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Breeding biology of Rufous-bellied Woodpecker *(Dendrocopos hyperythrus)* in Rudraprayag District (Western Himalayas), Uttarakhand, India

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Abstract Cavity nesting species such as woodpeckers comprise a major component of many forest communities and play an important role in forest ecosystems. To conserve the population of these species, proper field observations on their breeding ecology are required. On the Indian subcontinent, there has been almost no scientific study about the breeding ecology of Rufous-bellied Woodpecker (RBW) *(Dendrocopos hyperythrus)*. We studied the breeding ecology of RBW from February 2018 to July 2020 in Rudraprayag (Western Himalayas), Uttarakhand, India. Results indicated that the breeding season of RBW extends from March to July. RBW is a primary cavity excavator in which the pair excavates the nest cavity in various tree species, such as rhododendron *(Rhododendron arboreum)*, Nepalese alder *(Alnus nepalensis)*, brown oak *(Quercus semecarpifolia)*, walnut *(Juglans regia)*, and moru oak *(Quercus floribunda)*. The most often selected tree for nest cavities in the study species was rhododendron (n=8). The average depth of the nest chamber was 29.5±6.67 cm (22–45 cm) and the diameter of the cavity entrance was 7.09±0.067 cm (7.0–7.2 cm). Nests were located at heights between 2–14 m above ground level with an average of 6.7±4.7 m. All the nesting sites found were between range 1800–2589 m a.s.l. Nests were orientated in all directions except for the North and Northeast. Twelve active nests were located on tree trunks (n=7) and branches (n=5). One nest was found abandoned before completion by the pair due to conflict with Himalayan Woodpecker *(Dendrocopos himalayensis)* which excavated a nesting cavity on the same tree. Clutch size ranged from 2–3 with an average of 2.90±0.30 (n=32). The incubation period ranged between 16–18 days (16.72±0.78 days). A total of 28 eggs hatched successfully with a success rate of 87.5%. The average fledgling period was 25.81±1.40 days (range 24–28 days). Nesting success was estimated at 81.25%.

Keywords: Indian subcontinent, breeding ecology, nesting, clutch size, breeding success, woodpecker

Összefoglalás Az odúban fészkelő fajok, mint például a harkályok, számos erdei életközösség fontos részét képezik, és fontos szerepet játszanak az erdei ökoszisztémákban. E fajok megőrzése érdekében szükség van a költési ökológiájuk tanulmányozására. Az indiai szubkontinensen szinte semmilyen tanulmány nem készült a vöröshasú fakopáncs *(Dendrocopos hyperythrus)* költési ökológiájáról, melyet 2018 februárjától 2020 júliusáig vizsgáltunk Rudraprayagban (Nyugat-Himalája), Uttarakhandban, Indiában. Az eredmények azt mutatták, hogy a szaporodási időszak márciustól júliusig tart. A vöröshasú fakopáncs elsődleges odúkészítő, különböző fafajokban készíti odúját, mint például *Rhododendron arboreum*, *Alnus nepalensis*, *Quercus semecarpifolia*, *Juglans regia* és *Quercus floribunda*. A vizsgált fajok közül a leggyakoribb fafaj a *Rhododendron arboreum* volt (n=8). A fészekkamra átlagos mélysége 29,5±6,67 cm (22–45 cm), a röpnyílás átmérője pedig 7,09±0,067 cm (7,0–7,2 cm) volt. Az odúk a talajszint felett 2–14 m (átlagosan 6,7±4,7 m) magasságban helyezkedtek el. Az összes költőhely 1,800–2,589 m tengerszint feletti magasságon volt (terjedelem: 1800–2589 m). Az odúk tájolására az északi és északkeleti irány kivételével minden égtáj jellemző volt. Tizenkét aktív odút találtunk fatörzseken (n=7) és ágakon (n=5). Egy odút a pár az odúkészítés befejezése előtt elhagyott, mert konfliktusba került egy himalájai fakopáncscsal *(Dendrocopos himalayensis)*, amely ugyanazon a fán készítette odúját. A fészekalj mérete 2–3 között változott, átlagosan 2,90±0,30 (n=32) volt. A keltetési idő 16–18 nap volt (16,72±0,78 nap). Összesen 28 tojás kelt ki

sikeresen, a sikerességi arány 87,5% volt. Az átlagos időtartam 25,81±1,40 nap volt (24–28 nap). A fészekrakás sikerességét 81,25%-ra becsülték.

Kulcsszavak: indiai szubkontinens, szaporodási ökológia, költés, fészekalj méret, költési siker, harkály

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Introduction

Woodpeckers are important components of forest communities and play a vital role in forest ecosystems. They are mainly insectivorous, and help in controlling the populations of bark living invertebrate pests by direct predation and by altering the micro-climatic conditions on tree bark (McCambridge & Knight 1972, Kroll & Fleet 1979, Otvos 1979, Kroll *et al.* 1980, Mendel *et al.* 1984). Woodpeckers are susceptible to habitat changes and act as indicators of forest biodiversity and specific forest bird species (Mikusiński *et al.* 2001). Habitat requirements and breeding success are poorly studied for many species of woodpeckers in India and particularly in the Western Himalayas, Uttarakhand, India.

As primary cavity users excavating holes in trees, woodpeckers provide nesting opportunities for secondary hole-users that often depend upon woodpecker cavities (Short 1979, 1982, Gorman 2020a). By providing sites for secondary cavity nesters such as parakeets, tits, owlets, and others, woodpeckers interact with many species and act as keystone species (Smith 2006, Diamond 2019). The conservation of keystone species is very important since a loss of them can lead to cascading negative effects in many other species from different taxonomic groups. As mentioned above, woodpeckers, as insectivores have an important role in controlling bark beetles and other insects, and ultimately in the restoration processes of natural habitats. It is known that the Rufous-bellied Woodpecker *(Dendrocopos hyperythrus)* is also a sap-sucking species (Gorman 2014, Shahabuddin *et al.* 2018).

Avian reproduction represents an integral and energetically demanding phase within the life history strategy of birds. This period necessitates substantial investment of time and metabolic energy directed towards critical reproductive behaviors, including nest site selection, nest construction, egg incubation, and the provisioning of altricial or precocial young (Fargallo *et al.* 2001, de León & Mínguez 2003, Mänd & Tilgar 2003). Unfortunately, there is limited data available on the breeding biology of the woodpeckers of the Indian subcontinent in general and of the Himalayan region in particular. Woodpeckers excavate their own nest holes, and it is difficult to locate their nests during nest making stage. As a result, there is little data available on their breeding ecology in India with only anecdotal evidence existing on the breeding phenology, number of fledglings and breeding/nesting success of the woodpeckers occurring in the country. The Rufous-bellied Woodpecker is thinly distributed and often uncommon in the study area (personal observation). Habitat varies across the range but is mainly damp subtropical jungle and upland temperate

coniferous, broadleaved and mixed forests (Gorman 2014). The range stretches across SE Asia with breeding in the Himalayas, SE Russia and NE China (possibly NW Thailand) to Indochina (Gorman 2014, Heim *et al.* 2016). Altitudinal movements in the Himalayas from 500 m to over 4,000 m are made.

Materials and Method

Study area

This study was conducted in the Kedarnath Wildlife Sanctuary (KWLS) of Rudraprayag, Uttarakhand (Western Himalayas). KWLS was established in 1972 and is situated in the north-eastern part of the Garhwal Himalayas between 30°250–30°410 N; 78°550–79°220 E *(Figure 1)*. The sanctuary falls under the IUCN management Category IV (Managed Nature Reserve) in the biogeographical province 2.38.12 of the Himalayan highlands. KWLS is one of the largest protected areas with 975.178 km^2 in the Western Himalaya. The sanctuary lies in the upper catchment of the Alaknanda and Mandakini Rivers, which are major tributaries of Ganges. It is bordered by high mountain peaks. The highest temperature recorded was 25 °C during summer and the lowest temperature observed was −10 °C during the winter seasons (IMD web). There is heavy snowfall during the winter (December–February) in the study area. A total of 485.7 km^2 area was covered during the study.

Field data collection

The study was conducted from 2018 to 2020, from the pre-breeding period until the end of the breeding season, and nests were located and marked. At each nest site, the presence of a Rufous-bellied Woodpecker was confirmed by two observers. Nesting locations of the woodpecker were located by listening to the drumming and vocalizations. It was observed that both males and females excavate many nests before the start of the breeding season and only a few are occupied by the pair for nesting purposes. Field observations were made during early morning (6:30 am to 11:30 am) and late afternoon (4:00 pm to 6:30 pm). We observed the activities of each breeding pair using Nikon binoculars (10×50mm), Canon 70 D still image camera (100–400 mm zoom lens), and a LED camera (RC_51001715 7 mm 6 LED Endoscope Waterproof Inspection Borescope Camera) was used for the inspection of nest contents. We marked nest trees with red-colored ribbons and local villagers were requested not to approach the nest trees. The number of cavities (occupied or unoccupied) was noted during the breeding season and the number of active woodpecker nests was also confirmed. Subsequently, the following nest/breeding parameters were recorded: entrance diameter, nest height above ground, depth of the nest cavity, altitude of nesting site, tree species on which cavities were found, cavity status (occupied or unoccupied), breeding parameters (clutch size, incubation period, nestling numbers and number of fledgling) and losses (eggs and nestlings). Tree cavities were measured using a collapsible ruler and a flashlight bulb, fixed with a flexible wire only after the nestlings fledged. The egg laying

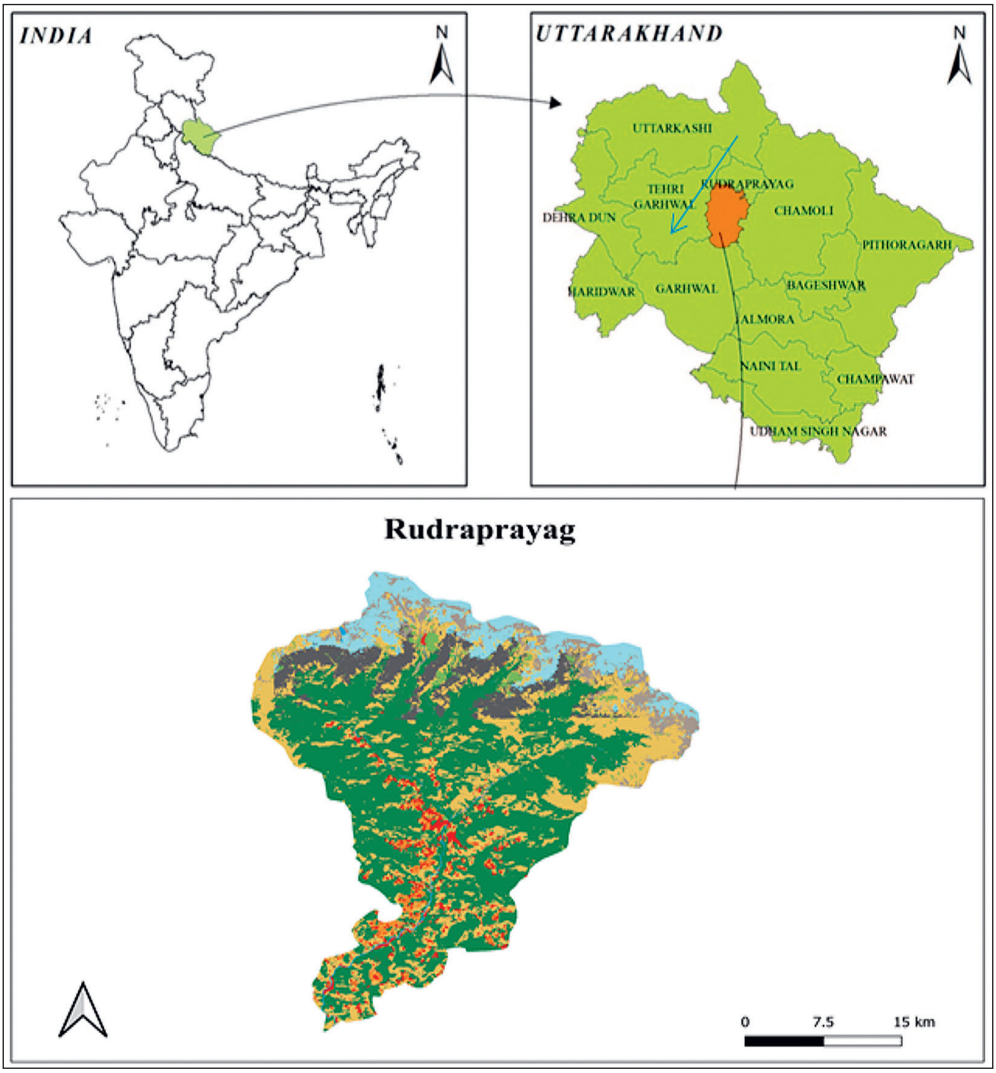

Figure 1. Map of the study area (Rudraprayag, Western Himalayas, India). Red dots represent the locations of nest sites in the lower map

1. ábra A vizsgálati terület térképe (Rudrapraang, Nyugat-Himalája, India). A piros pontok a felmért költőhelyek helyzetét mutatják

was observed through daily visit in different sites. The authors and volunteers visited each nesting cavity seven times in a week during the breeding season.

Data analysis

Nests were included only if they were truly active (i.e. had at least one egg or nestling). We began counting days, starting from zero, on the day the first egg was laid. Daily survival rate and nesting success were calculated following Mayfield's method (Mayfield 1975).

For nests whose outcome, successful or failed, was known, we stopped counting the days between the last date observed active and the subsequent nest check. For nests whose outcome was unknown, we stopped counting on the last active check. The nesting period was calculated by adding total exposure days (i.e. egg laying, incubation and nestling). In nests in which nestlings were not observed, the number of young fledged from the nests was assumed to be equal to the number of nestlings observed on the last nest visit only if the fledglings were found around the nest as the young do not leave the territory before 30 to 40 days after fledging (Kumar 1999).

Hatching success was also calculated using the traditional method formula:

$$\text{Hatching success} = (\text{No.of eggs hatched}) \div (\text{Total No.of eggs laid}) \times 100$$

MS Office Excel (version 10) was used for the data analysis.

Results

Nest tree use

Nest cavity entrances were found to be orientated in line with the direction from which direct sunlight arrived, more precisely nests were orientated in all directions except for the north and northeast *(Table 1)*.

It was also observed that slightly tilted trees were preferred for cavities and in every breeding season, the pairs created a new cavity for nesting. It is interesting to note that in the study site where rainfall was frequent. So, the RBW preferred those trees for nesting where the growth of the fungus *Trametes versicolor*, a common species in the study area was found.

Twelve cavities were excavated by the RBW during the study period on five tree species such as rhododendron *(Rhododendron arboreum)*, Nepalese alder *(Alnus nepalensis)*, brown oak *(Quercus semecarpifolia)*, walnut *(Juglans regia)*, and moru oak *(Quercus floribunda) (Table 1)*. The most often used tree species for nest building were rhododendron (n=8) and walnut (n=3) *(Table 1)*. Among the years of study, all the tree species selected for nests were close to small patches of grassland.

All the nest sites were found between 1,800–2,589 m a.s.l. The height of the nest varied between 2 and 14 m above ground level. Nests were located by inspecting all approachable snags. Nest cavities were completed in 4 to 6 weeks, and chips were more abundant as excavation proceeds. The average nest height from the ground was 6.7±4.8 m (n=12 nests). The depth of tree cavities ranged between 22 and 45 cm with an average of 29.5±6.67 cm (n=12 nests). The entrance diameter of the nests was between 7.0 and 7.2 cm with a mean of 7.09±0.07 cm. During this study 50% of the nests (n=6) were either east or southeast facing and the rest of the nest were in southwest directions. Most nests were found in March (n=5) throughout the study period *(Figure 2)*. Out of twelve cavities excavated, eleven nests were successful to raise the young, while one pair built the nest but abandoned it before egg-laying due to a conflict/fight with a Himalayan Woodpecker *(Dendrocopos himalayensis)*.

Table 1. Nesting and breeding parameters of RBW in the study site

1. táblázat A vizsgált költések paraméterei. Az oszlopok balról jobbra: fafaj, tengerszint feletti magasság, a röpnyílás tájolása, a röpnyílás talajszint feletti magassága, az odú mélysége, a röpnyílás átmérője, fészekalj méret, kotlási időszak hossza, kikelt tojások száma, fiókanevelési időszak hossza, kirepült fiatalok száma

S. No.	Tree species	Altitude of nesting site in meters	Nest cavity orientation	Height of the nest above ground (m)	Depth of cavity (cm)	Entrance diameter (cm)	Clutch size	Incubation period	Eggs hatched	Provisioning period	No. of youngs fledged
1.	*Quercus semecarpifolia*	2230	W	10	30	7.1	3	15	3	26	3
2.	*Juglans regia*	2150	NW	7	23	7.1	3	17	3	25	3
3.	*Rhododendron arboreum*	1800	E	2	40	7.0	3	17	3	25	2
4.	*Lyonia ovalifolia*	1906	SE	4	26	7.1	3	16	2	24	2
5.	*Rhododendron arboreum*	2100	NW	2.4	30	7.2	3	17	2	25	2
6.	*Juglans regia*	2200	SE	8.3	28	7.1	2	16	2	24	2
7.	*Alnus nepalensis*	2300	SW	14	45	7.2	3	17	3	28	3
8.	*Quercus floribunda*	2320	E	13	28	7.0	3	17	3	27	3
9.	*Rhododendron arboreum*	2470	W	2.1	25	7.1	3	17	2	26	2
10.	*Rhododendron arboreum*	2500	SW	2.1	29	7.1	3	18	3	26	2
11.	*Rhododendron arboreum*	2560	E	2.8	28	7.1	3	17	2	28	2
12.	*Juglans regia*	2110	SE	13	22	7.0	0	0	0	0	0
	Mean	**2220.50**	–	6.725	**29.500**	**7.091**	**2.900**	**16.727**	**2.540**	**25.818**	**2.360**
	Standard Deviation	**219.80**	–	4.780	**6.667**	**0.066**	**0.300**	**0.786**	**0.520**	**1.401**	**0.50**

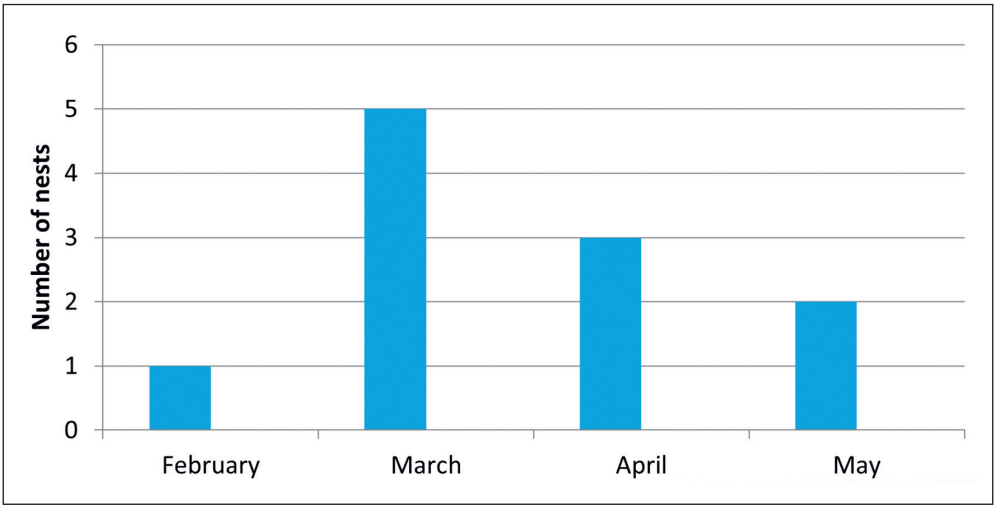

Figure 2. Monthly variation in number of nests found during the breeding season
2. ábra A talált költőodúk számának hónapok szerinti eloszlása

Clutch size and hatching success

The RBW laid a total of 32 eggs in all the nests observed during the study period. The mean clutch size of the 11 successful nests was 2.90±0.30 eggs (n=11) and ranged between 2 and 3 eggs. Out of the total 32 eggs laid 28 eggs hatched successfully. The hatching success during the study period was 87.5%

Fledgling success

Out of a total of 28 eggs hatched only 26 were fledged successfully. The fledgling success was calculated 92.85%

Nesting success

Out of a total of 32 eggs laid, only 26 young were fledged successfully from the nest. The nesting period was 35 days. The daily survival probability was 0.982 and the nesting success 81.25%

Discussion

Field observations revealed that cavities for nesting were excavated by the RBW on six tree species and the most frequently used tree species seems to be *Rhododendron arboreum*. The preference may simply be because the wood is softer where a big fungus growth takes place in the tree which makes this place more attractive. This would also explain why the RBW

makes a new cavity each year as the ones used for nesting in one year are probably not re-usable the next year due to the rotten and decaying wood.

Woodpeckers, renowned for their arboreal life stages, exhibit remarkable adaptations for excavating nesting and roosting cavities in trees, a behavior critical to their reproductive success and often beneficial to a host of secondary cavity users (Martin & Li 1992, Cornelius *et al.* 2008). This behavior has been documented for other *Dendrocopos* woodpeckers, too (Gorman 2020b, 2021). The selection of specific tree species and cavity characteristics varies considerably across woodpecker taxa, influenced by factors such as wood hardness, decay presence, and microclimatic conditions (Kozma & Kroll 2012). For instance, species like the Hairy Woodpecker *(Picoides villosus)* and Downy Woodpecker *(Dryobates pubescens)* are known to prefer softer, often decaying wood for excavation, enhancing construction efficiency (Kilham 1974). Similarly, the Black-backed Woodpecker *(Picoides arcticus)* frequently utilizes snags killed by fire, as the wood is softer and more amenable to excavation (Murphy & Lehnhausen 1998). Our field observations on the RBW further underscore the influence of wood characteristics on cavity site selection. During our study, RBW cavities were excavated on six tree species, with rhododendron being the most frequently utilized. This preference for rhododendron may be attributed to the prevalence of significant fungal growth in these trees, which softens the wood and makes it more attractive for excavation, aligning with observations in other woodpecker species where decay facilitates cavity creation (Elchuk & Wiebe 2003). This hypothesis is further supported by the RBW's tendency to excavate a new cavity each year, suggesting that the previously used sites, likely composed of extensively rotted and decaying wood, become unsuitable for subsequent nesting attempts.

This work presents the first detailed information regarding the various breeding ecology parameters of RBW including nesting success in its natural habitat. The nesting success of RBW in the study area was slightly higher (81.25%) as compared to other woodpeckers such as Lesser Spotted Woodpecker *(Dryobates minor)* (LSW). Rossmanith *et al.* (2007) reported 74.2% nesting success in LSW in German forest near Frankfurt. In general, cavity-nesting birds are known for their relatively high probability of nesting success (Martin & Li 1992). In this study, we observed very few occasions of nest predation. However, there was competition for nesting with Himalayan Woodpecker because of the same habitat they share and same tree was frequently used for nest making (Elchuk & Wiebe 2003).

According to Hogstad (2006), the mean incubation period of the woodpeckers (12.4±2.2 days) does not differ significantly from that of the secondary hole-nesters (17.6±6.3 days). In our study, the mean incubation period was 16.72±0.78 days which appears to be close to secondary hole nesters. However, when woodpeckers are compared with passerine species, they are seen to have a significantly longer nestling period (Hogstad 2006). A nestling period of about four weeks (24–28 days) was observed in this study which is higher than that of the Lesser Spotted Woodpecker (21–25 days) (Rossmanith *et al*. 2007) and passerine species in general. But clutch size was higher (mean 5.4 eggs) in LSW compared to RBW (mean 2.90 eggs). The mean nestling period of the woodpeckers (25.81±1.40 days) does not differ significantly from that of the secondary hole-nesters (22.7±6.9 days; p=0.57). However, the RBW has a longer nestling period (25.81 days) than LSW (23.2 days) and passerines

(18.5 days) (Hogstad 2006). It is generally perceived that compared with open nesters, woodpeckers have relatively small clutches (Winkler & Christie 2002). Similar observations have been made in the present study. Future studies about the role of acoustic signals in breeding biology and provisioning behavior in RBW would be important to understand the complete breeding behaviors and ecology of this species.

The breeding biology findings for the Rufous-bellied Woodpecker in Rudraprayag District, Western Himalayas, offer crucial insights for conservation and forest management practices in this ecologically sensitive region. The species' strong preference for rhododendron and other tree species exhibiting significant fungal decay for nesting cavities highlights the importance of maintaining a diversity of tree ages and health stages within the forest ecosystem.

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