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Patterns of diversity, species richness and community structure in West African savannah small mammals (rodents and shrews)

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Abstract: Tropical savannah ecosystems are characterized by extensive grasslands with more or less sparse trees and thickets, and are threatened globally by anthropogenic forces. These grassland habitats house a rich and diversified fauna assemblage, with some of its conspicuous elements (for instance, small mammals) that have not been sufficiently investigated so far. In this paper, we meta-analyze the literature data available on the community structure and diversity patterns of shrews and rodents in West African savannahs. Overall, 10,197 small mammal individuals belonging to 111 species of Rodentia and 55 species of Soricomorpha were found in the various studies carried out in the countries covered by the present study. Studies using a combination of methods (e.g., live trapping, pitfalls, cover boards, visual encounter) detected more species in both Soricomorpha and Rodentia, and there was a positive survey (= trap/night) effort effect on the species richness in rodents. GLM models showed (i) that there was also no effect of trapping design (transect versus grid) on species richness per site, (ii) in both rodents and soricomorphs, the number of savannah species by country depended on the total species richness of that given country, but there was no effect of the relative surface covered by savannahs in that country. The number of sympatric species per site was 2.73±1.7 (range = 1-7) in Soricomorpha and 6.33±3.8 (range = 1-15) in Rodentia. Dominance index was significantly different among countries, with Nigeria having lower values than all other countries and Ghana, Benin and Sierra Leone had significantly higher values. The conservation implications of the observed patterns are discussed.

Key words: Rodentia; Soricomorpha; savannah; West Africa; meta-analysis; small mammals.

Introduction

Tropical savannah ecosystems are characterized by extensive grasslands with more or less sparse trees and thickets, and are threatened globally by anthropogenic forces producing broad-shifts in woody vegetation that tend to homogenize their structure (McCleery et al. 2018). These environments house a remarkable diversity of small mammal species (e.g., Happold and Happold 1991; Decher and Bahian 1999), but concerning the Afrotropical

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regions there is no comprehensive study meta-analyzing the diversity patterns, the number of sympatric species by site, and more in general the community structure of savannah rodents and shrews. Conversely, several local studies are available (e.g., Happold and Happold 1991; Decher and Bahian 1999; Papillon et al. 2006; Olayemi and Akinpelu 2014; Decher et al. 2021), but is still unclear whether the locally observed patterns may be generalized to broad savannah regions in the African continent.

The case of the savannahs of Western Africa is especially interesting, given that the species diversity of various animal groups has been shown to be remarkably different in West Africa compared to the rest of the savannah environments in the African continent. In this paper, we provide a meta-analysis of the available data on small mammal (shrews and rodents) communities from the West African savannahs, with a focus on (i) the species richness patterns (diversity, dominance, evenness) per site, (ii) the species' detectability by surveying methods, and (iii) the geographic variations, if any, of the observed patterns.

Materials and methods

Data source and criteria for selection of literature studies

We obtained data from the literature by searching across ISI Web of Knowledge and Google Scholar (key words: "Small mammals west African savannah" (31,900 results); "rodent west African savannah" (13,000 results); "shrews west African savannah" (3,359 results) from 20 to 25 October 2021. We selected for further analysis only articles with the following characteristics: (i) they present raw data of numbers of individuals captured in the various study areas; (ii) they used only standard methodology to capture animals, with only data from carefully explained trapping and not, for instance, opportunistic sightings or general surveys being reported; and (iii) they report explicit mentioning of the study place-names. Some studies, albeit interesting, did not provide this type of data: for instance, they presented figures without raw data. These latter types of articles were not considered in the present paper. The various selected articles, although presenting fully-analyzable data, presented details of bait and trap type (live traps, pitfalls, etc.), trapping design (transect versus grid), and survey effort (expressed as trap / nights) in a heterogeneous way across studies. However, details of some of these aspects were not explained in some of the reviewed studies and hence were not taken into account in this review. For the present study, we considered the following categories of habitat: (i) Guinea savannah, (ii) Sudanese savannah, (iii) Sahel savannah. Some studies reported additional habitats than just the ones mentioned above (for instance, suburbs, forest, etc.). In these cases, we did not consider the data relative to these additional habitats for our analyses. Overall, we re-analysed datasets for 118 populations of rodents (in 10 countries) and 116 of soricomorphs (from 11 countries) (Table 1).

Species richness by country was compiled using data from Amori et al. (2012). Each species was attributed to the savannah category by checking the "habitats" search filter in IUCN (2019).

Statistical analyses

For each site, and only for rodents due to a sufficiently high species richness per site, we calculated various diversity indices used to analyze the community: species richness (i.e. the number of species that were captured in each site), Shannon and Weaver (1949) diversity index, Piélou (1966) evenness index, Dominance index and Simpson's diversity index (Piélou 1969, Pearson and Rosenberg 1978). Piélou's evenness index allows to evaluate whether the individuals are equitably distributed among the species of the target site and varies between 0 and 1. It tends towards 0 when almost the totality of the captured individuals is concentrated on one species and towards 1, when all species have the same abundance within the given sample. We also used the Chao-1 bias corrected index. This is an estimate of total species richness:

$$Chao1 = S + F1 (F1 - 1) / (2 (F2 + 1))$$

where F1 is the number of singleton species and F2 the number of doubleton species.

Bootstrap analysis was used in order to generate upper and lower confidence intervals for the various indices. For the bootstraps, we generated 9,999 random samples, each with the same total number of individuals as in each original sample being generated (Harper 1999).

Differences in the frequencies of savannah species by country, between rodents and soricomorphs, were analyzed by χ^2 test. A General Linear Model (GLM) was performed in order to analyze the effects of total number of species by country and the relative coverage of savannah habitat by country (introduced as independent variables in the model) on the number of savannah species of both Rodentia and Soricomorpha (dependent variable) (Hosmer and Lemeshow 2000). The identity of the link function and a normal distribution of error were used (McCullagh and Nelder 1989). Mann-Whitney U test was used to assess the differences between Soricomorpha and Rodentia in terms of mean number of sympatric species per site. Kruskal-Wallis ANOVA was used to evaluate the among-country differences in the mean number of species per site. Spearman's rank correlation coefficient was used to evaluate the correlation between number of employed methodologies and species richness at each site. Effects of trap/nights effort on the number of rodent species detected were assessed by Pearson's correlation coefficient. This analysis was not performed on Soricomorpha because their species richness per site was low (see below for details). Homoscedasticity and normality were verified by Levene's test and Kolmogorov–Smirnov test prior applying parametric statistics. In the text, means are followed by ± 1 Standard Deviation.

Table 1. Synopsis of the total number of study sites that were re-analyzed for the present study, by country.

	Rodents	Soricomorphs
Benin	10	10
Congo	0	8
Cote d'Ivoire	4	1
Ghana	19	19
Guinea	3	3
Mali	7	3
Mauritania	1	1
Niger	52	52
Nigeria	3	1
Senegal	15	15
Sierra Leone	4	3
TOTAL	118	116

Results

General considerations

The number of species of rodents and soricomorphs by country, with their relative percentage of savannah species, is given in Table 2. Overall, a total of 10,197 small mammal individuals belonging to 111 species of Rodentia and 55 species of Soricomorpha are found in the various countries covered by the present study. The synopsis of the species mentioned in the various studies is given in Appendix 1. The number of species mentioned in the various meta-analyzed studies was 74 (66.6%) for Rodentia and 27 (49.1%) for Soricomorpha. The mean percentage of savannah species by country was 83.3±15.8% in Rodentia and 76.0±22.3% in Soricomorpha. Although the frequencies of savannah species varied considerably from country to country (Table 2), there was no significant difference between rodents and soricomorphs (χ^2=20.38, df=15, p=0.158).

We found that studies using a combination of methods (e.g., live trapping, pitfalls, cover boards, visual encounter) detected more species in both Soricomorpha and Rodentia (correlation between number of methods employed per site and number of species: r_s>0.4, p<0.05). In addition, there was a positive survey (= trap ⁄ night) effort effect on the species richness in rodents (r=0.432, p<0.01). A GLM model showed that there was also no effect of trapping design (transect versus grid), including its interaction with survey effort, on species richness per site ($F_{6,1}$=0.73, p=0.715).

The frequencies of studied populations of both Soricomorpha and Rodentia (Figure 1)

Table 2. Species of rodents and soricomorphs, with the relative percentage of savannah species, by country. Species richness by country was compiled using data from Amori et al. (2012), and the attribution of each species to the savannah habitat category was made according to IUCN (2019).

	Rodentia (total N)	% savannah rodent species	Soricomorpha (total N)	% savannah soricomorph species
Benin	37	81.1	11	81.8
Burkina Faso	35	100	10	100
Cameroon	86	61.6	41	36.6
Central African Republic	62	67.7	31	35.5
Congo	53	54.7	21	19.0
Chad	33	100	8	100
Cote d'Ivoire	55	69.1	17	52.9
Ghana	60	60	12	66.6
Guinea	54	75.9	18	61.1
Mali	47	100	13	100
Mauritania	28	100	8	87.5
Niger	38	100	9	100
Nigeria	67	79.1	25	64
Senegal	35	100	10	100
Sierra Leone	41	65.8	14	64.3
Sudan	79	96.2	18	77.7
Togo	42	76.2	8	87.5

did not differ significantly among countries (χ^2=12.53, df=10, p=0.251), but Niger was more studied than any other country in terms of number of examined populations.

A GLM model revealed that, in both rodents and soricomorphs, the number of savannah species by country depended on the total species richness of that given country, but there was no effect of the relative surface covered by savannahs in that country (Table 3). In addition, there were no significant differences among countries in median soricomorph and rodent species richness per site (Kruskal–Wallis ANOVA: v2=7.00, df=6, p=0.214).

The number of sympatric species per site was 2.73±1.7 (range = 1-7) in Soricomorpha and 6.33±3.8 (range = 1-15) in Rodentia. The differences between the two groups in terms of mean number of sympatric species was statistically significant (Mann-Whitney U test, z=-4.79, U=361, p<0.0001).

Diversity metrics

For rodents, all but two sites (one in Cote d'Ivoire and one in Ghana) were adequately sampled, as the plateau in the new species discovered by individuals captured was clearly reached (Figure 2). Therefore, the diversity metrics were calculated only on the adequately sampled sites. The synopsis of the rodent community diversity metrics per site, including the bootstrapped confidence intervals, are given in the Table 4.

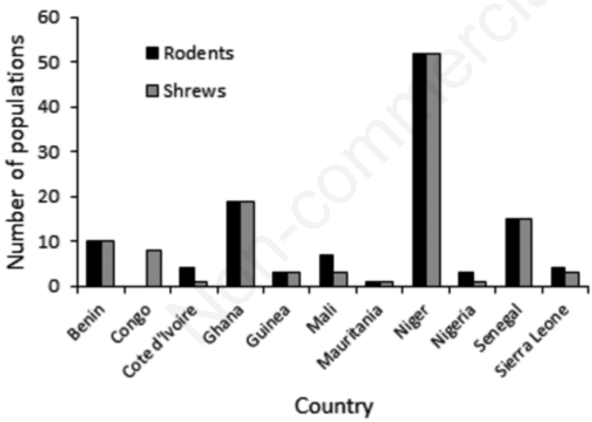

Figure 1. Distribution by country of the number of populations of Soricomorpha and Rodentia meta-analyzed in the present study.

Table 3. Output of a GLM analysis on the effects of total number of species by country and relative coverage of savannah habitat by country (independent variables) on the number of savannah species of both Rodentia and Soricomorpha (dependent variable).

	Sum of squares	df	Mean square	F	p
Rodentia					
total number of species	287.2	1	287.2	8.253	0.018
savannah percentage in country	112.8	4	28.2	0.81	0.549
Soricomorpha					
total number of species	25.08	1	25.08	5.408	0.045
savannah percentage in country	49.27	4	12.32	2.656	0.103

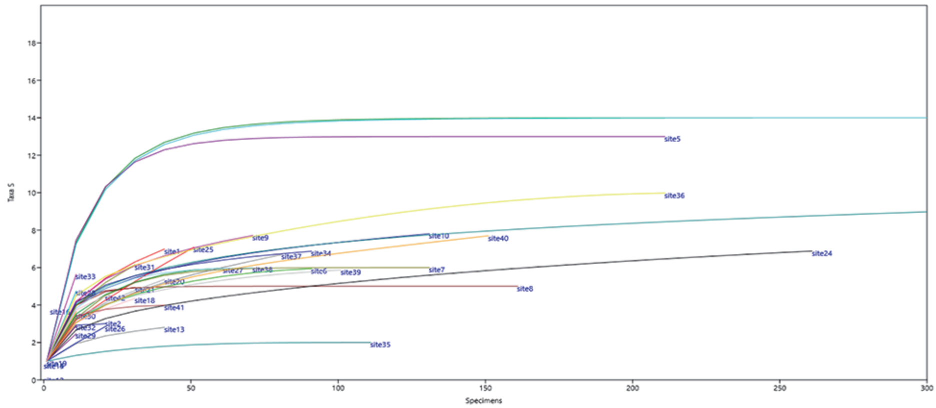

Figure 2. Saturation curves (with 95 % confidence intervals after 9999 bootstraps) for the community diversity of rodents in the various sites for which literature data are available.

Table 4. Synopsis of the diversity metrics for the various rodent communities meta-analyzed in the present study. Lower = bootstrapped lower confidence limits (95% of the estimate). Upper = bootstrapped upper confidence limits (95% of the estimate).

	Species richness	Number of Individuals	Dominance	Simpson	Shannon	Evenness	Chao-1	Country
site1	8	59	0.3094	0.6906	1.453	0.5346	9.5	Mauritania
Lower	7	59	0.2422	0.6004	1.232	0.4618	7	Mauritania
Upper	8	59	0.399	0.7578	1.652	0.6851	14	Mauritania
site2	3	38	0.3837	0.6163	1.022	0.9264	3	Nigeria
Lower	3	38	0.3393	0.5	0.8393	0.7716	3	Nigeria
Upper	3	38	0.5	0.6607	1.09	0.9912	3	Nigeria
site3	14	680	0.09321	0.9068	2.511	0.8799	14	Nigeria
Lower	14	680	0.08726	0.897	2.46	0.8364	14	Nigeria
Upper	14	680	0.1029	0.9127	2.539	0.9049	14	Nigeria
site4	14	408	0.09786	0.9021	2.484	0.8563	14	Nigeria
Lower	14	408	0.09005	0.8871	2.408	0.794	14	Nigeria
Upper	14	408	0.1129	0.9099	2.52	0.8877	14	Nigeria
site5	13	224	0.08598	0.914	2.503	0.9401	13	Nigeria
Lower	13	224	0.08379	0.9019	2.422	0.8667	13	Nigeria
Upper	13	224	0.09805	0.9162	2.519	0.9552	13	Nigeria
site6	6	109	0.3847	0.6153	1.156	0.5294	6	Nigeria
Lower	5	109	0.3366	0.5565	0.9864	0.459	5	Nigeria
Upper	6	109	0.4433	0.6632	1.292	0.6337	7	Nigeria
site7	6	146	0.552	0.448	1.004	0.455	6	Mali
Lower	6	146	0.4593	0.3473	0.7895	0.3671	6	Mali
Upper	6	146	0.6526	0.5406	1.171	0.5375	6	Mali
site8	5	178	0.264	0.736	1.462	0.8626	5	Mali
Lower	5	178	0.2355	0.6897	1.363	0.7817	5	Mali
Upper	5	178	0.3103	0.7645	1.522	0.9164	5	Mali
site9	8	82	0.3501	0.6499	1.409	0.5116	8.5	Cote d'Ivoire
Lower	8	82	0.2668	0.5419	1.198	0.4141	8	Cote d'Ivoire
Upper	8	82	0.4581	0.7332	1.606	0.6231	11	Cote d'Ivoire
site10	8	145	0.3124	0.6876	1.415	0.5148	9	Cote d'Ivoire
Lower	8	145	0.267	0.6263	1.275	0.4478	8	Cote d'Ivoire
Upper	8	145	0.3737	0.7329	1.546	0.5866	11	Cote d'Ivoire

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Table 4. Continued from previous page.

	Species richness	Number of Individuals	Dominance	Simpson	Shannon	Evenness	Chao-1	Country
site11	15	3898	0.3141	0.6859	1.451	0.2844	18	Cote d'Ivoire
Lower	13	3898	0.3036	0.6748	1.419	0.2787	13	Cote d'Ivoire
Upper	15	3898	0.3251	0.6964	1.481	0.3334	21	Cote d'Ivoire
site12	3	5	0.44	0.56	0.9503	0.8621	4	Cote d'Ivoire
Lower	2	5	0.36	0.48	0.673	0.8621	2	Cote d'Ivoire
Upper	3	5	0.52	0.64	1.055	0.9572	4	Cote d'Ivoire
site13	3	51	0.7885	0.2115	0.4152	0.5049	3	Ghana
Lower	3	51	0.6432	0.1123	0.2612	0.4328	3	Ghana
Upper	3	51	0.8877	0.3568	0.6368	0.6301	3	Ghana
site14	5	11	0.2893	0.7107	1.414	0.8227	5.3	Ghana
Lower	4	11	0.2231	0.5455	1.034	0.6377	4	Ghana
Upper	5	11	0.4545	0.7769	1.547	0.9568	11	Ghana
site15	5	14	0.449	0.551	1.128	0.6176	6.5	Ghana
Lower	5	14	0.2347	0.4694	0.9944	0.5406	5	Ghana
Upper	5	14	0.5306	0.7653	1.512	0.9076	11	Ghana
site16	5	22	0.4959	0.5041	1.032	0.5612	5.5	Ghana
Lower	3	22	0.3223	0.2479	0.5481	0.4627	3	Ghana
Upper	5	22	0.7521	0.6777	1.325	0.8166	8	Ghana
site17	2	16	0.6953	0.3047	0.4826	0.8101	2	Ghana
Lower	2	16	0.5313	0.1172	0.2338	0.6317	2	Ghana
Upper	2	16	0.8828	0.4688	0.6616	0.9689	2	Ghana
site18	5	45	0.436	0.564	1.03	0.5602	6	Ghana
Lower	5	45	0.3412	0.4642	0.8956	0.4898	5	Ghana
Upper	5	45	0.5358	0.6588	1.254	0.7006	8	Ghana
site19	7	19	0.3241	0.6759	1.486	0.6314	10	Ghana
Lower	5	19	0.1911	0.5042	1.044	0.509	5	Ghana
Upper	7	19	0.4958	0.8089	1.767	0.8754	13	Ghana
site20	6	52	0.5133	0.4867	0.9957	0.4511	9	Ghana
Lower	6	52	0.3691	0.3654	0.81	0.3746	6	Ghana
Upper	6	52	0.6346	0.6309	1.279	0.5986	9	Ghana
site21	5	42	0.3571	0.6429	1.284	0.7223	5	Ghana
Lower	5	42	0.2664	0.4909	0.9863	0.5379	5	Ghana
Upper	5	42	0.5091	0.7336	1.452	0.854	5	Ghana
site22	4	7	0.3878	0.6122	1.154	0.7925	7	Ghana
Lower	4	7	0.2653	0.6122	1.154	0.7925	4	Ghana
Upper	4	7	0.3878	0.7347	1.352	0.9661	7	Ghana
site23	3	8	0.4063	0.5938	0.9743	0.8831	3	Ghana
Lower	3	8	0.3438	0.4063	0.7356	0.6956	3	Ghana
Upper	3	8	0.5938	0.6563	1.082	0.9837	4	Ghana
site24	7	277	0.5896	0.4104	0.8179	0.3237	7.5	Ghana
Lower	7	277	0.5227	0.3505	0.721	0.2938	7	Ghana
Upper	7	277	0.6495	0.4773	0.9488	0.3689	10	Ghana
site25	8	62	0.4334	0.5666	1.122	0.3838	13	Benin
Lower	7	62	0.3325	0.5021	1.009	0.3643	7.25	Benin
Upper	8	62	0.4979	0.6675	1.406	0.5167	18	Benin
site26	4	34	0.8339	0.1661	0.3954	0.3712	7	Benin
Lower	4	34	0.6073	0.1661	0.3954	0.3712	4	Benin
Upper	4	34	0.8339	0.3927	0.7748	0.5426	7	Benin

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Table 4. Continued from previous page.

	Species richness	Number of Individuals	Dominance	Simpson	Shannon	Evenness	Chao-1	Country
site27	6	72	0.4302	0.5698	1.16	0.5317	6	Benin
Lower	6	72	0.3345	0.4622	0.9458	0.4292	6	Benin
Upper	6	72	0.5378	0.6655	1.359	0.6484	7	Benin
site28	6	22	0.3099	0.6901	1.451	0.7112	6	Benin
Lower	6	22	0.2025	0.562	1.199	0.5527	6	Benin
Upper	6	22	0.438	0.7975	1.685	0.8987	9	Benin
site29	3	23	0.5539	0.4461	0.7393	0.6982	3	Benin
Lower	3	23	0.4253	0.2987	0.5598	0.5835	3	Benin
Upper	3	23	0.7013	0.5747	0.9502	0.8621	3	Benin
site30	5	29	0.4411	0.5589	1.089	0.5942	6	Benin
Lower	5	29	0.2985	0.4067	0.8609	0.4731	5	Benin
Upper	5	29	0.5933	0.7015	1.37	0.787	8	Benin
site31	7	42	0.3243	0.6757	1.367	0.5604	8.5	Benin
Lower	7	42	0.2404	0.6145	1.227	0.4874	7	Benin
Upper	7	42	0.3855	0.7596	1.622	0.723	13	Benin
site32	3	24	0.4618	0.5382	0.9192	0.8357	3	Benin
Lower	3	24	0.3576	0.3438	0.616	0.6172	3	Benin
Upper	3	24	0.6563	0.6424	1.064	0.9655	3	Benin
site33	8	26	0.2041	0.7959	1.795	0.7522	9.5	Benin
Lower	7	26	0.1538	0.6923	1.53	0.5945	8	Benin
Upper	8	26	0.3077	0.8462	1.962	0.8889	14	Benin
site34	7	103	0.3266	0.6734	1.406	0.583	7	Sierra Leone
Lower	7	103	0.2648	0.5852	1.231	0.4891	7	Sierra Leone
Upper	7	103	0.4146	0.735	1.552	0.6744	8	Sierra Leone
site35	2	127	0.939	0.06101	0.1399	0.5751	2	Sierra Leone
Lower	2	127	0.882	0.01562	0.04599	0.5235	2	Sierra Leone
Upper	2	127	0.9844	0.118	0.2351	0.6325	2	Sierra Leone
site36	10	225	0.2533	0.7467	1.617	0.5036	10	Sierra Leone
Lower	8	225	0.2246	0.7045	1.479	0.4543	8	Sierra Leone
Upper	10	225	0.2954	0.7753	1.71	0.5972	16	Sierra Leone
site37	7	90	0.5378	0.4622	0.9678	0.376	10	Sierra Leone
Lower	6	90	0.4333	0.3417	0.7299	0.3099	6	Sierra Leone
Upper	7	90	0.6573	0.5664	1.182	0.4718	13	Sierra Leone
site38	6	89	0.4084	0.5916	1.245	0.579	6	Senegal
Lower	6	89	0.3205	0.4754	1.007	0.4561	6	Senegal
Upper	6	89	0.5243	0.6795	1.412	0.6837	6	Senegal
site39	6	115	0.3954	0.6046	1.169	0.5363	6	Senegal
Lower	5	115	0.3344	0.5205	0.9885	0.459	5	Senegal
Upper	6	115	0.4793	0.6656	1.304	0.629	7	Senegal
site40	8	168	0.5402	0.4598	0.9786	0.3326	11	Senegal
Lower	7	168	0.4618	0.3697	0.7956	0.2917	7	Senegal
Upper	8	168	0.6301	0.5381	1.13	0.4197	11	Senegal
site41	4	55	0.321	0.679	1.216	0.8434	4	Senegal
Lower	4	55	0.2866	0.6083	1.063	0.7234	4	Senegal
Upper	4	55	0.3917	0.7134	1.306	0.9226	4	Senegal
site42	5	34	0.346	0.654	1.251	0.6985	5	Senegal
Lower	5	34	0.2647	0.5311	1.031	0.5607	5	Senegal
Upper	5	34	0.4689	0.7353	1.44	0.8444	6	Senegal

Dominance: this index was significantly different among countries ($F_{7,118}=4.534$, $p<0.0001$); Tukey HSD post-hoc test revealed that Nigeria had significantly lower values than all other countries and Ghana, Benin and Sierra Leone had significantly higher values (in all cases, $p<0.0001$). Exactly the same intercountry pattern, but with opposite effects, were observed in all other indices ($p<0.0001$ in all cases), with Nigeria on the one extreme side of the continuum, and Ghana, Benin and Sierra Leone on the other extreme side of the continuum. However, in terms of Evenness index of the rodent communities ($F_{7,118}=3.342$, $p<0.01$), the Tukey HSD post hoc test revealed that Ghana did not differ from Nigeria ($p=0.114$), whereas Benin and Sierra Leone were still very different (at least $p<0.05$).

Values of diversity indices for rodent communities are reported in Appendix 2.

Discussion

As expected, given that we examined countries with savannahs being the most widespread vegetation zone, we observed that the mean percentage of savannah species was higher than that of forest species in each country, despite the forests are well known to house a higher species richness and a higher diversity of sympatric species than any other Afrotropical habitat (e.g. Kasangaki et al. 2003). Obviously, there are several small mammal species that are known to inhabit both forests and savannahs, so our reasoning applies only to those taxa that inhabit only one of these two biomes.

Our study revealed no effect of using line transects or grids on the probability of increasing the number of detected species by site, so, both can be used indifferently for biodiversity studies focusing on small mammals in savannahs. This fact contrasts with previous studies showing that line transects are more efficient than grids in terms of both number of detected species and number of captured individuals in small mammal surveys (Pearson and Ruggiero 2003). However, expectably our study revealed that a multi-methodological approach (using live trapping, pitfalls, cover boards, visual encounter surveys) was better in finding higher numbers of sympatric species per site. Additional methods, such as examining indirect signs of presence for the various species, were however not analyzed in any of the reviewed studies, although being potentially useful. Thus, for defining a given methodology to survey the species composition of small mammals in Afrotropical savannahs, it should be preferred to apply a multi-methodological approach instead of focusing only on live trapping. There is a plethora of reasons that may explain the observed pattern. For instance, traps can be selective for body size categories, as some species are simply too large to fit into the commercially-made live traps (Longworth; Sherman) (Laurance 1992). A second reason may be that the area covered by a trapping grid or transect is generally smaller compared to the territory that can be surveyed with other methodologies. In addition, live trapping is usually time-consuming and not at all cost-effective, thus typically resulting in short-term studies especially in Afrotropical areas where the economic costs are an important constraint to the field research. Obviously, this is a minor problem in Europe or North America, where several long-term live trapping surveys have been made (e.g., Pucek et al. 1993; Krebs 2009; Kataev 2012; Amori et al. 2015; Henttonen et al. 2017; Casula et al. 2019). It is also important to remind that some species are behaviorally less likely to be trapped than others (e.g., Allan 2020). For instance, gerbils tend to avoid traps whereas murids are easily trapped (our unpublished observations).

Our study also revealed that there were no significant differences among countries in median soricomorph and rodent species richness per site, with the number of sympatric species per site being about 3 (range = 1-7) in Soricomorpha and about 6 (range = 1-15) in Rodentia. Also recent studies from Ghana and Benin revealed a number of species (in Ghana 3 for shrews and 12 for rodents; in Benin 2 for shews and 10 for rodents) that is consistent with our analyses (Nicolas et al. 2020; Decher et al. 2021), and the same is true for rodent communities in Malawi (9 sympatric species; Happold and Happold 1991). Interestingly, a relatively stable number of sympatric species per site was also seen in turtles from West African savannahs (Gbewaa et al. 2021), thus suggesting that the ecological conditions of the various West African savannah sites are functionally similar and support a inter-site similar number of sympatric species although not necessarily the same taxa.

Future studies should explore whether the history of the West African savannahs (largely a human-derived vegetation zone generated from deforestation during historical times, especially in the so-called Dahomey Gap area) has shaped the current diversity and community structure of small mammals, thus explaining the homogeneity in the observed patterns.

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Conflict of interest

The authors declare no potential conflict of interest.

Contributions

GA and LL planned the research, made the analyses and wrote the text; EDB searched the literature and built the database; all authors reviewed the submitted draft.

Availability of data and materials

All data generated or analyzed during this study are included in the published article.

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Appendix

Appendix 1. List of Soricomorpha and Rodentia species mentioned in the various studies meta-analysed in the present paper, including the country where each species has been studied. Taxonomy has been updated according to Wilson et al. (2016, 2017) and Wilson and Mittermeier (2018).

Genus	Species	Authority	Country	Reference
Soricomorpha				
Crocidura	cf. *viaria*	(I. Geoffroy, 1834)	Senegal	Bâ et al. 2012
Crocidura	cf. *lamottei*	Heim de Balsac, 1968	Senegal	Bâ et al. 2012
Crocidura	sp.		Senegal	Konečný et al. 2010
Crocidura	*crossei*	Thomas, 1895	Nigeria	Omogbeme and Oko 2018
Crocidura	*flavescens*	(I. Geoffroy, 1827)	Nigeria	Omogbeme and Oko 2018
Crocidura	*lusitania*	Dollman, 1910	Mauritania	Bruderer and Denys 1999
Crocidura	*olivieri*	(Lesson, 1827)	Benin	Houèmènou et al. 2014
Crocidura	sp.		Benin	Houèmènou et al. 2014
Crocidura	cf. *foxi*	Dollman, 1915	Benin	Nicolas et al. 2010
Crocidura	*fuscomurina*	(Heuglin, 1865)	Benin	Nicolas et al. 2010
Crocidura	*lamottei*		Benin	Nicolas et al. 2010
Crocidura	*nanilla*	Thomas, 1909	Benin	Nicolas et al. 2010
Crocidura	*olivieri*		Benin	Nicolas et al. 2010
Suncus	*megalura*	Jentink, 1888	Benin	Nicolas et al. 2010
Crocidura	cf. *denti*	Dollman, 1915	Congo	Barrière et al. 2005
Crocidura	cf. *hildegardeae*	Thomas, 1904	Congo	Barrière et al. 2006
Crocidura	cf. *poensis*	(Fraser, 1843)	Congo	Barrière et al. 2007
Crocidura	*fuscomurina*		Congo	Barrière et al. 2008
Crocidura	*lamottei*		Congo	Barrière et al. 2009
Crocidura	*littoralis*	Heller, 1910	Congo	Barrière et al. 2010
Crocidura	*ludia*	Hollister, 1916	Congo	Barrière et al. 2011
Crocidura	*nanilla*		Congo	Barrière et al. 2012
Crocidura	*olivieri*		Congo	Barrière et al. 2013
Crocidura	*roosvelti*	(Heller, 1910)	Congo	Barrière et al. 2014
Crocidura	*turba*	Dollman, 1910	Congo	Barrière et al. 2015
Crocidura	*yankariensis*	Hutterer & Jenkins, 1980	Congo	Barrière et al. 2016
Suncus	*infinitesimus*	(Heller, 912)	Congo	Barrière et al. 2017
Suncus	*megalura*		Congo	Barrière et al. 2018
Crocidura	sp.		Ivory Coast	Gautun 1975
Crocidura	*fuscomurina*		Mali	Meinig 2000
Crocidura	*lamottei*		Mali	Meinig 2000
Crocidura	*lusitania*		Mali	Meinig 2000
Crocidura	*nanilla*		Mali	Meinig 2000
Crocidura	*olivieri*		Mali	Schwan et al. 2016
Crocidura	*buettikoferi*	Jentink, 1888	Ghana	Decher and Bahian 1999
Crocidura	*crossei*		Ghana	Decher and Bahian 1999
Crocidura	*lamottei*		Ghana	Decher and Bahian 1999
Crocidura	*poensis*		Ghana	Decher and Bahian 1999
Crocidura	*olivieri*		Ghana	Ofori et al. 2014
Crocidura	*foxi*		Ghana	Ofori et al. 2014
Crocidura	*buettikoferi*		Ghana	Decher et al. 2005
Crocidura	*crossei*		Ghana	Decher et al. 2005
Crocidura	*foxi*		Ghana	Decher et al. 2005
Crocidura	*muricauda*	(Miller, 1900)	Ghana	Decher et al. 2005
Crocidura	*obscurior*	Heim de Balsac, 1958	Ghana	Decher et al. 2005
Crocidura	*olivieri*		Ghana	Decher et al. 2005
Crociruda	*olivieri*		Ghana	Ofori et al. 2016
Crocidura	*grandiceps*	Hutterer, 1983	Ghana	Weber and Fahr 2007
Crocidura	spp.		Guinea	Mariën et al. 2018

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Appendix 1. Continued from previous page.

Genus	Species	Authority	Country	Reference
Rodentia				
Hylomyscus	*alleni*	(Waterhouse, 1838)	Sierra Leone	Weber et al. 2019
Cricetomys	*gambianus*	Waterhouse, 1840	Sierra Leone	Weber et al. 2019
Lemniscomys	*striatus*	(Linnaeus, 1758)	Sierra Leone	Weber et al. 2019
Malacomys	*edwardsi*	Rochebrune, 1885	Sierra Leone	Weber et al. 2019
Mastomys	*erythroleucus*	(Temmninck, 1853)	Sierra Leone	Weber et al. 2019
Praomys	*rostratus*	(Miller, 1900)	Sierra Leone	Weber et al. 2019
Gerbilliscus	*kempi*	(Wroughton, 1906)	Sierra Leone	Weber et al. 2019
Lophuromys	*sikapusi*	(Temminck, 1853)	Sierra Leone	Barnett et al. 2000
Mastomys	*erythroleucus*		Sierra Leone	Barnett et al. 2000
Uranomys	*ruddi*	Dollman, 1909	Sierra Leone	Barnett et al. 2000
Mastomys	*erythroleucus*		Senegal	Bâ et al. 2012
Arvicanthis	*niloticus*	(Desmarest, 1822)	Senegal	Bâ et al. 2012
Praomys	*daltoni*	(Thomas, 1892)	Senegal	Bâ et al. 2012
Mastomys	*natalensis*	(Smith, 1834)	Senegal	Bâ et al. 2012
Lemniscomys	*zebra*	(Heuglin, 1864)	Senegal	Bâ et al. 2012
Mus	*mattheyi*	Petter, 1969	Senegal	Bâ et al. 2012
Gerbilliscus	*guineae*	(Thomas, 1910)	Senegal	Bâ et al. 2012
Taterillus	sp.		Senegal	Bâ et al. 2012
Cricetomys	*gambianus*		Senegal	Bâ et al. 2012
Steatomys	*caurinus*	Thomas, 1912	Senegal	Bâ et al. 2012
Heliosciurus	*gambianus*	(Ogilby, 1835)	Senegal	Bâ et al. 2012
Xerus	*erythropus*		Senegal	Bâ et al. 2012
Xerus	*erythropus*		Senegal	Konečný et al. 2010
Heliosciurus	*gambianus*		Senegal	Konečný et al. 2010
Gerbilliscus	*gambianus*	(Thomas, 1910)	Senegal	Konečný et al. 2010
Gerbilliscus	*guineae*		Senegal	Konečný et al. 2010
Taterillus	*gracilis*	(Thomas, 1892)	Senegal	Konečný et al. 2010
Arvicanthis	*ansorgei*	Thomas, 1910	Senegal	Konečný et al. 2010
Lemniscomys	*zebra*		Senegal	Konečný et al. 2010
Mastomys	*erythroleucus*		Senegal	Konečný et al. 2010
Mus	*mattheyi*		Senegal	Konečný et al. 2010
Praomys	*daltoni*		Senegal	Konečný et al. 2010
Hylomyscus	*stella*	(Thomas, 1911)	Nigeria	Olayemi and Akinpelu 2008
Praomys	*tullbergi*	(Thomas, 1894)	Nigeria	Olayemi and Akinpelu 2008
Mastomys	*natalensis*		Nigeria	Olayemi and Akinpelu 2008
Arvicanthis	*rufinus*	(Temminck, 1853).	Nigeria	Olayemi and Akinpelu 2008
Lemniscomys	*striatus*		Nigeria	Olayemi and Akinpelu 2008
Lophuromys	*sikapusi*		Nigeria	Olayemi and Akinpelu 2008
Praomys	*tullbergi*		Nigeria	Omogbeme and Oko 2018
Rattus	*rattus*	(Linnaeus, 1758)	Nigeria	Omogbeme and Oko 2018
Mastomys	*natalensis*		Nigeria	Omogbeme and Oko 2018
Mus	*muscoloides*	Temminck, 1853	Nigeria	Omogbeme and Oko 2018
Cricetomys	*gambianus*		Nigeria	Omogbeme and Oko 2018
Xerus	*erythropus*	(E. Geoffroy, 1803)	Nigeria	Omogbeme and Oko 2018
Lophuromys	*sikapusi*		Nigeria	Omogbeme and Oko 2018
Lemniscomys	*striatus*		Nigeria	Omogbeme and Oko 2018
Dasymys	*rufulus*	Miller, 1900	Nigeria	Omogbeme and Oko 2018
Arvicanthis	*niloticus*		Nigeria	Omogbeme and Oko 2018
Hylomyscus	*alleni*		Nigeria	Omogbeme and Oko 2018
Gerbilliscus	*robustus*	(Cretzschmar, 1826)	Nigeria	Omogbeme and Oko 2018
Thryonomys	*gregorianus*		Nigeria	Omogbeme and Oko 2018
Atherurus	*africanus*		Nigeria	Omogbeme and Oko 2018
Heliosciurus	*rufobrachium*	(Waterhouse, 1842)	Nigeria	Omogbeme and Oko 2018

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Appendix 1. Continued from previous page.

Genus	Species	Authority	Country	Reference
Protoxerus	*stangeri*	(Waterhouse, 1842)	Nigeria	Omogbeme and Oko 2018
Gerbillus	*nanus*	Blanford, 1875	Mauritania	Bruderer and Denys 1999
Gerbillus	*gerbillus*	(Olivier, 1801)	Mauritania	Bruderer and Denys 1999
Gerbillus	*nigeriae*	Thomas & Hinton, 1920	Mauritania	Bruderer and Denys 1999
Gerbillus	*riggenbachi*	taxonomy unresolved	Mauritania	Bruderer and Denys 1999
Taterillus	*arenarius*	Robbins, 1974	Mauritania	Bruderer and Denys 1999
Mastomys	*huberti*	(Wroughton, 1908)	Mauritania	Bruderer and Denys 1999
Arvicanthis	*niloticus*		Mauritania	Bruderer and Denys 1999
Nannomys	sp.		Mauritania	Bruderer and Denys 1999
Jaculus	*jaculus*	(Linnaeus, 1758)	Mauritania	Bruderer and Denys 1999
Arvicanthis	*niloticus*		Benin	Houemenou et al. 2014
Cricetomys	*gambianus*		Benin	Houèmènou et al. 2014
Dasymys	*rufulus*	Miller, 1900	Benin	Houèmènou et al. 2014
Mus	*musculus*	Linnaeus, 1758	Benin	Houèmènou et al. 2014
Mastomys	sp.		Benin	Houèmènou et al. 2014
Rattus	*norvegicus*	(Berkenhout, 1769)	Benin	Houèmènou et al. 2014
Rattus	*rattus*		Benin	Houèmènou et al. 2014
Taterillus	*gracilis*		Benin	Houèmènou et al. 2014
Gerbilliscus	*kempi*		Benin	Houèmènou et al. 2014
Cricetomys	*gambianus*		Benin	Nicolas et al. 2010
Dendromus	*cf. messorius*		Benin	Nicolas et al. 2010
Gerbilliscus	*guineae*		Benin	Nicolas et al. 2010
Gerbilliscus	*kempi*		Benin	Nicolas et al. 2010
Gerbilliscus	sp.		Benin	Nicolas et al. 2010
Hylomyscus	sp.		Benin	Nicolas et al. 2011
Lemniscomys	*bellieri*	Van der Straeten, 1975	Benin	Nicolas et al. 2010
Lophuromys	cf. *sikapusi*		Benin	Nicolas et al. 2010
Mastomys	*erythroleucus*		Benin	Nicolas et al. 2010
Mus	*baoulei*	(Vermeiren & Verheyen, 1980)	Benin	Nicolas et al. 2010
Mus	*minutoides*		Benin	Nicolas et al. 2010
Praomys	cf. *daltoni*		Benin	Nicolas et al. 2010
Praomys	*misonnei*	Van der Straeten and Dieterlen, 1987	Benin	Nicolas et al. 2010
Steatomys	cf. *caurinus*		Benin	Nicolas et al. 2010
Lemniscomys	*striatus*		Ivory Coast	Traoré et al. 1980
Uranomys	*ruddi*		Ivory Coast	Traoré et al. 1980
Dasymys	*incomtus*	Sundevall, 1847)	Ivory Coast	Traoré et al. 1980
Myomys	*daltoni*		Ivory Coast	Traoré et al. 1980
Lophuromys	*sikapusi*		Ivory Coast	Traoré et al. 1980
Mastomys	*erythroleucus*		Ivory Coast	Traoré et al. 1980
Gerbilliscus	*kempi*		Ivory Coast	Traoré et al. 1980
Graphiurus	*spurreli*	taxonomy unresolved	Ivory Coast	Traoré et al. 1980
Leggada	sp.		Ivory Coast	Traoré et al. 1980
Praomys	*tullbergi*		Ivory Coast	Traoré et al. 1980
Taterillus	*gracilis*		Ivory Coast	Traoré et al. 1980
Lemniscomys	*striatus*		Ivory Coast	Gautun 1975
Lemniscomys	*barbarus*	(Linnaeus, 1766)	Ivory Coast	Gautun 1975
Myomys	*daltoni*		Ivory Coast	Gautun 1975
Tatera	sp.		Ivory Coast	Gautun 1975
Mus (Leggada)	sp.		Ivory Coast	Gautun 1975
Mastomys	*erythroleucus*		Ivory Coast	Gautun 1975
Uranomys	*ruddi*		Ivory Coast	Gautun 1975
Graphiurus	sp.		Ivory Coast	Gautun 1975
Arvicanthis	*niloticus*		Ivory Coast	Gautun 1975
Grammomys	*buntingi*	(Thomas, 1911)	Ivory Coast	Gautun 1975

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Appendix 1. Continued from previous page.

Genus	Species	Authority	Country	Reference
Praomys	*tullbergi*		Ivory Coast	Gautun 1975
Praomys	*rostratus*		Mali	Granjon and Duplantier 2011
Praomys	*daltoni*		Mali	Granjon and Duplantier 2011
Mastomys	*erytholeucus*	(Temmninck, 1853)	Mali	Granjon and Duplantier 2011
Mastomys	*natalensis*		Mali	Granjon and Duplantier 2011
Lemniscomys	*linulus*	(Thomas, 1910)	Mali	Granjon and Duplantier 2011
Lemniscomys	*striatus*		Mali	Granjon and Duplantier 2011
Lemniscomys	*zebra*		Mali	Granjon and Duplantier 2011
Arvicanthis	*ansorgei*		Mali	Granjon and Duplantier 2011
Mus	*minutoides*		Mali	Granjon and Duplantier 2011
Mus	*mattheyi*		Mali	Granjon and Duplantier 2011
Dasymys	*rufulus*		Mali	Granjon and Duplantier 2011
Acomys	*johannis*	Thomas, 1912	Mali	Granjon and Duplantier 2011
Uranomys	*ruddi*		Mali	Granjon and Duplantier 2011
Gerbilliscus	*gambianus*		Mali	Granjon and Duplantier 2011
Taterillus	*gracilis*		Mali	Granjon and Duplantier 2011
Gerbilliscus	*guineae*		Mali	Granjon and Duplantier 2011
Cricetomys	*gambianus*		Mali	Granjon and Duplantier 2011
Steatomys	*caurinus*		Mali	Granjon and Duplantier 2011
Xerus	*erythropus*		Mali	Granjon and Duplantier 2011
Heliosciurus	*gambianus*		Mali	Granjon and Duplantier 2011
Funisciurus	*pyrropus*	(F. Cuvier, 1842)	Mali	Granjon and Duplantier 2011
Felovia	*vae*	Lataste, 1886	Mali	Granjon and Duplantier 2011
Graphiurus	*kelleni*	(Reuvens, 1890)	Mali	Granjon and Duplantier 2011
Thryonomys	*swinderianus*	(Temminck, 1827)	Mali	Granjon and Duplantier 2011
Gerbilliscus	*guineae*		Mali	Meinig 2000
Taterillus	cf. *pygargus*		Mali	Meinig 2000
Mus	*haussa*	(Thomas & Hinton, 1920)	Mali	Meinig 2000
Mastomys	sp.		Mali	Meinig 2000
Myomys	*daltoni*		Mali	Meinig 2000
Steatomys	*caurinus*		Mali	Meinig 2000
Mastomys	*natalensis*		Mali	Schwan et al. 2016
Mastomys	*erythroleucus*		Mali	Schwan et al. 2016
Praomys	*daltoni*		Mali	Schwan et al. 2016
Arvicanthis	*niloticus*		Mali	Schwan et al. 2016
Taterillus	*gracilis*		Mali	Schwan et al. 2016
Rattus	*rattus*		Mali	Schwan et al. 2016
Graphiurus	*lorraineus*	Dollman, 1910	Ghana	Decher and Bahian 1999
Hylomyscus	*alleni*		Ghana	Decher and Bahian 1999
Lemniscomys	*striatus*		Ghana	Decher and Bahian 1999
Mastomys	*erythroleucus*		Ghana	Decher and Bahian 1999
Mastomys	*huberti*		Ghana	Decher and Bahian 1999
Mus	*minutoides*	Smith, 1834	Ghana	Decher and Bahian 1999
Praomys	*daltoni*		Ghana	Decher and Bahian 1999
Gerbilliscus	*kempi*		Ghana	Decher and Bahian 1999
Uranomys	*ruddi*		Ghana	Decher and Bahian 1999
Praomys	*daltoni*		Ghana	Ofori et al. 2014
Rattus	*rattus*		Ghana	Ofori et al. 2014
Arvicanthis	*niloticus*		Ghana	Ofori et al. 2014
Mastomys	*erythroleucus*		Ghana	Ofori et al. 2014
Circetomys	*emini*	Wroughton, 1910)	Ghana	Decher et al. 2005
Dephomys	*defua*	(Miller, 1900)	Ghana	Decher et al. 2005
Grammomys	*kuru*	(Thomas and Wroughton, 1907).	Ghana	Decher et al. 2005
Graphiurus	*nagtglasii*	Jentink, 1888	Ghana	Decher et al. 2005

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Appendix 1. Continued from previous page.

Genus	Species	Authority	Country	Reference
Hybomys	*trivirgatus*	(Temminck, 1853)	Ghana	Decher et al. 2005
Hylomyscus	*alleni*		Ghana	Decher et al. 2005
Lophuromys	*sikapusi*		Ghana	Decher et al. 2005
Malacomys	*cansdalei*	Ansell, 1958	Ghana	Decher et al. 2005
Malacomys	*edwardsi*		Ghana	Decher et al. 2005
Praomys	*tullbergi*		Ghana	Decher et al. 2005
Hylomyscus	*alleni*		Ghana	Ofori et al. 2016
Grammomys	*kuru*		Ghana	Ofori et al. 2016
Lemniscomys	*barbarus*	(Linnaeus, 1766)	Ghana	Ofori et al. 2016
Lemniscomys	*striatus*		Ghana	Ofori et al. 2016
Malacomys	*edwardsi*		Ghana	Ofori et al. 2016
Mastomys	*eruthroleucus*	(Temmninck, 1853)	Ghana	Ofori et al. 2016
Praomys	*tullbergi*		Ghana	Ofori et al. 2016
Gerbilliscus	*kempi*		Ghana	Ofori et al. 2016
Uranomys	*ruddi*		Ghana	Ofori et al. 2016
Praomys	*tullbergi*		Ghana	Weber and Fahr 2007
Malacomys	*edwardsi*		Ghana	Weber and Fahr 2007
Mastomys	sp.		Guinea	Denys et al. 2009
Mus	sp.		Guinea	Denys et al. 2009
Lophuromys	sp.		Guinea	Denys et al. 2009
Praomys	sp.		Guinea	Denys et al. 2009
Praomys (Myomys)	sp.		Guinea	Denys et al. 2009
Gerbilliscus	sp.		Guinea	Denys et al. 2009
Grammomys	sp.		Guinea	Denys et al. 2009
Lemniscomys	sp.		Guinea	Denys et al. 2009
Rattus	sp.		Guinea	Denys et al. 2009
Arvicanthis	sp.		Guinea	Denys et al. 2009
Cricetomys	sp.		Guinea	Denys et al. 2009
Xerus	sp.		Guinea	Denys et al. 2009
Mastomys	*natalensis*		Guinea	Mariën et al. 2018
Praomys	*rostratus*		Guinea	Mariën et al. 2018
Praomys	*daltoni*		Guinea	Mariën et al. 2018
Lemniscomys	*striatus*		Guinea	Mariën et al. 2018
Mus	spp.		Guinea	Mariën et al. 2018
Grammomys	*butingi*	(Thomas, 1911)	Guinea	Mariën et al. 2018
Uranomys	*ruddi*		Guinea	Mariën et al. 2018
Lophuromys	*sikapusi*		Guinea	Mariën et al. 2018
Gerbilliscus	*guineae*		Guinea	Mariën et al. 2018
Rattus	*rattus*		Guinea	Mariën et al. 2018
				Fichet-Calvet et al. 2014

Appendix 2. Diversity indices for rodent communities studied in the various sites meta-analysed in the present paper. Upper = 95% upper limit of the confidence intervals after 9999 bootstraps; lower = lower limit of the confidence intervals after 9999 bootstraps

	Taxa_S	Individuals	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S	Chao-1	Country
site1	8	59	0.3094	0.6906	1.453	0.5346	9.5	Mauritania
Lower	7	59	0.2422	0.6004	1.232	0.4618	7	
Upper	8	59	0.399	0.7578	1.652	0.6851	14	
site2	3	38	0.3837	0.6163	1.022	0.9264	3	Nigeria
Lower	3	38	0.3393	0.5	0.8393	0.7716	3	
Upper	3	38	0.5	0.6607	1.09	0.9912	3	
site3	14	680	0.09321	0.9068	2.511	0.8799	14	
Lower	14	680	0.08726	0.897	2.46	0.8364	14	
Upper	14	680	0.1029	0.9127	2.539	0.9049	14	
site4	14	408	0.09786	0.9021	2.484	0.8563	14	
Lower	14	408	0.09005	0.8871	2.408	0.794	14	
Upper	14	408	0.1129	0.9099	2.52	0.8877	14	
site5	13	224	0.08598	0.914	2.503	0.9401	13	
Lower	13	224	0.08379	0.9019	2.422	0.8667	13	
Upper	13	224	0.09805	0.9162	2.519	0.9552	13	
site6	6	109	0.3847	0.6153	1.156	0.5294	6	
Lower	5	109	0.3366	0.5565	0.9864	0.459	5	
Upper	6	109	0.4433	0.6632	1.292	0.6337	7	
site7	6	146	0.552	0.448	1.004	0.455	6	Mali
Lower	6	146	0.4593	0.3473	0.7895	0.3671	6	
Upper	6	146	0.6526	0.5406	1.171	0.5375	6	
site8	5	178	0.264	0.736	1.462	0.8626	5	
Lower	5	178	0.2355	0.6897	1.363	0.7817	5	
Upper	5	178	0.3103	0.7645	1.522	0.9164	5	
site9	8	82	0.3501	0.6499	1.409	0.5116	8.5	Cote d'Ivoire
Lower	8	82	0.2668	0.5419	1.198	0.4141	8	
Upper	8	82	0.4581	0.7332	1.606	0.6231	11	
site10	8	145	0.3124	0.6876	1.415	0.5148	9	
Lower	8	145	0.267	0.6263	1.275	0.4478	8	
Upper	8	145	0.3737	0.7329	1.546	0.5866	11	
site11	15	3898	0.3141	0.6859	1.451	0.2844	18	
Lower	13	3898	0.3036	0.6748	1.419	0.2787	13	
Upper	15	3898	0.3251	0.6964	1.481	0.3334	21	
site12	3	5	0.44	0.56	0.9503	0.8621	4	
Lower	2	5	0.36	0.48	0.673	0.8621	2	
Upper	3	5	0.52	0.64	1.055	0.9572	4	
site13	3	51	0.7885	0.2115	0.4152	0.5049	3	Ghana
Lower	3	51	0.6432	0.1123	0.2612	0.4328	3	
Upper	3	51	0.8877	0.3568	0.6368	0.6301	3	
site14	5	11	0.2893	0.7107	1.414	0.8227	5.3	
Lower	4	11	0.2231	0.5455	1.034	0.6377	4	
Upper	5	11	0.4545	0.7769	1.547	0.9568	11	
site15	5	14	0.449	0.551	1.128	0.6176	6.5	
Lower	5	14	0.2347	0.4694	0.9944	0.5406	5	
Upper	5	14	0.5306	0.7653	1.512	0.9076	11	
site16	5	22	0.4959	0.5041	1.032	0.5612	5.5	
Lower	3	22	0.3223	0.2479	0.5481	0.4627	3	
Upper	5	22	0.7521	0.6777	1.325	0.8166	8	
site17	2	16	0.6953	0.3047	0.4826	0.8101	2	
Lower	2	16	0.5313	0.1172	0.2338	0.6317	2	
Upper	2	16	0.8828	0.4688	0.6616	0.9689	2	
site18	5	45	0.436	0.564	1.03	0.5602	6	
Lower	5	45	0.3412	0.4642	0.8956	0.4898	5	
Upper	5	45	0.5358	0.6588	1.254	0.7006	8	
site19	7	19	0.3241	0.6759	1.486	0.6314	10	
Lower	5	19	0.1911	0.5042	1.044	0.509	5	
Upper	7	19	0.4958	0.8089	1.767	0.8754	13	
site20	6	52	0.5133	0.4867	0.9957	0.4511	9	
Lower	6	52	0.3691	0.3654	0.81	0.3746	6	
Upper	6	52	0.6346	0.6309	1.279	0.5986	9	

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Appendix 2. Continued from previous page.

	Taxa_S	Individuals	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S	Chao-1	Country
site21	5	42	0.3571	0.6429	1.284	0.7223	5	
Lower	5	42	0.2664	0.4909	0.9863	0.5379	5	
Upper	5	42	0.5091	0.7336	1.452	0.854	5	
site22	4	7	0.3878	0.6122	1.154	0.7925	7	
Lower	4	7	0.2653	0.6122	1.154	0.7925	4	
Upper	4	7	0.3878	0.7347	1.352	0.9661	7	
site23	3	8	0.4063	0.5938	0.9743	0.8831	3	
Lower	3	8	0.3438	0.4063	0.7356	0.6956	3	
Upper	3	8	0.5938	0.6563	1.082	0.9837	4	
site24	7	277	0.5896	0.4104	0.8179	0.3237	7.5	
Lower	7	277	0.5227	0.3505	0.721	0.2938	7	
Upper	7	277	0.6495	0.4773	0.9488	0.3689	10	
site25	8	62	0.4334	0.5666	1.122	0.3838	13	Benin
Lower	7	62	0.3325	0.5021	1.009	0.3643	7.2	
Upper	8	62	0.4979	0.6675	1.406	0.5167	18	
site26	4	34	0.8339	0.1661	0.3954	0.3712	7	
Lower	4	34	0.6073	0.1661	0.3954	0.3712	4	
Upper	4	34	0.8339	0.3927	0.7748	0.5426	7	
site27	6	72	0.4302	0.5698	1.16	0.5317	6	
Lower	6	72	0.3345	0.4622	0.9458	0.4292	6	
Upper	6	72	0.5378	0.6655	1.359	0.6484	7	
site28	6	22	0.3099	0.6901	1.451	0.7112	6	
Lower	6	22	0.2025	0.562	1.199	0.5527	6	
Upper	6	22	0.438	0.7975	1.685	0.8987	9	
site29	3	23	0.5539	0.4461	0.7393	0.6982	3	
Lower	3	23	0.4253	0.2987	0.5598	0.5835	3	
Upper	3	23	0.7013	0.5747	0.9502	0.8621	3	
site30	5	29	0.4411	0.5589	1.089	0.5942	6	
Lower	5	29	0.2985	0.4067	0.8609	0.4731	5	
Upper	5	29	0.5933	0.7015	1.37	0.787	8	
site31	7	42	0.3243	0.6757	1.367	0.5604	8.5	
Lower	7	42	0.2404	0.6145	1.227	0.4874	7	
Upper	7	42	0.3855	0.7596	1.622	0.723	13	
site32	3	24	0.4618	0.5382	0.9192	0.8357	3	
Lower	3	24	0.3576	0.3438	0.616	0.6172	3	
Upper	3	24	0.6563	0.6424	1.064	0.9655	3	
site33	8	26	0.2041	0.7959	1.795	0.7522	9.5	
Lower	7	26	0.1538	0.6923	1.53	0.5945	8	
Upper	8	26	0.3077	0.8462	1.962	0.8889	14	
site34	7	103	0.3266	0.6734	1.406	0.583	7	Sierra Leone
Lower	7	103	0.2648	0.5852	1.231	0.4891	7	
Upper	7	103	0.4146	0.735	1.552	0.6744	8	
site35	2	127	0.939	0.06101	0.1399	0.5751	2	
Lower	2	127	0.882	0.01562	0.04599	0.5235	2	
Upper	2	127	0.9844	0.118	0.2351	0.6325	2	
site36	10	225	0.2533	0.7467	1.617	0.5036	10	
Lower	8	225	0.2246	0.7045	1.479	0.4543	8	
Upper	10	225	0.2954	0.7753	1.71	0.5972	16	
site37	7	90	0.5378	0.4622	0.9678	0.376	10	
Lower	6	90	0.4333	0.3417	0.7299	0.3099	6	
Upper	7	90	0.6573	0.5664	1.182	0.4718	13	
site38	6	89	0.4084	0.5916	1.245	0.579	6	Senegal
Lower	6	89	0.3205	0.4754	1.007	0.4561	6	
Upper	6	89	0.5243	0.6795	1.412	0.6837	6	
site39	6	115	0.3954	0.6046	1.169	0.5363	6	
Lower	5	115	0.3344	0.5205	0.9885	0.459	5	
Upper	6	115	0.4793	0.6656	1.304	0.629	7	
site40	8	168	0.5402	0.4598	0.9786	0.3326	11	
Lower	7	168	0.4618	0.3697	0.7956	0.2917	7	
Upper	8	168	0.6301	0.5381	1.13	0.4197	11	
site41	4	55	0.321	0.679	1.216	0.8434	4	
Lower	4	55	0.2866	0.6083	1.063	0.7234	4	
Upper	4	55	0.3917	0.7134	1.306	0.9226	4	
site42	5	34	0.346	0.654	1.251	0.6985	5	
Lower	5	34	0.2647	0.5311	1.031	0.5607	5	
Upper	5	34	0.4689	0.7353	1.44	0.8444	6	