GSC Biological and Pharmaceutical Sciences

eISSN: 2581-3250 CODEN (USA): GBPSC2

Cross Ref DOI: 10.30574/gscbps

Journal homepage: https://gsconlinepress.com/journals/gscbps/

(RESEARCH ARTICLE)

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# The turtle fauna of a West African rainforest (Taï national park, Côte d'Ivoire)

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GSC Biological and Pharmaceutical Sciences, 2024, 26(01), 341–348

Publication history: Received on 29 November 2023; revised on 13 January 2024; accepted on 16 January 2024

Article DOI: https://doi.org/10.30574/gscbps.2024.26.1.0008

## Abstract

The turtle population of Taï National Park (TNP), located in southwest Côte d'Ivoire, was surveyed to determine the diversity of turtles in this Park and to identify their preferred habitats. Data collection was carried out from April to October 2021 in different habitats of the park using the unmarked observation method. This method involved opportunistic sampling during reconnaissance walks for terrestrial species and baited traps were used for aquatic species. A total of four turtle species were recorded: two terrestrial species (*Kinixys erosa* and *Kinixys homeana*) and two aquatic species (*Pelusios cupulatta* and *Trionyx triunguis*). The turtle fauna study sites were composed of open undergrowth, closed undergrowth and swamp habitats for terrestrial turtles. Aquatic turtles were observed in the Meno River. According to the IUCN Red List, the species *Kinixys homeana* and *Trionyx triunguis* are classified as critically endangered and vulnerable respectively. As for the other two species, there is insufficient data to assess their international conservation status.

**Keywords:** Turtles; Diversity; Rainforest; Conservation; Taï National Park; West Africa

## 1. Introduction

Chelonians, or turtles, are among the most threatened groups of vertebrates on Earth [1, 2]. Nearly 61% of the 356 turtle species documented worldwide are considered endangered or extinct. This decline is attributed to various factors, including the destruction of natural habitats and climate change [3]. Like many long-lived species, they are characterized by high adult survival rates, late sexual maturity and low recruitment rates [4]. For over 200 million years, turtles have held a unique place in various ecosystems, contributing to crucial ecological roles such as energy transfer, participation in the calcium cycle, and the dispersal of plant seeds [3].

In Côte d'Ivoire, Taï National Park (TNP), located in the evergreen tropical forest in the southwest of the country, harbors exceptional biodiversity. However, data on the turtles of this UNESCO World Heritage Site [5] are very limited. Currently, the only study conducted on TNP turtles is by [6], focusing mainly on the systematic classification of these vertebrates. Thus, since 2012, no publication updating the results of [6]'s work is available. Yet, this forest faces some anthropogenic disturbances related to illegal mining and agricultural activities on the periphery. This deficiency constitutes a gap in the database on the herpetological fauna of TNP and limits the assessment of the ecological value of its habitats. This study aims to determine the diversity of turtles in Taï National Park. This involved identifying the different turtle species present in this park and determining their preferred habitats.

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## 2. Material and methods

### 2.1. Study area

Taï National Park (TNP), located in the southwest of Côte d'Ivoire (5° 10' to 6° 20' North latitude, 4° 20' to 6° 20' West longitude), is a protected area that spans a vast expanse of 536,000 hectares (Figure 1). It is situated between the Cavally and Sassandra rivers. The hydrographic network of TNP is dense and intricate; nearly 80% of its area is drained by the tributaries of the Cavally River (Hana, Meno and Andrénisrou), and 30,000 hectares of the park are irrigated by the San Pédro River tributary [7]. TNP is bordered by the cities of Guiglo, Buyo, San Pédro, and Tabou [8]. The current boundaries of TNP result from the merger of the former Park (457,000 hectares) and the N'Zo Wildlife Reserve (79,000 hectares) [9, 5]. To facilitate its management, TNP has been subdivided into five distinct sectors: in the North, the ADK/V6 and Taï sectors; in the Center, the Soubré and Djouroutou sectors and in the South, the Djapadji sector [5]. The climate of Taï National Park is subequatorial with two distinct seasons. According to data collected between 2008 and 2015, these seasons are distributed as follows: a major rainy season from February to November followed by a major dry season from December to January [10]. It is noteworthy that within TNP, no month passes without more or less significant precipitation. Dry seasons are characterized by low rainfall. The average annual rainfall varies from 1700 mm in the North to 2200 mm in the South [8]. Air temperatures generally range between 23 °C and 28 °C [11, 10]. The relative humidity of the air remains consistently high, oscillating between 85% and 90% under the forest canopy, with air saturation practically permanent during the night [12]. The harmattan (dry Sahara wind) is rare and barely noticeable, manifesting only for one to two weeks at most between December and January [8].

Taï National Park, along with its peripheral zone, boasts biodiversity of interest for consumption. It harbors species characteristic of ancient primary forests and significant genetic resources. There are approximately 1300 species of vascular plants, among which 12% are endemic [8]. Regarding fauna, the park is home to around 145 mammal species [13], 234 bird species [14], 60 fish species [15], 58 amphibian species [16, 17], and 51 squamate species [18, 19]. To date, six species of terrestrial and aquatic turtles have been documented in TNP [6]. Among these six species, *Pelusios gabonensis* appears to be endemic to this region.

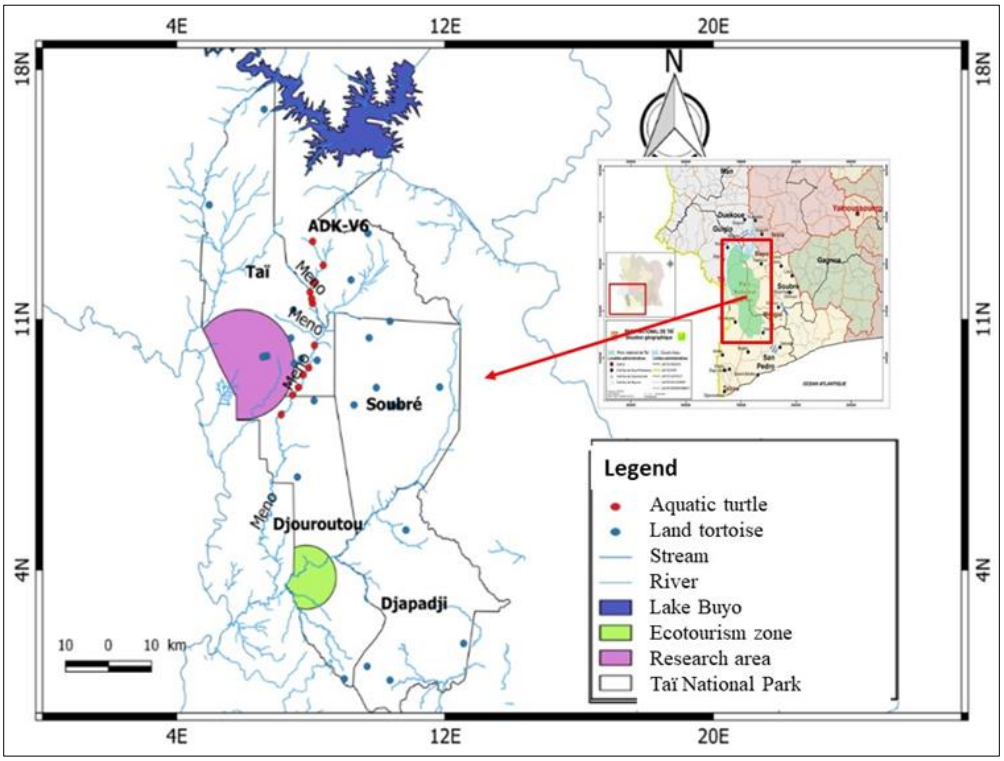


**Figure 1** Map of Taï National Park depicting sampling points for terrestrial turtles (blue) and aquatic turtles (red) across the 5 management sectors (IRI, 2022)

The turtle population was studied in four distinct habitat types (Figure 2): H1: open understory mixed forest, H2: closed understory mixed forest, H3: swampy forests (on hydromorphic soil), and H4: Meno River. The geographical positions

of all sampling points were recorded using a Garmin 64 St GPS device. Table 1 provides a brief description of each habitat type with corresponding geographical coordinates.


**Figure 2** Partial view of different habitat types in Taï National Park. (A) swampy habitat, (B) open undergrowth habitat, (C) River, (D) closed undergrowth habitat. (Photo: A.B.P. IRI, 2022)

**Table 1** Characteristics, geographical coordinates and sampling effort of the habitats surveyed in Taï National Park

| Sites | North Latitude | West Longitude | Number of visits | Sampling effort (p-h) | Description of habitats |
|---|---|---|---|---|---|
| H1 | 712990<br>709043<br>721578<br>675691<br>688525<br>696014<br>695554<br>717854 | 650889<br>635036<br>608828<br>679944<br>700857<br>644704<br>645245<br>576000 | 7 days | 126 | - Presence of tall trees<br>- Closed and/or sparse canopy<br>- Open undergrowth<br>- Abundant leaf litter |
| H2 | 707192<br>700150<br>700861<br>694760<br>708778<br>710646<br>712743 | 576285<br>637145<br>645950<br>650845<br>636613<br>637030<br>673726 | 7 days | 126 | - Presence of tall trees<br>- Closed undergrowth<br>- Presence of young shoots and vines<br>- Closed or sparse canopy |
| H3 | 691857<br>684434<br>688525<br>697161<br>688215 | 645174<br>659981<br>700857<br>646338<br>646739 | 7 days | 126 | - Presence of permanent or temporary watercourses and bodies of water (wetland environment)<br>- Presence of trees<br>- Sparse canopy |
| H4 | 700355<br>648047<br>645880<br>644287<br>642589<br>640944 | 649980<br>699650<br>699493<br>698475<br>697221<br>696098 | 7 days | 126 | - Absence of woody vegetation<br>- Sandbank<br>- Meno River |

H1: open undergrowth habitats, H2: closed undergrowth habitats, H3: swampy habitats, and H4: River

### 2.2. Sampling Method

The data collection was conducted by two individuals from April to October 2021. To determine the presence and abundance of different species in a habitat, the non-marking observation method from [20] was employed. Opportunistic sampling of terrestrial turtles was carried out across the five sectors of the park (Figure 1). Thus, three types of terrestrial habitats were meticulously searched (Figure 2A, B, and D). For aquatic turtles, sampling was performed in the Meno River (Figure 2C), which traverses the Taï and ADK/V6 sectors. Environmental parameters such as soil type and vegetation formations on the riverbank were taken into account during the turtle inventory. Active searches for turtles were conducted between 7 a.m. and 4 p.m. (the period of optimal turtle activity) with a constant sampling intensity of 9 hours per visit. Terrestrial turtles were captured by hand. Regarding the capture of aquatic turtles, baited traps were used. The identification keys from [6] were used to identify the different species. After identification, each specimen was measured using a measuring tape, weighed with a scale, and released back into its natural habitat.

### 2.3. Data Analysis

The data analysis initially involved estimating the total number of species present in TNP. This estimation of theoretical species richness was conducted using the software EstimateS (Version 9.1.0; [21]). The Jackknife 1 and Chao 2 estimators were employed for this purpose. These estimators are based on the presence or absence of species in the daily list over the entire 28 days of fieldwork. To eliminate any bias, we performed 500 random permutations of our species lists.

Subsequently, the frequency of occurrence was calculated to determine the habitat preferences of a given species. It involves counting the number of times species i appears in the samples [22]. This number is expressed as a percentage of the total number of surveys and provides information about species frequently encountered in a habitat. It is calculated as follows:

$$F = \frac{F_i \times 100}{F_t}$$

Fi = Number of surveys containing the species *i* ;
Ft = Total number of surveys conducted.

Based on the value of F, 3 species groups are distinguished:

- Constant species: F > 50% ;
- Accessory species: 25% < F < 50% ;
- Accidental species: F < 25%.

## 3. Results

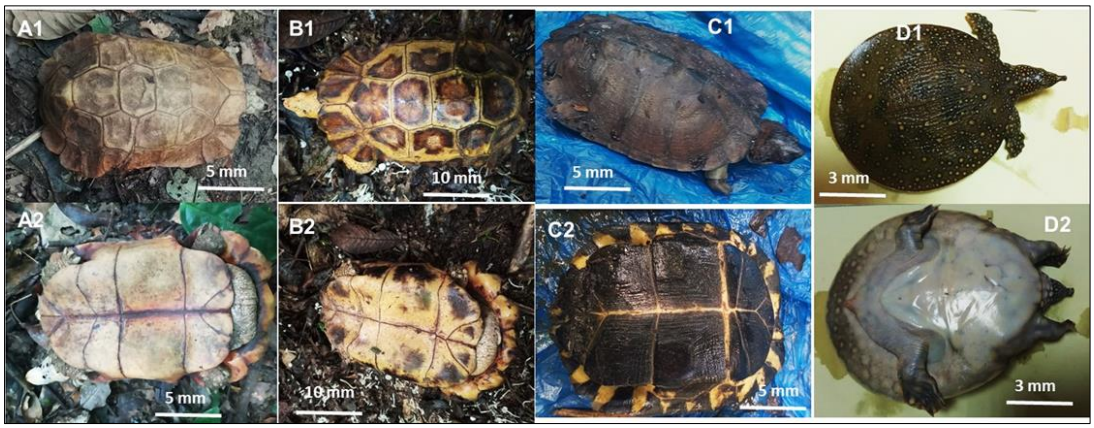


**Figure 3** Specimens (1: dorsal view; 2: ventral view) representing the observed turtle species in Taï National Park. Terrestrial species: (A) *Kinixys homeana*; (B) *Kinixys erosa*. Aquatic species: (C) *Pelusios cupulatta*, (D) *Trionyx triunguis*. (Photo: A.B.P. IRI, 2022)

In total, 4 turtle species distributed across three families and three genera were recorded in various habitats of TNP: *Kinixys homeana*, *Kinixys erosa*, *Trionyx triunguis*, and *Pelusios cupulatta* (Figure 3).

The Jackknife 1 and Chao 2 estimators allowed for the assessment of species richness at 4 species (4 ± 0 for Jackknife 1; 4 ± 0.4 for Chao 2) in the study area (Figure 4). Thus, it is likely that 100% of the local species pool has been inventoried.

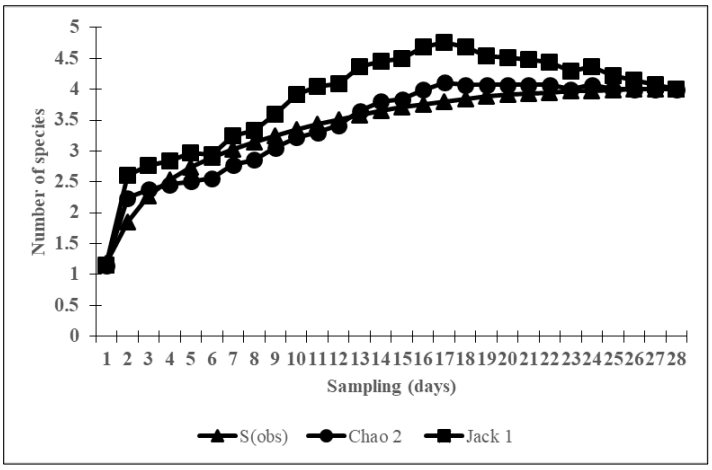


**Figure 4** Curve of observed species accumulation (triangles) and estimated species richness of turtles (Chao 2: circle, Jack-knife 1: square) in Taï National Park

The list of the four species with their preferred habitats, distribution in Africa, and their classification on the IUCN Red List is provided in Table 2. Regarding the distribution of species diversity in different habitats of TNP, the terrestrial turtles *Kinixys homeana* and *Kinixys erosa* were incidentally encountered in open undergrowth habitats (occurrence frequencies F ranging between 31.70 and 39.02 respectively). In closed undergrowth habitats, both species were accidentally observed (F = 12.19) (see Table 2). Concerning swampy habitats, only the species *Kinixys erosa* was accidentally encountered (F = 2.43). Thus, this species is common to all three types of terrestrial habitats. As for the aquatic species *Pelusios cupulatta* and *Trionyx triunguis*, they were preferentially encountered in the Meno River (Table 2). Indeed, *Trionyx triunguis* is a constant species (F = 58) in this river, while *Pelusios cupulatta* is an accessory species (F = 31).

**Table 2** List of turtle species recorded in Taï National Park, along with their preferred habitats

| **Families / Species** | **Frequency of occurrence** | | | | **Distribution in Côte d'Ivoire** | **Distribution in Africa** | **IUCN status** |
|---|---|---|---|---|---|---|---|
| | **H1** | **H2** | **H3** | **H4** | | | |
| **Testudinidae** | | | | | | | |
| *Kinixys homeana* | ** | * | | | Southwest, Central, and Southeast | West and Central Africa | CR |
| *Kinixys erosa* | ** | * | * | | Southwest and Southeast | West and Central Africa | DD |
| **Trionychidae** | | | | | | | |
| *Trionyx triunguis* | | | | *** | Southwest, Central, and East | Nile Basin, West and Central Africa | VU |
| **Pelomedusidae** | | | | | | | |
| *Pelusios cupulatta* | | | | ** | Southwest, Central, and Southeast | Liberia, Côte d'Ivoire, Ghana, and Nigeria | NE |

(H1 = Open undergrowth habitats, H2 = Closed undergrowth habitat, H3 = Swampy forests, and H4 = River), their distribution in Côte d'Ivoire; their distribution in Africa, and their IUCN status (CR = critically endangered, DD = data deficient, NE = note evaluated, VU = vulnerable); *** = Constant species, ** = Accessory species * = Accidental species.

The majority of species encountered in TNP have a broad distribution in West and Central Africa. Only *Pelusios cupulatta* appears to be restricted to four West African countries: Liberia, Côte d'Ivoire, Ghana, and Nigeria.

According to the IUCN Red List, the species *Kinixys homeana* is classified as critically endangered, and *Trionyx triunguis* is classified as vulnerable. Data on *Kinixys erosa* is insufficient, and the category for *Pelusios cupulatta* has not yet been evaluated.

## 4. Discussion

This study has contributed to a better understanding of the diversity of turtles in Taï National Park and their preferred habitats. The distribution of each turtle species was determined within this protected area.

The study identified two terrestrial species belonging to the Testudinidae family (*Kinixys erosa* and *Kinixys homeana*) and two aquatic species belonging to the Pelomedusidae (*Pelusios cupulatta*) and Trionychidae (*Trionyx triunguis*) families. This taxonomic composition mirrors that reported by [6] in TNP. Indeed, four aquatic turtle species (*Pelusios cupulatta*, *Pelusios gabonensis*, *Pelusios castaneus*, and *Trionyx triunguis*) and two terrestrial species (*Kinixys erosa* and *Kinixys homeana*) inhabit this forest. According to [6], the four turtle species recorded in this study are restricted to the Guinean Domain of Côte d'Ivoire (southern half of the country), characterized by evergreen forests, semi-deciduous forests and pre-forest savannahs. Their presence has not yet been reported in the Sudanese Domain (northern half of the country). In this northern zone, according to [6], the turtle communities present include the species *Kinixys belliana*, *Pelusios subrifa olivacea*, and *Cyclanorbis senegalensis*. During our survey, the species *Pelusios castaneus* and *Pelusios gabonensis* were not observed, likely because our samplings were conducted only on the Meno River.

The terrestrial species, *Kinixys erosa* and *Kinixys homeana*, exhibited a marked preference for forests with open undergrowth. This behavior can be attributed to the environmental characteristics of these forests. Indeed, these habitats, with abundant leaf litter, would facilitate the turtles' concealment to escape predators. Moreover, such habitats would host a diversity of prey under the leaf litter and provide optimal thermal and hygrometric conditions for the life of these vertebrates. Similar observations have been made by [23] and [24] on turtle communities in forested areas of Gabon. Additionally, [25], [26], and [27] have shown that the abundance of understory litter constitutes an ideal environment where an abundance of prey would reside. Furthermore, the dense vegetation in H2 habitats (closed undergrowth) would reduce understory visibility, hindering the observation of terrestrial turtles in this type of environment.

The aquatic turtles, *Pelusios cupulatta* and *Trionyx triunguis*, were observed on the banks of the Meno River, which serves as their nesting and thermoregulation site. These sites consist of eroded areas devoid of woody vegetation, with a sandbank along the entire shoreline. The presence of non-woody thickets near these banks provides an effective camouflage site for protecting eggs against predators [23]. However, the river remains their preferred habitat.

### 4.1. Description of the encountered species

#### *4.1.1. Kinixys homeana Bell, 1827*

*Kinixys homeana* (Figure 3A) is a small-sized forest turtle. It has a more restricted distribution than *Kinixys erosa* [6]. It follows an omnivorous diet and particularly enjoys mushrooms. It possesses a scaly shell, an articulated dorsum, with a small elongated median nuchal scale inserted between the first pair of marginal. The observed median carapace length (MCL) in this study ranges from 160mm to 270mm. The captured specimens weigh between 350 g and 2000 g. The maximum MCL obtained by [6] and [28] is smaller (220mm).

#### *4.1.2. Kinixys erosa (Schweigger, 1812)*

*Kinixys erosa* (Figure 3B) is the largest terrestrial turtle in African forests [6]. This turtle is active at night or after heavy rains. It seeks shelter under deadwood and other plant debris, in soil cavities, and in leaf litter. Its diet includes plants, fallen fruits, mushrooms, and various invertebrates. With a scaly shell and an articulated dorsum, it lacks a nuchal scale, distinguishing it from *Kinixys homeana.* The observed median carapace length (MCL) ranges from 230 to 320mm, with a weight range of 1000 g to 3000 g. [6] obtained a maximum MCL value greater than ours (160 mm to 400 mm).

#### *4.1.3. Pelusios cupulatta Bour & Maran, 2003*

*Pelusios cupulatta* (Figure 3C) is a species recently described in the southwest of Côte d'Ivoire, also known in Liberia, the southern forest of Ghana and Nigeria [6]. This forest species was previously confused with *Pelusios niger*. It is

observed in closed environments, watercourses within the forest, and flooded forest areas. *Pelusios cupulatta* has a flattened shell, with its height less than half of its width. The notch between the anal plates forms an acute angle. The observed median carapace length (MCL) in TNP ranges from 130mm to 180mm. The weights of the observed specimens vary between 300g and 700g. According to the studies of [6], the MCL ranges from 100mm to 230mm.

#### *4.1.4. Trionyx triunguis (Forskål, 1775)*

*Trionyx triunguis* (Figure 3D) is the largest turtle among African freshwater species. It frequents rivers and other large aquatic environments with sandbanks where it comes to lay eggs. It also ventures into the sea far from coastal lagoons and river mouths. Its diet includes various prey, especially fish, which it hunts by burying its shell in the sand and extending its neck to capture those within its reach. Its shell is covered with leather, and the ventral side lacks a skin flap at the rear of the plastron, near the hind limbs. The base of the hind limbs is always fully exposed. The observed median carapace length (MCL) measured on a juvenile specimen is 150 mm with a weight of 450 g. [6] obtained an MCL of 1200 mm with a weight of 60000 g in adults.

## 5. Conclusion

This study identified four turtle species in Taï National Park. The fauna consists of two terrestrial species (*Kinixys erosa* and *Kinixys homeana*) and two aquatic species (*Pelusios cupulatta* and *Trionyx triunguis*). The two terrestrial species were more frequently encountered in open undergrowth habitats than in closed undergrowth habitats. However, *Kinixys erosa* was accidentally observed in swampy habitats. As for the aquatic turtles, they are associated with the Meno River, with a higher frequency of occurrence in *Trionyx triunguis*. The distribution of these four species appears to be restricted to the southern forest of Côte d'Ivoire. Furthermore, their distribution range covers West and Central Africa, except for *Pelusios cupulatta*, which has only been identified in West Africa. Finally, the species *Kinixys homeana* and *Trionyx triunguis* are classified as critically endangered and vulnerable, respectively. As for the other two species, data are insufficient to assess their conservation status.

## Compliance with ethical standards

### *Acknowledgments*

We are grateful to the Ivorian authorities, particularly the" Ministry of the Environment, Sustainable Development and Ecological Transition", and the "Ivoirian Office of Parks and Reserves (IOPR)", for authorizing this study in the Taï national Park. We acknowledge the Jean Lorougnon Guédé University for its scientific support. We are very grateful to the "IOPR" South-West Zone Management (Soubré) for technical and logistical support. We would like to express our gratitude to the field assistants for their work during the sampling campaigns. We are grateful to the anonymous reviewers who improved the quality of this manuscript.

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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