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ABSTRACT

Habitat use and population biology of the northern redbelly snake (*Storeria occipitomaculata occipitomaculata*) were studied at the Oak Lake Field Station to enhance existing knowledge and future management efforts for this species in eastern South Dakota. The redbelly snake is listed as a monitored species in South Dakota, species of special concern in Nebraska and protected species in Iowa. Forty three snakes were caught by hand and from drift fences from May-August 2003. Three snakes (7%) were recaptured during the sampling period. Time duration between recaptures ranged from 1-63 days and all three recaptures occurred within 50m of their first collection. Nearly twice as many females (65%) as males (35%) were collected. Snout to vent length ranged from 97 to 245 mm (mean=185 mm) and body mass (WW) ranged from 1.0-10.7 g (mean =4.4 g). Air and ground temperatures at collection locations ranged from 17.8°C to 29.6°C. Over half (65.8%) of captured snakes were found on northerly aspects with soil moisture at collection sites ranging from 0%-100% (mean=56%). Many snakes (63%) were captured on unpaved roads consisting of 90% or greater sand and gravel. Vegetation cover at collection sites ranged from 0%-100% (median=38.8%). Those sites with vegetation were dominated by grasses and forbs. No snakes were found between 1200 hrs-1600 hrs throughout the summer and more than half of snakes were captured late during the growing season (58.1% during August). This study enhances our understanding of redbelly snake habitat use and demographics in eastern South Dakota. Future efforts will focus on descriptions of hibernacula and population estimates for the Oak Lake Field Station.

INTRODUCTION

Storeria occipitomaculata occipitomaculata, the northern redbelly snake, is a rare, non-venomous species. It is one of three subspecies found throughout much of the United States and parts of southern Canada (Ashton and Doud 1991). Redbelly snakes belong to the largest snake family, Colubridae. Snakes within this family have one lung and no limb remnants (Stidworthy 1974). *S.o. occipitomaculata* has been documented in Brookings, Codington, Day, Deuel, Grant, Hamlin, Lincoln, Minnehaha, and Roberts Counties (Ashton and Doud 1991).

The northern subspecies is currently listed as a monitored species in South Dakota, but previously carried a threatened status (Ashton and Doud 1991). It is currently listed as protected in Iowa and is a species of special concern in Nebraska. No special status has been granted in North Dakota or Minnesota.

Adults of *S.o. occipitomaculata* are slender, small-bodied and can range from 20-25 cm in total length. Ground color varies from reddish brown to gray with faint brown stripes on the sides and a lighter stripe along the mid-dorsum (Ballinger et al 2000). They are reported to feed on annelids, mollusks and insects in wooded and wet habitats (Smith and Stephens 2003; Thompson and Backlund 2000; Blanchard 1937).

While the northern subspecies is widely distributed throughout the eastern United States, it does not appear to be overly abundant anywhere (Conant 1975). The species was first described by Storer in 1839 and the first detailed ecological study was conducted by Blanchard (1937) at the University of Michigan Biological Station on Douglas Lake. Blanchard's survey from 1930-1936 resulted in the collection of only 157 individuals with an average of 22 collected per year. He described the diet, size distribution, sex ratio and general habits of the snake in northern Michigan. His study is still one of the most cited life history studies of *S.o. occipitomaculata*.

In other states, *S.o. occipitomaculata* make use of rock crevices, abandoned ant mounds and animal burrows as hibernacula (Carpenter 1953). Females apparently emerge in the spring already gravid with eggs. Offspring are born alive between the months of July and August (Brodie and Ducey 1989). While few young have been captured, brood size appears to range up to 21 young per year (Oldfield and Moriarty 1994; Wright and Wright 1957) and varies with parental female size (Brodie and Ducey 1989). *S.o. occipitomaculata* approach sexual maturity by the end of their first year and first reproduction is believed to take place the following spring or summer (Semlitsch and Moran 1984).

Years of previous observation suggest that *S.o. occipitomaculata* are locally abundant within the boundaries of the South Dakota State University Oak Lake Field Station. Little is known regarding hibernacula, brood size, population size distribution, diet and specific habitat requirements of these snakes in eastern South Dakota. Thus, long-term observations and a locally abundant snake population provided the opportunity to (1) establish baseline natural history information and (2) begin population studies of *S.o. occipitomaculata* within eastern South Dakota. Oak Lake Field Station provides a good location for collecting this data because it provides optimal habitat, snakes are frequently observed and the station is near the western edge of the known distribution for this subspecies.

STUDY AREA

S.o. occipitomaculata were collected over the period May – August 2003 at Oak Lake Field Station, Brookings County, SD. Oak Lake Field Station is a 232 ha facility managed by South Dakota State University (Figure 1). This facility includes tall grass prairie, oak woodland, grazed pastures and pothole wetland

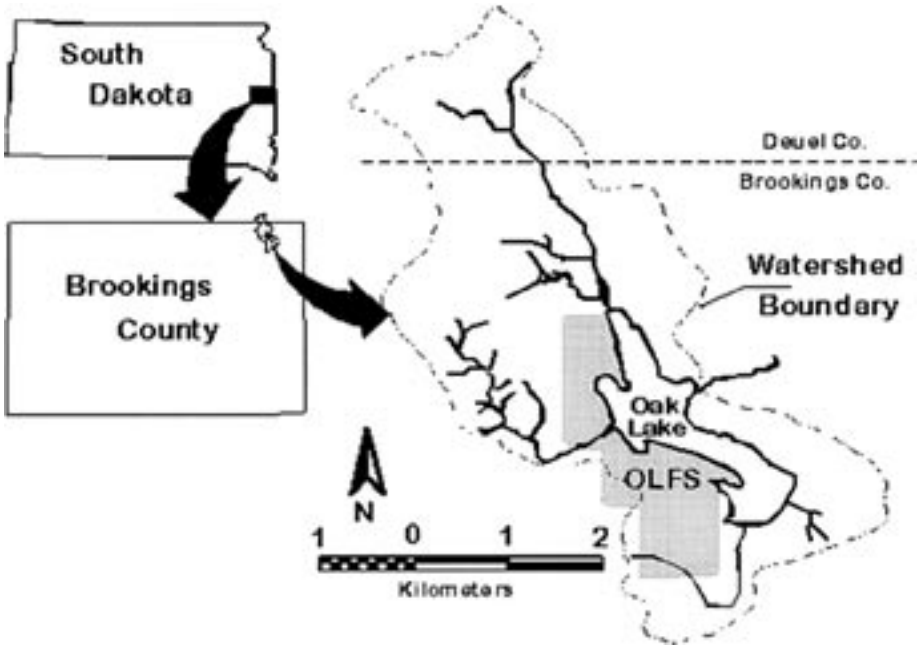

Figure 1.* S. occipitomaculata *were collected from Oak Lake Field Station in northeastern Brookings County, South Dakota during summer 2003.

environments. Observations over several years suggest that *S.o. occipitomaculata* are locally abundant.

METHODS

S.o. occipitomaculata were collected using a combination of manual searches (Blanchard 1937) and drift fences with associated pitfall traps (Floyd et al. 2002; Semlitsch and Moran 1984). Sites frequented by redbelly snakes were manually searched at intervals throughout the day and evening five days a week throughout the summer. Six drift fences were constructed and placed in areas that snakes had previously been observed and also in a varying array of habitat surroundings (Table 1). Drift fences consisted of three - 3.0 m sections of flashing separated by 11 L bucket + funnel pitfalls. Four pitfalls were buried to the ground surface in each fence. Pitfall traps were checked every 24 hours

Habitat attributes were evaluated within a 1 m^2 quadrat placed at the site of each collection. A global positioning system was used to define each collection point. Air temperature, humidity and wind speed were evaluated with a Kestrel meteorological instrument. Light intensity reaching the surface was measured with an Extech Lux meter. Soil temperature and moisture were measured with a Rheotemp soil thermometer and Lincoln soil moisture probe. Percent of ground surface with clay-silt, sand-gravel and cobble-boulder substrate was visually estimated. Percent total vegetative cover and cover of grasses, forbs, shrubs and trees at the point of collection were also visually estimated.

Table 1. Location of drift fences and pitfall traps placed at Oak Lake Field Station, Brookings County, SD.

Fence	Latitude	Longitude
1	44º 30.82'N	096º 32.47'W
2	44º 30.34'N	096º 32.00'W
3	44º 30.53'N	096º 31.96'W
4	44º 30.65'N	096º 31.96'W
5	44º 30.65'N	096º 31.75'W
6	44º 30.35'N	096º 31.76'W

Any snakes sampled from manual surveys and pitfall traps were measured (snout-vent length, SVL), sexed and marked by clipping a single ventral scale. Canadian herpetologists suggest clipping subcaudal scales as there is less risk of injury to the snake from penetration into the abdominal cavity (Ministry of Environment, Lands and Parks 1998). The clipping of the scale does not harm the snake but the mark will remain with the snake even as it sheds its skin. Scale clippings were used to mark and identify snakes. A code was devised identifying the side and number of the clipped scale (e.g., 1L). Right and left were assigned with the snake ventral side-up and the head facing away from the researcher. Snakes were clipped until scales were deemed too close to the tip of the tail. This was repeated for the right side. From this point on, snakes were double clipped (e.g., 1L1R). Clipping was performed with small hand scissors. A triangular notch was cut, which revealed a dark, almost black underside. This darkened portion contrasted greatly with the red belly and made recaptures easy to identify.

Snakes were sexed by (1) manual eversion of the hemipenal sacs and (2) breadth, length and shape of tail. Hemipene eversion can sometimes be difficult because older or large males can be difficult to evert and excess pressure may cause injury (Ministry of Environment, Lands and Parks 1998). Male snakes have a noticeably broader tail due to the presence of the retracted hemipenes in that portion of the tail (Ministry of Environment, Lands and Parks 1998). Also, male *S.o. occipitomaculata* have been found to have significantly longer tails than those of females (Semlitsch and Moran 1984). The use of a probe was considered unsafe because of small body size. Care was taken to insure snakes were released where they had been collected.

All data were entered onto spreadsheet and submitted to the Oak Lake Field Station database. A one-way ANOVA was used to compare differences in length and mass among sexes (Snedecor and Cochran 1980). Linear regression was utilized to quantify the relationship between snake mass and length. Due to the small number of recaptures, a population estimate was not calculated.

RESULTS

Forty three *S.o. occipitomaculata* were captured between the months of May and August 2003 by hand or with pitfalls at Oak Lake Field Station. Live females

(65.0%) outnumbered live males (35.0%) throughout the study period. Three snakes were found dead. These specimens were preserved and donated to the Oak Lake Field Station collection. Of the 40 snakes which were captured alive and clipped, three were recaptured later during the summer (Table 2). Two of the three recaptured snakes were collected within a week of their original capture. All three were collected within 50 meters of their original capture point.

Table 2. Date, time, body mass and length of* S.o. occipitomaculata *captured and recaptured at Oak Lake Field Station, Brookings County, SD.

Specimen	Julian Date	Time (hrs)	Weight (g)	Length (mm)
3L	155	17:20	3.2	191
3L Recapture	218	21:05	4.7	195
1R	181	9:43	2	127
1R Recapture	188	20:20	2	127
8R	217	9:20	2.9	179
8R Recapture	218	20:42	2.1	179

Snake SVL varied from 97 mm to 245 mm and averaged 185 mm (Table 3). No significant difference in SVL was observed between males and females (ANOVA, $p = 0.228$). Snake wet weight varied from 1.0 g to 10.7 g and averaged 4.4 g (Table 3). Again, no significant difference was observed between males and females (ANOVA, $p = 0.409$). However, the body mass of several individuals appeared to be below what might be expected based upon the mass-SVL relationship (Figure 2). In addition, the body mass of four individuals was far above that predicted by this relationship. These specimens may have been gravid or may have recently fed. Snake SVL was found to explain 44% of snake mass when all snake measurements were considered. However, the high body mass of four individuals were found to be statistical outliers ($p < 0.05$). When these individuals were eliminated from the analysis, snake SVL explained 72% of the variability in snake mass (Figure 2).

Table 3. Morphology of male and female* S.o. occipitomaculata *collected (minimum, median, maximum, mean and coefficient of variation (%)) at Oak Lake Field Station, Brookings County, South Dakota.

Dimension	n	Min	Med	Max	Mean	C.V.
Male Length (mm)	14	100	203	245	195	19.2
Male Mass (g)	14	1.0	4.7	10.7	4.7	48.4
Female Length (mm)	27	97	180	225	180	18.7
Female Mass (g)	27	2.0	3.8	10.2	4.1	45.4

Snake collections were conducted at set and random times during the day from 0800 hrs to 2300 hrs. Fences were also checked during each search. *S.o.*

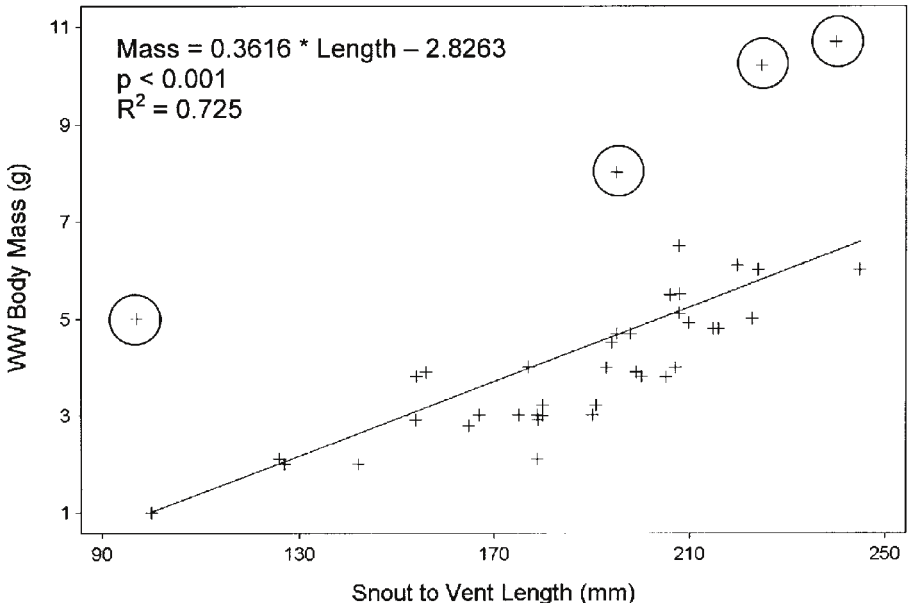

Figure 2. Relationship between S. occipitomaculata mass (WW) and snout to vent length from collections at Oak Lake Field Station, Brookings Co., South Dakota. Circled points are statistical outliers (p < 0.05).

occipitomaculata were collected during the early morning and evening hours. No snakes were collected from 1200 hrs to 1600 hrs throughout the sampling period (Figure 3). Snakes were not found until after 1700 hrs from mid-July to late August. At this time during the summer, snakes were captured from dusk (around 2000 hrs) to near midnight (2300 hrs) using hand-held flashlights and spotlights. On August 7th (2000 hrs to 2200 hrs), nine individual snakes were caught during one search. This concentration of snakes had not previously been seen nor was again seen during the project period.

Habitat measurements were made from each snake collection point. Many snakes were found on gravel roads and trails, presumably to sun or cross from one habitat range to the other. A positive correlation was found between air and ground temperatures where snakes were collected. Nearly 80% percent of collected snakes (30 of the 38 recorded) were found at air temperatures between 21° C and 26° C. A similarly high percentage of collected snakes were found on soils within this same range. More snakes were collected from habitat with northerly aspects than any other direction (65.8%). Most of the captured snakes (63%) were collected on unpaved roads consisting of 90% or more sand and gravel (Table 4). Soil moisture was typically greater than 50% of saturation and vegetative cover at collection points was typically less than 50%. Those sites with vegetative cover were dominated by grasses and forbs.

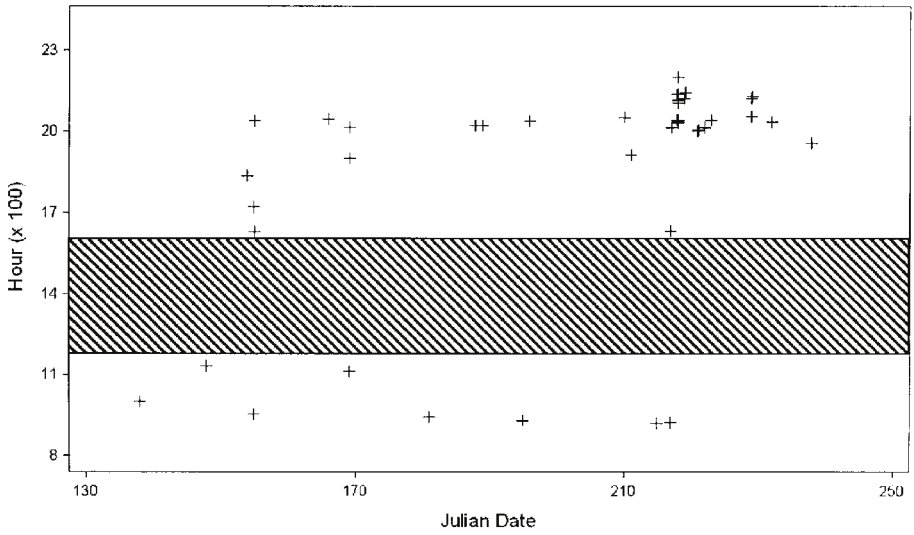

Figure 3. Variation in snake collections throughout the growing season and during the course of the day at Oak Lake Field Station, Brookings Co., South Dakota.

Table 4. Summary of habitat conditions at S.o. occipitomaculata collection points, Oak Lake Field Station, Brookings County, SD.

Dimension	n	Min	Med	Max	Mean	C.V.
Air Temperature (C)	40	17.8	22.8	29.6	23.1	9.8
Ground Temperature (C)	38	20.1	25.0	27.2	24.6	7.2
Clay & Silt (%)	42	0.0	0.0	1.0	0.2	205.6
Sand & Gravel (%)	42	0.0	0.9	1.0	0.8	43.5
Cobble & Boulder (%)	42	0.0	0.0	0.5	0.1	186.5
Soil Moisture (%)	41	0.0	80.0	100.0	56.4	71.3
Vegetative Cover (%)	42	0.0	1.5	100.0	22.6	165.0
Grasses (%)	42	0.0	0.0	100.0	16.0	187.4
Forbs (%)	42	0.0	0.0	60.0	5.6	222.4
Shrubs (%)	42	0.0	0.0	20.0	<0.1	478.3
Trees (%)	42	0.0	0.0	10.0	<0.1	648.1

DISCUSSION

Forty individual snakes were caught within a three month sampling period during this effort. It is unknown if this number is high or low for a population of *S.o. occipitomaculata* because numbers captured vary greatly from one study to another. Blanchard (1937) captured 157 individuals in Michigan over the period 1930-1936 (average of 22 per year) while Semlitsch and Moran (1984) collected 249 individuals in South Carolina over a one year period. Trapido

(1944) concluded that *S.o. occipitomaculata* may be locally abundant in some areas and totally absent in others with seemingly similar habitat.

A low recapture rate (4.7%) prevented estimation of *S.o. occipitomaculata* population size at Oak Lake Field Station. However, others have witnessed similar difficulty estimating population size using mark-recapture methods. Blanchard (1937) recaptured only 2 of 157 marked *S.o. occipitomaculata*. This low recapture success was attributed to the "interhabitat wanderings" of this species as other snake species sampled within the same study were more frequently recaptured. Semlitsch and Moran (1984) recaptured 4 of 61 marked snakes in South Carolina. They attributed low recaptures to rapid turnover of individuals within their population.

We observed a sex ratio of nearly 2F:1M at Oak Lake Field Station throughout the summer collecting period. This ratio was similar to that observed by Blanchard (1937) in Michigan. In contrast, Semlitsch and Moran (1984) collected roughly equal numbers of adult male and female snakes in South Carolina. Over half the snakes we collected were found on gravel roads in August. Female snakes give birth to live young late in the summer (Ashton and Doud 1991), so it is possible that female snakes may seek warmer, exposed areas to (1) enhance development of their young or (2) find optimal birthing locations (Blanchard 1937).

Snake size (snout to vent length and body mass) observed from this eastern South Dakota population appears to fall within the range reported from other studies. However, others have reported sexual dimorphism in body size with males exceeding females in total length (longer tails) and females exceeding males in body mass (Semlitsch and Moran 1984; Blanchard 1937).

Drift fences and pitfall traps are frequently used to collect semi-fossorial snakes (Floyd et al. 2002; Semlitsch and Moran 1984) and we employed use of this equipment in this study. However, we collected only 2 (4.7%) snakes in pitfalls and 1 snake was captured under a pitfall trap. High prairie winds frequently destroyed fences and rainfall events sometimes flooded and filled pitfall buckets with water and sediment. In addition, wildlife frequented the pitfalls and often pulled the buckets from their holes and removed the funnels. Thus, fences and pitfalls required continuous maintenance with little return. While fences and pitfalls were somewhat difficult to maintain and snakes were infrequently caught, other animals were captured throughout the sampling season. Small mammals, (esp. Least Shrew (*Cryptotis parva*) and Prairie Vole (*Microtus ochrogaster*)) were frequently caught and released. In addition, several Silphidae, Carabidae, and Gryllidae species (all Insecta) were trapped almost daily within pitfalls and released. Such frequent captures support the assumption that our fences and traps were working properly, but were not particularly effective for collecting redbelly snakes. Smith and Stephens (2003) recently recommended timed visual encounter surveys to monitor the status of the Black Hills subspecies (*S.o. pehasapae*).

S.o. occipitomaculata were found most frequently from northerly aspects. This orientation may have been related to snake preference for reduced sun exposure and lower temperatures during mid-summer. Most snakes collected from this effort were found in semi-mesic habitats with air and ground temperatures ranging between 21° C and 26° C. However, experimental studies of redbelly

snake thermal tolerance suggest that the critical thermal temperature for this species may be nearly 38º C (Brattstrom 1965). As summer air and ground temperatures commonly exceed 30º C in eastern South Dakota, one might conclude that *S.o. occipitomaculata* may be avoiding areas of direct sunlight and hot temperatures. Elick and Sealander (1972) found *S.o. occipitomaculata* to have a high resistance to desiccation compared with other small colubrid snakes. However, their study also suggested that these snakes may seek out places with high humidity to avoid dessication.

S.o. occipitomaculata is widely distributed in the eastern half of the United States but does not appear to be overly abundant anywhere (Conant 1975; Trapido 1944). This snake is currently listed as a protected species in Iowa and a species of special concern in Nebraska. Listed previously as threatened in South Dakota (Ashton and Doud 1991), this status has now been downgraded to a monitored species. No special status has been granted in North Dakota or Minnesota. Even so, factors influencing mortality are of primary importance to non-game managers. Prior to this study, several *S.o. occipitomaculata* were found partially eviscerated but otherwise intact along the roads and in tallgrass prairie habitat of Oak Lake Field Station. While these snakes had obviously been attacked by other animals, they were not even partially consumed. Two observations made during the course of this study seemed to shed light on this phenomenon. Four barn swallows (*Hirundo rustic*a) were observed to attack one snake within short, grass habitat. These birds would swoop down, pick up the snake and release it in mid-flight. The birds continued to do this until the snake was rescued. When recovered, the snake appeared unhurt (albeit stunned) with no puncture wounds evident. Another attack from an American Robin (*Turdus migratorius*) was observed in similar short grass habitat. Again, the snake was recovered before the bird had managed to cause mortal injury. Perhaps the deceased snakes observed previously had been similarly attacked by avifauna. Curiously, the victims of these attacks were not consumed. Barrett and Villarroul (1992) reported an *S.o. occipitomaculata* inside a Kestrel's (*Falco sparverius*) nest box. Smith and Stephens (2003) listed ruffed grouse (*Bonasa umbellus*), American robin (*T. migratorius*) and American kestrels (*F. sparverius*) among the known predators of redbelly snakes.

Vehicle traffic may also pose considerable threat to redbelly snakes in high traffic areas. Oak Lake Field Station roads have limited vehicle access. However, even this low traffic area witnessed mortality of three redbelly snakes from vehicles during this study. *S.o. occipitomaculata*'s tendency to "freeze" rather than "flee" from danger may increase chances of mortality from vehicular traffic.

Oak Lake Field Station appears to contain a fairly large and possibly isolated population of *S.o. occipitomaculata*. South Dakota government documents suggest that this subspecies is only found in small pockets found on the eastern edge of South Dakota (Ballinger et al. 2000; Ashton and Dowd 1991). Oak Lake appears to be an optimal study site for this species due to an abundance of mesic habitat and population size. This study has enhanced our understanding of redbelly snake habitat use and demographics in eastern South Dakota. Future efforts will focus on hibernacula use and population estimates at Oak Lake Field Station.

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