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## Odonata of the Hlanzoun (Lokoli) swamp forest in Benin: updated checklist, new records and conservation concerns

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### Abstract

Between May 2021 and July 2021, 59 species of odonates were recorded in Hlanzoun swamp forest (Benin) - giving a total of 61 known species - representing an increase of 154% compared with the previous study, which reported 24 species. Of the 59 species observed in 2021, five are new to Benin and 14.75% of these species are strictly threatened (CR, EN, VU) according to the national expert-based Red List. With six odonates assessed as Critically Endangered in Benin, Hlanzoun is home to 75% of the country's CR species. In addition, Hlanzoun harbours the largest population of *Ceriagrion citrinum* currently known in the world. Hlanzoun could therefore be a major hotspot for dragonfly conservation in West Africa. This article also reports on the threats to the Hlanzoun ecosystem and proposes some ideas for its conservation.

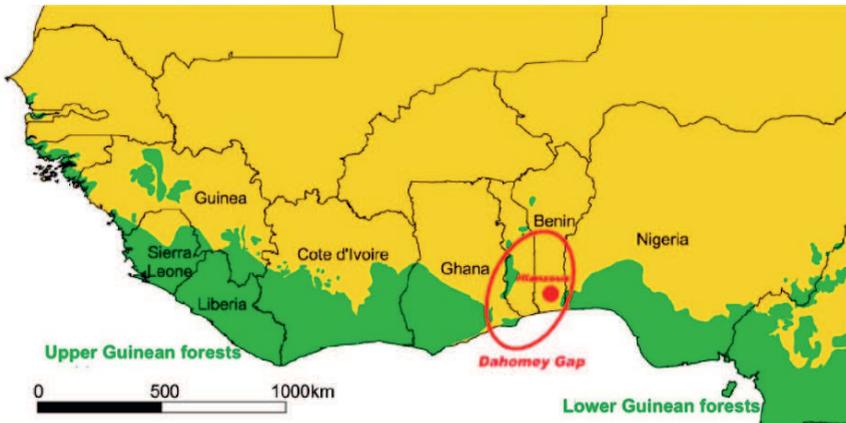
**Keywords:** damselflies, dragonflies, endangered species, *Ceriagrion citrinum*, West Africa, biodiversity, regional checklist, new country records, species conservation

### Introduction

Between May 2021 and July 2021, the NGO HUMY (contraction for “Human and Biodiversity”, and HUMY’s motto is “Acting for Biodiversity and People”) and its partner ECO-DEC NGO (Ecologie & Développement Communautaire au Bénin) initiated wildlife inventories in the Hlanzoun swamp forest – better known as the Lokoli forest – in southern Benin, and covering a large number of taxonomic groups (for details see the Methods section). Here, the name Hlanzoun will be used, as this is the real local name of this forest in the language of the local Fon people. From the beginning of May to the end of July, the Hlanzoun forest was surveyed to identify as many animal species as possible. In this article, only the results concerning Odonata are presented.

Hlanzoun is located in southern Benin, in what is known as the Dahomey Gap. This is a break created by dry forests and savannahs in the continuity of the “Guineo-Congolese” humid forest block. The Dahomey Gap thus splits the “Guineo-Congolese” forest block into two distinct entities (Fig. 1), the Upper Guinean Forest block to the west and the Lower Guinea and Congolese Forest blocks to the east (Adomou et al., 2009).

Located in the Zou department where the ethnic group of Fon comprise 91% of the population ([https://en.wikipedia.org/wiki/Zou\\_Department](https://en.wikipedia.org/wiki/Zou_Department)), Hlanzoun lies between latitudes 7°02 and 7°05 North and longitudes 2°10 and 2°18 East, mainly in the commune of Zogbodomey. The swamp forest (Fig. 2 and 3) is crossed by the Hlan River which stretches for some thirty kilometers, from its source northwest of Hlanzoun to Lake Hlan in the south of the forest (Figure 4). The area covered by the results presented here is around 4,000 ha.

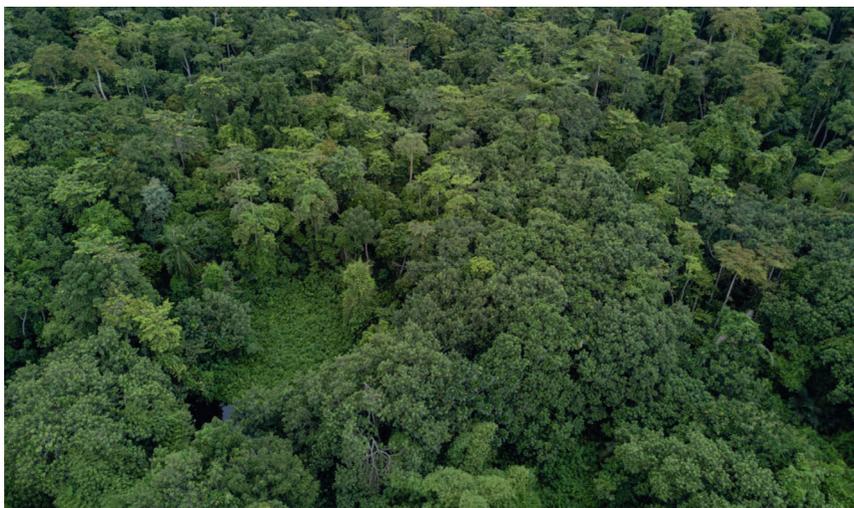


**Figure 1 :** Presentation of the Dahomey Gap and location of the Hlanzoun forest in West Africa.

The region was declared as RAMSAR site No. 1018 « Basse Vallée de l'Ouémé, Lagune de Porto-Novo, Lac Nokoué » (for more detail see: RAMSAR Sites Informations Services, 2019); in 2020, the Hlanzoun forest was officially declared as an integral part of the « Basse Vallée de l'Ouémé » (Lower Ouémé Valley) Biosphere Reserve of the UNESCO Man & Biosphere program (BVO BR UNESCO MAB) (UNESCO MAB, 2020). A previous study on the odonates (Tchiboza et al., 2008) made it possible to draw up a preliminary list of dragonflies and damselflies of Hlanzoun.



**Figure 2:** Looking north over Lake Hlan towards the Hlanzoun swamp forest.



**Figure 3: Aerial view of Hlanzoun swamp forest.**

The region is characterized by a humid tropical or sub-equatorial climate, with four alternating seasons. According to Adam & Boko (1993), there is a long rainy season from April to July, a short dry season from August to September, followed by a short rainy season from October to November, and finally a long dry season from December to March. It should be noted that this climatic characterisation dates back to the early 1990s, and might require revision due to climate change. For an assessment of the current situation see: <https://climateknowledgeportal.worldbank.org/country/benin/climate-data-historical>). In fact, during the diagnostic mission carried out between April and the end of July 2021, we noted a significant shortfall in rainfall, with the first rains only appearing in mid-July.

Hlanzoun is home to a type of hydromorphic forest that is very rare in West Africa: the climax forest of *Alstonia congensis* x *Xylopia rubescens* (Fig. 5). Some authors consider it a primary forest, while other consider it a secondary forest. In any case, botanical studies carried out on Hlanzoun's vegetation all agree that this forest is unique in Benin and West Africa. Indeed, according to Prof. Brice Sinsin (pers. comm.), Dan et al. (2010) and Adomou et al. (2009), Hlanzoun is the only swamp forest of its type with a permanent stream running through it known in West Africa, because of this it is the single location in West Africa for several plant species.

The vegetation of the Hlanzoun swamp forest and associated ecosystems can be characterised by seven vegetation types or phyto-sociological groups. These plant formations are presented below as follows, organized from the climax habitat to the most degraded habitat (regressive vegetation series) and following Dan et al. (2012):

- Flooded primary forest with *Alstonia congensis* and *Xylopia rubescens*;
- Flooded secondary forest with *Ficus congensis* and *Spondianthus preussii*; (see Fig. 6; there no identification of tree species was made, but the figure illustrates the structure and appearance of such forests)

- Raphiale (palm forest) with *Raphia hookeri* and *Anthocleista vogelii*;
- Riparian forest with *Alchornea cordifolia* and *Mitragyna inermis*;
- Swamp savannah with *Ficus asperifolia* and *Paullinia pinnata*;
- Swamp meadow with *Cyclosorus gongyloides* and *Polygonum pulchrum*;
- Swamp meadow with *Rhynchospora corymbosa* and *Ludwigia abyssinica*.

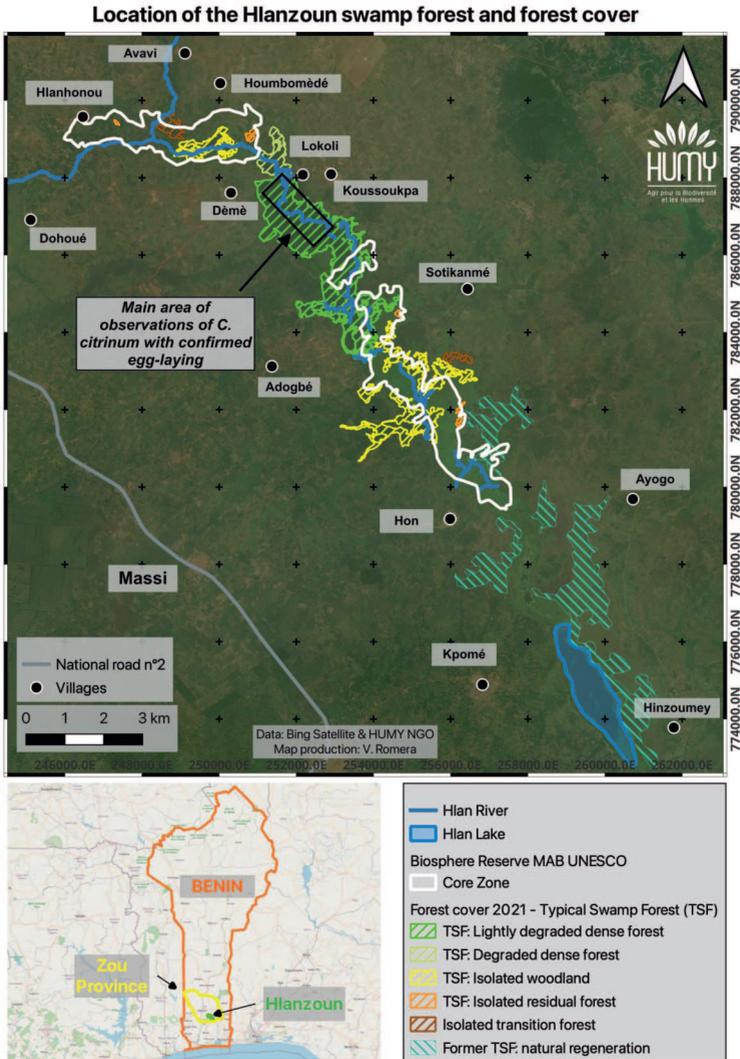


Figure 4: General location of the study area and mapping of forest cover in 2021 of Hlanzoun swamp forest.



**Figure 5:** View of the understorey on the Hlan River in the *A. congensis* and *X. rubescens* forest.



**Figure 6:** Understorey of *Ficus* sp. forest.



**Figure 7: Aerial view of an area of marshy meadows upstream from Lac Hlan (visible in the background), looking south.**



**Figure 8: From left to right: Mr Désiré one of the local guides and boatmen, Abdou Chérifou Ikoukomon (ECODEC NGO) and Vincent Romera (HUMY NGO), (photo: Arnaud Niesz).**

## Methods

As no authorization to capture odonates was obtained by the team, all odonate inventories were carried out using the photo hunting method. For this, V. Romera used a Canon 7D mk II and a Canon 100-400mm f/4-5.6 IS USM II telephoto zoom (with georeferencing of the photos via the camera's built-in GPS), and the photos were then processed using Adobe Lightroom Classic software. Sight observations were also carried out using Leica Trinovid 10x42 HD binoculars.

All photographs - with the exception of Fig. 8 - were taken by V. Romera.

For species identification, V. Romera relied mainly on the African Dragonflies & Damselflies Online – ADDO website (Dijkstra 2016), which presents the known species on the continent, detailed descriptions and identification keys, as well as known distribution maps for each species. In addition, the help of specialists on the citizen science website iNaturalist.org and on the Facebook group "Dragonflies and Damselflies of Southern Africa", and in particular the help of Klaas-Douwe Dijkstra, John Wilkinson and Robert Taylor was invaluable.

The areas surveyed were diverse and represented the vegetation types listed above, and as many biotopes along the Hlan River as possible were visited. The use of dugout canoes (Fig. 8) was essential for the study to reach sampling areas. The studied natural habitats include (1) the main watercourse of Hlan River and its tributaries (within the studied perimeter) with more or less lentic and more or less shaded environments, (2) the interior of different types of forest formations (forest with *A. congensis* x *X. rubescens*, forest with *Ficus* sp., *Raphiales* (*Raphia* sp. palm forest), (3) secondary forest with *Mitragyna* sp., etc., (4) swampy meadows, (5) anthropized/disturbed environments: abandoned crops (Fig. 10)



**Figure 9: Pioneer habitat: temporary wetland in an abandoned laterite quarry (with Little Egret). Observation site for *Lestes tridens*, *Azuragrion vansomereni* and *Orthetrum austeni*.**



**Figure 10: Example of a swampy area cleared and converted to farmland, inside a core zone of the UNESCO MAB RB.**

and (6) laterite extraction pits (pioneer environment), etc. (Fig. 9). It is important to point out here that, despite habitats that now can hardly be described as swamp forest, almost all the sites visited during the study have historically been an integral part of the former extensive forest. In fact, over the last few decades, the forest has lost a very significant surface area, a subject which will be explored in greater detail later in this article.

Given that the study involved a large number of taxa (mammals, birds, reptiles, amphibians, lepidopteran rhopalocerans and odonates), and that only the author was experienced in wildlife observation, the workload was more than considerable. As a result, individuals were not systematically counted. However, the author does provide an estimation on the relative abundance of species, particularly the rarer ones such as *Ceriagrion citrinum* (Campion, 1914).

## Results

55 odonate species were observed and identified during this study, five of which are new for Benin. To this can be added four taxa with provisional species identifications, bringing the results of the 2021 study to 59 species. Tchiboza et al. (2008) reported 24 odonate species for the Hlanzoun forest, with survey periods covering more or less the same season, but with lower survey frequencies. Compared with the list drawn up by Tchiboza et al. (2008), two species were not encountered in 2021, so the total list of known species for the Hlanzoun swamp forest amounts to 61 odonate species.

**Table 1: Checklist of Damselflies and Dragonflies of Hlanzoun swamp forest, 61 species.**

Scientific name	IUCN status	Red List Benin (provisonnaal)	Tchiboze et al., 2008	HUMY / ECODEC 2021
<b>Zygoptera (Damselfies)</b>				
<b>Calopterygidae</b>				
<b><i>Phaon iridipennis</i></b> (Burmeister, 1839)	LC	LC		X
Very common in the understorey				
<b>Chlorocyphidae</b>				
<b><i>Chlorocypha curta</i></b> (Hagen, 1853)	LC	LC	X	X
Uncommon, a few sightings on sunny stretches of the main river				
<b><i>Chlorocypha pyriformosa</i></b> (Fraser, 1947)	LC	CR	X	X
Uncommon to rare, few sightings in sunny areas of the main river, including degraded sections (Fig. 11)				
<b><i>Chlorocypha sp. (rubida/selysi)</i></b>	-	CR		X
Very rare. Only observed once; Based on the photo it is not possible to decide which of the two species was found. (Dijkstra com. pers.) (Fig. 11)				
<b>Coenagrionidae</b>				
<b><i>Agriocnemis maclachlani</i></b> (Selys, 1877)	LC	LC	X	X
Very common in the understorey				
<b><i>Agriocnemis zerafica</i></b> (Le Roi, 1915)	LC	LC		X
Common in open marsh areas				
<b><i>Azuragrion vansomereni</i></b> * (Pinhey, 1956)	LC	DD		X
Very rare, a single observation in a pioneer habitat, an abandoned laterite quarry (Fig. 12)				
<b><i>Ceriagrion citrinum</i></b> (Campion, 1914)	EN	CR	X	X
Rare and localized but can be locally abundant (Fig. 13, 23 and 24)				
<b><i>Ceriagrion corallinum</i></b> (Campion, 1914)	LC	LC	X	X
Uncommon, few sightings in sunny stretches of the main river				
<b><i>Ceriagrion glabrum</i></b> (Burmeister, 1839)	LC	LC	X	X
Common in sunny stretches of the main river				
<b><i>Ceriagrion rubellocerinum</i></b> (Fraser, 1947)	LC	LC	X	X
Fairly common in the understorey				
<b><i>Ischnura senegalensis</i></b> (Rambur, 1842)	LC	DD		X
Quite common in open marsh areas				
<b><i>Pseudagrion glaucum</i></b> (Sjöstedt, 1869)	LC	NT	X	X
Uncommon, some sightings in sunny areas of the main river (Fig. 14)				
<b><i>Pseudagrion hamoni</i></b> (Fraser, 1955)	LC	LC	X	X
Common in open areas especially in disturbed areas and pioneer habitats				
<b><i>Pseudagrion nubicum</i></b> (Selys, 1876)	LC	LC		X
Few observations in marsh areas, uncommon				
<b><i>Pseudagrion sjoestedti</i></b> (Förster, 1906)	LC	LC	X	X
Fairly rare, 3 sightings in sunny areas of the main river				
<b><i>Pseudagrion sublacteum</i></b> (Karsch, 1893)	LC	DD		X
Rare (?), a single observation on a small and degraded stream				

Scientific name	IUCN status	Red List Benin (provissonal)	Tchibozo et al., 2008	HUMY / ECODEC 2021
<b>Lestidae</b>				
<i>Lestes tridens</i> * (McLachan, 1985)	LC	DD		X
Very rare, a single observation in a pioneer habitat, an abandoned laterite quarry (Fig. 15)				
<b>Platycnemididae</b>				
<i>Copera sikassoensis</i> (Martin, 1912)	LC	LC		X
Quite common, several observations along degraded stream and the main river (open)				
<i>Elatoneura nigra</i> * (Kimmins, 1938)	LC	DD		X
Uncommon to rare, some sightings in degraded area near small stream (Fig. 16)				
<i>Mesocnemis singularis</i> (Karsch, 1891)	LC	LC		X
Uncommon, some sightings in sunny areas of the main river				
<b>Anisoptera (Dragonflies)</b>				
<b>Aeshnidae</b>				
<i>Anax ephippiger</i> (Burmeister, 1839)	LC	DD		X
Rare (?), a single observation in an open marsh				
<i>Anax imperator</i> * (Leach, 1815)	LC	DD		X
Very rare, a single observation in an open marsh (Fig. 17)				
<i>Anax tristis</i> (Hagen, 1867)	LC	VU		X
Rare (?), a single observation in an open marsh				
<i>Gynacantha cylindrata</i> (Karsch, 1891)	LC	VU	X	X
Rare, a single observation along the main river in dense forested area				
<b>Gomphidae</b>				
<i>Gomphidia gamblesi</i> (Gauthier, 1987)	LC	CR		X
Uncommon to rare, few observations along the river in sunny areas inside dense forest (Fig. 18)				
<i>Lestinigomphus</i> sp. *	-			X
Rare (?), a single observation along degraded small stream (not <i>L. minutus</i> ) (Fig. 19)				
<b>Libellulidae</b>				
<i>Acisoma inflatum</i> (Selys, 1871)	LC	LC	X	X
Common, several observations in marshes, along streams and main river				
<i>Acisoma triffidum</i> (Kirby, 1889)	LC	LC	X	X
Uncommon, same habitats as <i>A. inflatum</i>				
<i>Aethriamanta rezia</i> . (Kirby, 1889)	LC	DD		X
Uncommon (to quite rare), few observations in marshes (open and forested areas)				
<i>Brachythemis impartita</i> (Karsch, 1890)	LC	DD		X
Common in open areas especially in disturbed areas and pioneer habitats				
<i>Chalcostephia flavifrons</i> (Kirby, 1889)	LC	LC	X	X
Very common everywhere in marsh areas				
<i>Crocothemis erythrae</i> (Brullé, 1832)	LC	LC		X
Common to very common in open marshes				
<i>Diplacodes deminuta</i> *	LC	DD		X

Scientific name	IUCN status	Red List Benin (provisonnal)	Tchibozo et al., 2008	HUMY / ECODEC 2021
Very rare, a single observation in a pioneer habitat, an abandoned laterite quarry (Fig. 20)				
<i>Diplacodes lefebvreii</i> (Rambur, 1842)	LC	LC		X
Fairly common in open marshes areas				
<i>Diplacodes luminans</i> (Karsch, 1892)	LC	DD		X
Rare, few individuals in an abandoned laterite quarry				
<i>Hemistigma albipunctum</i> (Rambur, 1842)	LC	LC		X
Uncommon, a few sightings in open marshes				
<i>Nesciothemis sp.</i>	-			X
Rare (?), 2 observations along degraded small stream				
<i>Olpogastra lugubris</i> (Karsch, 1895)	LC	LC	X	X
Common along the main river, especially in clearing in forested area				
<i>Orthetrum africanum</i> (Selys, 1887)	LC	CR	X	X
Rare, 2 observations in forested area along the main river (Fig. 21)				
<i>Orthetrum austeni</i> (Kirby, 1900)	LC	DD		X
Rare, a single observation on a pioneer habitat, an abandoned laterite quarry (Fig. 26)				
<i>Orthetrum brachiale</i> (Palisot de Beauvois, 1817)	LC	LC		X
Quite common, several observations in open areas				
<i>Orthetrum chrysostigma</i> (Burmeister, 1839)	LC	DD		X
Uncommon to rare				
<i>Orthetrum sp. (hintzi)</i>	-			X
Rare (?), a single observation in an open area (uncertain ID)				
<i>Orthetrum julia</i> (Kirby, 1900)	LC	DD		X
Uncommon, few observations in degraded areas along streams				
<i>Orthetrum stemmale</i> (Burmeister, 1839)	LC	LC		X
Quite common, several observations in open areas				
<i>Oxythemis phoenicosceles</i> (Ris, 1909)	LC	LC	X	X
Common, several observations in along streams and main river in forested and degraded areas (Fig. 27)				
<i>Palpopleura lucia</i> (Drury, 1773)	LC	DD		X
Very common everywhere in marshy				
<i>Palpopleura portia</i> (Drury, 1773)	LC	DD		X
Infrequent in open marsh areas near forest				
<i>Pantala flavescens</i> (Fabricius, 1798)	LC	LC	X	X
Very common everywhere in open marsh areas				
<i>Parazyxomma flavicans</i> (Martin, 1908)	LC	DD	X	
Rare or very rare, not observed in 2021				
<i>Rhyothemis notata</i> (Fabricius, 1787)	LC	EN	X	X
Rare, 2 observations in forested area along the main river (clearing) (Fig. 22)				
<i>Trithetrum navasi</i> (Lacroix, 1921)	LC	LC	X	X

Scientific name	IUCN status	Red List Benin (provissonal)	Tchibozo et al., 2008	HUMY / ECODEC 2021
Common, several observations in marshes, along streams and main river (clearing)				
<i>Tholymis tillarga</i> (Fabricius, 1798)	LC	LC		X
Infrequent to rare (?), a single observation in open marsh				
<i>Trithemis annulata</i> (Palisot de Beauvois, 1807)	LC	LC		X
Infrequent, few observations along degraded streams				
<i>Trithemis arteriosa</i> (Burmeister, 1839)	LC	LC	X	X
Common to infrequent, few observations along degraded streams				
<i>Trithemis grouti</i> (Pinhey, 1961)	LC	DD	X	X
Infrequent to rare, few observations in forested area along the main river (clearing)				
<i>Urothemis assignata</i> (Selys, 1872)	LC	LC		X
Common in open marsh areas				
<i>Urothemis edwardsii</i> (Selys, 1849)	LC	DD		X
Infrequent, few observations in forested area along the main river (clearing)				
<i>Zyomma atlanticum</i> (Selys, 1889)	LC	CR	X	
Rare or very rare, not observed in 2021				

Species marked with a star "\*" are new records for Benin in 2021.

IUCN status: CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT = Near-threatened; LC = Least concern; DD = Data Deficient.

Table 1 lists all species recorded during field surveys carried out in 2021, and adds data from Tchibozo et al. (2008). Furthermore, the global threat status according to the IUCN Red List of Threatened Species ([www.iucnredlist.org](http://www.iucnredlist.org)) is given. Information in Table 1 is complemented by the conservation status of the species in Benin, which was proposed by Deliry (2021), and validated by S. Tchibozo. For the moment Deliry (2021), although based on the judgement of odonatological experts, only has an indicative value, as it is not official, but it is clearly relevant here.

The odonate fauna of the Hlanzoun swamp forest consists of 21 zygopterans and 40 anisopterans, a significant proportion of which are threatened or near-threatened.

The odonate fauna of Hlanzoun include one species, *Ceriagrion citrinum*, which is globally assessed as "Endangered" and nationally assessed as "Critically Endangered". *Chlorocypha pyriformosa*, *Chlorocypha* sp. *rubida/selysi* (Fig. 11), *Gomphidia gamblesi* (Fig. 18), *Orthemis africanum* (Fig. 21) and *Zyomma atlanticum* are assessed as Critically Endangered in Benin; *Chlorocypha* sp. *concerns* either *C. rubida* or *C. selysi* (K.-D. Dijkstra pers. com.), both are assessed as "CR" by Deliry (2021). *Rhyothemis notata* is rated "Endangered", *Anax tristis* and *Gynacantha cylindrata* are considered "Vulnerable", and *Pseudagrion glaucum* (Fig. 14): is assessed "Near Threatened".

14.75% of species are strictly threatened (CR, EN, VU), which appears to be representative of the overall situation in the country, with 18.3% of the Benin list considered strictly

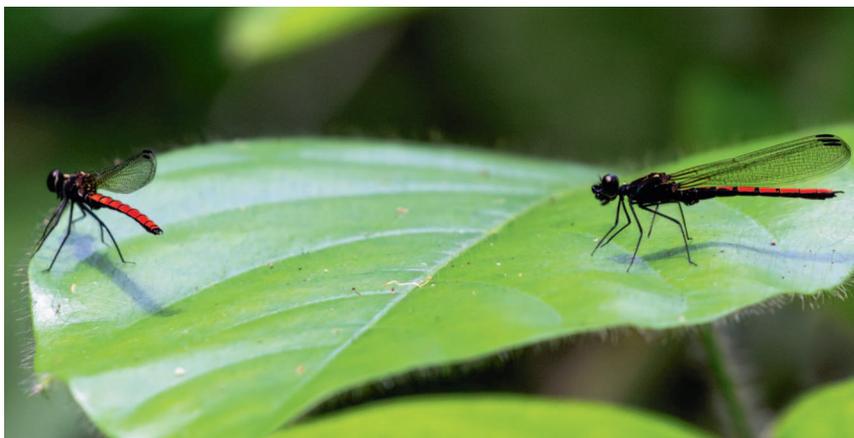


Figure 11: *Chlorocypha pyriformosa* ♂ (right) and *C. rubida* or *selysi* ♂ (K.-D. Dijkstra com. pers.) (left), all are assessed as "CR" in the proposed Red List for Benin.



Figure 12: *Azuragrion vansomereni* ♂, 1st record for Benin, assessed as "DD" in the proposed Red List for Benin.

threatened (Deliry, 2021). Only one species is assessed as "Near Threatened", and 19 have insufficient data to be assessed, i.e. 31.15%. Many of the 'DD' (data deficient) species will likely prove to be threatened at the national level when more data on Odonata in Benin as a whole becomes available.

*Azuragrion vansomereni* (Fig. 12), *Lestes tridens* (Fig. 15), *Elattonneura nigra* (Fig. 16), *Anax imperator* (Fig. 17) and *Diplacodes deminuta* (Fig. 20) are reported for the first time in



Figure 13: *Ceriagrion citrinum* ♂, globally assessed as "EN" by IUCN and as "CR" in the proposed Red List for Benin.



Figure 14: *Pseudagrion glaucum* pair, assessed as "NT" in the proposed Red List for Benin.



Figure 15: *Lestes tridens* ♂, 1st record for Benin, assessed as "DD" in the proposed Red List for Benin.



Figure 16: *Elatoneura nigra* ♀, 1st record for Benin, assessed as "DD" in the proposed Red List for Benin.



Figure 17: *Anax imperator* ♀, 1st record for Benin, assessed as "DD" in the proposed Red List for Benin.

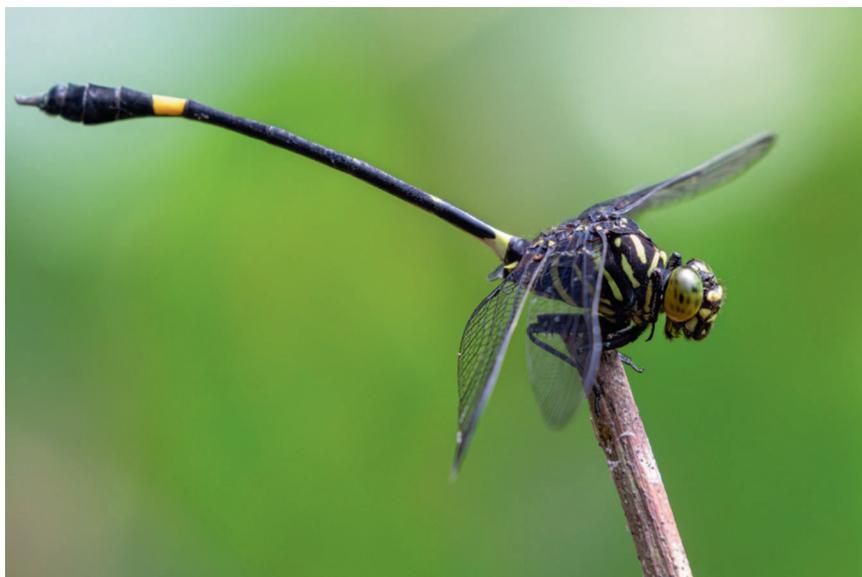


Figure 18: *Gomphidia gamblesi* ♂, assessed as "CR" in the proposed Red List for Benin.



Figure 19: *Lestinogomphus* sp. ♀, but not *L. minutus* (K-D Dijkstra pers. com.), new species for Benin but which *Lestinogomphus*?



Figure 20: *Diplacodes deminuta* ♀, 1st record for Benin, not assessed in the proposed Red List for Benin.



Figure 21: *Orthetrum africanum* ♂, assessed as "CR" in the proposed Red List for Benin.



Figure 22: *Rhythemis notata* ♂, assessed as "EN" in the proposed Red List for Benin.

Benin. In addition to these five species recorded during the Hlanzoun surveys, there was a sighting of *Nesciothemis nigeriensis* during a Sunday outing to Togbadji Lagoon in the neighboring Mono department, not part of the study area.

### Focus on *Ceriagrion citrinum* (Fig 13, 23 - 25)

This damselfly is a very rare species, known only from very few localities in south-western Nigeria and from two swamp forests in southern Benin: the Gnanhouzoumè community forest (area of intervention of ODDDB NGO, a HUMY partner since 2022) and the Hlanzoun (or Lokoli) community forest. The Gnanhouzoumè forest, where a few individuals of *C. citrinum* have been observed in the past, notably in 2002 (Tchiboza, 2020), is probably still home to the species, but no observations have been made recently (Mariano Houngbédji - ODDDB Technical Director, pers. com. 2021 & S. Tchiboza pers. com. in Dec. 2023).

In Nigeria, Ekpah et al. (2021) reports only rare sightings of the species, where *C. citrinum* is present only in the locality known as Ijele Sunmoge Creek; there, only 12 individuals were observed in 7 months of fieldwork in 2019. In Hlanzoun, between early May and mid-June 2021, in total, probably several hundreds of individuals were observed. Around 30 tandem pairs were seen simultaneously on 13th May on a heavily vegetated back-water very close to the Dèmè pier. Then on 21st June, around 40-60 tandem pairs were found simultaneously in an obviously highly favorable habitat south of the Dèmè - Lokoli line in what is called the "core zone" by local guides, which corresponds to the best-preserved portion of forest (see Fig. 4: black rectangle). These sites, where the species has been seen in large numbers, share the same characteristics: stretches of river or river back-water with particularly weak or even no currents, and highly-developed floating vegetation, with large numbers of *Salvinia* sp. (probably *S. nymphellula*), *Nymphaea lotus* and *Pistia stratiotes* forming veritable floating carpets. Unfortunately all of this floating vegetation was destroyed in May 2021 (see the Threats section below).



Figure 23: *Ceriagrion citrinum* ♂ on Palm leaf



Figure 24: *Ceriagrion citrinum*, mating couple on *Pistia stratiotes* leaf.



Figure 25: Habitat of *C. citrinum*: part of a slow-moving and heavily vegetated stream.

The hydromorphic soil (peats) in Hlanzoun and the great difficulty of accessing numerous flooded areas meant that many places were not surveyed by HUMY and ECODEC NGO, but it would appear that other sectors are also very favorable for the species. In particular, the more or less open areas within the raffia palm groves to the south of the "dense core" between the forest blocks to the north and Lac Hlan to the south, where a few isolated sightings of the species have been made. These field observations suggest that the Hlanzoun swamp forest harbours the global core population of *C. citrinum*.

## Discussion

Benin is a country that is still under-prospected by naturalists and where knowledge of certain species groups is lacking, as is the case for odonates. In 2021, at the time of the inventories and the drafting of the diagnostic mission report, the public list of known odonates in Benin comprised only 94 species (100 species including observations made in 2021 by the author). This list can be found on the "La Selysienne" website, created and maintained by Cyrille Deliry. In 2022, the list of dragonflies and damselflies known in Benin was updated to include 116 species. With 61 species, the Hlanzoun swamp forest accounts for more than half (52.6%) of the diversity of odonates currently known in the country.

Hlanzoun swamp forest is a site of national importance, and probably even the most important for dragonflies and damselflies in Benin. In addition, it seems safe to say that Hlanzoun is also habitat (Fig. 25) of the largest population of *Ceragrion citrinum* currently known. Furthermore, Hlanzoun is home to numerous other animal species that are highly threatened on a national or global scale, including several other odonates; this alone justifies the protection of this exceptional site. With six odonate species assessed as Critically Endangered in Benin (Deliry, 2021), Hlanzoun is home to 75% of the country's CR species.



Figure 26: *Orthetrum austeni* ♂, assessed as "DD" in the proposed Red List for Benin.

The 61 Odonata species recorded demonstrate that Hlanzoun and its immediate surroundings are potentially one of the most important sites for odonates in West Africa in spite of its small area (prospected area approximately 4000 ha, Hlanzoun forest with forest cover approximately 900 ha in 2021). By way of comparison, the 454,000 ha of the Taï forest in Côte d'Ivoire, often cited as one of the last primary tropical forests in West Africa, has 51 species of Odonata recorded (Legrand & Couturier, 1985), but is approximately one hundred times as large as the Hlanzoun forest area. In the Takamanda Forest reserve (Cameroon), the presence of 67 species is reported, which enjoys a wide range of ecological niches due to the variety of altitudes within the reserve's 67,599 ha: from 100 m to over 1,500 m above sea level (Vick, 2003). In Ghana, O'Neill & Paulson (2001) report 71 species caught in 8 different localities with very different ecosystems (coastal zones, savannahs and tropical rainforests). These authors also compile in their Table 2 West African localities which are at least moderately well-sampled for Odonata, showing a diversity of 33 – 92 species for ten different regional forest or savanna habitats.

The fact that we observed so many species, including five new species for the country, without capturing any individuals, shows that on the one hand the diversity of odonates in the country is still poorly known. On the other hand, there are that very likely other species to be added to the regional list. Indeed, some anisopterans, notably the Aeshnidae and Macromiidae, are almost impossible to observe perched in the field and therefore almost impossible to photograph, and capturing individuals is often the only way to identify them.



**Figure 27:** *Oxythemis phoenicosceles* ♂, assessed as “LC” in the proposed Red List for Benin.

## Threats

### Deforestation:

First and foremost, the direct destruction of the natural habitat appears to be the main cause of biodiversity erosion in the Hlanzoun swamp forest. This threat concerns all species of flora and fauna. Adomou et al. (2009) estimated the surface area of the Hlanzoun forest at 2964.96 ha, based on satellite imagery from 2000 to 2009. Following drone mapping carried out by HUMY and ECODEC in 2021, the remaining forest area is estimated at less than 900 ha. This represents a loss of more than 2,000 ha of forest cover in around 20 years, which is a reduction of forest area by approximately 70%.

Land clearing is a response to the ever-increasing demand for arable land. There are several reasons for this: on the one hand, natural human population growth is quite high, requiring an increase in agricultural production to meet local needs. On the other hand, there are more insidious factors leading to increased land clearing, such as the presence 2km from the forest of a 200-hectare industrial farm for the mass production of tomatoes (Fig. 28), or the multiplication of laterite quarries (notably in the Dèmè and Adogbé sectors) (Fig. 29). Both of these factors result in a net loss of arable land for local communities, who must compensate with new fields, which often means clearing forest areas.

With regard to the expansion of laterite quarries, it is interesting to note that the urbanization of the peripheral region of the towns Cotonou and Abomey-Calavi is having a negative effect even on the Hlanzoun swamp forest, which is almost 100km away. Indeed, the laterite extracted from the Zogbodomey region is used to fuel infrastructure development work in the Cotonou area. The negative environmental impact of development in the south of the country is also felt downstream of Hlanzoun, in the Sô River valley and on the Ouémé River, where a large number of material extraction sites are found in the riverbed (T. Helsen, IRD hydrogeologist, pers. com. and personal observation).



**Figure 28: Industrial farm producing tomatoes for export to the Asian market (China?), surface area = 200 ha.**



**Figure 29: Opening of new laterite extraction pits a few hundred meters from the edge of the Hlanzoun forest.**

Two types of clearing can be distinguished in the Hlanzoun region:

- Clearing carried out by one or more individuals from local communities for subsistence farming. This is generally done without the use of mechanized tools and usually concerns relatively small areas. This is the case, for example, on the outskirts of Dèmè and Lokoli.
- Clearing is carried out by landowners who do not, in principle, reside in the riverside communities, but who lease the newly-cleared land to their families. Clearing operations are often carried out using chainsaws, and the areas involved can be very relatively large (from a few hectares to several dozen) (Fig. 30). This type of clearing is mainly observed in the Adogbé area (map in Fig. 4) and concerns where it occurs for the establishment of oil palm plantations.

From drone photography compilation and cartographic analysis, an orthophoto map was created and a cumulative total of 23 linear km of active deforestation fronts in 2021 is visible in the study area, which is very worrying. While the total area deforested over the last 10-15 years and analyzed on the map covers 573.46 ha (of which 358 ha is largely dominated by agricultural land or heavily degraded areas in the UNESCO MAB Core Zone - north of Dèmè), if this area is combined with burnt but not logged Raphiales (Fig. 31), the total degraded area reaches 636.34 ha. The number of localized deforestation points (surface less than 1 ha) is 90 for the entire area.



**Figure 30: Large active deforestation front with corn and banana plantations prior to oil palm plantations.**



**Figure 31: Partial view of a vast oil palm grove (over 15 ha) following the destruction of the forest, with destruction in progress: on the left of the picture the trees (*Raphia hookeri* palm) have been burnt to the ground before clearing new plots.**

### **Drainage**

In May 2021, while the HUMY-ECODEC team was working in the field in the Hlanzoun forest, groups of men from riverside communities equipped with machetes and decameters were seen going into the forest to cut roots and branches of trees "obstructing the passage of water and navigation" (Fig. 32). After some investigation, it became clear that these people were being paid by an NGO involved in the OmiDelta program, which aims to improve man-



**Figure 32: The Hlan River after the curving works resulting in forest draining. Less than 72 hours before this photo was taken, the same spot was covered with an impressive quantity of *Salvinia* sp. and *Pistia stratiotes* where numerous pairs of *Ceriagrion citrinum* were mating and egg-laying.**



**Figure 33: Creation of a strong current and destruction of *Ceriagrion citrinum*' natural habitat after cleaning/draining work.**

agement of the watershed of the Ouémé River, the country's largest river. More specifically, this project to "clean up the Hlan river and control flooding of fields in the Hlanzoun area" is part of the Integrated Water Resources Management (IWRM) component of the OmiDelta project. However, no prior environmental impact assessment has been carried out for this action, which is mandatory under Beninese law. The NGO responsible of reopening the

Hlan River / streams and draining the Hlanzoun swamp forest, didn't take the time to study the local ecosystems, or take note of the site's status (RB MAB UNESCO, RAMSAR site and community forest), or even find out about the area's known conservation issues.

The direct consequences of this were:

- The rapid and significant lowering of water levels in tributaries located upstream of Hlanzoun (a drop of around 40-50cm in water level within 48 to 72 hours of the start of work), resulting in accelerated drying out of low-lying areas and fields located upstream;
- Modification of the Hlan river current (Fig. 33), with a significant increase in water velocity, leading to the downstream migration of large quantities of floating vegetation. This resulted in the destruction of numerous *Ceragrion citrinum* egg-laying sites, and consequently of the eggs themselves, since the work was carried out at the height of the species' breeding season;
- The opening up of the dense forest core, providing uncontrolled and easy access for poachers and others exploiting the forest's resources in an unsustainable way;
- Increased drying out of the external edges of the swamp forest, leading to increased clearing of the edges;
- An abnormal rise in the level of Hlan Lake, located downstream of Hlanzoun (testimonies from inhabitants of the village of Kpomé), with an increased risk of flooding for lake residents.

Although the original intentions were probably well-intentioned, it has to be said that the supervision and management of this project has been entrusted to a NGO that lacks the necessary skills to assess the environmental issues and the risks to the ecosystems. Thus, European funds initially intended for better management of a particularly complex system of wetlands were partly used to accelerate the destruction of ecosystems of very high ecological value and great importance in flood absorption (natural expansion area of the watercourse), but also to indirectly destroy the clutches of an extremely rare and endangered species.

Faced with the NGO's refusal to stop the intervention in progress, the decision was taken to contact as many scientists and competent people as possible to convince the NGO. It was only after lengthy exchanges and several meetings, and thanks to the support of renowned Beninese scientists (notably from the Laboratoire d'Écologie Appliquée (Laboratory for Applied Ecology) of the University of Abomey-Calavi), that it was finally possible to stop this destructive action for the Hlanzoun forest.

### **Other threats:**

Poaching, even for cultic purposes (such as Voodoo), does not currently affect dragonflies and damselflies. Illegal hunting is therefore not a threat to this group of species, but it is a real threat to all other animal species in Hlanzoun.

Certain methods of collecting Non-Timber Forest Products (NTFPs) can also cause significant collateral damage to natural habitats. This is the case, for example, with the collection of giant snails, where the use of fires at night, and their uncontrolled spread, can lead to the destruction of riverside vegetation, as can the collection of wild honey.

## Conclusion

The primary assessment mission carried out by HUMY and ECODEC in 2021 has enabled us to significantly improve our knowledge of the fauna of the Hlanzoun forest (in particular mammals, birds, reptiles and odonates), stop a curing / drainage action that was shaping up to be catastrophic for the ecosystems, slow down deforestation actions over the year 2021, map and evaluate forest areas, obtain a consensus between the various conservation stakeholders and local politicians on the need to consider Hlanzoun a priority conservation area.

In addition, the mapping work revealed that the UNESCO MAB zoning, and in particular the "Core Areas", did not sufficiently take into account certain sectors of the forest which appear to be the most important for biodiversity conservation (*A. congensis* x *X. rubescens* forest, *C. citrinum* egg-laying sites in particular). A proposal to extend the core zone has been sent to the relevant committee.

More specifically concerning odonates, the number of species known from the Hlanzoun swamp forest jumped from 24 to 61 species, an increase of 154% compared with the previous work. Of these, five are newly reported for Benin and six are assessed as Critically Endangered at national level (according to Deliry, 2021). By comparing the available information from different publications, it seems possible to say that Hlanzoun is the largest population of *Ceriagrion citrinum* known to date in the world. It is also probably one of the most important hotspots for odonates in the whole of West Africa.

As such, Hlanzoun corresponds to one of the descriptions of priority sites for dragonfly conservation on the African continent given by Dijkstra & Vick (2004). In Dijkstra & Vick (2004) the authors explain the importance of isolated forest islands in the middle of agricultural plains or degraded environments, which constitute reservoirs for odonate populations, and also of the importance of swamp forests, which are often poorly known. Hlanzoun meets both of these criteria.

Considering the extremely limited distribution of *Ceriagrion citrinum*, the very low number of known sightings outside Hlanzoun and the threats to Hlanzoun's natural habitats from destruction, it seems appropriate to propose the re-evaluation of this species' global conservation status from "Endangered" to "Critically Endangered". Work will be undertaken in 2024 in collaboration with the IUCN/SSC dragonfly specialist group and Séverin Tchibozo, with the aim of updating the species' conservation status.

In 2021, HUMY and its local partner ECODEC Bénin began to provide assistance to Hlanzoun's neighboring communities, notably through donations for the local health center and the delivery of three new dugout canoes for public transport between the villages of Dèmè and Lokoli. In 2022, 5 micro-nursery growers were trained and equipped, and have already produced over 15,000 trees (species and seeds native to Hlanzoun), which will be planted in 2023 in priority areas for ecological restoration. In addition, 10 beekeepers were trained in December 2023, with more to follow. Awareness-raising activities in schools and wildlife observation have begun, and a micro-credit project aimed at community women has been initiated. Thanks to funding from IUCN's Small Projects and Initiatives (IUCN PPI) program, participatory and integrated forest management will be set up (via the creation of local management committees, village committees and hunters' associations),

environmental training will be provided to administrative authorities and an ethnobotanical garden will be created. In addition, HUMY will be funding several teams of community rangers from local villages to set up a participatory surveillance system.

Even though the destruction of Hlanzoun has been slowed down, and in part stopped, since the mission, there are still many things to be done to sustain the situation in the long term. HUMY, together with its partners ECODEC Bénin and ODDB, would like to set up a number of alternative income-generating activities as soon as possible, to try and save this very special ecosystem - the Hlanzoun swamp forest - in the long term.



**Figure 34:** *Nesciothemis nigeriensis* ♂, 1st record for Benin (Togbadji Lake, Mono Province), assessed as "DD" in the proposed Red List for Benin.

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