

Article

Riparian Vegetation Conversion to an Oil Tea Plantation: Impacts on Small Mammals at the Community, Population, and Individual Level

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Abstract: Riparian vegetation is crucial for maintaining terrestrial and aquatic biodiversity, but it is threatened by land-use activities. To assess the ecological impacts of riparian vegetation conversion to an oil tea (*Camellia oleifera*) plantation, we quantified the responses of small mammals in two natural habitats (mature forest and flood-meadow) and in *Camellia* forests at the community, population, and individual level. We found that the community diversity was similar between *Camellia* forests and mature forests, but higher than the flood-meadow. Meanwhile, the community composition differed across three habitats, with *Camellia* forests favoring habitat generalist species. At the population level, *Camellia* forests and flood-meadow had a similar population density, which were higher than mature forests. At the individual level, *Rattus nitidus* was less sensitive to this conversion, but the body condition index of *Niviventer confucianus* was higher in *Camellia* forests than in mature forests, and *Apodemus agrarius* in *Camellia* forests had more ectoparasite load than in the flood-meadow, indicating a species-specific response to the impacts of oil tea plantation. Our study highlights that the occurrence of habitat generalist species and high ectoparasite loads may threaten regional biodiversity and increase the risk of parasite transmission with enlarging the oil tea plantation area within riparian zones.

Keywords: *Camellia oleifera*; riparian areas; community composition; population dynamics; body condition; ectoparasite



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1. Introduction

The riparian area is an important transition zone between terrestrial and aquatic ecosystems [1–3]. Riparian vegetation, a key component of the riparian ecosystem, plays a significant role in filtering pollutants, sediments, and nutrients from runoff and groundwater, thereby regulating water quality and influencing the survival of aquatic organisms. [4]. Additionally, the plant composition and structure of the riparian area determine the dynamics of terrestrial animals by offering diverse food and habitats [5]. Nevertheless, human activities, such as land-use and land-cover change, have resulted in the replacement of native plant species with economic plants including food, oil, fiber, and timber plants to meet the rising demand of the increasing human population and economic growth [6–8]. This can lead to the loss of natural habitats and the collapse of riparian ecosystems [9–11]. For example, 88% of riparian forests have disappeared in Europe due to the conversion

to agricultural land and changes in flow patterns, and up to 90% of North America flood-plains are ecologically dysfunctional following human activities [12,13]. Thanks to the establishment and monitoring of the vegetation of protected areas and the assessment of biodiversity, it will hopefully be possible to preserve these environments [14]. In China, seven national observation and research stations for water and wetland ecosystems have been established with the specific purpose of conducting long-term monitoring of flora, fauna, and environment factors [15].

Oil tea (*Camellia oleifera*) is a subtropical evergreen shrub or small tree that is native to southern China, and is one of the world's four famous woody oil plants, along with olive, palm, and coconut. Its seeds can be pressed to yield tea oil (also known as oriental olive oil), which is rich in unsaturated fatty acids, vitamin E, and phytochemicals, and has been used for culinary, medicinal, and cosmetic purpose [16,17]. Because of its high economic and commercial value, oil tea is extensively planted in the south region of the Yangtze River in China. As of 2020, the planting area reached approximately 4.53 million ha, and it is projected to extend to 6 million ha by 2025 [18,19]. This has resulted in the local and landscape-level conversion of natural vegetation into managed economic plantations. A meta-analysis of 125 works of literature found that a tea (*Camellia sinensis*) monoculture plantation can cause a decline in biodiversity, while traditional rustic tea agroecosystems have the potential to support a greater amount of wildlife [20]. Previous studies have demonstrated that an oil tea plantation influences the community assembly of soil microorganisms [21,22], while its impact on local fauna remains poorly understood. In particular, seed-caching rodents have been identified as crucial contributors to the seed fate of oil tea plants, playing a key role in shaping their regeneration process [17,23].

Small mammals, including rodents and shrews, play a critical role in riparian ecosystems and can serve as important indicators of biodiversity. They act as both predators and prey, regulating animal communities through top-down and bottom-up effects by consuming invertebrates and serving as food for larger predators such as carnivores, snakes, and raptors [24]. In addition, small mammals also impact plant regeneration by consuming plants, dispersing seeds, and pollinating flowers [25,26]. Their burrows can also affect soil processes such as aeration and organic turnover, which in turn influence the community dynamics of soil organisms [27]. Therefore, monitoring and assessing small mammals can provide valuable insights into the ecological process occurring in the riparian zones and help to reveal the ecological consequences of enlarging oil tea plantations. In 2019, a specific local standard for wetland monitoring in Anhui Province was developed to establish a standardized monitoring protocol, which potentially enhances the protection of wetland ecosystems [28].

To evaluate the ecological impact of converting native riparian vegetation to oil tea plantations, we sampled small mammal assemblages in natural habitats, including a mature forest and flood-meadow, and in a habitat planted with oil tea (hereafter *Camellia* forest) in the Shengjin Lake National Nature Reserve, China. Our study assessed the effect of an oil tea plantation on small mammals at three levels: (1) community level, evaluating diversity, and composition; (2) population level, assessing density, and sex ratio; and (3) individual level, examining body condition index, and ectoparasite load. As oil tea plantations are a monoculture in our study area, we predict that the conversion of natural habitats to *Camellia* forests could result in low community diversity and population density because of the absence of habitat diversity and complexity [29], and poor body condition due to ecosystems simplification and anthropic disturbance [24,30]. Our findings hold significant implications for riparian vegetation restoration and management, given the critical role of small mammals in ecosystems.

2. Materials and Methods

2.1. Study Area

The field experiment was conducted in Shengjin Lake National Nature Reserve, located on the right bank of the lower Yangtze River in Chizhou City, Anhui Province, China

(WGS84: 30°15′–30°30′ N, 116°55′–117°15′ E). The region experiences a humid subtropical monsoon climate, characterized by four distinct seasons, including hot and rainy summers, and cold and dry winters. The average annual temperature and precipitation is 16.1 °C and 1600 mm, respectively. Shengjin Lake experiences a significant rise in water level during the flood season, peaking at 12.5 m, typically occurring between May and August. Conversely, during the dry season (November to the following April), the water level drops to 8.9 m [31,32]. This natural fluctuation exposes large areas of fluctuating zones, creating a crucial habitat for the survival of numerous endangered and endemic species (e.g., *Grus monachal* and *Aquila heliaca*) [33]. The reserve spans an area of 33,340 ha and is divided into three parts: a core area of 10,150 ha, a buffer area of 10,300 ha, and an experimental area of 12,890 ha (Figure 1). It is inhabited by approximately 70,000 people, with 20,000 residing in the buffer area and 50,000 in the experimental area. Local residents rely on various activities for their livelihoods, including fishing, pen culture, woodland exploitation, and agricultural practices. However, these activities have resulted in extensive loss of natural habitats and the conversion of land for fish ponds, crop cultivation, and commercial forestry within the buffer and experimental areas [34,35].

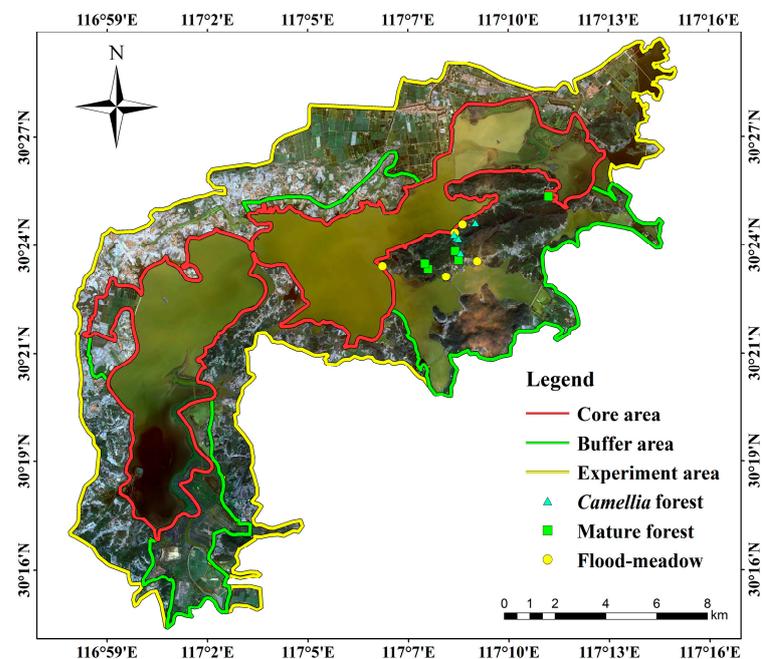


Figure 1. Map of the Shengjin Lake National Nature Reserve illustrating the core, buffer, and experimental area, as well as the sampling sites for small mammals in the *Camellia* forest, mature forest, and flood-meadow.

2.2. Quantifying Habitat Characteristics

To evaluate the impact of an oil tea plantation on small mammals, we selected two different natural habitats, namely a mature forest and a flood-meadow, as comparisons to the *Camellia* forest. The mature forest, dominated by *Quercus* spp., *Cyclobalanopsis* spp., and *Lithocarpus* spp., has a diverse understory structure. Local residents primarily rely on aquatic resources in Shengjin Lake and rarely utilize the mature forest [35]. Affected by seasonal fluctuations in water levels of Shengjin Lake, the flood-meadow emerges in November and becomes submerged by June. It mainly comprises *Carex* spp., *Polygonum* spp., and *Phalaris* spp., with *C. brownie* and *C. argyi* having a coverage rate over 85%. *Carex* spp. exhibit two distinct growing seasons: the first occurs from late October to late January, while the second spans from early February to mid-April. The peak seed production of these plants occurs in May [36]. The *Camellia* forest is composed of oil tea trees planted in 2006, with an average tree height of 2 m. Flowers begin to bloom in mid-October, and

young fruits start to develop in March of the following year. In mid-May, tea fruits undergo rapid growth and ultimately mature by late September. The fruits or seeds are hand-picked by humans. However, some seeds are unintentionally dropped and fall to the ground, becoming available as food source for animals until the following spring [17]. Oil tea management involves various tasks such as soil loosening, branch pruning, fertilization, pest control, and weeding. At our study site, soil loosening, fertilization, and pest control were performed for seedlings, while branch pruning and weeding were carried out for adult trees during March and April.

2.3. Sampling for Small Mammals

In May 2021, we conducted a small mammal survey using iron snap traps in the mature forest, flood-meadow, and *Camellia* forest. We randomly selected five sites for each habitat (Figure 1). At each site, we established two parallel lines spaced approximately 50 m apart. Along each line, we placed a total of 100 traps baited with peanuts, with each trap spaced at intervals of 2–3 m. The traps were set at nightfall and collected the following morning. Each site was surveyed four times during May, except for one site in the flood-meadow, which was destroyed due to human activities. All of the captured individuals were then given a unique number and placed into sealed bag before being transported to the laboratory. Species identification was based on pelage (e.g., color, texture, and length) and morphological characteristics (e.g., body size, tail, and foot length). Gender identification was determined by examining their external genitalia or reproductive glands [37]. In addition, we measured each individual's body mass and length and counted their ectoparasite loads.

2.4. Data Analysis

At the community level, we calculated four diversity indexes: Margalef's richness index, Shannon–Wiener diversity index, Pielou's evenness index, and Simpson's diversity index for each sample site to reflect species richness, diversity, evenness, and dominance of small mammals in the mature forest, flood-meadow, and *Camellia* forest. These four metrics were achieved using *abdiv* package (*margalef* and *pielou_e* function) and *vegan* (*diversity* function) package. Generalized linear models (GLMs) with a Gaussian distribution were used to evaluate their variations across habitats. In addition, we applied a multivariate generalized linear model (*manyglm*) with a Poisson error structure and 999 Monte-Carlo permutations to assess the variation in community composition across habitats. The *anova.manyglm* function in the *mvabund* package was used to test for multivariate significance with a log-likelihood ratio test statistic [24,38].

The effects of oil tea plantation at the population level were determined by two metrics: population density and sex ratio. Population density was recorded as the total number of captured individuals in each sample site. As the number of captures can be affected by the number of effective traps, we fit the population density data using Poisson GLMs with log-transformed number of traps as an offset [39]. For the analysis of the sex ratio (i.e., ratio of males to all captured individuals), we first evaluated whether our observed ratio deviated from the theoretical ratio of 0.5 using the Chi-square goodness of fit test. Then, we compared the differences in sex ratios across habitats using GLMs with a Binomial distribution [40].

At the individual level, we measured two metrics: body condition index, which serves as a proxy for an animal's ecological fitness [41], and ectoparasite load, which can have negative effects on host health [42]. The body condition index was calculated as $C = (Q/L^3) \times 10^5$, where C represents the body condition index, Q represents body mass, and L represents body length [43]. In the analysis of the oil tea plantation impact at the individual level, we only included species with more than 10 individuals in each habitat to reduce the potential bias due to the small sample size. Furthermore, we included the sex of each individual as an explanatory variable in the model due to the sexual variations. The differences in body condition index across habitats were examined using

GLMs with a Gaussian distribution. As the ectoparasite was found in 39.8% of individuals, we first checked for zero-inflation using the *vuong* function in the *pscl* package and for overdispersion using the *qcc.overdispersion.test* function in the *qcc* package. Because of the overdispersion found, we used the negative binomial regression models (NB) to assess the differences in ectoparasite load across habitats [39].

All of the statistical analyses were conducted using R version 4.1.3. GLMs and NB were constructed using the *stats* and *MASS* package, respectively. The *Anova* function in the *car* package was utilized to calculate the likelihood ratio χ^2 test statistic and associated model significance. Additionally, the *glht* function in the *multcomp* package was used to perform Tukey HSD tests for post hoc pairwise comparisons.

3. Results

3.1. Community Diversity and Composition

A total of 235 small mammals belonging to seven species were trapped in 11,168 effective trap-nights (Table 1). The mean Margalef's richness index, Shannon–Wiener diversity index, Pielou's evenness index, and Simpson's index were 0.63, 0.64, 0.72, and 0.37, respectively. The Margalef's richness index, Shannon–Wiener diversity index, and Simpson's index significantly differed across habitats (all $\chi^2 > 8.337$, $p < 0.015$), while Pielou's evenness index was similar ($\chi^2 = 2.637$, $p = 0.268$). Compared with the flood-meadow, the oil tea plantation significantly increased 1.66, 1.50, and 1.40 times in Margalef's richness index, Shannon–Wiener diversity index, and Simpson's index, respectively (Tukey HSD test: all $p < 0.013$; Figure 2), while the Shannon–Wiener diversity index and Simpson's index in mature forest increased 1.03 and 1.12 times (Tukey HSD test: all $p < 0.048$; Figure 2). No differences in diversity indexes were observed between the *Camellia* forest and the mature forest (Tukey HSD test: all $p > 0.532$; Figure 2).

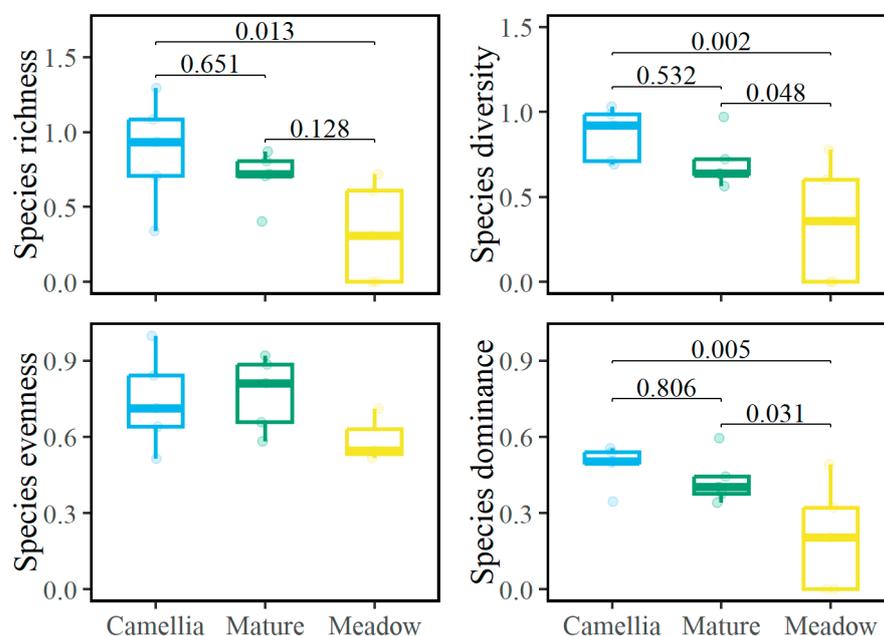
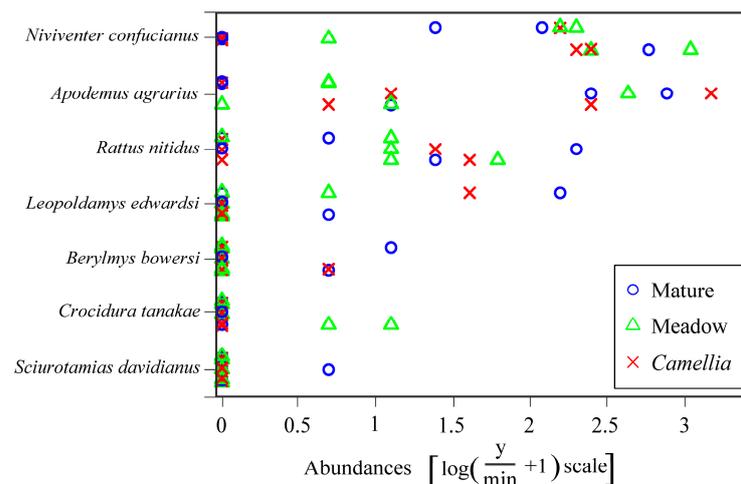


Figure 2. Species richness (i.e., Margalef's richness index), diversity (i.e., Shannon–Wiener diversity index), evenness (i.e., Pielou's evenness index), and dominance (i.e., Simpson's index) of small mammals in the *Camellia* forest, mature forest, and flood-meadow within riparian zones at Shengjin Lake. Box plots show the median (center line), interquartile range (hinges), and 1.5 times the interquartile range from the hinge (whiskers). The observed data points are overlaid on the boxplot, and p -values of Tukey HSD tests are shown above the boxplot.

Table 1. Abundance of small mammals captured from 11,168 effective trap-nights in the *Camellia* forest, mature forest, and flood-meadow within riparian zones at Shengjin Lake.

Species	Family	<i>Camellia</i> Forest	Mature Forest	Flood-Meadow
<i>Apodemus agrarius</i>	Muridae	15	2	65
<i>Berylmys bowersi</i>	Muridae	2	2	0
<i>Niviventer confucianus</i>	Muridae	64	35	1
<i>Rattus nitidus</i>	Muridae	14	3	14
<i>Leopoldamys edwardsi</i>	Muridae	1	13	0
<i>Sciurotamias davidianus</i>	Sciuridae	0	0	1
<i>Crociodura tanakae</i>	Soricidae	3	0	0
Total		99	55	81

The community composition of small mammals significantly differed among three habitats ($\chi^2 = 209.229$, $p = 0.001$; *anova.manyglm* function in *mvabund*; Figure 3), with clear impacts observed for *Niviventer confucianus*, *Apodemus agrarius*, *Rattus nitidus*, and *Leopoldamys edwardsi* (all $p < 0.014$). In the *Camellia* forest, *N. confucianus*, *A. agrarius*, and *R. nitidus* were the predominant species, accounting for 64.65%, 15.15%, and 14.14% of all captured individuals, respectively. In the mature forest, *N. confucianus* and *L. edwardsi* were the predominant species, accounting for 63.64% and 23.64%, respectively. In the flood-meadow, the *A. agrarius* and *R. nitidus* were the predominant species, accounting for 80.25% and 17.28%, respectively (Table 1).

**Figure 3.** The abundance of small mammals in the *Camellia* forest, mature forest, and flood-meadow within riparian zones at Shengjin Lake, and samples in the same habitat are coded with the same color.

3.2. Population Density and Sex Ratio

The mean population density of small mammals was 15.67, ranging from 11 in the mature forest to 19.8 in the *Camellia* forest. Significant differences were observed in population density across habitats ($\chi^2 = 15.638$, $p < 0.001$). The higher population density was found in the *Camellia* forest and flood-meadow compared with that in the mature forest (Tukey HSD test: both $p < 0.004$; Figure 4), while no difference was observed between the *Camellia* forest and the flood-meadow (Figure 4). The mean sex ratio of small mammals was 0.46, 0.40, and 0.62 in the *Camellia* forest, mature forest, and flood-meadow, and did not deviate from the theoretical ratio of 0.5 (all $\chi^2 < 0.891$, $p > 0.345$). No significant differences in the sex ratio were found across habitats ($\chi^2 = 0.767$, $p = 0.682$; Figure 4).

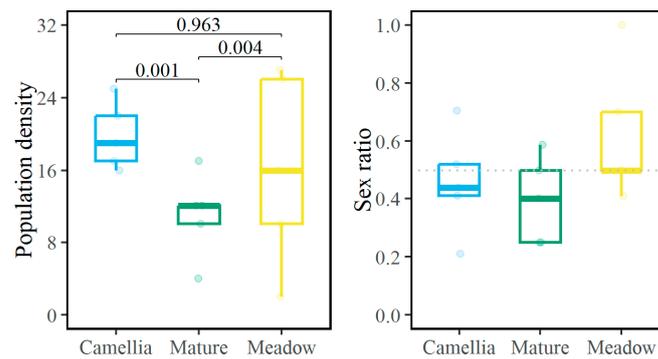


Figure 4. Population density and sex ratios for small mammals in the *Camellia* forest, mature forest, and flood-meadow within riparian zones at Shengjin Lake. Box plots show the median (center line), interquartile range (hinges), and 1.5 times the interquartile range from the hinge (whiskers). The observed data points are overlaid on the boxplot, and p -values of Tukey HSD tests are shown above the boxplot.

3.3. Body Condition Index and Ectoparasite Load

For *N. confucianus*, *A. agrarius*, and *R. nitidus*, the mean body condition index was 3.85, 3.86, and 3.31, and the mean ectoparasite load was 1.06, 0.52, and 1.64, respectively. The effect of the oil tea plantation on the body condition index ($\chi^2 = 8.932$, $p = 0.011$) and ectoparasite load ($\chi^2 = 5.639$, $p = 0.060$) varied among the different species. For *N. confucianus*, a higher body condition index was found in the *Camellia* forest compared with the mature forest ($\chi^2 = 5.722$, $p = 0.017$, Figure 5a), while no differences in ectoparasite load were observed between different habitats ($\chi^2 = 0.463$, $p = 0.496$, Figure 5d). For *A. agrarius*, individuals from the *Camellia* forest had a higher ectoparasite load than that in the flood-meadow ($\chi^2 = 4.492$, $p = 0.034$, Figure 5e), while the body condition index was similar between different habitats ($\chi^2 = 0.775$, $p = 0.379$, Figure 5b). The body condition index ($\chi^2 = 0.058$, $p = 0.811$, Figure 5c) and ectoparasite load ($\chi^2 = 2.110$, $p = 0.146$, Figure 5f) of *R. nitidus* were not affected by the oil tea plantation. Significant sexual differences were only found in body condition index for *A. agrarius*, with higher value for female individuals ($\chi^2 = 3.906$, $p = 0.048$, Figure 5b).

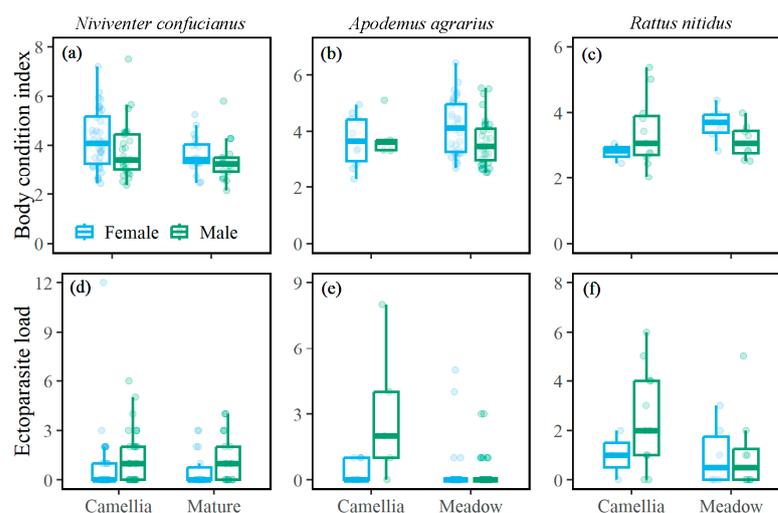


Figure 5. Body condition index and ectoparasite load of *Niviventer confucianus* (a,d), *Apodemus agrarius* (b,e) and *Rattus nitidus* (c,f) in the *Camellia* forest, mature forest, and flood-meadow within riparian zones at Shengjin Lake. Box plots show the median (center line), interquartile range (hinges), and 1.5 times the interquartile range from the hinge (whiskers). The observed data points are overlaid on the boxplot.

4. Discussion

Land use is regarded as one of the most important drivers of biodiversity loss [44,45]. In this study, we found that the conversion of riparian vegetation to an oil tea plantation did not influence community diversity of small mammals. Instead, it resulted in changes to the community composition and population density, as well as species-specific effects on individual body condition and health.

According to the structural complexity hypothesis, increasing the structural complexity of plantation forests can create habitat heterogeneity and thus support the occurrence of more small mammal species [46,47]. However, this hypothesis was partly supported by our study. Despite the low structural complexity of the oil tea monoculture plantation, it did not lead to a reduction in community diversity, as evidenced by the similar species richness, diversity, evenness, and dominance in the *Camellia* forest and the mature forest. In our study area, the oil tea trees are pruned to a height of ca. 2 m for easy harvesting of fruits. This results in extremely high shrub cover in the *Camellia* forest, which may provide shelter for small mammals to avoid predation [48]. Additionally, *Camellia* seeds are one of the main food resources for rodents [17], which attracts some species to enter the *Camellia* forest. In contrast, community diversity in the flood-meadow is low, which may be due to structural simplification. The lack of habitat heterogeneity in the flood-meadow may result in the reduced occurrence of small mammal species and finally a decrease in community diversity [46,47].

However, the community composition of small mammals varied across three habitats. The mature forest was predominantly occupied by *N. confucianus* and *L. edwardsi*, with *N. confucianus* being a habitat generalist found in various habitats such as forests, steppes, and farms [49], while *L. edwardsi* is a large-bodied rodent species that prefers forest habitats [50]. In comparison, the *Camellia* forest had more *N. confucianus* individuals, but was less suitable for the survival of *L. edwardsi*. The flood-meadow, on the other hand, was predominantly occupied by *A. agrarius* and *R. nitidus*, both of which prefer damp environments and are able to swim [51]. Additionally, *A. agrarius* and *R. nitidus* are often found in agricultural habitats and exhibit a high tolerance to human disturbance [37], allowing them to adapt to the *Camellia* forest.

The population density of small mammals in the *Camellia* forest and flood-meadow were found to be similar and higher than that in the mature forest. The survival and persistence of a population is influenced by many extrinsic factors such as food availability and predation risk [52]. In the *Camellia* forest, the high shrub cover and large quantity of *Camellia* seeds may contribute to the increased population density by reducing predation risk and providing abundant food resources. Similarly, the *Carex* spp. and *Phalaris* spp. in the flood-meadow produce abundant seed crops during our study period, providing an ample food source for *A. agrarius* [53]. The sex ratio in a population is also critical for population persistence [54]. In plantation forests, studies have found male-biased sex ratios of small mammals due to a high predation risk [24,48]. Maternal diet can also influence offspring sex, with high saturated fat but low carbohydrate leading to high probability of male pups [55,56]. Our study observed similar sex ratios across different habitats, indicating that changes in predation risk and food quality could have contributed to this multifactorial result. Thus, our findings suggest that habitat characteristics (i.e., high shrub cover here) and food resources (i.e., *Camellia* seeds) are important factors that shape the population dynamics of small mammals in our study area.

At the individual level, our study revealed that different small mammal species exhibit varying responses to the impact of oil tea plantations. In particular, we found that *N. confucianus* and *A. agrarius* are more susceptible to habitat alteration than *R. nitidus*. Interestingly, our findings contradict a previous study that reported a poor body condition of *N. confucianus* in plantation forests [24]. Instead, we found that *N. confucianus* in the *Camellia* forest had a higher body condition index, potentially due to the abundant production of *Camellia* seeds that could counteract the detrimental effects of the artificial habitat [57]. As predicted by epidemiological models, a high host density increases the

likelihood of parasite infection [58,59]. Although there were fewer *A. agrarius* individuals in the *Camellia* forest than the flood-meadow, the ectoparasite load was greater in the *Camellia* forest, possibly due to habitat anthropogenization, which is known to promote the presence and density of parasites [30,60]. Notably, during the rainy season, the flood-meadow is submerged, and small mammals such as *A. agrarius* will migrate to surrounding habitats. Individuals that enter the *Camellia* forest will face an increased risk of infection by ectoparasites. When the flood-meadow reemerges, these individuals will return, potentially increasing the risk of ectoparasite transmission.

5. Conclusions

Our findings emphasize the significance of utilizing multiple indicators at different levels (e.g., diversity, density, body condition, and ectoparasite abundance) to evaluate the ecological impacts of land conversion. In our study, the replacement of natural riparian vegetation with an oil tea plantation appeared to have positive effects on community diversity and population density of small mammals. However, the *Camellia* forest was more likely to support the habitat generalist or disturbance-tolerant species, which could potentially result in regional species loss if oil tea plantations continue to expand. Given that different small mammal species have varied responses to this conversion, we encourage long-term monitoring of diverse taxa to provide comprehensive assessments of the influence of oil tea plantations, thus minimizing the negative impacts and achieving sustainable coexistence between agriculture and biodiversity conservation. Furthermore, it is important to note that rodents serve as reservoir hosts for various zoonotic diseases, which can be transmitted to humans through their ectoparasites [61,62]. Our study found a higher prevalence of ectoparasites in *A. agrarius* individuals within the *Camellia* forest. Considering the higher frequency of human activities in the *Camellia* forest compared with the other two natural habitats, the increased ectoparasite load may pose an elevated risk of disease transmission. Therefore, it is imperative to incorporate ectoparasite monitoring in future studies. By assessing ectoparasite abundance and diversity, we can gain a better understanding of the potential health risks associated with zoonotic diseases in the context of oil tea plantations.

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Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

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References

1. Naiman, R.J.; Decamps, H. The ecology of interfaces: Riparian zones. *Annu. Rev. Ecol. Syst.* **1997**, *28*, 621–658. [[CrossRef](#)]
2. Riis, T.; Kelly-Quinn, M.; Aguiar, F.C.; Manolaki, P.; Bruno, D.; Bejarano, M.D.; Clerici, N.; Fernandes, M.R.; Franco, J.C.; Pettit, N. Global overview of ecosystem services provided by riparian vegetation. *BioScience* **2020**, *70*, 501–514. [[CrossRef](#)]
3. Zhang, X.Y.; Ci, X.Q.; Hu, J.L.; Bai, Y.; Thornhill, A.H.; Conran, J.G.; Li, J. Riparian areas as a conservation priority under climate change. *Sci. Total Environ.* **2023**, *858*, 159879. [[CrossRef](#)]
4. Dala-Corte, R.B.; Melo, A.S.; Siqueira, T.; Bini, L.M.; Martins, R.T.; Cunico, A.M.; Pes, A.M.; Magalhães, A.L.; Godoy, B.S.; Leal, C.G.; et al. Thresholds of freshwater biodiversity in response to riparian vegetation loss in the Neotropical region. *J. Appl. Ecol.* **2020**, *57*, 1391–1402. [[CrossRef](#)]
5. Marczak, L.B.; Sakamaki, T.; Turvey, S.L.; Deguise, I.; Wood, S.L.; Richardson, J.S. Are forested buffers an effective conservation strategy for riparian fauna? An assessment using meta-analysis. *Ecol. Appl.* **2010**, *20*, 126–134. [[CrossRef](#)]

6. Accogli, R.; Tomaselli, V.; Drenzo, P.; Perrino, E.V.; Albanese, G.; Urbano, M.; Laghetti, G. Edible halophytes and halo-tolerant species in Apulia region (Southeastern Italy): Biogeography, traditional food use and potential sustainable crops. *Plants* **2023**, *12*, 549. [[CrossRef](#)]
7. Tonello, G.; Decian, V.S.; Restello, R.M.; Hepp, L.U. The conversion of natural riparian forests into agricultural land affects ecological processes in Atlantic forest streams. *Limnologia* **2021**, *91*, 125927. [[CrossRef](#)]
8. Sheaves, M.; Johnston, R.; Miller, K.; Nelson, P.N. Impact of oil palm development on the integrity of riparian vegetation of a tropical coastal landscape. *Agric. Ecosyst. Environ.* **2018**, *262*, 1–10. [[CrossRef](#)]
9. Espinoza-Toledo, A.; Mendoza-Carranza, M.; Castillo, M.M.; Barba-Macías, E.; Capps, K.A. Taxonomic and functional responses of macroinvertebrates to riparian forest conversion in tropical streams. *Sci. Total Environ.* **2021**, *757*, 143972. [[CrossRef](#)] [[PubMed](#)]
10. González, E.; Felipe-Lucia, M.R.; Bourgeois, B.; Boz, B.; Nilsson, C.; Palmer, G.; Sher, A.A. Integrative conservation of riparian zones. *Biol. Conserv.* **2017**, *211*, 20–29. [[CrossRef](#)]
11. Richardson, D.M.; Holmes, P.M.; Esler, K.J.; Galatowitsch, S.M.; Stromberg, J.C.; Kirkman, S.P.; Pyšek, P.; Hobbs, R.J. Riparian vegetation: Degradation, alien plant invasions, and restoration prospects. *Divers. Distrib.* **2007**, *13*, 126–139. [[CrossRef](#)]
12. Hughes, F.M.; Rood, S.B. Allocation of river flows for restoration of floodplain forest ecosystems: A review of approaches and their applicability in Europe. *Environ. Manag.* **2003**, *32*, 12–33. [[CrossRef](#)] [[PubMed](#)]
13. Tockner, K.; Stanford, J.A. Riverine flood plains: Present state and future trends. *Environ. Conserv.* **2002**, *29*, 308–330. [[CrossRef](#)]
14. Pisani, D.; Paziienza, P.; Perrino, E.V.; Caporale, D.; De Lucia, C. The economic valuation of ecosystem services of biodiversity components in protected areas: A review for a framework of analysis for the Gargano National Park. *Sustainability* **2021**, *13*, 11726. [[CrossRef](#)]
15. Guo, X.B.; Tang, X.Z.; He, H.L. Data production and data product standards construction of long-term observation for ecosystem. *China Sci. Technol. Resour. Rev.* **2021**, *53*, 47–54. [[CrossRef](#)]
16. Chen, T.; Liu, L.; Zhou, Y.L.; Zheng, Q.; Luo, S.Y.; Xiang, T.T.; Zhou, L.J.; Feng, S.L.; Yang, H.Y.; Ding, C.B. Characterization and comprehensive evaluation of phenotypic characters in wild *Camellia oleifera* germplasm for conservation and breeding. *Front. Plant Sci.* **2023**, *14*, 1052890. [[CrossRef](#)]
17. Xiao, Z.S.; Zhang, Z.B.; Wang, Y.S. Impacts of scatter-hoarding rodents on restoration of oil tea *Camellia oleifera* in a fragmented forest. *For. Ecol. Manag.* **2004**, *196*, 405–412. [[CrossRef](#)]
18. Deng, Q.E.; Li, J.N.; Gao, C.; Cheng, J.Y.; Deng, X.Z.; Jiang, D.Z.; Li, L.; Yan, P. New perspective for evaluating the main *Camellia oleifera* cultivars in China. *Sci. Rep.* **2020**, *10*, 20676. [[CrossRef](#)]
19. Zhang, F.; Zhu, F.; Chen, B.L.; Su, E.Z.; Chen, Y.Z.; Cao, F.L. Composition, bioactive substances, extraction technologies and the influences on characteristics of *Camellia oleifera* oil: A review. *Food Res. Int.* **2022**, *156*, 111159. [[CrossRef](#)]
20. Chowdhury, A.; Samrat, A.; Devy, M.S. Can tea support biodiversity with a few “nudges” in management: Evidence from tea growing landscapes around the world. *Glob. Ecol. Conserv.* **2021**, *31*, e01801. [[CrossRef](#)]
21. Qiao, H.; Chen, L.S.; Hu, Y.J.; Deng, C.H.; Sun, Q.; Deng, S.H.; Chen, X.B.; Mei, L.; Wu, J.S.; Su, Y.R. Soil microbial resource limitations and community assembly along a *Camellia oleifera* plantation chronosequence. *Front. Microbiol.* **2021**, *12*, 736165. [[CrossRef](#)] [[PubMed](#)]
22. Chen, L.J.; Lichao, W.; Sun, Q.; Chen, Y.Q.; Wang, C.Y.; Lu, S. Long-term *Camellia oleifera* cultivation influences the assembly process of soil bacteria in different soil aggregate particles. *Land Degrad. Dev.* **2023**, *34*, 441–452. [[CrossRef](#)]
23. Chang, G.; Zhang, Z.B. Differences in hoarding behaviors among six sympatric rodent species on seeds of oil tea (*Camellia oleifera*) in Southwest China. *Acta Oecol.* **2011**, *37*, 165–169. [[CrossRef](#)]
24. Wu, N.; Zhong, J.; Lei, B.Y.; Xie, Z.Q.; Zhou, Y.B. Community reestablishment and poor body conditions of small mammal assemblages in subtropical afforested ecosystems. *Ecol. Eng.* **2019**, *135*, 1–7. [[CrossRef](#)]
25. Curtin, C.G.; Kelt, D.A.; Frey, T.C.; Brown, J.H. On the role of small mammals in mediating climatically driven vegetation change. *Ecol. Lett.* **2000**, *3*, 309–317. [[CrossRef](#)]
26. Xiao, Z.S. Dual ecological functions of scatter-hoarding rodents: Pollinators and seed dispersers of *Mucuna sempervirens* (Fabaceae). *Integr. Zool.* **2022**, *17*, 918–929. [[CrossRef](#)]
27. Surkova, E.; Popov, S.; Tchabovsky, A. Rodent burrow network dynamics under human-induced landscape transformation from desert to steppe in Kalmykian rangelands. *Integr. Zool.* **2019**, *14*, 410–420. [[CrossRef](#)]
28. DB34/T3422-2019; Technical Specification for Ecological Monitoring of Wetlands of Provincial Importance and General Wetlands. Local Standards of Anhui Province: Hefei, China, 2019.
29. Bockerhoff, E.G.; Jactel, H.; Parrotta, J.A.; Quine, C.P.; Sayer, J. Plantation forests and biodiversity: Oxymoron or opportunity? *Biodivers. Conserv.* **2008**, *17*, 925–951. [[CrossRef](#)]
30. Teixeira, D.; Carrilho, M.; Silva, M.; Nunes, M.; Vieira, M.L.; Novo, M.T.; Santos-Reis, M.; Rosalino, L.M. Mediterranean Eucalyptus plantations affect small mammal ectoparasites abundance but not individual body condition. *Ecol. Res.* **2019**, *34*, 415–427. [[CrossRef](#)]
31. Li, C.L.; Zhou, L.Z.; Xu, L.; Zhao, N.N.; Beauchamp, G. Vigilance and activity time-budget adjustments of wintering hooded cranes, *Grus monacha*, in human-dominated foraging habitats. *PLoS ONE* **2015**, *10*, e0118928. [[CrossRef](#)]
32. Wang, M.Z.; Chen, W.W.; Li, C.L.; Zhao, J.M. Definition of spatial positions within foraging Greater White-fronted Geese flocks from an individual’s perspective: Cost-benefit dynamics change with the distance to flock edge. *Avian Res.* **2022**, *13*, 100056. [[CrossRef](#)]

33. Wan, W.J.; Zhou, L.Z.; Song, Y.W. Shifts in foraging behavior of wintering Hooded Cranes (*Grus monacha*) in three different habitats at Shengjin Lake, China. *Avian Res.* **2016**, *7*, 13. [[CrossRef](#)]
34. Pan, C.; Zhou, L.Z.; Wang, X.H.; Xu, W.B.; Song, Y.W. Impact of artificial activities on the landscape patterns in Shengjin Lake National Nature Reserve. *Ecol. Sci.* **2021**, *40*, 116. [[CrossRef](#)]
35. Peng, L.; Dong, B.; Wang, P.; Sheng, S.W.; Sun, L.; Fang, L.; Li, H.R.; Liu, L.P. Research on ecological risk assessment in land use model of Shengjin Lake in Anhui province, China. *Environ. Geochem. Health* **2019**, *41*, 2665–2679. [[CrossRef](#)] [[PubMed](#)]
36. Guo, W.L.; Zhou, Z.Z.; Chen, J.W.; Zheng, X.D.; Ye, X.Y. Effects of extreme flooding on aquatic vegetation cover in Shengjin Lake, China. *Hydrol. Process.* **2022**, *36*, e14459. [[CrossRef](#)]
37. Smith, A.T.; Xie, Y.; Hoffmann, R.S.; Lunde, D.; MacKinnon, J.; Wilson, D.E.; Wozencraft, W.C.; Gemma, F. *A Guide to the Mammals of China*; Princeton University Press: Princeton, NJ, USA, 2010.
38. Chen, W.W.; Zhong, J.; Carson, W.P.; Tang, Z.H.; Xie, Z.Q.; Sun, S.C.; Zhou, Y.B. Proximity to roads disrupts rodents' contributions to seed dispersal services and subsequent recruitment dynamics. *J. Ecol.* **2019**, *107*, 2623–2634. [[CrossRef](#)]
39. Zhang, C. Statistical Modeling of Count Data with Over-Dispersion or Zero-Inflation Problems. Master's Thesis, Montclair State University, Montclair, NJ, USA, 2019.
40. Hardy, I.C. *Sex Ratios: Concepts and Research Methods*; Cambridge University Press: Cambridge, UK, 2002.
41. Schulte-Hostedde, A.I.; Zinner, B.; Millar, J.S.; Hickling, G.J. Restitution of mass-size residuals: Validating body condition indices. *Ecology* **2005**, *86*, 155–163. [[CrossRef](#)]
42. Hillegass, M.A.; Waterman, J.M.; Roth, J.D. The influence of sex and sociality on parasite loads in an African ground squirrel. *Behav. Ecol.* **2008**, *19*, 1006–1011. [[CrossRef](#)]
43. Balčiauskas, L.; Stirké, V.; Balčiauskienė, L. Rodent fertility in commercial orchards in relation to body mass and body condition. *Agric. Ecosyst. Environ.* **2022**, *329*, 107886. [[CrossRef](#)]
44. Fitzherbert, E.B.; Struebig, M.J.; Morel, A.; Danielsen, F.; Brühl, C.A.; Donald, P.F.; Phalan, B. How will oil palm expansion affect biodiversity? *Trends. Ecol. Evol.* **2008**, *23*, 538–545. [[CrossRef](#)]
45. Semenchuk, P.; Plutzer, C.; Kastner, T.; Matej, S.; Bidoglio, G.; Erb, K.-H.; Essl, F.; Haberl, H.; Wessely, J.; Krausmann, F. Relative effects of land conversion and land-use intensity on terrestrial vertebrate diversity. *Nat. Commun.* **2022**, *13*, 615. [[CrossRef](#)] [[PubMed](#)]
46. Garden, J.G.; Mcalpine, C.A.; Possingham, H.P.; Jones, D.N. Habitat structure is more important than vegetation composition for local-level management of native terrestrial reptile and small mammal species living in urban remnants: A case study from Brisbane, Australia. *Austral Ecol.* **2007**, *32*, 669–685. [[CrossRef](#)] [[PubMed](#)]
47. Ramírez, P.A.; Simonetti, J.A. Conservation opportunities in commercial plantations: The case of mammals. *J. Nat. Conserv.* **2011**, *19*, 351–355. [[CrossRef](#)]
48. Carrilho, M.; Teixeira, D.; Santos-Reis, M.; Rosalino, L.M. Small mammal abundance in Mediterranean Eucalyptus plantations: How shrub cover can really make a difference. *For. Ecol. Manag.* **2017**, *391*, 256–263. [[CrossRef](#)]
49. Ge, D.Y.; Lu, L.; Abramov, A.V.; Wen, Z.X.; Cheng, J.L.; Xia, L.; Vogler, A.P.; Yang, Q.S. Coalescence models reveal the rise of the white-bellied rat (*Niviventer confucianus*) following the loss of Asian megafauna. *J. Mamm. Evol.* **2019**, *26*, 423–434. [[CrossRef](#)]
50. Morand, S.; Bordes, F.; Blasdel, K.; Pilosof, S.; Cornu, J.F.; Chaisiri, K.; Chaval, Y.; Cosson, J.F.; Claude, J.; Feyfant, T. Assessing the distribution of disease-bearing rodents in human-modified tropical landscapes. *J. Appl. Ecol.* **2015**, *52*, 784–794. [[CrossRef](#)]
51. Zhang, M.W.; Wang, Y.; Li, B.; Guo, C.; Huang, G.X.; Shen, G.; Zhou, X.J. Small mammal community succession on the beach of Dongting Lake, China after the Three Gorges Project. *Integr. Zool.* **2014**, *9*, 294–308. [[CrossRef](#)]
52. Prevedello, J.A.; Dickman, C.R.; Vieira, M.V.; Vieira, E.M. Population responses of small mammals to food supply and predators: A global meta-analysis. *J. Anim. Ecol.* **2013**, *82*, 927–936. [[CrossRef](#)]
53. Gebczyńska, Z.; Sołtys, H.; Sienkiewicz, M. Food composition in striped field mice living at localities of various degrees of urban development. *Acta Theriol.* **1987**, *32*, 325–330. [[CrossRef](#)]
54. Dyson, E.A.; Hurst, G.D. Persistence of an extreme sex-ratio bias in a natural population. *Proc. Natl. Acad. Sci. USA* **2004**, *101*, 6520–6523. [[CrossRef](#)]
55. Rosenfeld, C.S.; Grimm, K.M.; Livingston, K.A.; Brokman, A.M.; Lamberson, W.E.; Roberts, R.M. Striking variation in the sex ratio of pups born to mice according to whether maternal diet is high in fat or carbohydrate. *Proc. Natl. Acad. Sci. USA* **2003**, *100*, 4628–4632. [[CrossRef](#)] [[PubMed](#)]
56. Rosenfeld, C.S.; Roberts, R.M. Maternal diet and other factors affecting offspring sex ratio: A review. *Biol. Reprod.* **2004**, *71*, 1063–1070. [[CrossRef](#)] [[PubMed](#)]
57. Cui, J.F.; Lei, B.Y.; Newman, C.; Zhou, Y.B.; Wang, Z.P. Food resources and competition rather than eco-geographic rules explain trait variations in two contrasting rat species: Implications for future climate change. *Glob. Ecol. Conserv.* **2022**, *40*, e02339. [[CrossRef](#)]
58. Côté, I.M.; Poulin, R. Parasitism and group size in social animals: A meta-analysis. *Behav. Ecol.* **1995**, *6*, 159–165. [[CrossRef](#)]
59. Stanko, M.; Miklišová, D.; Goüy de Bellocq, J.; Morand, S. Mammal density and patterns of ectoparasite species richness and abundance. *Oecologia* **2002**, *131*, 289–295. [[CrossRef](#)]
60. Friggens, M.M.; Beier, P. Anthropogenic disturbance and the risk of flea-borne disease transmission. *Oecologia* **2010**, *164*, 809–820. [[CrossRef](#)]

61. Han, B.A.; Schmidt, J.P.; Bowden, S.E.; Drake, J.M. Rodent reservoirs of future zoonotic diseases. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, 7039–7044. [[CrossRef](#)]
62. Blasdell, K.R.; Morand, S.; Laurance, S.G.W.; Doggett, S.L.; Hahs, A.; Trinh, K.; Perera, D.; Firth, C. Rats and the city: Implications of urbanization on zoonotic disease risk in Southeast Asia. *Proc. Natl. Acad. Sci. USA* **2022**, *119*, e2112341119. [[CrossRef](#)]

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