

Subtle trophic differentiation and seasonal reorganization among sympatric pipistrelle-like bats in West African rice agroecosystems

Carolina Ribeiro¹; Patrícia A.P. Chaves¹; Paula Lopes^{1,2}; Gonçalo Fernandes¹; Sérgio Timóteo³; Ricardo Rocha⁴; Christoph Meyer⁵; Vanessa Mata^{6,7}; Jorge M. Palmeirim¹ and Ana Rainho^{1,8}

1. CE3C- Centre for Ecology, Evolution and Environmental Changes & CHANGE- Global Change and Sustainability Institute, Departamento de Biologia Animal, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisbon, Portugal; 2. SPEA- Portuguese Society for the Study of Birds, 1700-031 Lisboa, Portugal; 3. Centre for Functional Ecology, Associate Laboratory TERRA, Department of Life Sciences, University of Coimbra, Calçada Martim de Freitas, 3000-456 Coimbra, Portugal; 4. Department of Biology, University of Oxford, 11a Mansfield Rd, OX1 3SZ, Oxford, UK; 5. School of Science, Engineering and Environment, University of Salford, Salford, M5 4WT, UK; 6. CIBIO- Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO- Laboratório Associado, Campus de Vairão, 4485-661 Vairão, Portugal; 7. BIOPOLIS- Program in Genomics, Biodiversity and Land Planning, Campus de Vairão, 4485-661 Vairão, Portugal; 8. ICS- Instituto de Ciências Sociais, Universidade de Lisboa, Av. Professor Aníbal de Bettencourt 9, 1600-189 Lisboa, Portugal

Biodiversity and Conservation | Corresponding author: Ana Rainho amrainho@ics.ulisboa.pt

Supplementary material

Table of Contents

Table S1. Number of faecal samples analysed	2
Table S2. Most frequently detected arthropod prey OTUs in the diets	2
Table S3. Potential agricultural pest insect species found in the diet	3
Figure S1. Sample-size-based rarefaction and extrapolation curves for dietary richness.....	3
Table S4. Body and craniodental measurements, foraging behaviour, habitat and diet.....	4
Table S5. Generalized linear mixed-model results for prey richness.....	5
Table S6. Estimated marginal prey richness per individual and pairwise comparisons	5
Table S7. Pairwise PERMANOVA comparisons of OTU-level dietary composition	6
Table S8. Pairwise dietary niche overlap among the three bat species	6
Table S9. Pairwise PERMANOVA comparisons of OTU-level dietary composition among bat species within June and December at Bironqui	6
Table S10. Pairwise dietary overlap.....	7
Table S11. Species-specific smooth terms from generalized additive models.....	8
Table S12. Parametric coefficients from joint generalized additive models	8
Table S13. Estimated marginal means of the dietary contribution of Coleoptera, Hemiptera, and Lepidoptera.....	9
Table S14. Pairwise comparisons of estimated marginal dietary contribution among bat species	9
Table S15. Comparison of reduced and full generalized additive models.....	9
Table S16. Sensitivity analyses assessing the robustness of temporal dietary patterns to spatial and interannual imbalance.....	10
Figure S2. Sensitivity of fitted temporal GAM trajectories to spatial and interannual data restrictions	12
Figure S3. Seasonal variation in insect abundance recorded by yellow sticky traps in lowland rainfed rice fields in Guinea-Bissau.....	13
References	14

Table S1. Number of faecal samples analysed for *Afronycteris nanus*, *Neoromicia somalicus*, and *Pseudoromicia rendalli* by year and month of sampling. Totals are shown for each sampling month and species.

Year	Month	<i>A. nanus</i>	<i>N. somalicus</i>	<i>P. rendalli</i>	Total
2021	October	1	0	0	1
	November	1	0	0	1
	December	1	3	3	7
2022	June	17	9	6	32
	July	4	4	2	10
	September	1	0	0	1
	October	1	0	2	3
	November	5	4	4	13
	December	6	3	1	10
Total		37	23	18	78

Table S2. Most frequently detected arthropod prey OTUs in the diets of the three bat species, showing the best available taxonomic assignment and occurrence across individual bats.

#	Best assignment	Ind	Detection %	<i>A. nanus</i>	<i>N. somalicus</i>	<i>P. rendalli</i>	Similarity BOLD
1	<i>Macrotermes bellicosus</i> (otu5)	31	39.74	14	9	8	100
2	<i>Microtermes</i> otu17	26	33.33	18	7	1	96.57
3	Cicadellidae otu74	20	25.64	9	5	6	100
4	Delphacidae otu19	17	21.79	8	5	4	100
5	Cicadellidae otu116	11	14.10	7	3	1	100
6	Blattodea otu796	9	11.54	8	0	1	92
7	<i>Stenolophus</i> otu196	9	11.54	0	5	4	100
8	Gelechiidae otu77	9	11.54	4	4	1	100
9	Lepidoptera otu129	9	11.54	4	4	1	92.65
10	Ectobiidae otu164	7	8.97	0	7	0	96.08
11	Blattodea otu893	7	8.97	5	1	1	90.72
12	Blattodea otu880	6	7.69	5	0	1	89.71
13	Cicadellidae otu2315	6	7.69	5	1	0	99.51
14	Formicidae otu192	6	7.69	1	4	1	99.5
15	<i>Platymetopus vestitus</i> (otu12)	5	6.41	0	0	5	100
16	Blattodea otu1131	4	5.13	3	0	1	91.67
17	Cicadellidae otu1124	4	5.13	2	2	0	100
18	Rhyparochromidae otu446	4	5.13	0	3	1	100
19	Rhyparochromidae otu90	4	5.13	0	3	1	100
20	Lepidoptera otu499	4	5.13	1	1	2	90.69
21	Podallea otu1093	4	5.13	2	0	2	100
22	Psocodea otu179	4	5.13	3	1	0	94.61
23	<i>Macrotermes</i> otu124	3	3.85	2	0	1	100
24	<i>Parophonus</i> otu32	3	3.85	0	2	1	100
25	<i>Stenolophus</i> otu751	3	3.85	0	1	2	99.51
26	Staphylinidae otu1343	3	3.85	0	3	0	98.53
27	Staphylinidae otu3142	3	3.85	2	1	0	97.55
28	Cicadellidae otu1805	3	3.85	0	3	0	99.51
29	Cicadellidae otu455	3	3.85	2	1	0	100
30	Cicadellidae otu82	3	3.85	2	0	1	100

Table S3. Potential agricultural pest insect species found in the diet of *Afronycteris nanus* (An), *Neoromicia somalicus* (Ns), and *Pseudoromicia rendalli* (Pr).

Prey species	Bat species	Ecology	References
<i>Macrotermes bellicosus</i>	An, Ns, Pr	Rice pest; Crop pest	Heinrichs, 2004; Hill, 2008; Wagner et al., 2008; Rouland Lefèvre, 2011; Heinrichs, 2017
<i>Ancistrotermes cavithorax</i>	An	Crop pest	Akpesse et al., 2008; Wagner et al., 2008; Rouland-Lefèvre, 2011; Ano et al., 2018
<i>Orseolia oryzae</i>	An	Rice pest	Pathak & Khan, 1994; Hill, 2008
<i>Polydesma umbricola</i>	Pr	Crop pest	Kamran, 1968
<i>Poophilus costalis</i>	Pr	Rice pest; Crop pest	Ajayi & Oboite, 2000; Saini et al., 2011; Bhat, 2017
<i>Trigonidium cicindeloides</i>	An	Crop pest	Garg & Tandon, 1982; Ranjith et al., 2022
<i>Xyleborus affinis</i>	An	Crop pest	Merkl & Tusnádi, 1992; Zanuncio et al., 2002; Hill, 2008; Castrejón-Antonio et al., 2020

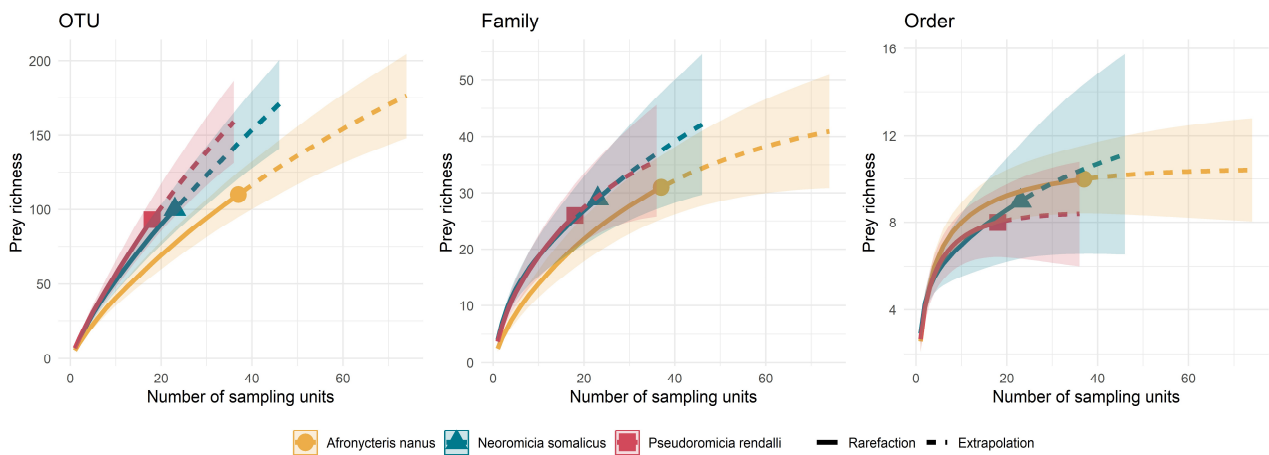


Figure S1. Sample-size-based rarefaction and extrapolation curves for dietary richness of *Afronycteris nanus*, *Neoromicia somalicus*, and *Pseudoromicia rendalli* at OTU, family, and order taxonomic levels. Solid lines represent interpolation (rarefaction) and dashed lines extrapolation. Symbols indicate observed richness at the reference sample size, and shaded areas represent 95% confidence intervals based on 1,000 bootstrap replicates.

Table S4. Body and craniodental measurements, foraging behaviour, habitat and diet of *Afronycteris nanus*, *Neoromicia somalicus*, and *Pseudoromicia rendalli*. TL – Total length; FA - Forearm length; WS – Wingspan; W – Body mass; GLS – Greatest skull length; GWS – Greatest skull width; ZYGO – Zygomatic breadth; MAND – Mandibular length; C-C – Width across upper canines; C-M³ – Maxillary tooththrow length; M³-M³ – Width across third molars; FMaxE – Frequency of maximum energy

Measurements	<i>Afronycteris nanus</i>	<i>Neoromicia somalicus</i>	<i>Pseudoromicia rendalli</i>
TL (mm)	76.00	78.50	89.50
FA (mm)	29.61	28.90	36.23
WS (mm)	214.00	-	261.00
W (g)	3.55	4.10	6.25
GLS (mm)	11.76	12.20	13.36
GWS (mm)	7.10	7.80	8.90
ZYGO (mm)	6.90	7.38	9.16
MAND (mm)	7.62	8.21	9.83
C-C (mm)	3.27	4.05	4.26
C-M ³ (mm)	3.89	4.36	4.65
M ³ -M ³ (mm)	4.76 mm	5.13	5.87
FMaxE (kHz)	69.52 – 74.51 kHz	40.00 – 45.00	44.70 – 48.50
Aspect ratio	Low	Low	Low
Wing loading	Very Low	Not known	Low
Foraging behaviour	Slow hawkler in moderately uncluttered places such as clearings, gaps between trees, and around tree canopies. It forages acrobatically and shows manoeuvrability.	Slow-hawker, 2-6 meters aboveground, in open spaces, and more than 1 meter from vegetation	Slow-hawker, 2 meters aboveground. The bat's flight is slow, with bursts of speed, and poor manoeuvrability
Habitat	Diverse forest and savanna habitats, and desert steppe. It may be dependent on musaceous plants to roost.	Riverine forests (Nigeria); areas of dense thorn scrub, shrubs and stands, with scattered patches of grassland, and riverine woodland (Kenya)	Mainly woodland savannas from West Africa to Sudan and Somalia, and degraded lowland rainforest at rainforest margins. Reported over ditches, small ponds and permanent freshwater pools in gallery forest, and in well-watered habitats.
Diet	Diptera, Hemiptera, Trichoptera and Lepidoptera	-	Lepidoptera, Coleoptera, and Orthoptera

Sources: Norberg & Rayner 1987; Goodman & Ranivo 2004; Lausen & Barclay 2005; Schoeman & Jacobs 2008; Wilson & Mittermeier 2009; Monadjem et al. 2010a, 2010b; Patterson & Webala 2012; Bates et al. 2013; Happold & Happold 2013; Monadjem et al. 2013; Naidoo et al. 2013; Decher et al. 2015; Kangoyé et al. 2015; Monadjem et al. 2021; Taylor et al. 2022; Grunwald et al. 2023; Grunwald et al. 2025; Taylor-Boyd et al. 2025.

Table S5. Generalized linear mixed-model results for prey richness per individual at OTU, family and order taxonomic levels. Models included bat species as a fixed effect and month–year as a random intercept. OTU richness was modelled using a negative-binomial distribution, family richness using a Poisson distribution, and order richness using a Conway–Maxwell–Poisson distribution, all with log links. Fixed-effect estimates are presented on the link scale, with *Afronycteris nanus* as the reference category. χ^2 , df and P refer to the overall likelihood-ratio test of the species effect. Overall species effects were assessed using likelihood-ratio tests comparing models with and without the species term. The only significant *P*-value is shown in bold.

Taxonomic level	Model distribution	Model term	Estimate	SE	Z	χ^2	df	P
OTU	Negative binomial	Intercept	1.807	0.121	14.94	2.04	2	0.360
		<i>N.somalicus</i>	0.167	0.117	1.43			
		<i>P. rendalli</i>	0.107	0.131	0.82			
Family	Poisson	Intercept	0.961	0.124	7.76	10.55	2	0.005
		<i>N.somalicus</i>	0.463	0.149	3.11			
		<i>P. rendalli</i>	0.362	0.166	2.19			
Order	COM-Poisson	Intercept	0.943	0.103	9.19	1.77	2	0.413
		<i>N.somalicus</i>	0.126	0.160	0.79			
		<i>P. rendalli</i>	0.038	0.177	0.21			

Table S6. Estimated marginal prey richness per individual and pairwise comparisons among bat species at family level. Estimated marginal means and 95% confidence intervals are presented on the response scale. Pairwise species comparisons were derived from the corresponding generalized linear mixed models and adjusted for multiple comparisons using the Tukey method. Ratios below 1 indicate lower estimated richness for the first species listed in the contrast relative to the second. The significant adjusted *P*-value is shown in bold.

Taxonomic level	Species / contrast	Estimate	95% CI	Ratio	Tukey-adjusted P
OTU	<i>A. nanus</i>	6.09	4.81–7.72	—	—
	<i>N. somalicus</i>	7.20	5.56–9.32	—	—
	<i>P. rendalli</i>	6.78	5.16–8.91	—	—
Family	<i>A. nanus</i>	2.62	2.05–3.33	—	—
	<i>N. somalicus</i>	4.15	3.26–5.30	—	—
	<i>P. rendalli</i>	3.76	2.87–4.91	—	—
	<i>A. nanus</i> - <i>N. somalicus</i>	—	—	0.629	0.005
	<i>A. nanus</i> - <i>P. rendalli</i>	—	—	0.696	0.074
	<i>N. somalicus</i> - <i>P. rendalli</i>	—	—	1.106	0.811
Order	<i>A. nanus</i>	2.57	2.28–2.89	—	—
	<i>N. somalicus</i>	2.91	2.53–3.36	—	—
	<i>P. rendalli</i>	2.67	2.25–3.15	—	—

Table S7. Pairwise PERMANOVA comparisons of OTU-level dietary composition among the three bat species. Analyses were based on binary Jaccard dissimilarities and 999 permutations, with month retained as a covariate to account for temporal variation in diet composition. For each species pair, the table reports the PERMANOVA F-statistic, proportion of variation explained (R^2), raw P-value, and Holm-adjusted P-value. Significant adjusted P-values are shown in bold.

Species 1	Species 2	F	R^2	P	P adj. Holm
<i>A. nanus</i>	<i>N. somalicus</i>	1.795	0.0259	0.013	0.02
<i>A. nanus</i>	<i>P. rendalli</i>	2.168	0.0336	0.001	0.003
<i>N. somalicus</i>	<i>P. rendalli</i>	1.899	0.0397	0.01	0.02

Table S8. Pairwise dietary niche overlap among the three bat species, quantified using Pianka's index based on OTU-level prey occurrence. Observed overlap was compared with distributions generated from 999 RA3 null-model randomisations. The table reports the observed Pianka index, mean expected overlap under the null model, the 95% interval of the simulated null distribution, the directional P-value, and the direction of departure from the null expectation. "Higher" indicates that observed overlap was significantly greater than expected under the null model.

Species 1	Species 2	Pianka	Null mean	Null 95% CI	P	Direction
<i>A. nanus</i>	<i>N. somalicus</i>	0.602	0.193	0.117 - 0.323	0.001	Higher
<i>A. nanus</i>	<i>P. rendalli</i>	0.491	0.200	0.124 - 0.330	0.003	Higher
<i>N. somalicus</i>	<i>P. rendalli</i>	0.544	0.230	0.153 - 0.346	0.001	Higher

Table S9. Pairwise PERMANOVA comparisons of OTU-level dietary composition among bat species within June and December at Bironqui. Analyses were based on binary Jaccard dissimilarities and 999 permutations. For each month, all pairwise species comparisons are shown with the PERMANOVA F-statistic, proportion of variation explained (R^2), raw P-value, and Holm-adjusted P-value. Significant adjusted P-values are shown in bold.

Month	Species 1	Species 2	F	R^2	p	P adj. Holm
June	<i>A. nanus</i>	<i>N. somalicus</i>	1.753	0.068	0.029	0.058
June	<i>A. nanus</i>	<i>P. rendalli</i>	2.866	0.120	0.006	0.024
June	<i>N. somalicus</i>	<i>P. rendalli</i>	2.401	0.156	0.002	0.012
December	<i>A. nanus</i>	<i>N. somalicus</i>	1.997	0.182	0.002	0.012
December	<i>A. nanus</i>	<i>P. rendalli</i>	1.908	0.175	0.012	0.036
December	<i>N. somalicus</i>	<i>P. rendalli</i>	1.121	0.157	0.201	0.201

Table S10. Pairwise dietary overlap among *Afronycteris nanus* (Anan), *Neoromicia somalicus* (Nsom), and *Pseudoromicia rendalli* (Pren) sampled at Bironqui in June and December, quantified using Pianka's index based on OTU-level prey occurrence. Observed overlap was compared with distributions generated from 999 RA3 null-model randomisations. The table reports the observed Pianka index, mean expected overlap under the null model, its 95% confidence interval, the directional P-value, and the direction of departure from the null expectation. Comparison types are abbreviated as WM-I, within-month interspecific; WS-T, within-species temporal; and BM-I, between-month interspecific. "Higher" and "Lower" indicate overlap significantly greater or lower than expected under the null model, respectively; NS indicates no significant departure from the null expectation.

Mo 1	Sp. 1	Mo 2	Sp. 2	Comparison type	Pianka	Null mean	Null 95% CI	P	Dir.
Dec	Anan	Dec	Nsom	WM-I	0.095	0.176	0.071 - 0.320	0.112	NS
Dec	Anan	Dec	Pren	WM-I	0.173	0.130	0.037 - 0.284	0.251	NS
Dec	Anan	Jun	Anan	WS-T	0	0.106	0.029 - 0.284	0.001	Lower
Dec	Anan	Jun	Nsom	BM-I	0	0.106	0.015 - 0.321	0.004	Lower
Dec	Anan	Jun	Pren	BM-I	0	0.065	0.000 - 0.206	0.053	NS
Dec	Nsom	Dec	Pren	WM-I	0.123	0.212	0.102 - 0.347	0.098	NS
Dec	Nsom	Jun	Anan	BM-I	0	0.171	0.071 - 0.309	0.001	Lower
Dec	Nsom	Jun	Nsom	WS-T	0.012	0.169	0.062 - 0.297	0.001	Lower
Dec	Nsom	Jun	Pren	BM-I	0	0.116	0.020 - 0.241	0.002	Lower
Dec	Pren	Jun	Anan	BM-I	0	0.130	0.043 - 0.291	0.001	Lower
Dec	Pren	Jun	Nsom	BM-I	0.013	0.125	0.026 - 0.284	0.01	Lower
Dec	Pren	Jun	Pren	WS-T	0	0.087	0.000 - 0.271	0.048	Lower
Jun	Anan	Jun	Nsom	WM-I	0.642	0.098	0.023 - 0.259	0.001	Higher
Jun	Anan	Jun	Pren	WM-I	0.631	0.069	0.006 - 0.298	0.003	Higher
Jun	Nsom	Jun	Pren	WM-I	0.543	0.065	0.000 - 0.278	0.002	Higher

Table S11. Species-specific smooth terms from generalized additive models describing temporal variation in the dietary contribution of major arthropod orders. For Coleoptera, Hemiptera and Lepidoptera, smooth terms were estimated within joint three-species GAMs; for Blattodea and Diptera, separate single-species GAMs were fitted where only one or two species met the predefined temporal-data criterion. The table reports estimated degrees of freedom (edf), reference degrees of freedom (Ref.df), *F*-statistics and associated *P*-values for each temporal smooth. Adjusted *R*² refers to the fit of the complete model and is therefore identical across species-specific smooths belonging to the same joint model. Significant *P*-values are shown in bold.

Order	Model type	Species	edf	Ref.df	F	p-value	Adj. R ²
Coleoptera	Joint species	<i>A. nanus</i>	0.563	4	0.264	0.1693	0.485
		<i>N. somalicus</i>	0.953	3	1.728	0.0170	
		<i>P. rendalli</i>	1.969	4	2.738	0.0037	
Hemiptera	Joint species	<i>A. nanus</i>	1.616	4	9.196	0.0000	0.579
		<i>N. somalicus</i>	1.337	3	4.891	0.0003	
		<i>P. rendalli</i>	0.985	4	1.139	0.0242	
Lepidoptera	Joint species	<i>A. nanus</i>	0.797	4	0.660	0.0638	0.031
		<i>N. somalicus</i>	0.00014	3	0.000	0.3282	
		<i>P. rendalli</i>	0.00001	4	0.000	0.7800	
Blattodea	Single species	<i>N. somalicus</i>	1.427	2	6.237	0.0025	0.523
Blattodea	Single species	<i>P. rendalli</i>	1.580	3	5.977	0.0010	0.828
Diptera	Single species	<i>A. nanus</i>	1.773	4	0.876	0.1414	0.135

Table S12. Parametric coefficients from joint generalized additive models describing the dietary contribution of Coleoptera, Hemiptera, and Lepidoptera to the diets of the three bat species. Models included bat species as a parametric effect and species-specific smooths of month, with *Afronycteris nanus* as the reference species. Estimates are presented on the model link scale with standard errors, *t*-statistics, and associated *P*-values. These coefficients represent contrasts with the reference species and are provided for model documentation; interspecific inference is based on Tukey-adjusted estimated marginal means reported separately. Significant *P*-values are shown in bold.

Order	Model type	Term	Estimate	Std. Error	t value	Pr(> t)
Coleoptera	Joint species	(Intercept)	-2.464	0.307	-8.018	1.48e⁻¹¹
		Species: <i>N. somalicus</i>	1.275	0.400	3.188	0.0021
		Species: <i>P. rendalli</i>	0.456	0.674	0.676	0.5014
Hemiptera	Joint species	(Intercept)	-1.452	0.285	-5.098	2.73e⁻⁰⁶
		Species: <i>N. somalicus</i>	0.116	0.416	0.279	0.7811
		Species: <i>P. rendalli</i>	0.163	0.420	0.389	0.6988
Lepidoptera	Joint species	(Intercept)	-2.192	0.256	-8.570	1.06e⁻¹²
		Species: <i>N. somalicus</i>	0.443	0.370	1.196	0.2355
		Species: <i>P. rendalli</i>	-0.153	0.458	-0.333	0.7397

Table S13. Estimated marginal means of the dietary contribution of Coleoptera, Hemiptera, and Lepidoptera for each bat species, derived from the joint generalized additive models. Estimated marginal means were averaged equally across sampled months and are presented on the model link (logit) scale, with standard errors and 95% confidence intervals.

Order	Species	emmean	SE	df	Lower CL	Upper CL
Coleoptera	<i>A. nanus</i>	-2.418	0.310	71.515	-3.036	-1.799
	<i>N. somalicus</i>	-1.100	0.264	71.515	-1.626	-0.575
	<i>P. rendalli</i>	-1.253	0.459	71.515	-2.167	-0.338
Hemiptera	<i>A. nanus</i>	-1.192	0.272	71.062	-1.734	-0.649
	<i>N. somalicus</i>	-0.999	0.322	71.062	-1.641	-0.358
	<i>P. rendalli</i>	-1.136	0.296	71.062	-1.727	-0.545
Lepidoptera	<i>A. nanus</i>	-2.263	0.280	74.203	-2.821	-1.705
	<i>N. somalicus</i>	-1.749	0.267	74.203	-2.282	-1.216
	<i>P. rendalli</i>	-2.345	0.380	74.203	-3.102	-1.587

Table S14. Pairwise comparisons of estimated marginal dietary contribution among bat species for Coleoptera, Hemiptera, and Lepidoptera. Comparisons were derived from the joint generalized additive models using estimated marginal means averaged equally across sampled months. Contrast estimates are presented on the model link (logit) scale and are expressed as the first species listed minus the second; negative values therefore indicate a lower estimated dietary contribution for the first species. *P*-values were adjusted for multiple comparisons using the Tukey method, and the only significant adjusted *P*-value is shown in bold.

Order	contrast	estimate	SE	df	T ratio	P
Coleoptera	<i>A. nanus</i> – <i>N. somalicus</i>	-1.317	0.407	71.515	-3.234	0.0052
Coleoptera	<i>A. nanus</i> – <i>P. rendalli</i>	-1.165	0.554	71.515	-2.104	0.0962
Coleoptera	<i>N. somalicus</i> – <i>P. rendalli</i>	0.152	0.529	71.515	0.287	0.9555
Hemiptera	<i>A. nanus</i> – <i>N. somalicus</i>	-0.192	0.421	71.062	-0.456	0.8919
Hemiptera	<i>A. nanus</i> – <i>P. rendalli</i>	-0.055	0.402	71.062	-0.137	0.9896
Hemiptera	<i>N. somalicus</i> – <i>P. rendalli</i>	0.137	0.438	71.062	0.313	0.9475
Lepidoptera	<i>A. nanus</i> – <i>N. somalicus</i>	-0.514	0.387	74.203	-1.326	0.3854
Lepidoptera	<i>A. nanus</i> – <i>P. rendalli</i>	0.082	0.472	74.203	0.173	0.9836
Lepidoptera	<i>N. somalicus</i> – <i>P. rendalli</i>	0.595	0.465	74.203	1.281	0.4103

Table S15. Comparison of reduced and full generalized additive models testing whether temporal trajectories in dietary contribution differed among bat species for Coleoptera, Hemiptera, and Lepidoptera. Reduced models included a common temporal smooth across species, whereas full models included species-specific temporal smooths. The table reports residual degrees of freedom for the reduced and full models the difference in deviance between models (Δ Deviance), the *F*-statistic, raw *P*-value, and Holm-adjusted *P*-value. None of the model comparisons remained significant after Holm correction.

Order	Resid. df (red.)	Resid. df (full)	Δ Deviance	F	P	P adj. Holm
Coleoptera	73.070	69.694	2.549	3.014	0.030	0.091
Hemiptera	72.769	69.040	1.792	1.904	0.124	0.124
Lepidoptera	73.693	73.659	0.039	5.557	0.032	0.091

Table S16. Sensitivity analyses assessing the robustness of temporal dietary patterns to spatial and interannual imbalance. (A) June–December PERMANOVA and PERMDISP results using only 2022 samples from Bironqui, thereby holding site and year constant. (B) Temporal Pianka overlap estimates for the same restricted dataset, including within-month interspecific comparisons in June and within-species June–December comparisons. (C) GAM sensitivity analyses comparing the full dataset with Bironqui-only, 2022-only, and 2022 Bironqui-only subsets. For each prey order, the table reports model eligibility, species-specific temporal smooths, and Holm-adjusted tests of differences among species-specific temporal trajectories.

Pannel A.

Analysis	Restriction	Effect	R2	F	P	Interpretation
PERMANOVA	2022 + Bironqui	Species	0.09051	2.09457	0.001	Species effect retained when year and site were held constant.
PERMANOVA	2022 + Bironqui	Month	0.13078	6.05325	0.001	Strong June-December effect retained when year and site were held constant.
PERMDISP	2022 + Bironqui	Species		1.62786	0.223	No significant difference in multivariate dispersion.
PERMDISP	2022 + Bironqui	Month		1.43601	0.239	No significant difference in multivariate dispersion.

Pannel B.

Comparison type	Restriction	Comparison	Obs. Pianka	P	Direction	Interpretation
Within-species temporal	2022 + Bironqui	Dec <i>A. nanus</i> vs Jun <i>A. nanus</i>	0	0.001	Lower	December 2022 n = 6; temporal shift remained strongly supported.
Within-species temporal	2022 + Bironqui	Dec <i>N. somalicus</i> vs Jun <i>N. somalicus</i>	0	0.054	NS	December 2022 n = 1; interpret this sensitivity estimate cautiously.
Within-species temporal	2022 + Bironqui	Dec <i>P. rendalli</i> vs Jun <i>P. rendalli</i>	0	0.675	NS	December 2022 n = 1; interpret this sensitivity estimate cautiously.
Within-month interspecific	2022 + Bironqui	Jun <i>A. nanus</i> vs Jun <i>N. somalicus</i>	0.6422	0.001	Higher	June overlap remained high in the 2022 Bironqui subset.
Within-month interspecific	2022 + Bironqui	Jun <i>A. nanus</i> vs Jun <i>P. rendalli</i>	0.6312	0.006	Higher	June overlap remained high in the 2022 Bironqui subset.
Within-month interspecific	2022 + Bironqui	Jun <i>N. somalicus</i> vs Jun <i>P. rendalli</i>	0.5430	0.001	Higher	June overlap remained high in the 2022 Bironqui subset.

Pannel C.

Dataset	Order	Sp. eligible n	Joint 3sp model	<i>A.nanus</i> smooth P	<i>N.somalicus</i> smooth P	<i>P.rendalli</i> smooth P	Trajectory diff P Holm	Interpretation
Full dataset	Blattodea	2	No		0.003	0.001		Joint model not eligible after applying the predefined replication criteria.
	Coleoptera	3	Yes	0.169	0.017	0.004	0.091	Joint model retained; no significant difference among species-specific trajectories.
	Diptera	1	No	0.141				Joint model not eligible after applying the predefined replication criteria.
	Hemiptera	3	Yes	0.000	0.000	0.024	0.124	Joint model retained; no significant difference among species-specific trajectories.
	Lepidoptera	3	Yes	0.064	0.328	0.780	0.091	Joint model retained; no significant difference among species-specific trajectories.
Bironqui only	Blattodea	2	No		0.004	0.001		Joint model not eligible after applying the predefined replication criteria.
	Coleoptera	3	Yes	0.157	0.012	0.004	0.108	Joint model retained; no significant difference among species-specific trajectories.
	Diptera	1	No	0.610				Joint model not eligible after applying the predefined replication criteria.
	Hemiptera	3	Yes	0.000	0.000	0.025	0.175	Joint model retained; no significant difference among species-specific trajectories.
	Lepidoptera	3	Yes	0.077	0.133	0.771	0.422	Joint model retained; no significant difference among species-specific trajectories.
2022 only	Blattodea	1	No			0.002		Joint model not eligible after applying the predefined replication criteria.
	Coleoptera	3	Yes	0.099	0.032	0.003	0.109	Joint model retained; no significant difference among species-specific trajectories.
	Diptera	1	No	0.644				Joint model not eligible after applying the predefined replication criteria.
	Hemiptera	3	Yes	0.000	0.001	0.009	0.247	Joint model retained; no significant difference among species-specific trajectories.
	Lepidoptera	2	No	0.078	0.382			Joint model not eligible after applying the predefined replication criteria.
2022 + Bironqui	Blattodea	1	No			0.002		Joint model not eligible after applying the predefined replication criteria.
	Coleoptera	3	Yes	0.101	0.019	0.003	0.115	Joint model retained; no significant difference among species-specific trajectories.
	Diptera	1	No	0.644				Joint model not eligible after applying the predefined replication criteria.
	Hemiptera	3	Yes	0.000	0.001	0.010	0.386	Joint model retained; no significant difference among species-specific trajectories.
	Lepidoptera	2	No	0.078	0.124			Joint model not eligible after applying the predefined replication criteria.

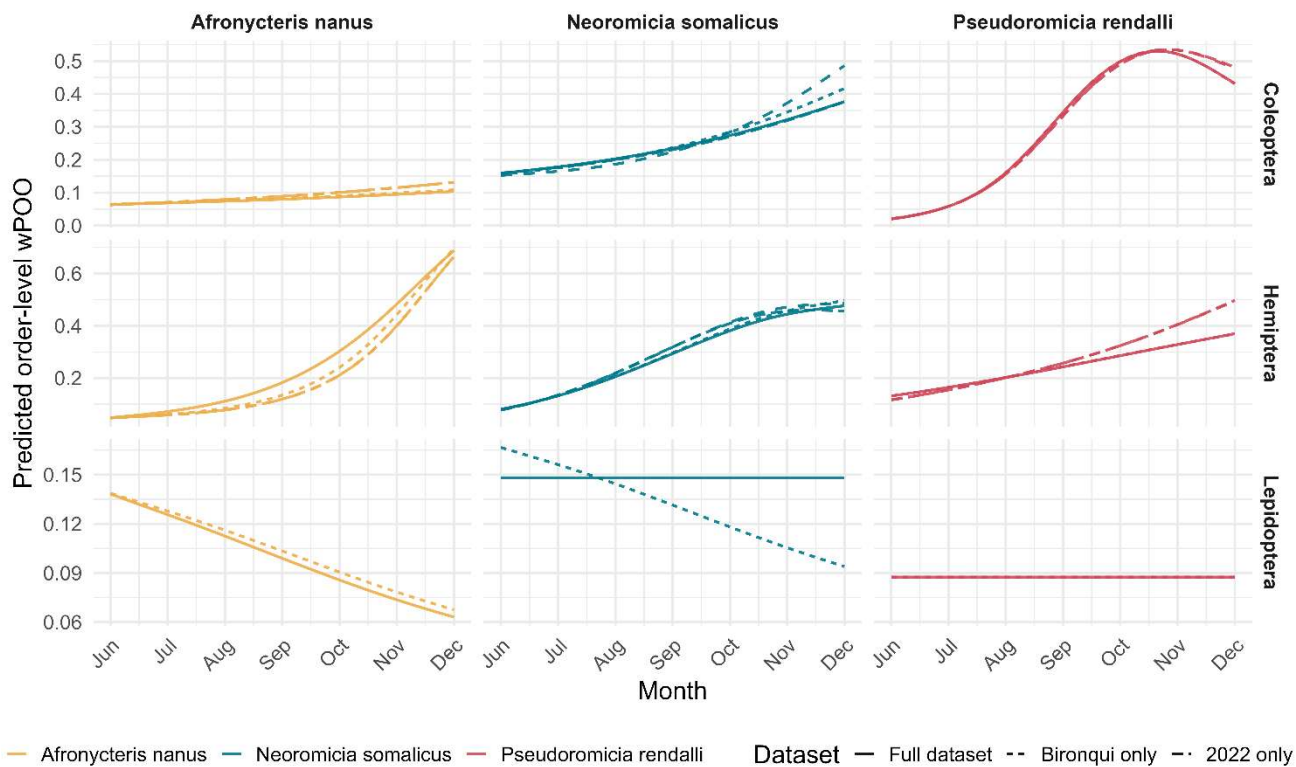


Figure S2. Sensitivity of fitted temporal GAM trajectories to spatial and interannual data restrictions. Predicted order-level weighted proportion of occurrence (wPOO) for Coleoptera, Hemiptera and Lepidoptera in the diets of *Afronycteris nanus*, *Neoromicia somalicus* and *Pseudoromicia rendalli* from June to December. Lines show fitted trajectories from the full dataset and from sensitivity analyses restricted to Bironqui only, 2022 only, and 2022 samples from Bironqui. Similarity among fitted curves indicates that the general form of the principal temporal patterns was largely robust to spatial and interannual sampling imbalance. Only species–order combinations meeting the predefined replication criteria in each dataset are shown.

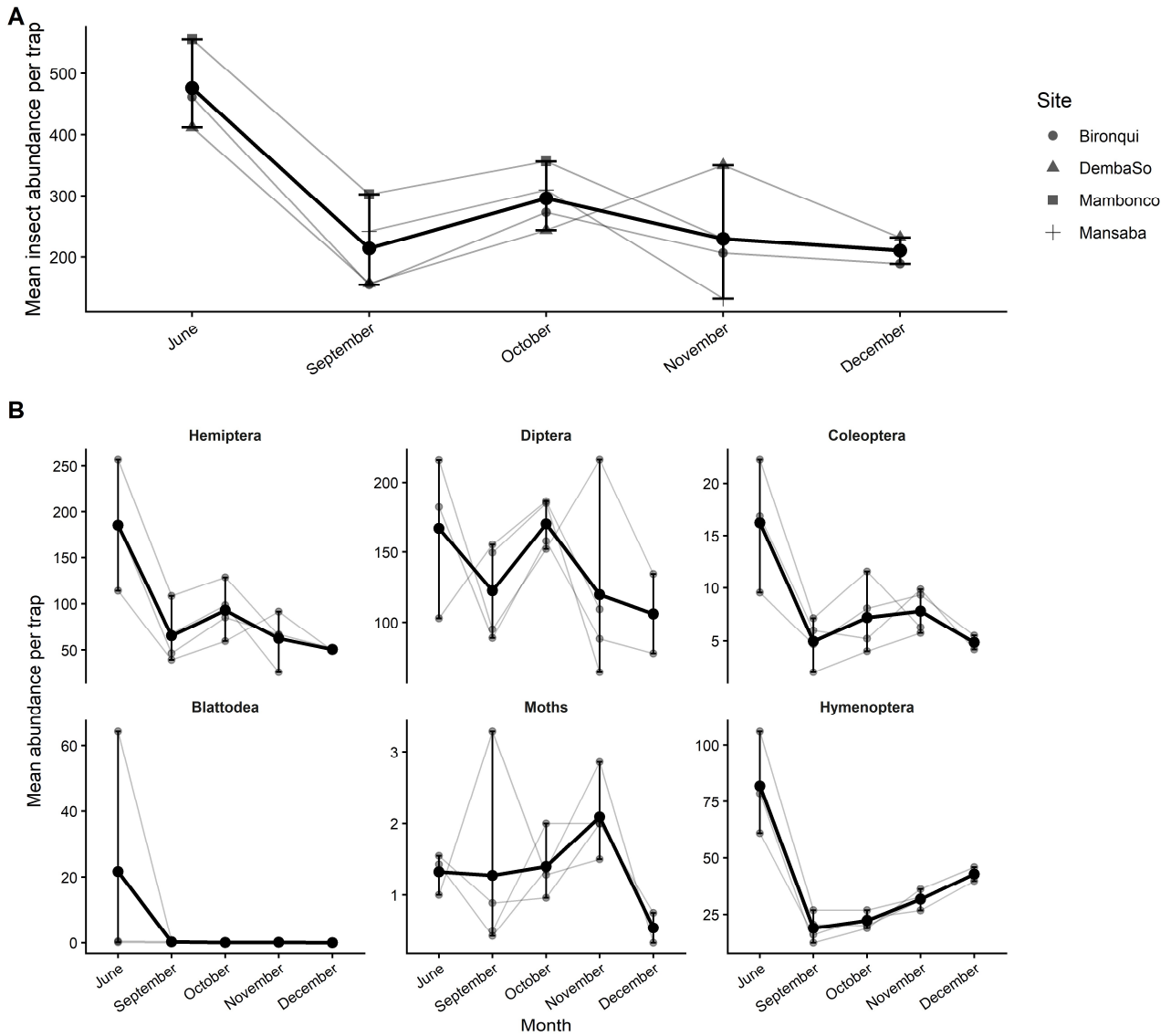


Figure S3. Seasonal variation in insect abundance recorded by yellow sticky traps in lowland rainfed rice fields in Guinea-Bissau during 2022. (A) Mean abundance ($\pm$ SE) of all insects per trap across the five sampling months. (B) Mean abundance ($\pm$ SE) of the principal insect orders detected on the traps. Grey lines represent site-specific means, whereas black lines represent means across sites. Counts from the two sides of each trap were combined before analysis. Butterflies (Lepidoptera) were excluded because they are unlikely to constitute bat prey, and Hymenoptera abundance was calculated using only flying individuals. These data derive from the insect survey described by Fernandes et al. (2025) and are presented here solely as contextual information illustrating seasonal variation in the relative abundance of flying insects; they were not included in the formal dietary analyses.

References

- Akpesse, A. A., Kouassi, P., Tano, Y., & Lepage, M. (2008). Impact des termites dans les champs paysans de Riz et de Mais en savane sub-soudanienne (Booro-Borotou, Côte-d'Ivoire). *Sciences & Nature*, 5(2), 121-131. <https://doi.org/10.4314/scinat.v5i2.42158>
- Ano, E., Annick, T., Siapo, Y., Martin, S., Yao, D., Diby, S. (2018). Comparative study of diversity and termite damage in the selected variety of cocoa "Mercedes or CNRA" and unselected "Tout venant" grown in Abengourou in eastern Côte d'Ivoire. *International Journal of Entomology Research*, 3(4), 27-35. <https://www.entomologyjournals.com/archives/2018/vol3/issue4> . Accessed 11 June 2025.
- Bates, P. J. J., Cameron, K., Pearch, M. J., & Hayes, B. (2013). A Review of the Bats (Chiroptera) Of the Republic of Congo, Including Eight Species New to the Country. *Acta Chiropterologica*, 15(2), 313–340. <https://doi.org/10.3161/150811013X678955>
- Bhat, D. M. (2017). First Report of Some Insect Pests Damaging *Rumex acetosa* L. in Kashmir Himalaya. *Trends in Biosciences*, 10, 2168-2171.
- Castrejón-Antonio, J. E., Tamez-Guerra, P., Montesinos-Matías, R., Ek-Ramos, M. J., Garza-López, P. M., & Arredondo-Bernal, H. C. (2020). Selection of *Beauveria bassiana* (Hypocreales: Cordycipitaceae) strains to control *Xyleborus affinis* (Curculionidae: Scolytinae) females. *PeerJ*, 8, e9472. <https://doi.org/10.7717/peerj.9472>
- Decher, J., Hoffmann, A., Schaer, J., Norris, R. W., Kadjo, B., Astrin, J., Monadjem, A., & Hutterer, R. (2015). Bat Diversity in the Simandou Mountain Range of Guinea, with the Description of a New White-Winged Vespertilionid. *Acta Chiropterologica*, 17(2), 255–282. <https://doi.org/10.3161/15081109ACC2015.17.2.003>
- Fernandes, G. A., Massaad, M., Chaves, P. A., & Rainho, A. (2025). Tree and landscape characteristics outweigh insect abundance in driving bat activity in West African rice fields. *Agriculture, Ecosystems & Environment*, 393, 109774. <https://doi.org/10.1016/j.agee.2025.109774>
- Garg, D. K., & Tandon, J. P. (1982). Major Insect Pests of Rice in Hilly Tracts of Uttar Pradesh, India. *International Rice Research Newsletter*, 7(1), 11–12. <https://doi.org/10.5281/zenodo.7303084>
- Goodman, S. M., & Ranivo, J. (2004). The taxonomic status of *Neoromicia somalicus malagasyensis*. *Mammalian Biology*, 69(6), 434–438. <https://doi.org/10.1078/1616-5047-00166>
- Grunwald, A. L., Demos, T. C., Atagana, P. J., Volk, C. M., Monadjem, A., Okono, F. P. M., Nguéagni, Y., Merrill, R. T., Bevers, I., Armstrong, K. D., Kilber, E. E., Talla, A., Fils, E. M. B., Patterson, B. D., Ballhorn, D. J., & Ruedas, L. A. (2025). Uncovering the Diversity of Bats in the Mbam Minkom Massif, Cameroon: Insights into the Importance of Tropical Inselbergs. *Acta Chiropterologica*, 26(2), 275-314. <https://doi.org/10.3161/15081109ACC2024.26.2.011>
- Grunwald, A. L., Demos, T. C., Nguéagni, Y., Tchamba, M. N., Monadjem, A., Webala, P. W., Peterhans, J. C., Patterson, B. D., & Ruedas, L. A. (2023). A review of bats of the genus *Pseudoromicia* (Chiroptera: Vespertilionidae) with the description of a new species. *Systematics and Biodiversity*, 21(1), 2156002. <https://doi.org/10.1080/14772000.2022.2156002>.
- Happold, M., Happold, D. (eds). (2013). Mammals of Africa: Hedgehogs, Shrews and Bats. *Bloomsbury Publishing, London*, 1, 198-735. <https://doi.org/10.5040/9781472926944.0390>
- Heinrichs, E. A., Barrion, A. T., & Hettel, G. P. (2004). Rice-feeding insects and selected natural enemies in west Africa: Biology, ecology, identification. *International Rice Research Institute & WARDA*, 243.
- Heinrichs, E. A., Nwilene, F., Stout, M., Hadi, B., & Freitas, T. (Eds.). (2017). Rice insect pests and their management. *Burleigh Dodds Science Publishing*, 1, 292. <https://doi.org/10.4324/9781351114240>
- Hill, D. S. (2008). Pests of crops in warmer climates and their control. *Springer, Dordrecht*, 13(5), 704. <https://doi.org/10.1007/978-1-4020-6738-9>
- Kamran, M. A. (1968). Life History and Behavior of *Polydesma umbricola* in Hawaii. *Annals of the Entomological Society of America*, 61(4), 795–802. <https://doi.org/10.1093/aesa/61.4.795>
- Kangoyé, N. M., Ouéda, A., Granjon, L., Thiombiano, A., Guenda, W., & Fahr, J. (2015). Diversity and distribution of bats (Mammalia Chiroptera) in Burkina Faso. *Biodiversity Journal*, 6(2), 597-632. <https://biostor.org/reference/295147> . Accessed on 11 June 2025
- Lausen, C. L., & Barclay, R. M. R. (2005). *Pipistrellus nanus*. *Mammalian Species*, 784, 1–7. <https://doi.org/10.1644/784.1>
- Merkel, O., Tusnádi, C. (1992). First introduction of *Xyleborus affinis* (Coleoptera: Scolytidae), a pest of *Dracaena fragrans* "Massangeana", to Hungary. *Folia Entomologica Hungarica*, 52, 67–72.

- Monadjem, A., Ellstrom, M., Maldonaldo, C., & Fasel, N. (2010a). The activity of an insectivorous bat *Neoromicia nana* on tracks in logged and unlogged forest in tropical Africa. *African Journal of Ecology*, 48(4), 1083–1091. <https://doi.org/10.1111/j.1365-2028.2010.01219.x>
- Monadjem, A.; Taylor, J.T.; Cotterill, F. P. D.; Schoeman M. (2010b). Bats of Southern and Central Africa—A Biogeographic and Taxonomic Synthesis, *Wits University Press*, 2, 728, <https://doi.org/10.18772/22020085829>
- Monadjem, A., Richards, L., Taylor, P. J., & Stoffberg, S. (2013). High diversity of pipistrelloid bats (Vespertilionidae: *Hypsugo*, *Neoromicia*, and *Pipistrellus*) in a West African rainforest with the description of a new species. *Zoological Journal of the Linnean Society*, 167(1), 191–207. <https://doi.org/10.1111/j.1096-3642.2012.00871.x>
- Monadjem, A., Demos, T. C., Dalton, D. L., Webala, P. W., Musila, S., Kerbis Peterhans, J. C., & Patterson, B. D. (2021). A revision of pipistrelle-like bats (Mammalia: Chiroptera: Vespertilionidae) in East Africa with the description of new genera and species. *Zoological Journal of the Linnean Society*, 191(4), 1114–1146. <https://doi.org/10.1093/zoolinlean/zlaa087>
- Naidoo, S., Vosloo, D., & Schoeman, M. C. (2013). Foraging at wastewater treatment works increases the potential for metal accumulation in an urban adapter, the banana bat (*Neoromicia nana*). *African Zoology*, 48(1), 39–55. <https://doi.org/10.1080/15627020.2013.11407567>
- Norberg, U. & Rayner, J. (1987). Ecological morphology and flight in bats (Mammalia; Chiroptera): Wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences*, 316(1179), 335–427. <https://doi.org/10.1098/rstb.1987.0030>
- Pathak, M.D. and Khan, Z.R. (1994). Insect Pests of Rice. *International Rice Research Institute*, Los Banos, Manila, 8(2), 89.
- Patterson, B. D., & Webala, P. W. (2012). Keys to the Bats (Mammalia: Chiroptera) of East Africa. *Fieldiana Life and Earth Sciences*, 6, 1–60. <https://doi.org/10.3158/2158-5520-12.6.1>
- Ranjith, M., Bajya, D. R., & Ramya, R. S. (2022). Abundance and composition of arthropods in sugarcane (*Saccharum officinarum*) ecosystem. *The Indian Journal of Agricultural Sciences*, 92(11), 1386–1390. <https://doi.org/10.56093/ijas.v92i11.108405>
- Saini, M. S., Razak, N., & Ahmad, I. (2011). *Poophilus costalis* Walker (Hemiptera: Cercopoidea: Aphrophoridae): A possible constraint to commercial exploitation of *Lavendula angustifolia* Mill in Kashmir Himalaya with affinity for C₃ photosynthetic plants. *Journal of Medicinal Plants Research*, 5, 2278–2282.
- Schoeman, M. C., & Jacobs, D. S. (2008). The Relative Influence of Competition and Prey Defenses on the Phenotypic Structure of Insectivorous Bat Ensembles in Southern Africa. *PLoS ONE*, 3(11), e3715. <https://doi.org/10.1371/journal.pone.0003715>
- Taylor, P. J., Strydom, E., Richards, L., Markotter, W., Toussaint, D. C., Kearney, T., Cotterill, F. P., Howard, A., Weier, S. M., Keith, M., Neef, G., Mamba, M. L., Magagula, S., & Monadjem, A. (2022). Integrative taxonomic analysis of new collections from the Central Angolan Highlands resolves the taxonomy of African pipistrelloid bats on a continental scale. *Zoological Journal of the Linnean Society*, 196(4), 1570–1590. <https://doi.org/10.1093/zoolinlean/zlac071>
- Taylor-Boyd, H., Fuentes-Montemayor, E., Monadjem, A., Cooper-Bohannon, R., Montauban, C., Mata, V. A., Rebelo, H., Kangwa, B., Mateke, C., & Park, K. (2025). Acoustic parameters of bat echolocation calls in Zambia: A collaborative effort to develop a call library for non-invasive research and monitoring. *Acta Chiropterologica*, 27(1), 111–124. <https://doi.org/10.3161/15081109acc2025.27.1.010>
- Wagner, M. R., Cobbinah, J. R., & Bosu, P. P. (2008). Forest Entomology in West Tropical Africa: Forests Insects of Ghana. *Springer Netherlands*, 2, 244. <https://doi.org/10.1007/978-1-4020-6508-8>
- Wilson, D. E., Mittermeier, R. A., & Cavallini, P. (2009). Handbook of the mammals of the world, Volume 9: Bats. Barcelona. *Lynx Edicions*, 9, 1008. <https://doi.org/10.1007/s42991-020-00026-w>
- Zanuncio, J. C., Sossai, M. F., Couto, L., & Pinto, R. (2002). Occurrence of *Euplatypus parallelus*, *Euplatypus* sp. (col.: Euplatypodidae) and *Xyleborus affinis* (col.: Scolytidae) in *Pinus* sp. in Ribas do Rio Pardo, Mato Grosso do Sul, Brazil. *Revista Árvore*, 26(3), 387–389. <https://doi.org/10.1590/s0100-67622002000300015>