

Research Article

Bats of the Safi-Essaouira Provinces (Morocco): New Inputs to the Knowledge of Bat Populations of the Atlantic Littoral

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In Morocco, investigations of bats are limited and fragmentary. The majority of studies were done in northern provinces close to the Mediterranean Sea and focused on the geographical distribution of bats. With the aim of overcoming these gaps, we used diurnal caves visits, hand nets and mist nets, and acoustic surveys to make an inventory of the Atlantic littoral of Safi-Essaouira provinces, which is considered one of the most neglected regions in the country. In total, five caves and nine foraging habitats were surveyed from 2020 to 2022. Our surveys highlighted the distribution of eleven bat species belonging to five families, of which *Rhinolophus blasii* and *Tadarida teniotis* species were newly recorded in the study area. Three caves, namely, Sbaa Fam, Haouya, and Sidi Benkrara were newly discovered and hosted medium-sized colonies of five species. They were important for bats during the daytime, hibernation, and breeding. In foraging habitats, 2650 passes of 10 species were recorded. *Pipistrellus pipistrellus* and *Pipistrellus kuhlii* were the most active, followed by *Miniopterus schreibersii* and *Eptesicus isabellinus*, while *Rhinolophus ferrumequinum*, *Hipposideros tephros*, *Rhinolophus mehelyi*, *T. teniotis*, *Myotis punicus*, and *R. blasii* were less active. Olive groves were the most diverse habitat with 8 species, followed by Safi pinewood and degraded Argane forest with 4 species each and Sidi Abderrahmane lake with 3 species. The other habitats hosted only two species each. This paper is the first to highlight data on bats in the coastal areas of Morocco and North Africa. Our results contribute to improve knowledge of the annual cycle of these bats and fill the gaps related to their distribution in the coastal area of the Safi-Essaouira provinces.

1. Introduction

The geographical position and landscape of Morocco, with 3500 km of seacoasts, four mountain chains, large plains, and low plateaus, generated a high diversity of ecosystems and wildlife [1, 2]. This diversity appeared during the late Tertiary and Quaternary periods when Morocco was exposed to high climate variations and insularity factors that created many original ecosystems [3].

Mammals reflect this diversity and originality well, as their species number reached 105, with a high rate of rare or endemic taxa estimated at 40% [4]. Among this group, 31 bat species have been discovered until now in Morocco [4–7]; this group is supposed to deserve a high priority in the

national strategies of research and conservation, as bats have a great socioeconomic importance. Indeed, they constitute major agents of insect pest control [8–14] and a source of infectious diseases [15–18]. In addition, bats are good indicators of environmental quality and climate change [19–24].

In Morocco, 31 bat species belonging to eight families were currently recorded. These species represent 29.5% of the total mammalian fauna in Morocco. In comparison with neighboring countries, Algeria hosts only 26 bat species, while Tunisia records only 20 bat species. Similarly, only seven families of Chiroptera are mentioned in Algeria and Tunisia [4–7, 25–28]. These findings demonstrate the high value of Moroccan landscapes for bat species.

Similar to other mammals, Moroccan bats are exposed to high losses, as eight species are endangered or vulnerable taxa, despite the fact that eleven bat species are not evaluated [30]. Human interference in their roosts, the use of pesticides, and misinformation about bats [31] are the most significant threats impacting their existence. The recurrent drought crises and the increasing number of wind farms have certainly had great effects on Moroccan bats but these effects are still unknown.

In Morocco, the first scientific investigations on Chiroptera, mainly focused on the Northern and Atlas regions, were generally based on traditional techniques, such as daily visits to caves, hand capture, roost counts, and mist-net trapping [32–48]. Despite the weakness of the available data, these investigations revealed 24 species among seven families.

In more recent works, some researchers [49] reported bats in the diet of nocturnal raptors, while others [50–55] used ultrasonic detectors [56–59]. This latter technique, considered as the nondestructive method, is generally combined with the aforementioned techniques. These works added five species to the former list of Moroccan Chiroptera. Furthermore, the use of both craniodental characteristics and genetic (mitochondrial and nuclear DNA) methods provided taxonomic precision for some species, such as *Miniopterus maghrebensis* [6] and *Myotis zenatius* [5].

Despite the several studies and notes dedicated to Moroccan bats [60], the distribution data gathered remain sparse and mainly focused on the northern half of the country, some of which are outdated. Some bat species, such as *Taphozous nudiventris*, *Myotis capaccini*, *Nyctalus lasiopterus*, and *Nyctinomus aegyptiacus*, have been identified from a few sites [33, 53, 61–65]. Furthermore, bats' health, their annual cycle, and their migration routes remain poorly studied. With this in mind, this work was definitely worth undertaking. Indeed, great monitoring efforts are needed in the whole country over the four seasons.

The development of acoustic tool detection, supported by other conventional techniques, promises new advances in bat investigations, notably in their distribution. In this study, we aimed to make an inventory of bat species in the coastal area of Safi-Essaouira provinces, west of Morocco. We investigated the diversity of bat species in caves and foraging habitats dominating the sampling sites. Equally, we noted the importance of the habitats for the recorded bat species to evaluate their roles in feeding and breeding activities of species.

2. Materials and Methods

2.1. Study Areas and Sites. Our study was carried out in the Atlantic littoral of Safi-Essaouira provinces (Figure 1), which is under a Mediterranean climate [66–68], more precisely semiarid (thermo-Mediterranean to sub-Mediterranean), with a protracted dry season (late spring to early autumn). More specifically, the two provinces have quite similar climates as follows: in Safi, the annual rainfall is 274 mm and the annual average of temperatures is 18.4°C, while these parameters are, respectively, 295 mm and 18.7°C in

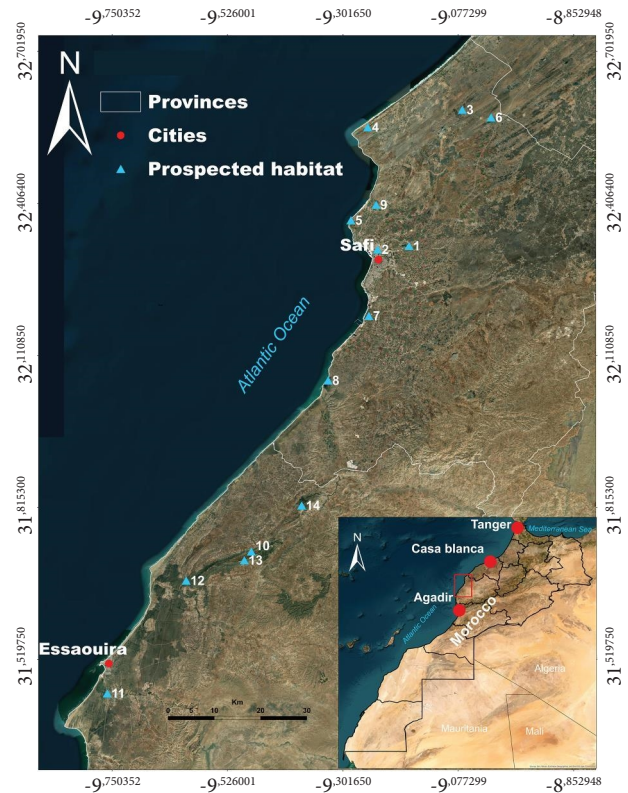


FIGURE 1: Bat sampling area and sites in the littoral area of Safi-Essaouira.

Essaouira (<https://climate-data.org>). In this latter area, the oceanic winds are quite permanently refreshed by the upwelling currents that mark the sea waters in this area and reduce the summer temperature in the littoral.

This climate, with its different variants, fosters diverse terrestrial plant communities dominated by a few species, the most important of which are *Argania spinosa*, *Tetraclinis articulata*, *Juniperus phoenicea*, *Olea europaea*, *Pistacia atlantica*, *Euphorbia regis-Jubae*, and *Senecio anteuphorbium*.

Bat investigations were conducted at fourteen sites (Figure 1, Table 1) and were identified for their potential importance as bat habitats as follows: five caves, one agricultural land, one artificial reservoir, and seven foraging habitats. Half of these sites are on the ocean coast or very close to it, and the others are more or less continental (up to 30 kilometers from the coastline).

2.2. Data Collection. This work started in September 2020, with the identification of potential bat habitats in the study area, using existing documentation, mainly Boualla et al. [69] and Camus and Lamouroux [70], satellite images, and in-person interviews. This permitted us to locate potential sites (caves, chasms, and forests) and potential foraging habitats (agricultural fields, surface waters, and farms). Four common methods were used to undertake the bat survey as follows: detecting echolocation calls, mist netting, diurnal visits to the accessible caves, and hand netting. All night

TABLE 1: Location of capture/recorded points by habitat types.

Site nos.	Site names	Coordinates (in decimal degrees)	Altitude (m)	Habitat type	Dist. to ocean (km)
1	Sidi Abderrahmane lake	32.323817, -9.172965	72	Artificial water reservoir	8.87
2	Safi pinewood	32.316973, -9.234215	75	Urban coniferous forest	2.07
3	Haouya cave	32.588635, -9.069457	112	Karstic cave in eucalyptus grove	9.88
4	Gora'an cave	32.554580, -9.253367	37	Karstic cave in agricultural land	0.96
5	Sidi Benkrara cave	32.373819, -9.285917	35	Sea cliff cave	0.11
6	Sbaa Fam cave	32.573713, -9.013361	128	Karstic cave in agricultural land	15.43
7	Degraded argane forest	32.187795, -9.251124	90	Degraded <i>Argania</i> forest	0.77
8	Souiria Laqdim dunes	32.062241, -9.330344	26	Coastal sand dune matorral	0.24
9	Lalla Mellouka forest	32.403855, -9.237051	118	Large glade in eucalyptus grove	1.88
10	Argane groves N Jbel Lahdid	31.729681, -9.479746	484	Small argane adjacent to agricultural lands	12.79
11	Coastal sand dunes	31.453819, -9.759740	52	<i>Retama</i> sand dune formation	3.16
12	Olive groves SW Jbel Lahdid	31.673139, -9.606306	58	Farmland near a pine forest	6.70
13	Maâden cave	31.712217, -9.492932	550	Karst cave in open forest	12.50
14	Mixed argane-pine forest	31.819046, -9.38176	455	Mountain open forest of <i>Argania-Pinus</i>	13.39

visits took place during the three first hours since sunset, where we recorded echolocation calls at fixed places and/or along foot transects.

The survey was made in suitable weather conditions (no rain and wind speed less than 20 km/h). In foraging habitats, we used acoustic detection at fixed points or along foot transects of 300–400 m with a constant speed of 2 km/h. Two bat detectors are used as follows: (1) the Song Meter 4 FS ultrasonic recorder (Wildlife-Acoustics, USA) coupled to a 5-meter microphone (SMM-U2 Ultrasonic Microphone) and (2) the time expansion bat detector, the Pettersson D240X (Uppsala, Sweden), coupled to a portable digital recorder (Edirol R-09HR, Roland Corporation, China). In caves, the closest bats were hand netted, but we also used mist nets (3m × 12m; 16 mm × 16 mm) that are installed in front of known roosts (Table 2).

2.3. Species Identification. Recorded calls were displayed using the Kaleidoscope program version 5.4.8 (Wildlife-Acoustics Inc., USA) as oscillograms and spectrograms concurrently. The settings utilized were as follows: the window size is 128, FFT size is 512, and cache size maximum is 256. The time period of recorded sequences was defined according to the bat detector as follows: every 34.7 s of recording with the D240X and every 5 s of recording with the SM4BAT-FS. One echolocation call from each bat pass was manually identified to the species level, using shape and other call parameters described in the sound library of Barataud [70]. Echolocation calls of recorded species were identified using regional acoustic characteristics [72, 73] and North-African data [74, 74]. In addition, we used unpublished reference calls that we gathered from several Moroccan locations. Captured individuals of bats were identified using different systematic resources [75–77].

During the 15 days of the internship, it aims to revise, reidentify, and draw up the story of the knowledge of described bats in Morocco and to assess the state of preservation of specimens deposited in the National Museum of Natural History of the Scientific Institute of Rabat. We have found 17 species divided into 6 families, and we noticed that no specimens were collected from the study area [78].

3. Results

During our survey along the coast of Safi-Essaouira provinces, we identified 11 bat species, representing 35.5% of the total registered species in the entire country (Table 3). They belong to five families, namely, Rhinolophidae, Vespertilionidae, Molossidae, Miniopteridae, and Hipposideridae. The species are as follows: greater horseshoe bat *Rhinolophus ferrumequinum*, lesser horseshoe bat *Rhinolophus hipposideros*, Mehely's horseshoe bat *Rhinolophus mehelyi*, Blasius' horseshoe bat *Rhinolophus blasii*, Maghrebian mouse-eared bat *Myotis punicus*, common *Pipistrellus pipistrellus*, Kuhl's pipistrelle *Pipistrellus kuhlii*, Isabelline serotine bat *Eptesicus isabellinus*, common bent-wing bat *Miniopterus schreibersii*, European free-tailed bat *Tadarida teniotis*, and Maghreb leaf-nosed bat *Hipposideros tephros*. Eight species have a Mediterranean character, three species are Palearctic, and one species is a Saharan species.

3.1. Cave's Bat Assemblages. Using conventional techniques, we identified four species in four caves. The most diverse assemblage is in the caves of Haouya and Gora'an, with three species each. In Sidi Benkrara and Sbaa Fam caves, we found, respectively, two and one species, while no species was recorded near the Maâden cave. At the Haouya cave, we hand netted on November 14th, 2021, three males belonging to three different species of Rhinolophidae, namely, *R. hipposideros*, *R. mehelyi*, and *R. blasii*. The ambient temperature was around 21.4°C and the relative humidity was 74.9%. While using echolocation calls and visual aids, we identified 75 individuals belonging to three species of *Rhinolophus* in Haouya cave, namely, *R. hipposideros* (15), *R. blasii* (37), and *R. mehelyi* (23).

On July 4th, 2021, in front of the Gora'an cave, we recorded 481 passes belonging to 4 species, namely, *R. blasii* (354), *R. mehelyi* (75), *M. punicus* (49), and *P. kuhlii* (3). However, on March 31st, 2022, at a lower temperature (16.5°C) and humidity (66.1%), we mist netted only 24 individuals, belonging to two species only, i.e., *M. punicus* (15 specimens: 9 males and 6 females) and *R. blasii* (9). Captured

TABLE 2: Sampling methods adopted in each habitat prospected.

Site Nos.	Site names	Dates of field visits	Sampling method*
1	Sidi Abderrahmane lake	20/12/2021	FP
2	Safi pinewood	21/05/2021; 03/05/2021	FP
3	Haouya cave	04/04/2021; 14/11/2021; 01/01/2022; 14/02/2022	DV & HC
4	Gora'an cave	21/06/2022; 31/03/2022	MN& FP
5	Sidi Benkrara cave	05/12/2021; 26/09/2022	DV & HC
6	Sbaa Fam cave	26/04/2022	DV& HC
7	Degraded argane forest	26-27/09/2021	FP
8	Souiria Laqdim dunes	06/06/2021	FT
9	Lalla Mellouka forest	11/06/2021	FT
10	Argane groves N Jbel Lahdid	02/08/2020	FT
11	Coastal sand dunes	02/06/2022	FT
12	Olive groves SW Jbel Lahdid	03-04-05/09/2020	FP
13	Maâden cave	03/06/2022	DV & HC
14	Mixed argane-pine forest	02/09/2020	FT

*DV: diurnal visit; FP: fixed point; FT: foot transects; HC: hand caught; MN: mist netting.

females were pregnant at the first stage. In the cave of Sidi Benkrara, visited in both winter (December 5th, 2021) and summer (August 24th, 2022), six individuals of *M. punicus* were found in winter (at a temperature of 21°C and humidity of 73.3%) and five of them (adult males) have been captured. The summer visit, with a temperature of 25°C and a humidity of 74%, revealed a small mixed colony composed of *M. punicus* (37 individuals) and *M. schreibersii* (23 individuals, among which one female was hand netted). In the Sbaa Fam cave, we identified visually five specimens of *M. punicus* on April 26, 2022.

3.2. Noncave Bat Assemblages. Bat echolocation calls were recorded at nine sites out of the 14 prospected (Table 4). A total of 2650 passes were recorded during 27 cumulated hours. Within the 10 identified species, *P. pipistrellus* and *P. kuhlii* were the most active (42.5% and 35.85% of passes, respectively). Two other species (*M. schreibersii* and *E. isabellinus*) were less abundant (15.7% and 4.22% of passes, respectively). The rarest species were *R. ferrumequinum*, *H. tephrosus*, *R. mehelyi*, *T. teniotis*, *M. punicus*, and *R. blasii*, as they were represented in 0.83% to 0.07% of passes. The most diversified assemblages were found in olive groves located in the SW Jbel Lahdid habitat (8 species in a private farmland near a pine forest), followed by Safi pinewood and degraded Argane forest with 4 species each, followed by Sidi Abderrahmane lake with 3 species. The other sites showed a maximum of two species.

4. Discussion

Our three-year monitoring provides new data on the occurrence and richness of bat species in the littoral area of Safi-Essaouira, mainly in comparison with those reported by Benda et al. [56, 72] in the littoral zone of Morocco. Indeed, before our study, five species were reported from Safi province, namely, *R. euryale*, *R. ferrumequinum*, *M. punicus*, *R. mehelyi*, and *M. schreibersii*. They were cited without precise coordinates [4, 79, 80], while *M. punicus*

and *R. mehelyi* were reported from corpses in Gora'an cave [81]. Previously, in Essaouira province, nine species of bats (*R. euryale*, *R. hipposideros*, *H. tephrosus*, *N. thebaica*, *M. schreibersii*, *E. isabellinus*, *P. pipistrellus*, *P. kuhlii*, and *M. punicus*) were described by Aulagnier et al. [4], Aulagnier and Thévenot [79], and Biollaz et al. [82]. Our investigations permitted us to enrich this inventory with 13 bat species, which represent 41.93% of the bat fauna known in Morocco [4–7, 10]. Globally, two species are new to the fauna of Safi-Essaouira provinces. This enrichment is due to a better coverage of the sampling program in both time and space, as we studied for the first time three caves in the Safi province (the caves of Haouya, Sbaa Fam, and Sidi Benkrara), with the Haouya cave being the richest in bats in the region. Indeed, it houses a small colony of three *Rhinolophus* species, namely, *R. hipposideros*, *R. blasii*, and *R. mehelyi*.

In Gora'an cave, where three species have been recorded, the mist net permitted the confirmation of the existence of *M. punicus*, while *R. blasii* was recently discovered in the cave and *R. mehelyi* was identified using ultrasound methods. For *R. blasii*, it was recorded for the first time in two caves in Safi province. In the Moroccan littoral, *R. blasii* was announced in only four places limited to the Souss-Massa coast [4, 73]; therefore, our findings expand its geographic distribution far to the north.

The presence of *R. mehelyi* has been confirmed by hand-net and with the use of echolocation calls in the province of Safi, especially in Haouya and Gora'an caves. However, *R. euryale* has not been confirmed in both provinces yet, while *R. mehelyi* is present in both provinces. These taxa have a wide distribution throughout the northern part of Morocco [4, 79, 83], while *R. euryale* shows some affinity to the Saharan area. Previously recorded in Safi, *R. ferrumequinum* was not recorded in this province during our monitoring, maybe because of its ability to migrate during seasons between roosts, notably in Tazarine cave (a breeding colony deserted the cave in late September), while others use Zaara and Zegzel caves during winter [32, 51, 83]. However, we recorded a few passes in Essaouira, where the species is

TABLE 3: Results of the bat investigations in the Safi-Essaouira littoral area (Morocco).

Families/species	Sites															
	Haouya cave	Gora'an cave	Sidi Benkrara cave	Sbaa Fam cave	Maâden cave	Abderrahmane lake	Sidi	Safi pinewood	Degraded argane forest	Souiria Laqdimia dunes	Lalla Mellouka forest	Argane groves N jbel Lahdid	Coastal sand dunes	Olive groves SW jbel Lahdid	Mixed argane-pine forest	
Rhinolophidae																
<i>Rhinolophus ferrumequinum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0
<i>Rhinolophus hipposideros</i>	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhinolophus mehelyi</i>	37	79	0	0	0	0	0	0	0	0	0	0	0	4	0	0
<i>Rhinolophus blasii</i>	38	363	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Vespertilionidae																
<i>Myotis punicus</i>	0	64	37	5	0	0	0	1	2	0	0	0	0	0	0	0
<i>Pipistrellus pipistrellus</i>	0	0	0	0	0	2	0	0	2	0	0	18	0	1104	0	0
<i>Pipistrellus kuhlii</i>	0	3	0	0	0	552	0	45	27	32	2	0	8	274	16	0
<i>Eptesicus isabellinus</i>	0	0	0	0	0	8	0	9	5	4	19	0	22	43	2	0
Miniopteridae																
<i>Miniopterus schreibersii</i>	0	0	23	0	0	0	0	0	0	0	0	0	0	416	0	0
Molossidae																
<i>Tadarida teniotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Hipposideridae																
<i>Hipposideros tephrus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
Species richness	4	5	2	1	0	3	4	4	4	2	2	1	2	8	2	2
Total number of individuals/passes	93	509	60	5	0	562	57	36	36	36	21	18	30	1872	18	18

TABLE 4: Results of noncave bat assemblages in the 9 selected foraging habitats in the Safi-Essaouira littoral area (Morocco).

Families/species	Sites									Mixed argane-pine forest
	Sidi Abderrahmane lake	Safi pinewood	Degraded argane forest	Souiria Laqdim dunes	Lalla Mellouka forest	Argane groves N Jbel Lahdid	Coastal sand dunes	Olive groves SW Jbel Lahdid		
Rhinolophidae										
<i>Rhinolophus ferrumequinum</i>	0	0	0	0	0	0	0	22	0	0
<i>Rhinolophus hipposideros</i>	0	0	0	0	0	0	0	0	0	0
<i>Rhinolophus mehelyi</i>	0	0	0	0	0	0	0	4	0	0
<i>Rhinolophus blasii</i>	0	2	0	0	0	0	0	0	0	0
Vespertilionidae										
<i>Myotis punicus</i>	0	1	2	0	0	0	0	0	0	0
<i>Pipistrellus</i>	2	0	2	0	0	0	18	1104	0	0
<i>Pipistrellus kuhlii</i>	552	45	27	32	2	2	0	274	16	16
<i>Eptesicus isabellinus</i>	8	9	5	4	19	0	0	43	2	2
Miniopteridae										
<i>Miniopterus schreibersii</i>	0	0	0	0	0	0	0	416	0	0
Molossidae										
<i>Tadarida teniotis</i>	0	0	0	0	0	0	0	4	0	0
Hipposideridae										
<i>Hipposideros tehrus</i>	0	0	0	0	0	0	0	5	0	0
Species richness	3	4	4	2	2	2	1	8	2	2
Total number of passes	562	57	36	36	21	18	30	1872	18	18

found for the first time, even though it has a wide distribution [44, 57, 84].

On March 31st, 2022, from 24 mist-netted individuals in the front of Gora'an cave, 14 females were pregnant (5 *M. punicus* and 9 *R. blasii*), which coincide with gestation periods that start in late spring in North Africa [74, 85]. However, we observed a transitory flight of one *P. kuhlii* just before sunset in front of the cave, but we consider that it does not use the cave. Indeed, *P. kuhlii* has anthropophilic mores and has never been found in caves or subterranean sites; however, it has been reported under old trees' bark [44], over water courses, and at cave entrances [56, 72]. It was also found in rock crevices and building slots [27, 86].

In reference to the period of surveillance of Haouya cave (14/11/2021), the suitable climate condition of the cave and due to the deep torpor observed in bats, this cave is used as a hibernaculum by the three recorded *Rhinolophus* species [87]. In Morocco, *Rhinolophus* species use caves, mines, or even khettara and share roosts with other dwelling bats, such as *M. punicus*, *M. schreibersii*, *Plecotus gaisleri*, and *Asellia tridens* [32, 51, 57, 79, 83]. Few works focused on the hibernation of this group; for *R. mehelyi*, hibernation was documented in Ain Sfa cave [88]; for *R. blasii*, it was studied in Tazzouguert cave [51]. In contrast, *R. hipposideros* is known to winter in caves or mines in small numbers [4].

In August 2022, at the artificial cave of Sidi Benkrara (newly discovered), we observed a small colony of the gregarious species *M. punicus* and *M. schreibersii*. Similar results were shown in Morocco and Algeria [56, 88, 89]. Contrary to other Moroccan regions, in the Safi area, *M. punicus* and *M. schreibersii* do not form large colonies such as those discovered in the caves of Win-Timdwine and Wad Imi n'Ouggoug (Agadir region), in Kahf Lakhal (Jbel Moussa in the North), and in the irrigation ditch of Wad Tessaout [56, 58, 81]. In our case, these species are suggested to be dispersed in several caves and crevices at the study sites.

Contrary to the other caves, the Maâden cave, which we visited during the day, did not have any bats. The absence of bats in this cave is suggested to be governed by anthropic disturbance since we noticed many fire plots and branches of *Argania* thorns inside the cave. These tools are probably used by local residents to catch bats.

In the nine foraging habitats, we recorded 2650 passes (based on ultrasonic methods), belonging to 10 species of bats. In such a subarid landscape, this species richness is similar to those reported in Algerian and Tunisian monitoring [74, 86, 90, 91].

Among these species, *P. pipistrellus* and *P. kuhlii* showed the highest number of passes. *P. pipistrellus*, discovered for the first time in Safi province, was recorded in four places; it is particularly active in agricultural lands where an artificial water basin was installed, where this bat was more attached [92]. It seems that it does not like arid areas where there is no water [57]. For that reason, the distribution of *P. pipistrellus* through the country showed a relative limitation to the mountainous regions, the Mediterranean basin, and a few sites in the low Draa [4, 72, 79]. In contrast, *P. kuhlii* is

widely distributed in the Atlantic littoral of Morocco, as it was reported from Tangier to Mohammedia and from Essaouira to Boujdour [36, 72, 79]. Our study permitted us to expand this distribution further, as we recorded the species for the first time in the Safi province. A similar wide distribution has also been noticed for this species in Algeria and Tunisia [74, 93].

Concerning *E. isabellinus*, it was recorded in eight sites in the study area. It has a wide distribution throughout the country, with relative preference towards arid zones [39, 72, 79, 94]. In contrast, the rarest species, *T. teniotis* and *H. tephros*, were only recorded in olive groves located in SW Jbel Lahdid. Furthermore, *H. tephros* lives in caves and channels, and its distribution in Morocco extends from the coastal region of Essaouira to the Oued Noun in the south [59, 79]. Moreover, *T. teniotis* is widely dispersed throughout the country, including desert habitats [4, 57, 58]. However, our observation of *T. teniotis* presents the first record for the species in the study area.

Despite the difficulties that this study faced, mainly the impossibility of achieving a complete spatiotemporal sampling program, we estimate that the 13 species recorded represent all the bat fauna of the study area. This richness indicates the great importance of the Atlantic littoral of Safi-Essaouira for bats. Furthermore, we discovered two new bat species for this littoral and registered new occurrence in each of the two provinces.

In Morocco, bats are legally protected under Dahir no. 1-11-84, prohibiting the commercialization of endangered wild animal and plant species. However, the implementation of this conservation measure is hampered by lack of information and execution. Therefore, the key to conservation remains raising local awareness of the ecological (economic) services provided by these animals instead of tons of pesticides.

These results are mainly due to the discovery of three caves (Gora'an, Haouya, and Sidi Benkrara), which constitute both important maternity roosts and hibernacula and are inhabited during swarming grouping by two vulnerable species and two near-threatened species, according to UICN (2023). Therefore, these habitats need more protection against environmental and anthropogenic factors. Indeed, caves were used to bury the corpses of animals for treasure hunting (Dbiba pers. obs.) and/or for the intentional catching of bats for witchcraft, while some of them were illuminated by fire plots [31, 74]. These activities and others have potential negative effects on bat communities [95–97]. Similar results were mentioned by Tanalgo et al., [98] who recorded the urgent need to protect caves due to their richness in bats worldwide. These authors mentioned that 48% of the known bat species habit caves for parts of their life histories and 15% of them are currently threatened. In our case, the protection of the caves is suggested to protect their associated fauna (i.e., chiropteran species) and to contribute to the local economy via the ecotouristic activities such as speleology and geotourism. All these elements will constitute a basis for sustainable activities looking for balance between the incomes and the use of natural resources.

5. Conclusion

In this study, we revealed new data on bats in coastal areas of Safi-Essaouira provinces. Recorded data demonstrated the importance of coastal habitats for bats on the western coasts of Morocco and North Africa. Our study highlighted the distribution of eleven bat species belonging to five families. Two species, *R. blasii* and *T. teniotis*, are newly recorded in the study area. Equally, this survey discovered for the first time three caves that hosted medium-sized colonies of five species, including Gora'an, Haouya, and Sidi Benkrara caves. The caves of Safi province showed significant importance for bats during the daytime, hibernation, and breeding compared to those visited in Essaouira. In parallel, 10 bat species were identified in foraging habitats with variable dominance. Olive groves were the most diverse site, followed by Safi pinewood and degraded argane forest, followed by Sidi Abderrahmane Lake. The other sites showed a maximum of two species each. The recorded results underline the importance of coastal regions for flying mammals. Equally, this work provides new data on the species richness of bats, reports the importance of caves, sheds light on the annual cycle of insectivorous bats for the first time in the coastal area of Morocco, and informs the concerned sectors and the scientific community of the current situation regarding bat caves and foraging habitats. However, more research is required in these key coastal regions all year round to assess the bioecology of Moroccan bats.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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