Regression analyses were performed showing that visibility increased as sedge density and leaf length declined (**Table 2**).

Extension of sedge leaves took place during April and May, and they reached their maximum mean length at the beginning of June (**Figure 3**). Consequently, there was a fall in the indices of visibility, or increase in cover. Cover continued to increase through June and the sedge bed was fully developed by early July.

Nest site selection

Sedge beds where grebes nested were 12.5 m (S.E. = 0.8) wide, on average. Nests in sedge beds were placed 7.2 m (S.E. = 0.8) from the shore and 5.3 m (S.E. = 0.7) from open water (**Table 3**). The percentages of 39 nests in each quarter band of sedge from shore to water were; 15.4%, 18.0%, 41.0% and 25.6%. Thus, although there was a tendency for nests to be between half and three-quarters of the way out

Table 2. The relationship between visibility indices and sedge densities (stems m^{-2}) and leaf lengths (n=30). ANOVA: $F_{(2,27)}$ = 100.4 P<0.001, Adjusted r^2=0.873

Expanatory variable	Coefficient	S.E.	t	P
Constant	109.2	7.4		
Density of sedges (stems m^{-2})	-0.057	0.007	-8.2	<0.001
Leaf length above water (cm)	-0.612	0.113	-5.4	<0.001

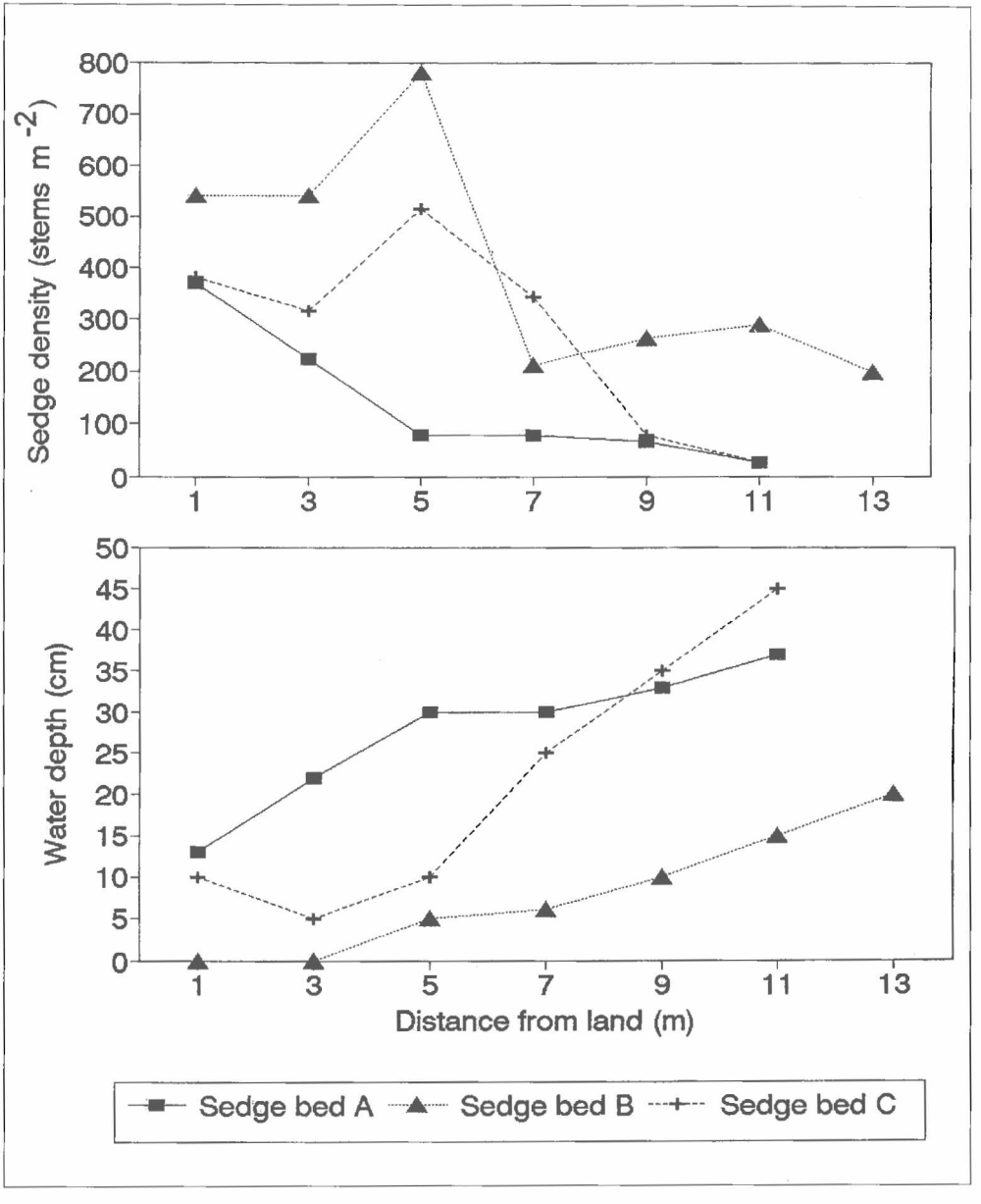


Figure 2. Changes in sedge density (stems m^{-2}) and water depth (cm) along transects through three sedge beds. Transects ran from the land to the outer edges of the sedge beds.

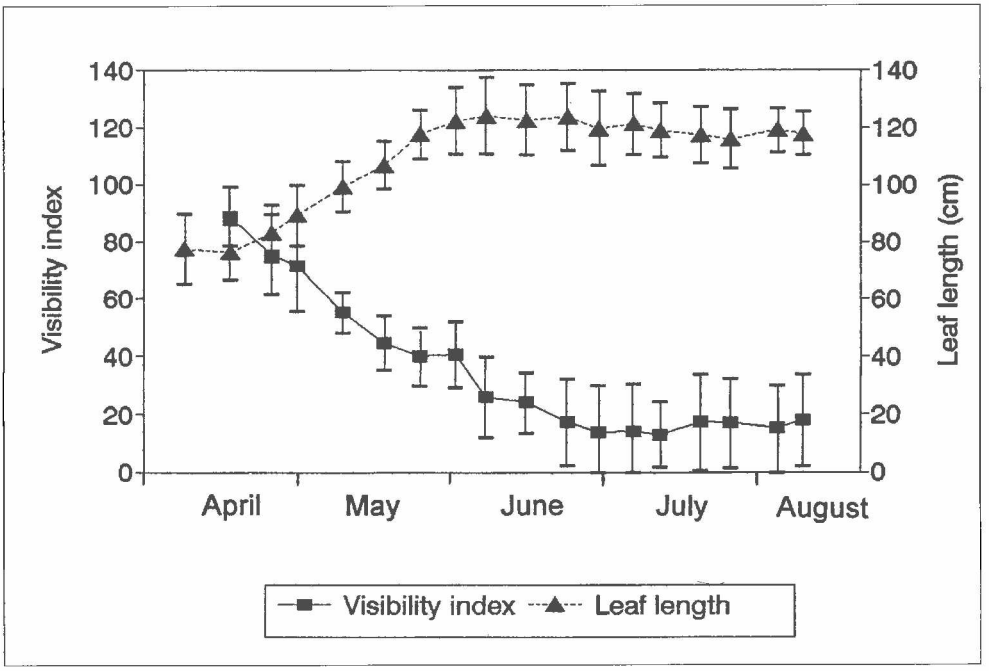


Figure 3. Seasonal changes in the mean indices of visibility and total leaf lengths in a sedge bed. Vertical lines show S.D.'s.

in a bed, this was not significantly different from an even spread ($X^2_3 = 6.24, P = 0.1$).

By comparing the visibility indices and water depths at nest sites in sedge beds with random sites, it was found that grebes selected areas with greater cover (lower visibility indices) (paired t-test = 4.7, df = 46, $P < 0.001$) (**Table 3**). Although there was no significant difference between the average water depths at nest sites and random sites, it appears that grebes nested in the middle range of depths available in sedge beds. They did not nest in water less than 17 cm deep and not more than 68 cm (**Table 3**). When the two habitat variables were entered together in a logistic model, the importance of cover was confirmed and the additional quadratic term for water depth showed that there was indeed a preference for the mid range of water depths (**Table 4**).

Time of breeding

The earliest date of nesting (laying the first egg) was 7 May in 1992 and 4 May in 1993. Those birds which nested early did so in stands of dead reeds or the semi-submerged branches of willows (**Table 5**). The average date for laying of all first clutches in sedge beds was 6 June, coinciding with the time when the leaves reached a maximum length (**Figure 3**). The average date of all first clutches, irrespective of habitat, was 5 June (S.D. = 12 days) in 1992, and 3 June (S.D. = 15 days) in 1993. The latest first-egg date of all clutches was 3 August, in 1993.

Discussion

The study confirmed the importance of beds of Bottle Sedge as the main nesting habitat for Slavonian Grebes in Scotland. Similarly, Fjeldså (1973c) found that most nests in Iceland and Norway were built in Bottle Sedge (63% of nests), with smaller numbers in *Equisetum fluviatile* (12%), *Salix sp.* (7%) and *Phragmites australis* (5%). The highest densities (nests per length of bank) of nests occurred in willows or a mixture of willows and Bottle Sedge (Fjeldså

Table 3. Characteristics of nest sites of Slavonian Grebes in beds of Bottle Sedge in Scotland. Values for depths and visibility indices are also given for random sites. Water depths were adjusted to the level at the date of the first egg.

	n	Mean	S.D.	Range
Width of the sedge beds	39	12.5	5.0	4.5-27.5
Distance to shore (m)	39	7.2	4.8	1-20
Distance to open water (m)	39	5.3	4.3	1-16
Sedge density (stems m^{-2})	39	612	275	180-1184
Leaf lengths (cm)	39	107	21	62-167
Water depth at nest site (cm)	42	34.4	11.3	17-68
Water depth at random sites (cm)	42	38.9	16.4	3-83
Visibility index at nest sites	47	35.9	17.4	0-63
Visibility index at random sites	47	49.5	21.2	11-96

1973b). Bottle Sedge is the commonest emergent water plant in the Highlands of Scotland and, on many lakes, the only one which can provide cover, so this will account for its extensive use by grebes.

We found that nest sites tended to have greater cover than random sites and that water depths at nests were in the mid range of what was available. Given that nest predation is common for Slavonian Grebes (Fjeldså 1973c, Ferguson & Sealy 1983) it is probably advantageous to nest where nest cover is greatest in order to hide nests from avian and mammalian predators, and to shelter nests from wave action which can destroy nests (Fjeldså 1973c). Also, it is probably advantageous to nest where the water is deep to deter terrestrial mammalian predators. Therefore, because there are opposing gradients of cover and water depth through a sedge bed, there will be an optimum band of suitable habitat where the sedge is sufficiently dense and high and the water sufficiently deep. Given that there are fluctuations in water levels, the position of this band will vary. Forbes *et al.* (1989) also found in their study of Pied-billed Grebes *Podilymbus podiceps* that cover by emergent vegetation and water depth were the two most important variables influencing nest site selection.

Slavonian Grebes breed very late compared with most birds in Scotland. The late nesting could be attributable to the growth of Bottle Sedge which, in Highland lakes, provides little cover until June (**Figure 3**). Even later nesting by Slavonian Grebes was found in Norway and

Table 4. Results of the logistic regression analysis showing the variables affecting nest site selection of Slavonian Grebes.

Explanatory variable	Coefficient	S.E.	X^2	df	*P*
Constant	-0.3387	1.551			
Visibility	-0.0475	0.0150	11.05	1	<0.001
Water depth	0.1708	0.0876 }			
		}	8.29	2	<0.02
Water depth^2	-0.0025	0.0012 }			

Table 5. Average laying dates for first nests of Slavonian Grebes nesting in different types of vegetation in 1992 and 1993. ANOVA: $F_{(2,71)} = 8.9, P < 0.001$. There was no year effect.

	Mean date of laying	S.E. (days)	*n*
Reed beds	14 May	6	5
Branches of willows	29 May	4	10
Sedge beds	6 June	2	59

Iceland where the mean first egg date was 13 June (Fjeldså 1973c). A comparative study of sedge growth in Norway or Iceland would establish whether the laying time of the grebes is determined by the provision of cover. It is pertinent that the earliest breeding attempts in Scotland were in reed-beds or willows. The dead over-wintering stems of reeds and willow branches provide some cover before new growth. The results of this study are similar to those of Forbes *et al.* (1989) who found that Pied-billed Grebes tended to nest earlier in Cattails *Typha* spp. compared with Burreed *Sparganium eurycarpum*. The large dead stems of *Typha* persist better than *Sparganium eurycarpum* over the winter and provide the earlier nesting habitat. A consequence of late breeding is that there is opportunity for raising only one brood. Our only record of double-brooding referred to a pair which nested early in reeds. Thus, productivity may be limited partly by the nesting habitat.

The Slavonian Grebe population in Scotland is small (58 pairs in 1995) and vulnerable (41% occurred on only three lakes in 1995) (RSPB unpubl. data). The population may be partly limited by available nesting habitat, because the numbers on a given lake are related to the amount of dense bottle sedge (Summers & Mavor 1995). Therefore, the population size and range of the grebes may be increased by improving existing sedge beds and creating new ones. The latter could be achieved by digging sheltered inlets and transplanting sedges. Further, the timing of breeding could be brought forward by creating reed-beds or planting willows on the banks. This, in turn, could increase the number of nesting attempts made by the grebes, and hopefully improve productivity.

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