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Floristic characterisation and population status of *Erythrina senegalensis* DC. and *Erythrina sigmoidea* Hua in the Guiriko region (Burkina Faso)

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Description of the subject. The dependence of populations on natural formations affects the survival of plant species.
Objectives. The objectives are to characterize the flora of plant formations with *Erythrina senegalensis* and *Erythrina sigmoidea* in the Guiriko region and to analyze the current state of their populations in order to guide their conservation.
Method. Floristic and dendrometric data were collected following a targeted sampling after a survey of *Erythrina* plant formations. The plant formations selected for the study were the classified forests of Péni, Dindéresso, Kuinima, Kou, and the sacred woods of the sandstone hills of Kôrô.
Results. A weakly similar floristic diversity (Cs = 0.45) with 213 and 165 species, respectively, in the *E. senegalensis* formation and the *E. sigmoidea* formation was observed with Rubiaceae, Combretaceae, Fabaceae-ceasalpinioideae, Anacardiaceae, Fabaceae-faboideae, and Fabaceae-mimosoideae as dominant families. The most dominant biological types are the Phanerophytes. A regressive population dynamic characterized by a near absence of large-diameter individuals and adult individual densities of 25.48 individuals·ha^{-1} for *E. senegalensis* and 13.15 individuals·ha^{-1} for *E. sigmoidea* was observed. The low densities of juveniles (< 50 individuals·ha^{-1}) and the low renewal potentials (< 2 individuals·ha^{-1}) observed constitute a major risk to the survival of *Erythrina* populations. The populations of *E. senegalensis* are more subject to debarking (13.30% of plants), while that of *E. sigmoidea* is more subject to bush fires (88% of plants).
Conclusions. The renewal of these species is seriously compromised in the Guiriko region. Studies must be carried out on their regeneration modes, and special protection measures must be taken in conjunction with the populations to conserve and sustainably manage them.

Keywords. Population structure, regeneration, human pressures, classified forests, West Africa.

Caractérisation floristique et états des populations d'*Erythrina senegalensis* DC. et d'*Erythrina sigmoidea* Hua dans la région du Guiriko (Burkina Faso)

Description du sujet. La dépendance des populations vis-à-vis des formations naturelles affecte la survie des espèces végétales.

Objectifs. Les objectifs sont de caractériser la flore des formations végétales à *Erythrina senegalensis* et *Erythrina sigmoidea* dans la région du Guiriko et d'analyser l'état actuel de leurs populations en vue d'orienter leur conservation.

Méthode. Les données floristiques et dendrométriques ont été collectées suivant un échantillonnage orienté à la suite d'une prospection des formations végétales à *Erythrina*. Les formations végétales retenues pour l'étude ont été les forêts classées de Péni, Dindéresso, Kuinima, Kou et les bois sacrés des collines gréseuses de Kôrô.

Résultats. Une diversité floristique faiblement similaire (Cs = 0,45) avec 213 et 165 espèces respectivement dans la formation à *E. senegalensis* et dans la formation à *E. sigmoidea* a été observée avec les Rubiaceae, les Combretaceae, les Fabaceae-ceasalpinioideae, les Anacardiaceae, les Fabaceae-faboideae et les Fabaceae-mimosoideae comme familles dominantes. Les types biologiques les plus dominants sont les Phanérophytes. Une dynamique en régression des populations avec une quasi-absence d'individus de gros diamètres et des densités d'individus adultes de 25,48 individus·ha^{-1} pour *E. senegalensis* et 13,15 individus·ha^{-1} pour *E. sigmoidea* a été obtenue. Les faibles densités des juvéniles (<< 50 individus·ha^{-1}) et les faibles potentiels de renouvellement (< 2 individus·ha^{-1}) observés constituent un risque majeur pour la survie des populations d'*Erythrina*. Les populations de *E. senegalensis* sont plus sujettes à l'écorçage (13,30 % des individus) tandis que celles de *E. sigmoidea* présentent des impacts de feux de brousse (88 % des individus).

Conclusions. Le renouvellement de ces espèces est gravement compromis dans la région du Guiriko. Des études doivent être menées sur leur mode de régénération et des mesures de protection doivent être prises de concert avec les populations pour leur conservation et gestion durable.

Mots-clés. Structure de la population, régénération, pressions anthropiques, forêts classées, Afrique de l'Ouest.

1. INTRODUCTION

Africa harbours an exceptionally high level of biological diversity, which is essential for the future of the planet (Avikpo et al., 2017). A significant portion of this diversity is preserved within natural formations or protected areas. Plant species colonise these habitats and offer a variety of ecosystem services to humans and animals, contingent upon their capacity to adapt to environmental conditions and their ecological requirements. Several studies have shown that humans exploit a number of plant species for the various products and services they provide to local populations (Bélem et al., 2017; Kouadio et al., 2020). This situation has led to the overexploitation of multipurpose tree species with high socio-economic potential, thereby placing their populations in a regressive dynamic characterised by the scarcity or absence of juvenile individuals (Ouédraogo et al., 2006). Furthermore, several studies have reported that population dependence on natural formations affects the richness, structure, density, and basal area of woody species (Sahoo & Davidar, 2013; Sharma & Kant, 2014). Consequently, the phytodiversity of protected areas is under threat due to the combined effects of demographic and anthropogenic pressures, as well as climatic disturbances.

In Burkina Faso, surveys conducted in protected areas have revealed a list of species that are overexploited due to their high value for local populations (Mbayngone & Thiombiano, 2011; Zerbo et al., 2022). These include *Erythrina senegalensis* DC. and *Erythrina sigmoidea* Hua, two species that are listed on the IUCN Red List. Field observations have revealed evidence of exploitation of *Erythrina* individuals. Furthermore, a scarcity or even absence of these two species has been observed in certain vegetation formations of the country despite the fact that they are endemic to these areas (Thiombiano et al., 2012; Arbonnier, 2019).

According to the studies of Ouédraogo (2006), Ouoba et al. (2006), Traoré (2013) and Tindano (2016), *E. senegalensis* is widely distributed in the Sudanian zone of Burkina Faso. In contrast, *E. sigmoidea* is only referenced in the catalogue of vascular plants of Burkina Faso by Thiombiano et al. (2012), probably due to its restricted distribution or its status as an endangered species. The importance of these species, particularly in traditional medicine in West Africa, has been highlighted by several studies (Togola et al., 2008; Catarino et al., 2016; Frazao-Moreira, 2016; Dougnon et al., 2017; Sangaré et al., 2024). In Burkina Faso, *E. senegalensis* is used to treat pericardial pain (Ouoba et al., 2006), urinary tract infections (Kam et al., 2020), malaria, haemorrhoids, colds, coughs, yellow fever, mental health issues, and epilepsy (Sangaré et al., 2024). The species *E. sigmoidea* is used to treat malaria, haemorrhoids, yellow fever, eye ailments, and sexual weakness (Sangaré et al., 2024). However, such exploitation threatens the survival of these species, particularly *E. sigmoidea*, which appears to be declining in certain areas (Sangaré et al., 2024).

Studies of the floristic and ecological characteristics of vegetation formations associated with a given species have often helped to restore declining populations and prevent their disappearance (Rabarison et al., 2013; Vitoekpon et al., 2018). Indeed, such studies provide essential information on the environmental conditions necessary for the survival, regeneration, and growth of species, as well as on interactions with other species within the ecosystem. They have also enabled the development of appropriate management plans that promote the restoration of degraded habitats and the implementation of effective conservation strategies. In the case of many threatened species, such as certain members of the Fabaceae family, understanding the vegetation formations with which they are associated has been essential for their reintroduction to ecosystems from which they were on the verge of disappearing (Mukenza et al., 2022). However, very limited information is available on the floristic and ecological characteristics of formations dominated by *E. senegalensis* and *E. sigmoidea* in Burkina Faso. For improved *in situ* and *ex situ* conservation of plant species, however, the adoption of sustainable harvesting techniques and a thorough understanding of their environment, dynamics, associations, and functioning are essential (Ouoba, 2006). Therefore, it is necessary to obtain scientific information on formations containing *E. senegalensis* and *E. sigmoidea* in Burkina Faso in order to identify favourable conditions for their preservation and prevent irreversible population decline. The present study was conducted within this context, with the overall objective of contributing to improved knowledge for the conservation and sustainable management of *E. senegalensis* and *E. sigmoidea* in Burkina Faso. Specifically, the study aims to characterise the floristic composition of formations containing *E. senegalensis* and *E. sigmoidea* in the Guiriko region and analyse the current status of their populations.

2. MATERIALS AND METHODS

2.1. Study environment

The study was conducted in the classified forests of Dindéresso, Kuinima, Péni and Kou, and in the sacred woods of the sandstone hills of Kôrô in the Guiriko region (**Figure 1**). This area has a Sudano-Sahelian climate, characterised by a dry season from October to April and a rainy season from May to September. Mean annual rainfall ranges from 747.9 mm to 1,349.8 mm. The highest temperatures are mainly observed in March (37.38° C) and April (37.92 °C), while the lowest occur in January (18.04 °C) and September (21.54 °C) (ASECNA/Bobo-Dioulasso Meteorological Service, 2024). The soils are gravelly, sandy, sandy-loamy, and hydromorphic. Vegetation formations encountered include wooded savannahs, open forests, a few remnants of dense forests, and gallery forests along watercourses. Floristically, most of the woody species of the Sudanian domain are present, with the most frequently encountered being *Afzelia africana* Sm. ex Pers., *Vitellaria paradoxa* C.F.Gaertn., *Detarium microcarpum* Guill. & Perr., *Parkia biglobosa* (Jacq.) R.Br. ex G.Don, *Lannea acida* A.Rich., *Combretum* sp., *Pterocarpus erinaceus* Poir., *Isoberlinia doka* Craib & Stapf ex Holland, *Anogeissus leiocarpa* (DC.) Guill. & Perr., and *Khaya senegalensis* (Desr.) A.Juss. (Thiombiano & Kampmann, 2010).

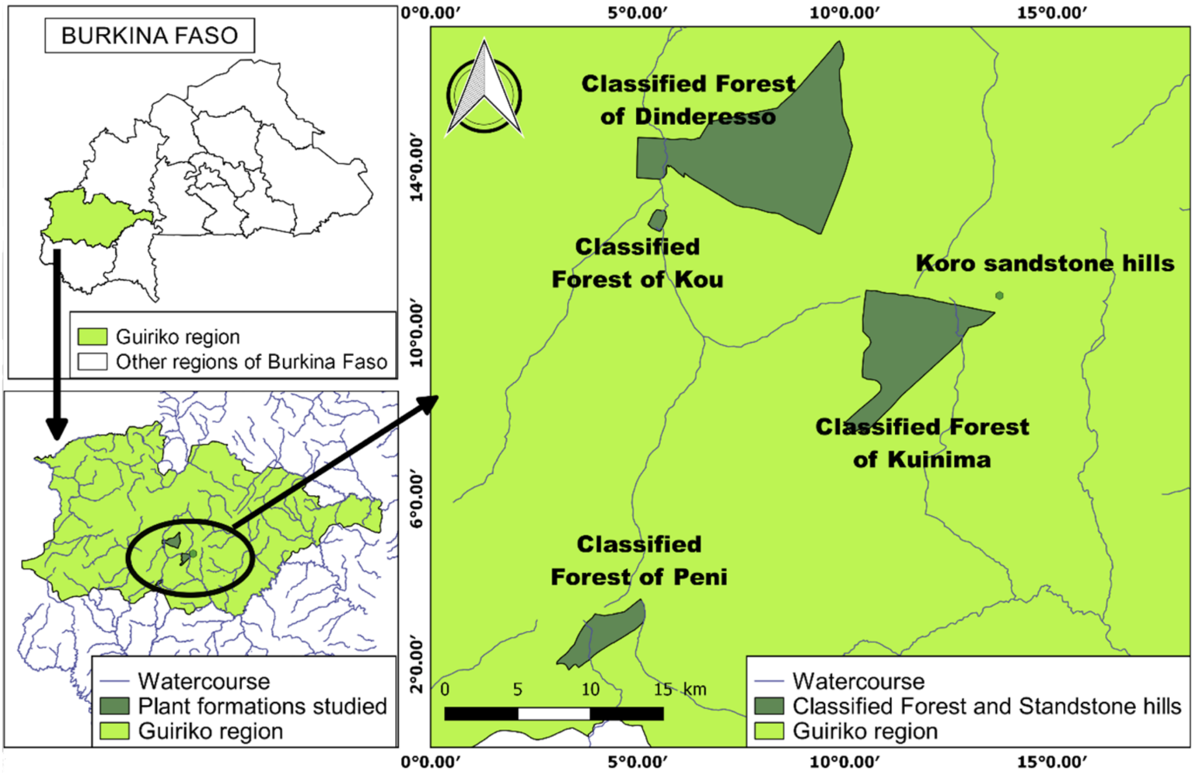

Figure 1. Location map of study sites – *Carte de localisation des sites de l'étude*.

Sources: BNDT, 2012 ; GPS surveys 2024.

2.2. Sampling

The identification of *Erythrina* formations in Burkina Faso was made possible through a literature review of previous studies conducted in the country (Ouédraogo, 2008; Thiombiano et al., 2016; Tiendrébeogo, 2023), investigations with local communities and key informants, and field surveys. Formations were selected based on the presence of at least one studied *Erythrina* species, the relatively high density of individuals of that or those species, and the accessibility of the site.

A targeted sampling approach involving the active search for individuals of *Erythrina* species was used to characterise their associated flora. This approach is suitable for the study of rare or threatened species (Acharya et al., 2000), although it does not allow for landscape-scale inferences. *Erythrina sigmoidea* is rare with a highly fragmented distribution, while *Erythrina senegalensis* is threatened and also has a fragmented distribution. Random or systematic sampling would risk failing to detect them altogether.

Surveys were conducted by stratum and were targeted (Nacoulma, 2012) according to the presence of at least one individual of the genus *Erythrina*. For each *Erythrina* species, at least 30 sampling points were established around each *Erythrina* plant community, wherever possible. For the adult woody stratum, survey plots covered 900 m² (30 m × 30 m) in savannah formations and open forest formations, and 500 m² (50 m × 10 m) in gallery forests and riparian forest formations, following the recommendations of the Niamey workshop (Thiombiano et al., 2016). These plot sizes have been used in our study region by several authors (Ouoba, 2006; Tiendrébeogo et al., 2022). The same adult woody stratum plots were used to study the woody regeneration of *Erythrina* woody species (Kabré et al., 2020). This choice was made in consideration of the rarity of these species, for the regeneration study.

2.3. Data collection

For each survey plot, a comprehensive list of species was compiled, and *Erythrina* individuals were recorded, counted, and measured for their diameter at breast height (DBH) at a height of 1.30 m above the ground and their total height (Ht). Individuals were classified as adults if their DBH was ≥ 5 cm and their Ht was ≥ 1.50 m, and as juveniles if their DBH was < 5 cm. To assess regeneration, juvenile individuals (DBH < 5 cm) were counted and grouped into height classes at 0.5 m intervals (Traoré, 2013). The health status of each *Erythrina* individual was recorded using the following code: 1) for apparently healthy individuals; 2) for pruned individuals; 3) for debarked individuals; 4) for uprooted individuals; and 5) for parasitised individuals.

2.4. Data analysis

Floristic richness and diversity. Species were identified, firstly, using the floras of Lebrun & Stork (1991–1997), Aubréville (1950), Hutchinson & Dalziel (1954–1972), and the botanical guide by Arbonnier (2019). Then, a list of the recorded species was compiled. These were subsequently classified by genus, family, biological type, and phytogeographical type. The spectra of families, biological types, and phytogeographical characteristics were presented in graphical form using Excel 2019. The same Excel spreadsheet was then used to calculate the diversity indices presented below:

Index	Formula	Characteristics
Shannon-Weaver diversity index (H')	$(H') = -\sum pi \log_2 (pi)$ where pi is the frequency of species i.	H' is expressed in bits per individual and ranges from the lowest diversity (0 bits) to the highest (4.5 bits). H' = 0 if all individuals in the stand belong to the same species; H' < 2.5 = low diversity; 2.5 ≤ H' < 4 = medium diversity; H' ≥ 4 = high diversity. pi calculated from abundance.
Pielou equitability index (1966) (E)	$(E) = \frac{H'}{H'max}$ with $H'max = \ln (S)$ where S is the total number of species in the *Erythrina* formation.	E expresses the regularity and even distribution of individuals among species. It ranges from 0 to 1, approaching 0 when one species is dominant and approaching 1 when individuals are evenly distributed among species.
Sorensen similarity index (Cs)	$Cs = \frac{2j}{(2j + a + b)}$ where j = number of species common to the different sites, a = number of species from site A, and b = number of species from site B.	Cs was calculated to assess the similarity among *Erythrina* formations. This index ranges from 0 to 1, with a value close to 1 indicating a high degree of similarity among the different formations.

To identify the characteristic species of the ecosystems of the two plant species studied, an indicator species analysis was performed using the Indicator Value Index (IVI) method developed by Dufrêne & Legendre (1997). This analysis was conducted using PC-ORD software version 7.10 (Ouoba, 2006). The method combines species specificity and fidelity to provide an IVI index ranging from 0 to 100.

The significance of the results was tested using Monte Carlo permutation tests (n = 4,999) at a significance level of 0.05

Dendrometric and structural characterisation of *Erythrina* populations. A dendrometric and structural assessment was performed by calculating the density (D) of individuals of each *Erythrina* species using the formula $D = 10{,}000 \text{ x } \frac{n}{S}$, where n is the total number of individuals of the *Erythrina* species considered, and S is the surface area of the plot (in m²).

The diameter and height structures of the *Erythrina* populations were determined for each *Erythrina* species. These were expressed as the distribution of individuals across diameter classes starting from 5 cm (Traoré, 2013), and height classes starting from 2 m, fitted to a three-parameter Weibull distribution. This Weibull distribution was chosen due to the high variability of its shapes depending on the values taken by its parameters. Its probability density function, f, is given by the following formula :

$$f(x) = \frac{a}{b}[(\frac{x-a}{b})]^{c=1} \text{Exp}\,[-(\frac{x-a}{b})]^{c}$$

with x = tree diameter ; f(x) = probability density value ; *a* = position parameter: it is equal to 0 if all trees categories are considered during the inventory, and it is non-zero if only trees with a diameter or height greater than or equal to *a* are considered. In this study, *a* is set to 5 cm for tree diameters and 1.50 m for the height of adult individuals ; *b* = scale or size parameter, related to the central value of the diameters of the trees in the population considered ; *c* = shape parameter linked to the diameter or height structure under consideration (**Table 1**). The Weibull parameters were calculated using Minitab 19 software and the structure graphs were established using Excel 2019.

Table 1. Shape of the Weibull distribution according to the values of parameter c – *Forme de la distribution de Weibull selon les valeurs du paramètre* c.

c < 1	Inverted "J" distribution, characteristic of multispecific or uneven-aged stands
c = 1	Exponentially decreasing distribution, characteristic of populations on the verge of extinction
1 < c < 3.6	Positive asymmetrical or straight asymmetrical distribution, characteristic of monospecific stands with a predominance of young or small-diameter individuals
c = 3.6	Symmetrical distribution, normal structure, characteristic of even-aged or monospecific stands of the same cohort
c > 3.6	Negative asymmetrical or left asymmetrical distribution, characteristic of monospecific stands with a predominance of older individuals

To detect the spatial patterns of *E. senegalensis* and *E. sigmoidea* individuals within stands, the Blackman index (IB) was calculated (Hamawa et al., 2018).

$$IB = {\delta^2}/{\mu}$$

with δ^2 and μ, respectively the variance and mean density of the species in the plant formation considered. The distribution is regular (or uniform) if IB < 1; random if IB = 1 and aggregated (or clumped) if IB > 1.

***Erythrina* sanitary status and population dynamics.** Population status and dynamics were, firstly, assessed by counting healthy, debarked, pruned, uprooted, parasitized, and dead individuals of each species across the different vegetation formations. Next, the histograms of juvenile individuals were analysed according to height classes starting from 0.50 m (Ouédraogo, 2006; Traoré, 2013). Finally, the regeneration potential (d) was calculated as the ratio of juvenile to adult tree density. The following criteria, adapted from Gampiné & Boussim (1995), were applied : low regeneration if d ≤ 100 individuals·ha^{-1}; medium regeneration if 100 < d ≤ 1,000; good regeneration if 1,000 < d ≤ 10,000; and very good regeneration if d > 10,000 individuals·ha^{-1}.

3. RESULTS

3.1. Characterisation of the flora accompanying *Erythrina* species in the Guiriko region

A total of 113 and 30 surveys were conducted for *E. senegalensis* and *E. sigmoidea*, respectively. Evaluation of the flora in *Erythrina* formations revealed a species richness ranging from 165 to 213, with high Shannon indices (3.63 bits and 4.21 bits) and Pielou's evenness indices (0.79 and 0.87), indicating high diversity and regular distribution of individuals in the *E. senegalensis* and *E. sigmoidea* formations (**Table 2**). Sorensen's similarity index (Cs = 0.45) is well below 1, reflecting the low similarity between the different *Erythrina* formations.

Table 2. Species richness and diversity indices of *Erythrina* formations – *Richesse spécifique et indices de diversité des formations d'*Erythrina.

Formation in *Erythrina*	Overall species richness	Shannon diversity index (*H'*)	Pielou equitability index (*E*)	Sorensen similarity index (*Cs*)
E. senegalensis	213	3.63	0.79	0.45
E. sigmoidea	165	4.21	0.87	

The floristic richness of the *E. senegalensis* formation is 213 species, including 116 woody species and 97 herbaceous species, distributed across 158 genera and 54 families. The most dominant families are Fabaceae-faboideae, followed by Rubiaceae, Malvaceae, Combretaceae, Fabaceae-ceasalpinioideae, Fabaceae-mimosoideae, Poaceae, and Lamiaceae. Families represented by no more than six species are grouped under "Other" (**Figure 2**).

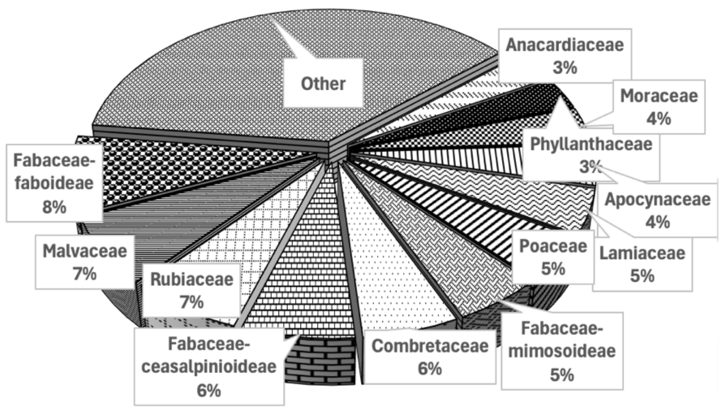

Figure 2. Spectrum of families in *Erythrina senegalensis* formations in the Guiriko region – *Spectre des familles dans les formations d'*Erythrina senegalensis *dans la région de Guiriko.*

The flora of the *E. sigmoidea* formation comprises 165 species, including 114 woody species and 51 herbaceous species, distributed across 129 genera and 47 families. The most dominant families are Rubiaceae, Malvaceae, Fabaceae-faboideae, followed by Fabaceae-Ceasalpinioideae, Combretaceae, Poaceae, Fabaceae-Mimosoideae, and Lamiaceae. Families represented by no more than six species are grouped under "Other" (**Figure 3**).

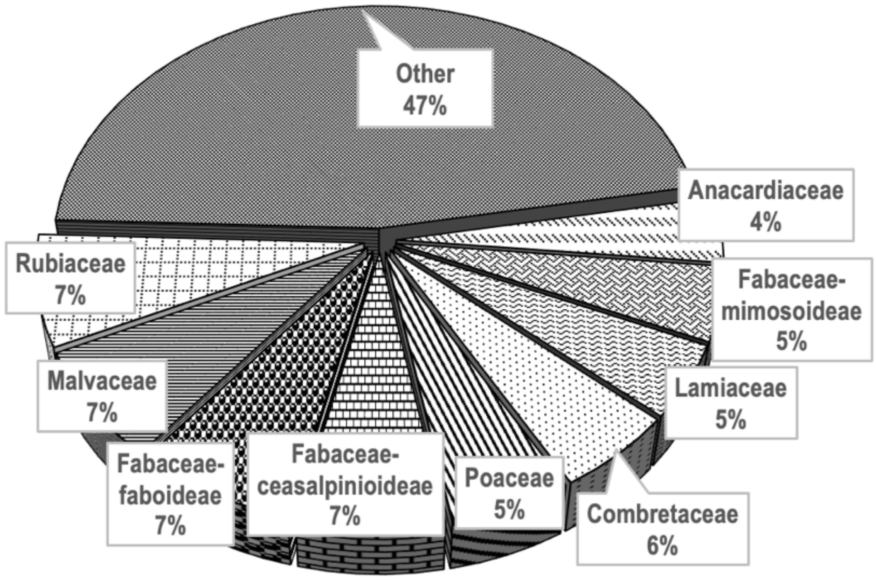

Figure 3. Spectrum of families in *Erythrina sigmoidea* formations in the Guiriko region – *Spectre des familles dans les formations* Erythrina sigmoidea *dans la région de Guiriko.*

The distribution of biological types (**Figure 4**) shows that *Erythrina* formations are dominated by Phanerophytes, followed by Therophytes, Chamephytes, Geophytes and Hemicryptophytes.

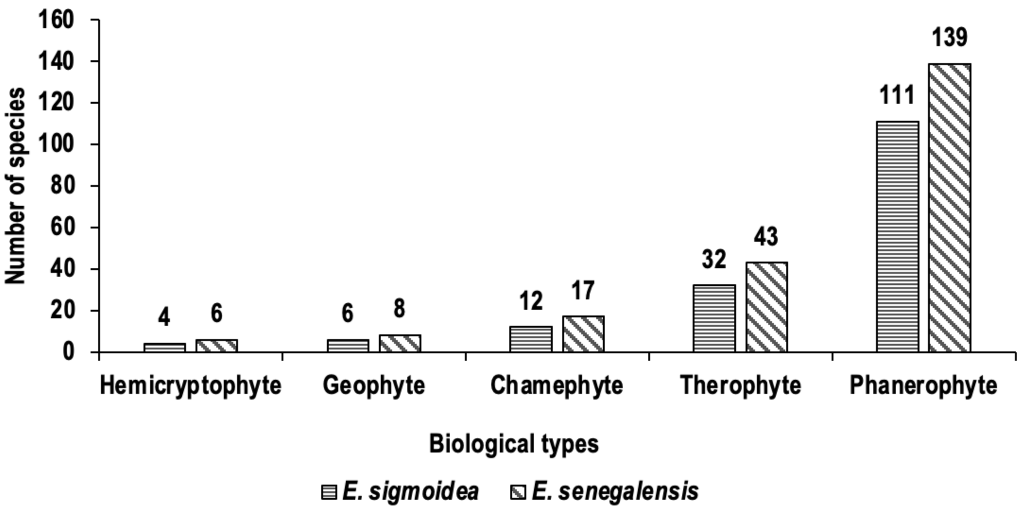

Figure 4. Biological spectrum of *Erythrina senegalensis* and *E. sigmoidea* formations in the Guiriko region – *Spectre biologique des formations d'*Erythrina *senegalensis et d'*E. sigmoidea *dans la région de Guiriko*.

Phytogeographical types show a dominance of Afro-tropical (AT) species in *Erythrina* formations, followed by Sudano-Zambesian (SZ), Sudanian (S), Pantropical (Pan), transitional Guineo-Congolese and Sudano-Zambesian (GC-SZ), and Paleo-tropical (Pal) species. Guineo-Congolese, Sudano-Guinean, African-American (AM), Pluri-regional African (PA), and Pluri-regional (PT) species are in tiny proportions, with less than 10 species (**Figure 5**).

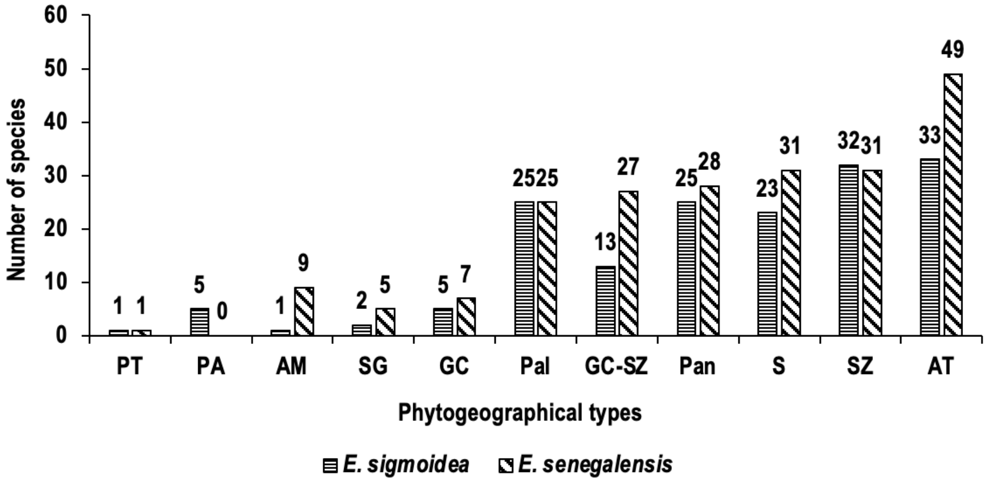

Figure 5. Phytogeographical spectrum of *Erythrina senegalensis* and *E. sigmoidea* formations in the Guiriko region – *Spectre phytogéographique des formations d'*Erythrina senegalensis *et d'*E. sigmoidea *dans la région de Guiriko.*

PT: Pluri-regional species – *Espèces plurirégionales*; PA: Pluri-regional African species – *Espèces africaines plurirégionales*; AM: African-American species – *Espèces africano-américaines*; SG: Sudano-Guinean species – *Espèces soudano-guinéennes*; GC: Guineo-Congolese species – *Espèces guinéo-congolaises*; Pal: Paleo-tropical species – *Espèces paléo-tropicales*; GC-SZ: Guineo-Congolese and Sudano-Zambesian species – *Espèces guinéo-congolaises et soudano-zambéziennes*; Pan: Pantropical species – *Espèces pantropicales;*S: Sudanian species – *Espèces soudaniennes*; SZ: Sudano-Zambesian species – *Espèces soudano-zambéziennes*; AT: Afro-tropical species – *Espèces afro-tropicales.*

3.2. Characteristic species of *Erythrina* formations

The analysis revealed several species with strong ecosystem indicators for both species (**Table 3**). For *E. senegalensis*, species such as *Guiera senegalensis* J.F.Gmel. (IVI = 70.8; $p = 0.0002$), *Vitellaria paradoxa* C.F.Gaertn. (IVI = 57.4; $p = 0.0002$) and *Entada africana* Guill. & Perr. (IVI = 48.8; $p = 0.0008$) show a strong affinity. As for *E. sigmoidea*, *Tetracera alnifolia* DC. (IVI = 95.8; $p = 0.0002$), *Leptadenia hastata* Vatke (IVI = 74.9; $p = 0.0002$) and *Sansevieria liberica* Gérôme & Labroy (IVI = 73.3; $p = 0.0002$) stand out as major indicator species. However, these characteristic species do not necessarily indicate the presence of the *Erythrina* species studied.

Table 3. Characteristic species of *Erythrina* formations – *Espèces caractéristiques des formations d'*Erythrina.

Plant formation	***E. senegalensis***	***E. sigmoidea***	
Number of readings	113	30	
Floristic richness	213	165	
Average number of species	31	38	
Shannon diversity index	3.63	4.21	
Characteristic species	IVI	IVI	P-value
Guiera senegalensis J.F.Gmel.	70.8		0.0002
Vitellaria paradoxa C.F.Gaertn.	57.4		0.0002
Terminalia macroptera Guill. & Perr.	54		0.0002
Feretia apodanthera Delile	49.6		0.0002
Entada africana Guill. & Perr.	48.8		0.0008
Saba senegalensis (A.DC.) Pichon	45.1		0.0006
Tetracera alnifolia Willd.		95.8	0.0002
Leptadenia hastata Vatke		74.9	0.0002
Sansevieria liberica Gérôme & Labroy		73.3	0.0002
Paullinia pinnata L.		68.7	0.0002
Secamone afzelii (Roem. & Schult.) K.Schum.		65.8	0.0002
Synsepalum pobeguinianum (Pierre ex Lecomte) Aké Assi & L.Gaut.		65.1	0.0002
Strychnos innocua Delile		64.3	0.0002
Vitex doniana Sweet		61.6	0.0002
Raphia sudanica A.Chev.		60	0.0002
Prosopis africana (Guill. & Perr.) Taub.		57.6	0.0002
Bombax costatum Pellegr. & Vuillet		54.3	0.0002
Cissus populnea Guill. & Perr.		53.7	0.0004
Annona senegalensis Pers.		48.4	0.0142

3.3. Dendrometric characterisation of *Erythrina* populations

The structural characteristics of *Erythrina* individuals (**Table 4**) show an average density of 25.48 ± 3.43 individuals·ha^{-1} in *E. senegalensis* formations, compared to 13.15 ± 1.95 individuals·ha^{-1} in the *E. sigmoidea* formation. The mean diameter at breast height (DBH) and mean total height were 12.42 ± 6.15 cm and 6.26 ± 1.96 m, respectively, in the *E. senegalensis* population and 19.60 ± 11.27 cm and 5.34 ± 1.85 m in the *E. sigmoidea* population.

Blackman index values indicate a clumped distribution of *E. senegalensis* and *E. sigmoidea* individuals (IB > 1) across the various formations.

Table 4. Structural characteristics of adult individuals of *E. senegalensis* and *E. sigmoidea* – Caractéristiques structurelles des individus adultes d'Erythrina senegalensis et d'*E. sigmoidea*.

Species	**Structural characteristics**			
	DHP (cm)	**Ht** (m)	**Density** (individuals.ha^{-1})	**IB**
E. senegalensis	12.42 ± 6.15	6.26 ± 1.96	25.48 ± 3.43	2.47
E. sigmoidea	19.60 ± 11.27	5.34 ± 1.85	13.15 ± 1.95	2.34

Diameter class distribution of *Erythrina* individuals. The diameter class distribution of *E. senegalensis* individuals (**Figure 6a**) shows an inverted J-shaped structure, which is characteristic of multispecific or uneven-aged stands (c < 1). As for the diameter class distribution of *E. sigmoidea* individuals (**Figure 6b**), it shows a positive or straight asymmetrical distribution (1 < c < 3.6), which is characteristic of monospecific stands with a predominance of young or small-diameter individuals.

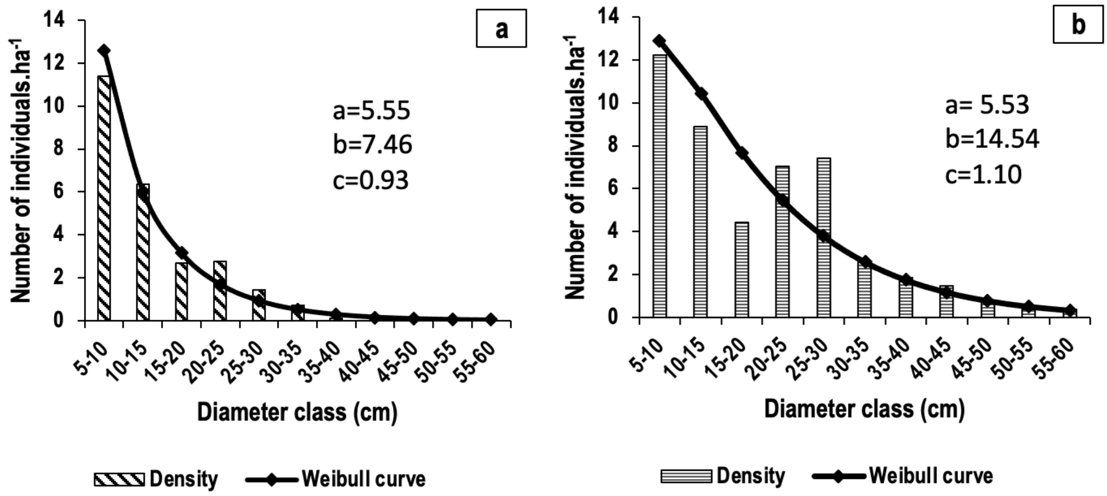

Figure 6. Diameter structures of adult individuals of *E. senegalensis* (**a**) and *E. sigmoidea* (**b**) – *Structures diamétrales des individus adultes d'*Erythrina senegalensis ***(a)*** *et d'*E. sigmoidea ***(b)***.

Height-class distribution of *Erythrina* individuals. Analysis of the height-class distribution of *Erythrina* individuals in the identified formations (**Figure 7**) shows a positive or right asymmetric distribution structure (1 < c < 3.6), which is characteristic of populations with a predominance of young or low-height individuals.

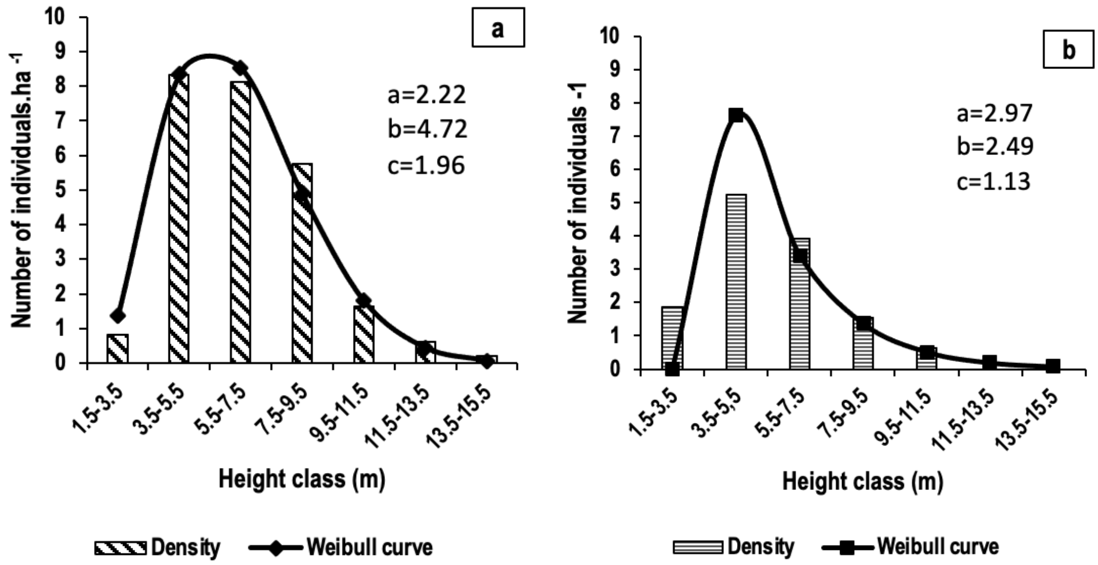

Figure 7. Height structures of adult individuals of *E. senegalensis* (**a**) and *E. sigmoidea* (**b**) – *Structures de hauteur des individus adultes d'*Erythrina senegalensis ***(a)*** *et d'*E. sigmoidea ***(b)***.

3.4. *Erythrina* population status and dynamics

Health status of *Erythrina* populations. The health status of *E. senegalensis* individuals in the different formations shows that anthropogenic pressures are low, with a small proportion (≤ 20%) of individuals exhibiting signs of exploitation. These individuals are more susceptible to bark removal and parasitism (termite attack). In contrast, the population of *E. sigmoidea* is in poor health, as the majority of individuals (95%) are subjected to anthropogenic pressures with bushfires affecting 88% of them (**Figure 8**).

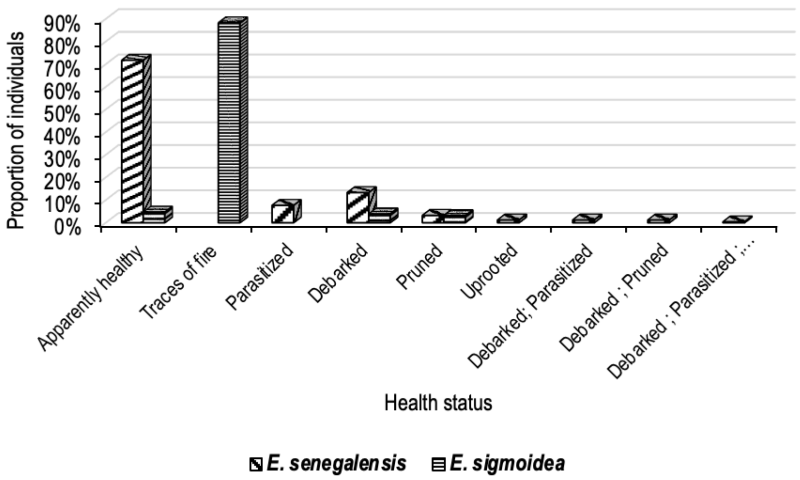

Figure 8. Health status of *E. senegalensis* and *E. sigmoidea* populations – *État sanitaire des populations d'*Erythrina senegalensis *et d'*E. sigmoidea.

Juvenile *Erythrina* population dynamics. The distribution of juvenile *Erythrina* individuals by height class (**Figure 9**) shows " inverted J-shaped " structures, indicating an abundance of individuals in the]0-0.5] m,]0.51-1] m, and > 2 m classes.

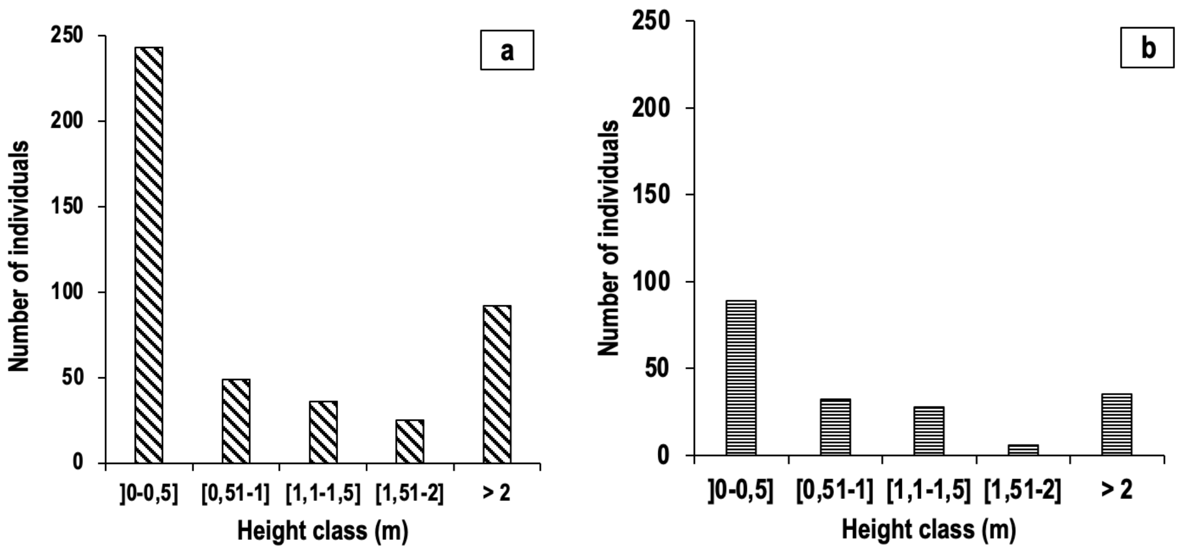

Figure 9. Juvenile population structures of *E. senegalensis* (**a**) and *E. sigmoidea* (**b**) – *Structures des populations juvéniles d'*Erythrina senegalensis *(a) et d'*E. sigmoidea *(b).*

Very low juvenile densities (**Table 5**) were observed for both species, with 25.48 individuals·ha^{-1} for the adult population of *E. senegalensis* and 45.73 individuals·ha^{-1} for its juvenile population. The adult density of *E. sigmoidea* is 13.15 individuals·ha^{-1}, while the juvenile population density is 19.53 individuals·ha^{-1}. The regeneration potentials are 1.80 individuals·ha^{-1} and 1.49 individuals·ha^{-1} for the *E. senegalensis* and *E. sigmoidea* populations, respectively.

Table 5. Values of density and regeneration potential parameters for *E. senegalensis* and *E. sigmoidea* – *Valeurs des paramètres de densité et du potentiel de régénération pour* Erythrina senegalensis *et* E. sigmoidea.

Species	Adult density (individuals·ha^{-1})	Juvenile density (individuals·ha^{-1})	Regeneration potentials (individuals·ha^{-1})
E. senegalensis	25.48	45.73	1.80
E. sigmoidea	13.15	19.53	1.49

4. DISCUSSION

Dendrometric characterization of *Erythrina* populations in the Guiriko region revealed low populations densities (<< 100 individuals·ha^{-1}) and average diameters of 12.42 ± 6.15 cm for *E. senegalensis* and 19.60 ± 11.27 cm for *E. sigmoidea*, with average heights of 6.26 ± 1.96 m and 5.34 ± 1.85 m, respectively. The diameter class distribution of *E. senegalensis* and *E. sigmoidea* individuals clearly reveals the predominance of young or small diameters individuals. The analysis of the distribution in height class shows an abundance in classes below 7 m compared to classes greater than or equal to 7 m. This form of distribution observed with the diameter classes of individuals of *E. senegalensis* and *E. sigmoidea* corroborates the findings reported by Hamawa et al. (2018) in Cameroon; Glèlè Kakaï & Sinsin (2009), Natta et al. (2011), Yehouenou Tessi et al. (2012), Dicko et al. (2017) in Benin, respectively, on the populations of *Haematostaphis barteri*, *Isoberlinia* spp., *Pentadesma butyracea*, *Antiaris toxicaria* and *Lophira lanceolata*. The low densities observed here are lower than those reported by Kabré et al. (2020) for *Ziziphus mauritiana* populations in eastern region of Burkina Faso. This could be explained by the strong anthropogenic pressure resulting from the removal of roots and bark and cutting. This finding corroborates the work of Nacoulma et al. (2011) and Kabré et al. (2020) whodemonstrated that anthropogenic pressures reduce the density of *Prosopis africana*, *Pterocarpus erinaceus* and *Ziziphus mauritiana* in the eastern region of Burkina Faso. The low values of the average diameter and height of *Erythrina* individuals in the Guiriko region may reflect the shrubby nature of these species. Indeed, according to the classification of Arbonnier (2019), these species are generally shrubs reaching a height between 4 and 4.5 m, rarely exceeding 7 m. However, this structure cannot only be derived from the behavior of the species; it could also be linked to anthropogenic pressure. The development of young individuals is disrupted by their disappearance due to excessive exploitation of the species, difficult pedoclimatic conditions, grazing and bushfires. This would weaken the population. Nevertheless, in order to maintain itself, the population requires a significant proportion of young individuals to be incorporated into the adult population (Bationo et al., 2001; Hamawa et al., 2018). According to Ouédraogo et al. (2006), the predominance of young individuals is linked to disturbances or vulnerabilities at certain stages of its development. The absence of adult individuals would also affect the recovery of the population due to a lack of seeds (Mapongmetsem et al., 2011).

Analysis of the health status of the populations shows that there are low proportions of healthy individuals among the adult population of *E. sigmoidea*, reflecting the vulnerability of the species in its natural habitats. This vulnerability is largely caused by bushfires (88% of individuals) in the sacred woods of the sandstone hills of Kôrô, the only site at which the species has been found. The low density observed at this site could be explained by grazing, fires and difficult soil conditions, which do not favour the proper development of individuals. In contrast, the low proportion of harvested individuals in the adult population of *E. senegalensis* indicates that the species is in good condition in its natural habitats. *Erythrina senegalensis* sites, such as the classified forests of Dindéresso, Kou, Kuinima, and Péni, as well as the sacred groves of the Kôrô sandstone hills, benefit from a degree of protection that mitigates the species' exposure to anthropogenic pressures.

In the *E. senegalensis* and *E. sigmoidea* formations, regeneration dynamics reveal a high number of individuals in the first and last height classes, respectively. This could explain the good regeneration capacity of these species but the difficulty of survival, as the other intermediate classes contain few juvenile individuals. Renewal potential is also very low (<< 100 individuals·ha^{-1}). This difficulty of survival could be explained by the types of habitats occupied by these species, as well as the challenging site and soil conditions found there. Habitats identified for *E. senegalensis* include gallery forests, riparian belts, hilltops, and bottoms on rocky soils and shrub savannas on clay-gravel soils. As for *E. sigmoidea*, gallery forests on rocky soils have been identified. These habitats, with their challenging environmental conditions, combined with bushfires and grazing, can compromise regeneration dynamics. Furthermore, as these habitats are periodically flooded, seeds can be washed away by runoff or rot due to excessive presence of water.

The *E. senegalensis* formation distributed in the Guiriko region has a very high floristic richness, with 213 species in 158 genera and 54 families. It is only slightly similar (Cs = 0.45) to the *E. sigmoidea* formation, which comprises 165 species in 129 genera and 47 families. The low level of similarity and the richness of the *E. senegalensis* formation could be explained by the diversity of habitats occupied by the species such as shrubby and wooded savannahs, forest galleries and riparian cordons, compared to *E. sigmoidea*, which is only found in forest galleries and riparian cordons. Alternatively, this could be due to the large number of plant formations (5 plant formations) sheltering the species, compared to *E. sigmoidea*, which was only recorded in a single plant formation. Furthermore, the low richness of the *E. sigmoidea* formation can also be explained by the topographic homogeneity of the study area. According to Bridgewater et al. (2003) and Mbayngone (2008), the greatest floristic diversity is associated with environmental heterogeneity or habitat diversity. The dominance of the Fabaceae-Faboideae, Rubiaceae, Malvaceae, Combretaceae, Fabaceae-Ceasalpinioideae, Fabaceae-Mimosoideae and Poaceae families over other families is a characteristic of African savannahs (Ouoba, 2006; Nacoulma, 2012). Consequently, the vegetation of *Erythrina* formations has retained its original flora despite the observed anthropogenic and grazing pressures.

The biological spectra of the *E. sigmoidea* and *E. senegalensis* formations are characterised by the dominance of phanerophytes (111 and 148 species, respectively), followed by therophytes (32 and 46 species, respectively). This reflects the fact that our study area belongs to the Sudanian zone of Burkina Faso (Ouoba, 2006; Thiombiano & Kampmann, 2010). The strong presence of phanerophytes offers hope for the natural restoration of degraded plant formations (Issifou et al., 2019). According to Havyarimana et al. (2013), phanerophytes dominate less disturbed environments, whereas chamephytes colonise stressful environments. This demonstrates that the protection status assigned to these studied ecosystems mitigates the effects of human impact. The "classified" status of Dindéresso, Kou, Kuinima and Péni forests and the presence of places of worship within the formation of the sandstone hills of Kôrô, could help to reduce anthropic pressures in these areas because cutting and other exploitation of species are prohibited there. The high proportion of phanerophytes in these plant formations could facilitate the survival of *Erythrina* species by creating a humid and relatively mild microclimate with only a slightly pronounced unfavorable season.

Analysis of the phytogeographic spectra of the *E. sigmoidea* and *E. senegalensis* formations reveals an abundance of African pluriregional species (Afrotropical, Sudanian, Sudano-Zambézian, Guineo-Congolese, species common to the last two taxa) followed by species with a wide distribution (Pantropical, Paleotropical). The high proportion of Guineo-Congolese, Sudano-Zambézian species and species common to the last two taxa confirms that the study environment belongs to the Sudanian zone. The abundance of species with wide (Pantropical and Paleotropical) and continental (Afrotropical) distributions after the Sudanian species indicates that the *E. senegalensis* and *E. sigmoidea* formations belong to the disturbed Sudanian domain (Sinsin, 2001; Melom et al., 2015).

The indicator species analysis approach made it possible to accurately distinguish the species most representative of each *Erythrina* formation. The results obtained demonstrate significant floristic differentiation between the two formation types, corroborating the previously observed weak similarity as determined by Sorensen's index (Cs = 0.45). Several species in the *E. senegalensis* formation have high and significant IVI values, reflecting their strong specificity and fidelity to this environment. These include *Guiera senegalensis*, *Vitellaria paradoxa*, *Terminalia macroptera* and *Entada africana*, which are known for their association with Sudanian savannahs (Thiombiano et al., 2012). These characteristic species confirm the ecological profile of the *E. senegalensis* formation, which is dominated by heliophilous species that can withstand anthropogenic disturbance. In the *E. sigmoidea* formation, the indicator species are even more specific, with very high IVI values: *Tetracera alnifolia* (95.8), *Leptadenia hastata* (74.9), *Sansevieria liberica* (73.3), and *Strychnos innocua* (64.3). These species are associated with more closed or humid formations (forest galleries) reflecting an ecological environment that is distinct from that of *E. senegalensis*. This corroborates field observations of the more restricted and specialised ecological distribution of *E. sigmoidea*, which is limited to more fragile and localised habitats. The abundance of multi-regional African species and/or those with a wide distribution indicates broad ecological tolerance to variations in climate and soil, and sometimes to non-extreme disturbances. These abundances could contribute to reducing the vulnerability of *Erythrina* species.

5. CONCLUSIONS

This study of the *Erythrina* species present in the Guiriko region reveals that their flora is rich and diverse, with an abundance of phanerophytes over therophytes. Phytogeographical spectra reveal an abundance of Pantropical, Paleotropical, Afrotropical, and Sudanian species, indicating that the *E. senegalensis* and *E. sigmoidea* formations belong to the disturbed Sudanian domain. Furthermore, a study of their availability reveals the presence of specimens of *E. sigmoidea* in the Guiriko region, specifically in the Houet province, on the sandstone hills of Kôrô. However, the structural characteristics of *Erythrina* individuals indicate that there are young populations subject to several anthropogenic pressures, with a significant proportion of apparently healthy *E. senegalensis* individuals and a more fire-prone *E. sigmoidea* population. Therefore, the different plant formations, by their status, contribute to the preservation of the species. In order not to compromise the conservation of *Erythrina* species, it is recommended that site protection against fires, logging and the uncontrolled exploitation of sensitive areas is strengthened, and that awareness of *E. senegalensis* debarking is raised, as well as the enrichment of identified favourable habitats through planting. For domestication and conservation purposes, particular attention must be given to investigating the modes of reproduction of *E. senegalensis* and *E. sigmoidea*.

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