# Annual patterns of small vertebrates roadkilled in a supercity of eastern China (#84573)



First submission

## Guidance from your Editor

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Review the raw data.

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# Structure and Criteria



## Structure your review

The review form is divided into 5 sections. Please consider these when composing your review:

1. **BASIC REPORTING**
2. **EXPERIMENTAL DESIGN**
3. **VALIDITY OF THE FINDINGS**
4. General comments
5. Confidential notes to the editor

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Use these criteria points to structure your review. The full detailed editorial criteria is on your guidance page.

**BASIC REPORTING**

- Clear, unambiguous, professional English language used throughout.
- Intro & background to show context. Literature well referenced & relevant.
- Structure conforms to PeerJ standards, discipline norm, or improved for clarity.
- Figures are relevant, high quality, well labelled & described.
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**EXPERIMENTAL DESIGN**

- Original primary research within Scope of the journal.
- Research question well defined, relevant & meaningful. It is stated how the research fills an identified knowledge gap.
- Rigorous investigation performed to a high technical & ethical standard.
- Methods described with sufficient detail & information to replicate.

**VALIDITY OF THE FINDINGS**

- Impact and novelty not assessed. *Meaningful* replication encouraged where rationale & benefit to literature is clearly stated.
- All underlying data have been provided; they are robust, statistically sound, & controlled.
- Conclusions are well stated, linked to original research question & limited to supporting results.

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|---|---|
| **Support criticisms with evidence from the text or from other sources** | *Smith et al (J of Methodology, 2005, V3, pp 123) have shown that the analysis you use in Lines 241-250 is not the most appropriate for this situation. Please explain why you used this method.* |
| **Give specific suggestions on how to improve the manuscript** | *Your introduction needs more detail. I suggest that you improve the description at lines 57- 86 to provide more justification for your study (specifically, you should expand upon the knowledge gap being filled).* |
| **Comment on language and grammar issues** | *The English language should be improved to ensure that an international audience can clearly understand your text. Some examples where the language could be improved include lines 23, 77, 121, 128 – the current phrasing makes comprehension difficult. I suggest you have a colleague who is proficient in English and familiar with the subject matter review your manuscript, or contact a professional editing service.* |
| **Organize by importance of the issues, and number your points** | *1. Your most important issue*<br>*2. The next most important item*<br>*3. …*<br>*4. The least important points* |
| **Please provide constructive criticism, and avoid personal opinions** | *I thank you for providing the raw data, however your supplemental files need more descriptive metadata identifiers to be useful to future readers. Although your results are compelling, the data analysis should be improved in the following ways: AA, BB, CC* |
| **Comment on strengths (as well as weaknesses) of the manuscript** | *I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.* |

# Annual patterns of small vertebrates roadkilled in a supercity of eastern China

**Qiong Wu** [1] , **Taozhu Sun** [1] , **Yumeng Zhao** [1] , **Cong Yu** [1] , **Junhua Hu** [2] , **Zhongqiu Li** [Corresp. 1]

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An assessment of wildlife road mortality can help develop road mitigation measures. This paper is the ûrst to report data on wildlife-vehicle collisions (WVC) in Nanjing, a megacity in eastern China. The research was conducted on a 224.27 km stretch of nine roads in Nanjing. Between November 2020 and October 2021, we conducted 26 monitoring missions to gather roadkill carcasses so that we could analyze their temporal and spatial distribution patterns. We collected 259 carcasses of 22 diûerent species, of which 46.42 % were mammals and 48.81% were birds. Cats and dogs are the most roadkilled mammals, and blackbirds and sparrows are the most roadkilled birds. The temporal analysis demonstrated that overall roadkills distribution was seasonal, with peak vertebrate road-kills occurring between May to July. Spatial analysis showed that the distribution patterns of vertebrate roadkills on diûerent roads were diûerent, generally non-random distribution and aggregation. By mapping accidents using kernel density analysis, we were able to pinpoint locations that were at high risk for roadkills. Our study suggests that the problem of car accidents due to wildlife should be a cause for concern, and the results of the analysis of temporal and spatial patterns contribute to the establishment of mitigation measures.

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## Abstract

An assessment of wildlife road mortality can help develop road mitigation measures. This paper is the first to report data on wildlife-vehicle collisions (WVC) in Nanjing, a megacity in eastern China. The research was conducted on a 224.27 km stretch of nine roads in Nanjing. In the period between November 2020 and October 2021, 26 monitoring missions were conducted to gather roadkill carcasses so that we could analyze their temporal and spatial distribution patterns. We collected 259 carcasses comprising 22 different species, of which 46.42 % were mammals and 48.81% were birds. Cats and dogs are the most roadkilled mammals, and blackbirds and sparrows are the most roadkilled birds. The temporal analysis demonstrated that overall roadkills distribution was seasonal, with peak vertebrate road-kills occurring between May to July. Spatial analysis showed that the distribution patterns of vertebrate roadkills on different roads varied, with a generally non-random distribution and aggregation. By mapping accidents using kernel density analysis, we were able to pinpoint locations that were at high risk for roadkills. Our study suggests that the problem of car accidents due to wildlife should be a cause for concern, and the results of the analysis of temporal and spatial patterns contribute to the establishment of mitigation measures.

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## Introduction

Roads act as barriers, fragmenting habitats just like any other human activity that changes ecosystems, which reduces biodiversity (Ferreguetti et al. 2020). The most significant ecological impact of roads, according to Coffin (2007) and Trombulak & Frissell (2000), appears to be traffic-related mortality from wildlife-vehicle collisions (WVCs, hereafter). In some cases, WVCs can have devastating effects on animal populations (Forman 2000; Forman & Alexander 1998). Numerous studies conducted over the past few years has produced WVCs results for many different countries. An estimated 340 million birds are killed on U.S. roads each year (Loss et al. 2014); around 335,000 European hedgehogs are killed on the roads in the U.K. per year (Wembridge et al. 2016); and around 9 million medium-large mammals are killed in traffic accidents in Brazil every year (Pinto et al. 2022). In addition, roadkill data has been reported from Spain (Colino-Rabanal et al. 2012; Diaz-Varela et al. 2011; Lagos et al. 2012; Rodriguez-Morales et al. 2013), Poland (Tajchman et al. 2010) and Sweden (Neumann et al. 2012).

The world's road network has been expanding steadily in recent years, and by 2050, it is anticipated that at least 25 million km will be added to the network (Laurance et al. 2014). With the continuous development of China's economy, the total mileage of China's road network and road network density is also increasing. By the end of 2020, the total mileage of China's road network reached 5.20 million km, and the density of the road network in China reached 54.15 km per 100 square km. Among them, the mileage of National highways, Provincial highways and County highways was approximately 0.37 million km, 0.38 million km and 4.46 million km, respectively. Roadkills, which are one of several reasons for the loss of vertebrates, have been proven in studies to increase with the development of road networks (Forman & Alexander 1998). However, there are very few studies related to wildlife roadkill in China's modern cities, and research has only been conducted in Taiwan (Lin et al. 2019), the Changbai Mountain Nature Reserve(Wang et al. 2016), the Huangnihe River Reserve (Li 2019), the Zoige Wetland National Nature Reserve (Gu et al. 2011), and the Wanglang National Nature Reserve (Zhang et al. 2018), mostly in ecologically sensitive areas and focusing on species that are endemic to China. Therefore, there is a need to investigate common wildlife and their roadkill status in a wide geographical space.

Previous research on small vertebrates (Clevenger et al. 2003; Morelle et al. 2013) and birds (Colino-Rabanal et al. 2011; Erritzoe et al. 2003) discovered that seasonal behaviors such as dispersal and migration are linked to temporal variations in roadkill patterns. Peak periods of animal road mortality occur during periods when animals are searching for mates or increasing their foraging activity (Lagos et al. 2012; Rodriguez-Morales et al. 2013; Smith-Patten & Patten 2008). Also, juvenile dispersal during periods of increased numbers of free-ranging and

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inexperienced juveniles can affect the seasonality of road mortality (Madden & Perkins 2017). Roadkill patterns exhibit temporal variability, which can be understood to improve mitigation methods, particularly those that can be handled in a timely manner (for example, limitation of traffic intensity or speed) (D'Amico et al. 2015).

The spatial distribution of casualties, which is arguably the most researched aspect of road ecology, is another key subject in roadkill research (Jaeger & Fahrig 2004; Trombulak & Frissell 2000). According to certain research, roadkill of mammals and other vertebrates, such as birds, does not occur randomly but rather at specific areas of the road (Coelho et al. 2008; Garriga et al. 2017). Mortality hotspots are stretches of road where roadkills are more common (Santos et al. 2015). These areas might be thought of as top priorities for the use of mitigation measures. By constructing wildlife crossing structures such as tunnels, ledges in culverts, and overpasses in these locations, we can reduce the amount of wildlife that is roadkilled (van der Grift et al. 2013).

The study's aim is to present Nanjing with the initial findings regarding the spatial and temporal patterns of WVCs. We monitored nine road stretches fortnightly for one year in Nanjing (a supercity in eastern China). The objectives of this study were (1) to describe the species composition of roadkills on the road studied; (2) to describe the seasonal pattern of roadkills in mammals and birds; and (3) to describe the spatial patterns of roadkills on the investigated road. For example, where are the located mortality hotspots? How are roadkills distributed across different spatial scales? Using the temporal and spatial distribution patterns in WVCs, we may also identify targeted hotspots of roadkills to apply mitigating actions.

## Materials & Methods

Study area

The study area (Figure 1) was located in Nanjing in the southwestern Jiangsu Province (31°14' to 32°37' N,118° 22' to 119°14' E). The climate is humid north subtropical with four distinct seasons and abundant rainfall, with annual rainfall averaging 1106.5 mm. The annual average temperature is 15.4°C, the highest annual extreme temperature is 39.7°C, and the lowest is -13.1°C. Topography is flat, and elevations range from 0 to 753 m, and the average altitude is 35 m. Nanjing is a supercity in eastern China with a resident population of approximately 10 million

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people. It is also an international integrated transport hub city with a total road mileage of 9,796.325 m and an extensive road network with varying road types and traffic intensities. We selected nine roads (three National highways, three Provincial highways and three Rural highways) within our study area. All nine roads are paved, with the annual average daily traffic volumes ranging from 30 000 to 60,000 vehicles per day on national highways, 10,000 to 40,000 vehicles per day on provincial highways, and 5,000 to 15,000 vehicles per day on rural highways. The types of roadside habitats on these roads cover residential areas, farmland, open fields and forests. The basic conditions of the sampled roads are shown in Table 1.

Roadkill survey data collection

To gather data on road vertebrate carcasses, we ran 26 monitoring campaigns over 224.27 kilometers of road, totalling 5831 km, between November 2020 and October 2021. Nine selected roads were monitored every fortnight over the course of a year. Sampling was done in good weather conditions, beginning at 9 a.m. and lasting as long as it took to complete the entire route while maintaining a speed of ÿ 40 km/h (Ferreguetti et al. 2020). Considering the safety of driving, our speed should not be too low. The survey team included drivers and observers who kept records of animal carcasses found on the survey roads. Additionally, driving recorders were installed in the automobiles to capture any roadkill events throughout the survey. All carcasses found during the survey were identified at class (to species level where possible). The Global Positioning System (GPS) was used for logging the locations of each road accident. Roadkill was georeferenced to an accuracy of 50 m. Once recorded, it was removed from the road. The accuracy of road kill hotspot detection is decreased due to the low frequency of our sample and the possibility of ignoring small-sized carcasses in car surveys (Santos et al. 2011; Santos et al. 2015); nonetheless, more frequent surveys are not practical given the scope of our investigation (Garriga et al. 2017).

Data analysis

Exploratory analysis was used to calculate the absolute and relative frequencies of WVCs in order to determine the species involved and the types of roads where incidents occurred. We used the Kruskal-Wallis test to examine seasonal trends in animal roadkill at the level of species groups (mammals and birds) and small vertebrate populations.

We evaluated the spatial distribution of WVCs in three steps. First of all, we used the nearest neighbor distance (NND) to evaluate the distribution of roadkills on the road network (Gonser et

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al. 2009). We compare the observed average distance between each incident and its nearest neighbor with the average distance that would be expected if the accidents were randomly distributed along the road (, complete spatial randomness) to determine whether WVCs are aggregated along the road network (Okabe & K.Sugihara 2012). The Clark-Evans index is calculated to confirm departure from a random distribution. The index is the ratio of the observed and expected mean distances: values >1, =1, <1, indicating that the points are aggregated, randomly distributed and dispersed, respectively (Clark & Evans 1954). Secondly, to locate collision hotspots for WVCs, we employed kernel density analysis (Okabe & K.Sugihara 2012). Kernel density is the number of road-killed animals per kilometer of road. Finally, we investigate the spatial structure of WVCs at different spatial scales using the Ripley K-function, which denotes the pattern of point distribution at various scales (Mountrakis & Gunson 2009; Ripley 1976). All the spatial analyses were performed with the use of the SANET Standalone and ArcGIS 10. SANET Standalone provides tools adapted to perform spatial analysis along linear features.

## Results

Species composition of roadkills

From November 2020 to October 2021, we examined a total of 5831 km through 26 surveys. A total of 293 animals (21 identified species) were collected. These included 136 mammals (6 species), 143 birds (14 species) and five reptiles (1 species) (Table 2). Birds made up 48.81% of the roadkills followed by mammals (46.42%) and reptiles (1.70%).

The most commonly mammalian roadkilled species were the cat (Felis catus) (28.7 % of mammalian casualties), the dog (Canis lupus familiaris) (26.5 %) and the weasel (Mustela sibirica davidiana) (9.6 %). The most common bird roadkilled species were the Blackbird (Turdus merula) (15.4 % of bird casualties) and the Sparrow (Passer montanus) (7.7 %). Together these five species accounted for 41.3 % (121) of all roadkills. The only recorded reptile species killed on the road is the Tabby-necked snake (Rhabdophis tigrinus).

Seasonality of roadkill numbers

Roadkill occurrences were not evenly distributed throughout the year (Fig. 2), with significant differences in the number of roadkills across months ($\xi 2 = 20.552$, df = 11, $p = 0.038$) and

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seasons ($\xi2 = 12.012$, df = 3, $p = 0.007$). The highest rates occurred in May (32 specimens), June (40 specimens) and July, compared to lower roadkill rates in February (13 specimens), March (15 specimens) and April (15 specimens). Seasonality tests indicated that the number of road kills was significantly higher in summer and autumn than in spring and winter. Seasonality of roadkill was also shown to significantly differ between specific taxonomic groups (Mammals: $\xi2 = 8.726$, df = 3, $p = 0.033$; Birds: $\xi2 = 11.211$, df = 3, $p = 0.011$). Mammals showed a higher road mortality in autumn. By contrast, birds showed peaks in summer (Fig. 3).

Description of the spatial pattern of roadkills

Among the different types of roads, provincial roads (5.76+0.65individuals/100km) had the highest road mortality, followed by national roads (5.38±0.62individuals/100km) and county roads (5.02±0.68individuals/100km), but no significant differences in road mortality were found among the different administrative levels of roads ($\xi2 = 0.471$, df = 2, $p = 0.790$) (Fig. 4).

We observed that carcasses were not randomly distributed along the road network. Among the nine roads investigated, the roadkills of G1, S1, and S2 showed a clustering pattern ($p < 0.05$; Table S1, Fig. S1). The heterogeneous distribution of WVCs along the road network was revealed by network kernel density analysis (Fig. 5). The shade of color in Figure 3 represented the density of roadkills. The Net-KDE results showed that the darker the road segment, the more road accidents occurred.

For the multi-distance clustering analysis, the network K function is executed on the road network. The results of the K-function show the clustering tendency of roadkills at multiple distances (Fig. 6). The distribution pattern of vertebrate roadkills on different roads varies, and it is generally non-random distribution and aggregation. On the national highway, the roadkill distribution of vertebrates on G1 and G3 is obviously clustered within 20 km; on G2, it presented a random distribution. On the provincial highway, there was significant clustering of roadkills at small spatial scales. The range of spatial scales over which clustering was significant was 0-5 km in roadkills; on a larger scale, it showed a scattered or random distribution. On the county roads, the distribution of roadkills on X2 and X3 are significantly clustered within 3 km and tend to be randomly distributed with increasing scale. On X1, it is randomly distributed in a small range, tends to be dispersed as the scale increases, and stabilizes at random after 10 km.

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## Discussion

Roadkill magnitude and species affected

A total of 293 road-killed wild animals were recorded in our 12-month study, with an average road mortality rate of 5.39±0.37 individuals/100km. Comparison of vertebrate road mortality across studies is difficult due to differences in survey methods and species conditions at survey sites (Elzanowski et al. 2009; Langen et al. 2007). However, the road mortality of wild animals has certainly been underestimated in these investigations. Many animals are thrown far from the road after a collision due to the impact, and it is clear that these individuals are often overlooked during surveys. Alternatively, animal carcasses remain on the road for only a short time due to vehicle movements, rain and the activities of road scavengers. Studies have shown this to be an important factor in underestimating road mortality (Pinto et al. 2022). In our case, over 90 % of vertebrate carcasses remained on the road for no more than 5 days (well below the sampling interval of this study) (Wu & Sun, unpublished data). Research approaches also play an important role in roadkill surveys. The low frequency of surveys (every fortnightly) may lead to an underestimation of roadkills, as the persistence of bodies on the road is much lower than the survey interval (Santos et al. 2011).

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Roadkill events tend to be concentrated in one or a few species, which are usually locally abundant, mobile and easily attracted by favorable resources or environmental conditions along the road (Forman 2000). Cats and dogs are the most commonly killed mammals on the roads sampled, probably because of their large numbers, wide distribution and high population density (Reference?).
For example, the total number of owned cats in urban areas of China is estimated to be 149,807,371 (Li et al. 2021). The high number of dogs and cats in Nanjing is closely related to the city's high population. In densely populated areas, more people treat cats and dogs as pets and they can accidentally breed, be abandoned by their owners or wander off and become stray animals (Ozen et al. 2016).

The blackbird and sparrow are the most commonly roadkilled birds, probably because they are both resident birds with large and widely distributed populations and are the dominant species among birds in Nanjing (Zhang et al. 2018). Particularly the blackbird, in contrast to other avians, feeds on cereals, fruit and insects, but also on rotten and foul-smelling carrion (Zhu 2019). This is why blackbirds are not only found around the mountains and forests but can also be seen in residential areas.

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Temporal patterns

Temporal patterns of roadkill may be correlated with the phenology and activity cycles of local wildlife, as well as local weather circumstances (Carvalho & Mira 2011). Some studies have associated roadkill with the season (Caro et al. 2000). Generally, the peak road kills for mammals appeared in summer and autumn, while the peak roadkill for birds appeared in spring and summer. However, this varies depending on the species' breeding season and dispersal patterns (Hell et al. 2005). For wild animals, their road mortality patterns are associated with three bursts of movement in their life: the mating seasons, the weaning of young to forage with their mothers, and the dispersal of juveniles (Smith-Patten & Patten 2008).

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In this study, overall roadkills distribution was seasonal. May to September were months in which vertebrates were found to be particularly vulnerable to road mortality. The animals' heightened reproductive activity in summer and autumn may be the cause of the rise in roadkill. In the spring and early summer, many taxa give birth to their young, and by the end of the summer, the populations have grown significantly (Raymond et al. 2021). Not only does this mean more individuals and therefore an increased likelihood of vehicle collisions, but also entails a large number of inexperienced juveniles that must disperse, with an often lacking ability to avoid vehicles (Legagneux & Ducatez 2013). In addition, due to the fact that parents are required to forage more frequently and for longer periods of time to raise their young, some adult animals may also be more susceptible to automobile accidents at this time of year (Gonser et al. 2009; Hell et al. 2005).

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In our study, mammalian roadkill peaks occurred in July to September and November, which is probably connected to the duration of the day and the animals' seasonal activity (Tajchman et al. 2010). The first peak occurs in association with mammalian breeding activity. From May to September, when most mammals enter the breeding season, increased breeding activity (Ignatavicius & Valskys 2018), mass movements (Herr 2008) and the dispersal of young can all lead to seasonal peaks in roadkill. Conversely, winter is a difficult time for many mammals and corresponds to a period of dormancy or decreased activity for species (Haigh 2012). It is also a time of reduced prey and food supply for many animals and as a result individuals may have to travel further in search of food leading to a greater susceptibility to roadkills that may account for the peak observed in mammals in November (Garriga et al. 2017).

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The time interval between adult breeding and juvenile dispersal is much shorter in birds compared to mammals (Dawson et al. 2001). The temporal convergence of mate search, juvenile nurturing and dispersal make it easier to observe a single-peak pattern of road mortality in birds, but the timing of the peak depends on the taxonomic unit (Raymond et al. 2021). In our study, May to July were the months when birds were particularly vulnerable to road mortality. This was also a time when birds were engaged in the breeding activity (incubation and fledging) and juveniles were dispersing (Colino-Rabanal et al. 2011; Erritzoe et al. 2003). Particularly, the high proportion of immature young people leaving the nest may be the cause of the elevated mortality (Grilo et al. 2009; Hell et al. 2005). On the other hand, during fledging, adults must frequently travel over large distances to forage for food in order to feed their young. As a result, birds may cross roads more frequently or forage among roadside vegetation, which increases the chance of roadkills (Holm & Laursen 2011; Kuitunen et al. 2003). In addition, as summer crops mature, seed-eating birds have access to more food sources close to roads, which may potentially be a factor in the increased bird mortality (da Rosa & Bager 2012). Meanwhile, we also observed a peak in road mortality in January. It may be correlated with the breeding habits of some bird species. Blackbirds and sparrows, for example, can successfully breed and raise two or more broods of young in a year, depending on weather conditions (Yuan 2017; Zhu 2019).

Spatial distributions

The distribution of the roadkills along the road network is not random, according to the spatial analyses. We indeed observed that most WVCs occurred on national and provincial roads and were highly clustered along these routes in Nanjing, southwestern Jiangsu Province. The study by Morelle et al. (Year?) in the Wallonia region of southern Belgium also found that although national roads and highways account for small parts of the total length of the road network, more than half of the WVC occur on these roads, and WVCs were highly concentrated in the highway and national roads in the south of Belgium (Morelle et al. 2013). Clevenger's (Year?) research in Western Canada found that the distribution of roadkills were uneven (Clevenger et al. 2003; Morelle et al. 2013). Possible explanations for the different patterns are differences in road structure and traffic flow (Girardet et al. 2015). In our study area, the average daily traffic volume on national and provincial highways (20,000 - 50,000 vehicles/day) is two to four times higher than on rural highways (5,000 - 15,000 vehicles/day). Although we found higher roadkill mortality on national and provincial roads than on county roads, we did not find significant differences, probably because the higher road density of county roads compensates for the effects of lower traffic volumes, so animals use county roads more frequently than national and provincial roads.

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The spatial distribution pattern of roadkill also shows variability between different road types. A map of kernel density revealed places at higher risk of WVCs. This non-random pattern is likely to be explained by road features and land cover (Gonser et al. 2009). Among our sampled roads, WVCs on G1 are concentrated around Xuanwu Lake and Zijin Mountain National Forest Park. The urban forest park is an important habitat for urban animals (Fernandez-Juricic 2004; Fontana et al. 2011), in which there is a large number and variety of wildlife and high biodiversity. The area is also located in the center of Nanjing, with a high population and road density, and large traffic flow. The increased probability of wildlife crossing the roads in this area makes it prone to wildlife-vehicle collisions.

The scale of roadkills on different grades of roads also varies. Network nearest neighbor analysis reveals that the scale of roadkill clusters was higher on national highways than on other roads. On national highways, the scale of roadkill aggregation is in the range of 0-20 km, while on rural highways, the scale of roadkill aggregation is only 0-5 km. Differences in vehicle speeds and road characteristics are one of the reasons behind this. Roads with many curves and low traffic speeds may result in more discontinuous roadkill patterns (i.e., roadkill aggregation on smaller spatial scales) than high-speed linear highways with high speeds and little speed variation (Clevenger et al. 2003).

Mitigation measures

Roadkill mitigation measures are widespread in many countries (Damarad & Bekker 2003). Mitigation measures to address the impact of roads on wildlife need to be considered when new roads are built, expanded or upgraded (Evink 2002). Common mitigation measures include wildlife warning signs, road traffic volume and speed restrictions in specific seasons and locations, wildlife detection systems, wildlife passages and wildlife fencing.

Our results aid in the creation of mitigating strategies to lessen roadkills in the research area. Wildlife corridors at roadkilled hotspots, combined with wildlife fencing, can be effective in preventing animals from entering the road. We recommend systematic and regular monitoring of animal roadkill for at least a year to identify roadkilled hotspots. If roadkill can be monitored for several years, the population dynamics of some species can be assessed on the basis of the results (Hell et al. 2005). Temporary mitigation measures, such as speed restrictions or temporary traffic control, can be implemented for hotspots where animal access is not readily available or where there are seasonal peaks of WVCs. Furthermore, long-term monitoring of mitigation after

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implementation to determine the effectiveness of these measures and timely adjustments based on actual conditions is conducive to minimizing roadkills.

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## Conclusions

In our study over a 12-month period from November 2020 to October 2021, we collected 293 roadkilled individuals along the sampling roads in Nanjing. Temporal analysis of roadkill events indicated that they were seasonal, with peaks in roadkill occurring mainly in summer and autumn for birds and mammals, respectively. Spatial analysis of roadkill events showed that their spatial distribution pattern on roads was generally non-random and aggregated. Our research shows that wildlife-vehicle collisions should be taken seriously. We should put in place the necessary mitigation measures to reduce road kill at certain times and on certain roads.

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## Acknowledgements

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## References

Caro TM, Shargel JA, and Stoner CJ. 2000. Frequency of medium-sized mammal road kills in an agricultural landscape in California. *American Midland Naturalist* 144:362-369.

Carvalho F, and Mira A. 2011. Comparing annual vertebrate road kills over two time periods, 9 years apart: a case study in Mediterranean farmland. *European Journal of Wildlife Research* 57:157-174.

Clark PJ, and Evans FC. 1954. Distance to Nearest Neighbor as a Measure of Spatial Relationships in Populations. *Ecology* 35:445-453.

Clevenger AP, Chruszczc B, and Gunson KE. 2003. Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations. *Biological Conservation* 109:15-26.

Coelho IP, Kindel A, and Coelho AVP. 2008. Roadkills of vertebrate species on two highways through the Atlantic Forest Biosphere Reserve, southern Brazil. *European Journal of Wildlife Research* 54:689-699.

Coffin AW. 2007. From roadkill to road ecology: A review of the ecological effects of roads. *Journal of Transport Geography* 15:396-406.

Colino-Rabanal VJ, Bosch J, Munoz MJ, and Peris SJ. 2012. Influence of new irrigated croplands on wild boar (Sus scrofa) road kills in NW Spain. *Animal Biodiversity and Conservation* 35:247-252.
Colino-Rabanal VJ, Lizana M, and Peris SJ. 2011. Factors influencing wolf Canis lupus roadkills in Northwest Spain. *European Journal of Wildlife Research* 57:399-409.
D'Amico M, Roman J, de los Reyes L, and Revilla E. 2015. Vertebrate road-kill patterns in Mediterranean habitats: Who, when and where. *Biological Conservation* 191:234-242.
da Rosa CA, and Bager A. 2012. Seasonality and habitat types affect roadkill of neotropical birds. *Journal of Environmental Management* 97:1-5.
Damarad T, and Bekker GJ. 2003. COST 341 - Habitat Fragmentation due to Transportation Infrastructure: Findings of the COST Action 341.
Dawson A, King VM, Bentley GE, and Ball GF. 2001. Photoperiodic control of seasonality in birds. *Journal of Biological Rhythms* 16:365-380.
Diaz-Varela ER, Vazquez-Gonzalez I, Marey-Perez MF, and Alvarez-Lopez CJ. 2011. Assessing methods of mitigating wildlife-vehicle collisions by accident characterization and spatial analysis. *Transportation Research Part D-Transport and Environment* 16:281-287.
Elzanowski A, Ciesiolkiewicz J, Kaczor M, Radwanska J, and Urban R. 2009. Amphibian road mortality in Europe: a meta-analysis with new data from Poland. *European Journal of Wildlife Research* 55:33-43.
Erritzoe J, Mazgajski TD, and Rejt L. 2003. Bird casualties on European roads - a review. *Acta Ornithologica* 38:77-93.
Evink GL. 2002. Interaction between roadways and wildlife ecology. *National Academy Press.*
Fernandez-Juricic E. 2004. Spatial and temporal analysis of the distribution of forest specialists in an urban-fragmented landscape (Madrid, Spain) - Implications for local and regional bird conservation. *Landscape and Urban Planning* 69:17-32.
Ferreguetti AC, Graciano JM, Luppi AP, Pereira-Ribeiro J, Rocha CFD, and Bergallo HG. 2020. Roadkill of medium to large mammals along a Brazilian road (BR-262) in Southeastern Brazil: spatial distribution and seasonal variation. *Studies on Neotropical Fauna and Environment* 55:216-225.
Fontana CS, Burger MI, and Magnusson WE. 2011. Bird diversity in a subtropical South-American City: effects of noise levels, arborisation and human population density. *Urban Ecosystems* 14:341-360.
Forman RTT. 2000. Estimate of the area affected ecologically by the road system in the United States. *Conservation Biology* 14:31-35.
Forman RTT, and Alexander LE. 1998. Roads and their major ecological effects. *Annual Review of Ecology and Systematics* 29:207-231.
Garriga N, Franch M, Santos X, Montori A, and Llorente GA. 2017. Seasonal variation in vertebrate traffic casualties and its implications for mitigation measures. *Landscape and Urban Planning* 157:36-44.

Girardet X, Conruyt-Rogeon G, and Foltete JC. 2015. Does regional landscape connectivity influence the location of roe deer roadkill hotspots? *European Journal of Wildlife Research* 61:731-742.
Gonser RA, Jensen RR, and Wolf SE. 2009. The spatial ecology of deer-vehicle collisions. *Applied Geography* 29:527-532.
Grilo C, Bissonette JA, and Santos-Reis M. 2009. Spatial-temporal patterns in Mediterranean carnivore road casualties: Consequences for mitigation. *Biological Conservation* 142:301-313.
Gu HJ, Dai Q, Wang Q, and Wang YZ. 2011. Factors contributing to amphibian road mortality in a wetland. *Current Zoology* 57:768-774.
Haigh A. 2012. Annual patterns of mammalian mortality on Irish roads. *Hystrix-Italian Journal of Mammalogy* 23:57-65. 10.4404/hystrix-23.2-4747
Hell P, Plavy R, Slamecka J, and Gasparik J. 2005. Losses of mammals (Mammalia) and birds (Aves) on roads in the Slovak part of the Danube Basin. *European Journal of Wildlife Research* 51:35-40. 10.1007/s10344-004-0068-6
Herr J. 2008. Ecology and Behaviour of Urban Stone Martens (*Martes foina*)in Luxembourg the University of Sussex
Holm TE, and Laursen K. 2011. Car traffic along hedgerows affects breeding success of Great Tits Parus major. *Bird Study* 58:512-515.
Ignatavicius G, and Valskys V. 2018. The influence of time factors on the dynamics of roe deer collisions with vehicles. *Landscape and Ecological Engineering* 14:221-229.
Jaeger JAG, and Fahrig L. 2004. Effects of road fencing on population persistence. *Conservation Biology* 18:1651-1657.
Kuitunen MT, Viljanen J, Rossi E, and Stenroos A. 2003. Impact of busy roads on breeding success in pied flycatchers *Ficedula hypoleuca*. *Environmental Management* 31:79-85.
Lagos L, Picos J, and Valero E. 2012. Temporal pattern of wild ungulate-related traffic accidents in northwest Spain. *European Journal of Wildlife Research* 58:661-668.
Langen TA, Machniak A, Crowe EK, Mangan C, Marker DF, Liddle N, and Roden B. 2007. Methodologies for surveying herpetofauna mortality on rural highways. *Journal of Wildlife Management* 71:1361-1368.
Laurance WF, Clements GR, Sloan S, O'Connell CS, Mueller ND, Goosem M, Venter O, Edwards DP, Phalan B, Balmford A, Van Der Ree R, and Arrea IB. 2014. A global strategy for road building. *Nature* 513:229-232.
Legagneux P, and Ducatez S. 2013. European birds adjust their flight initiation distance to road speed limits. *Biology Letters* 9: 20130788.
Li L. 2019. The Effect Zone of Land Vertebrace Roads on Forest Highway in Huangnihe Reservemaster. For Master. Jilin Agricultural University.
Li YH, Wan Y, Shen H, Loss SR, Marra PP, and Li ZQ. 2021. Estimates of wildlife killed by free-ranging cats in China. *Biological Conservation* 253:108929.

Lin YP, Anthony J, Lin WC, Lien WY, Petway JR, and Lin TE. 2019. Spatiotemporal identification of roadkill probability and systematic conservation planning. *Landscape Ecology* 34:717-735.
Loss SR, Will T, and Marra PP. 2014. Estimation of bird-vehicle collision mortality on US roads. *Journal of Wildlife Management* 78:763-771.
Madden JR, and Perkins SE. 2017. Why did the pheasant cross the road? Long-term road mortality patterns in relation to management changes. *Royal Society Open Science* 4:170617.
Morelle K, Lehaire F, and Lejeune P. 2013. Spatio-temporal patterns of wildlife-vehicle collisions in a region with a high-density road network. *Nature Conservation-Bulgaria*:53-73.
Mountrakis G, and Gunson K. 2009. Multi-scale spatiotemporal analyses of moose-vehicle collisions: a case study in northern Vermont. *International Journal of Geographical Information Science* 23:1389-1412.
Neumann W, Ericsson G, Dettki H, Bunnefeld N, Keuler NS, Helmers DP, and Radeloff VC. 2012. Difference in spatiotemporal patterns of wildlife road-crossings and wildlife-vehicle collisions. *Biological Conservation* 145:70-78.
Okabe A, and K.Sugihara. 2012. *Spatial Analysis Along Networks:Statistical and Computational Methods,Chichester:John Wiley,a volume in the Wiley series of Statistics in Practice*.
Ozen D, Bohning D, and Gurcan IS. 2016. Estimation of stray dog and cat populations in metropolitan Ankara, Turkey. *Turkish Journal of Veterinary & Animal Sciences* 40:7-12.
Pinto FAS, Cirino DW, Cerqueira RC, Rosa C, and Freitas SR. 2022. How Many Mammals Are Killed on Brazilian Roads? Assessing Impacts and Conservation Implications. *Diversity-Basel* 14:835.
Raymond S, Schwartz ALW, Thomas RJ, Chadwick E, and Perkins SE. 2021. Temporal patterns of wildlife roadkill in the UK. *Plos One* 16:e0258083.
Ripley BD. 1976. 2nd-order analysis of stationary point processes. *Journal of Applied Probability* 13:255-266.
Rodriguez-Morales B, Diaz-Varela ER, and Marey-Perez MF. 2013. Spatiotemporal analysis of vehicle collisions involving wild boar and roe deer in NW Spain. *Accident Analysis and Prevention* 60:121-133.
Santos SM, Carvalho F, and Mira A. 2011. How Long Do the Dead Survive on the Road? Carcass Persistence Probability and Implications for Road-Kill Monitoring Surveys. *Plos One* 6: e25383.
Santos SM, Marques JT, Lourenco A, Medinas D, Barbosa AM, Beja P, and Mira A. 2015. Sampling effects on the identification of roadkill hotspots: Implications for survey design. *Journal of Environmental Management* 162:87-95.
Smith-Patten BD, and Patten MA. 2008. Diversity, seasonality, and context of mammalian roadkills in the southern great plains. *Environmental Management* 41:844-852.
Tajchman K, Gawryluk A, and Drozd L. 2010. Effects of roads on populations of wild game in the lublin region. *Teka Kom Ochr Kszt Środ Przyr* 7:420-427.

Trombulak SC, and Frissell CA. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14:18-30.

van der Grift EA, van der Ree R, Fahrig L, Findlay S, Houlahan J, Jaeger JAG, Klar N, Madrinan LF, and Olson L. 2013. Evaluating the effectiveness of road mitigation measures. *Biodiversity and Conservation* 22:425-448.

Wang C, Wang Z, Luo Y, Hang N, Huang L, Zhang R, Zou C, Piao Z, and Niu L. 2016. Road Mortality Characteristic Analysis of Reptiles in Changbai Mountain National Nature Reserve *Sichuan Journal of Zoology* 35:123-128.

Wembridge DE, Newman MR, Bright PW, and Morris PA. 2016. An estimate of the annual number of hedgehog (*Erinaceus europaeus*) road casualties in Great Britain.

Yuan B. 2017. Pilot Study of Breeding Parameter and Incubation Rhythm of Tree Sparrow (*Passer Montanus*). *Chinese Journal of Wildlife* 38:410-413.

Zhang WY, Shu GC, Li YL, Xiong S, Liang CP, and Li C. 2018. Daytime driving decreases amphibian roadkill. *Peerj* 6:e5385.

Zhu C. 2019. Study on the Influence of Urbanization on the Reproduction of Blackbird Chinese Blackbird (*Turdus mandarnus*). For Master Degree. Nanchang University.

## Table 1 (on next page)

Table 1. Basic information of the nine sampled roads in Nanjing, China

Table 1. Basic conditions of the nine sampled roads in Nanjing, China.

| **Road** | **G1** | **S1** | **X1** | **G2** | **S2** | **X2** | **G3** | S3 | X3 |
|---|---|---|---|---|---|---|---|---|---|
| Highway classification | National Highway | Provincial Highway | County Highway | National Highway | Provincial Highway | County Highway | National Highway | Provincial Highway | County Highway |
| Number of lanes | 8 | 4/6 | 2 | 6 | 4 | 4 | 4/6 | 4 | 4 |
| Presence of road medians | Yes | Yes | No | Yes | No | Yes | Yes | Partly present | Yes |
| Main habitat types on roadsides | residential areas, open fields | residential areas, farmland | residential areas, farmland | farmland, forests | residential areas, forests | open fields, forests | residential areas, open fields | residential areas, forests | open fields, forests |
| Road width | 40~60m | 20~50m | 10~20m | 30m | 20m | 15m | 20~40m | 15~35m | 15~30m |

## Table 2(on next page)

Table 2. Frequency of small vertebrates roadkilled in the sampling roads of Nanjing, 2020-2021

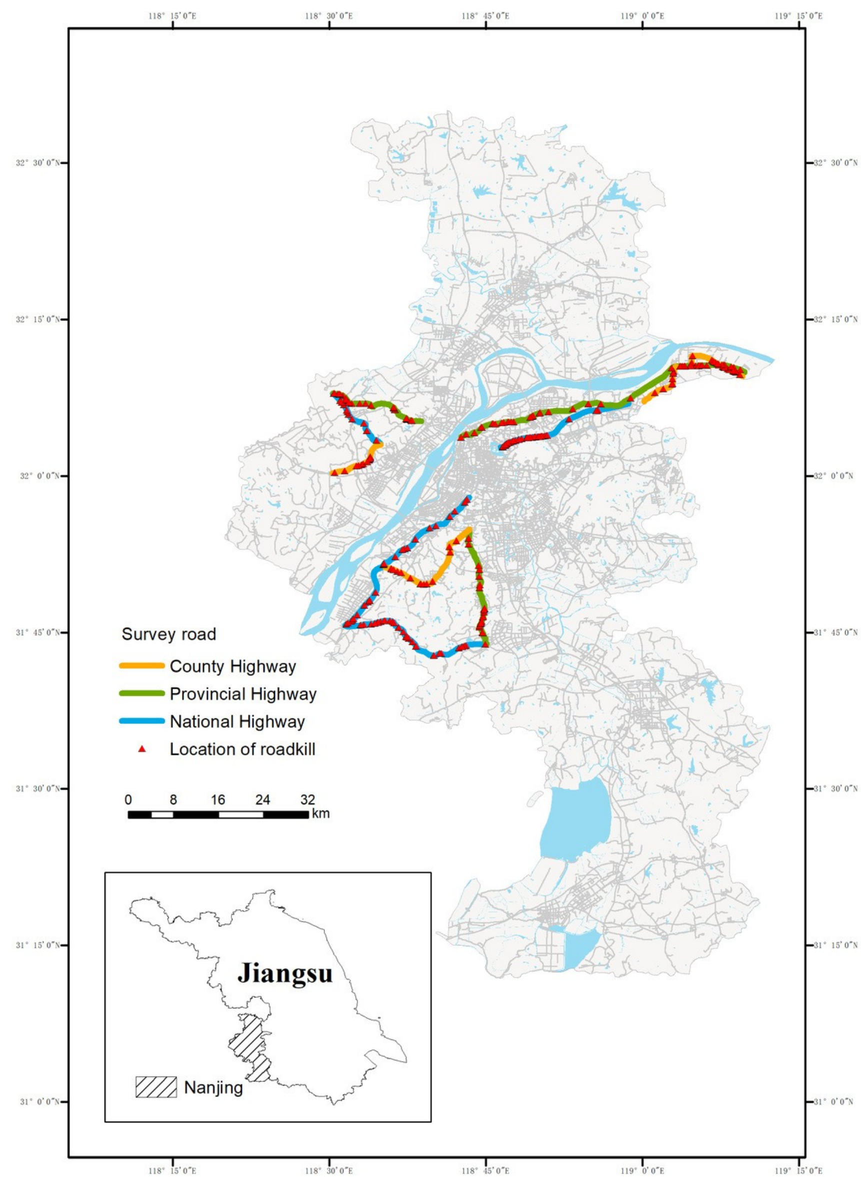
Table 2. Frequency of small vertebrates roadkilled in the sampling roads of Nanjing, 2020-2021.

| Common Name | Scientific Name | N | % of taxa | % of total kills |
|---|---|---|---|---|
| Mammal | | | | |
| Cat | *Felis catus* | 39 | 28.7 | 13.3 |
| Dog | *Canis lupus familiaris* | 36 | 26.5 | 12.3 |
| Weasel | *Mustela sibirica davidiana* | 13 | 9.6 | 3.8 |
| Mouse | *Muroidea* | 11 | 8.1 | 4.4 |
| Hedgehog | *Erinaceus amurensis* | 7 | 5.1 | 2.4 |
| Hare | *Lepus sinensis* | 1 | 0.7 | 0.3 |
| Unidentified mammal | | 29 | 21.3 | 9.9 |
| Total Mammals | | 136 | | |
| Bird | | | | |
| Blackbird | *Turdus merula* | 22 | 15.4 | 7.5 |
| Sparrow | *Passer montanus* | 11 | 7.7 | 3.8 |
| Spotted Dove | *Streptopelia chinensis* | 3 | 2.1 | 1.0 |
| Azure-winged Magpie | *Cyanopica cyanus* | 3 | 2.1 | 1.0 |
| Light-vented Bulbul | *Pycnonotus sinensis* | 3 | 2.1 | 1.0 |
| White-cheeked Starling | *Sturnus cineraceus* | 2 | 1.4 | <1 |
| Crested Myna | *Acridotheres cristatellus* | 2 | 1.4 | <1 |
| Magpie | *Pica pica* | 1 | <1 | <1 |
| Oriental Turtle Dove | *Streptopelia orientalis* | 1 | <1 | <1 |
| Chicken | *Gallus gallus domesticus* | 1 | <1 | <1 |
| Bamboo Partridge | *Bambusicola thoracica* | 1 | <1 | <1 |
| Red-billed Blue Magpie | *Urocissa erythroryncha* | 1 | <1 | <1 |
| Red-breasted Flycatcher | *Ficedula albicilla* | 1 | <1 | <1 |
| White Wagtail | *Motacilla alba* | 1 | <1 | <1 |
| Unidentified bird | | 90 | 62.9 | 30.7 |
| Total Birds | | 143 | | |
| Reptile | | | | |
| Tabby-necked snake | *Rhabdophis tigrinus* | 5 | 100.0 | 1.7 |
| Total Reptile | | 5 | | |
| Unidentified body | | 9 | | |
| Total | | 293 | | |

# Figure 1

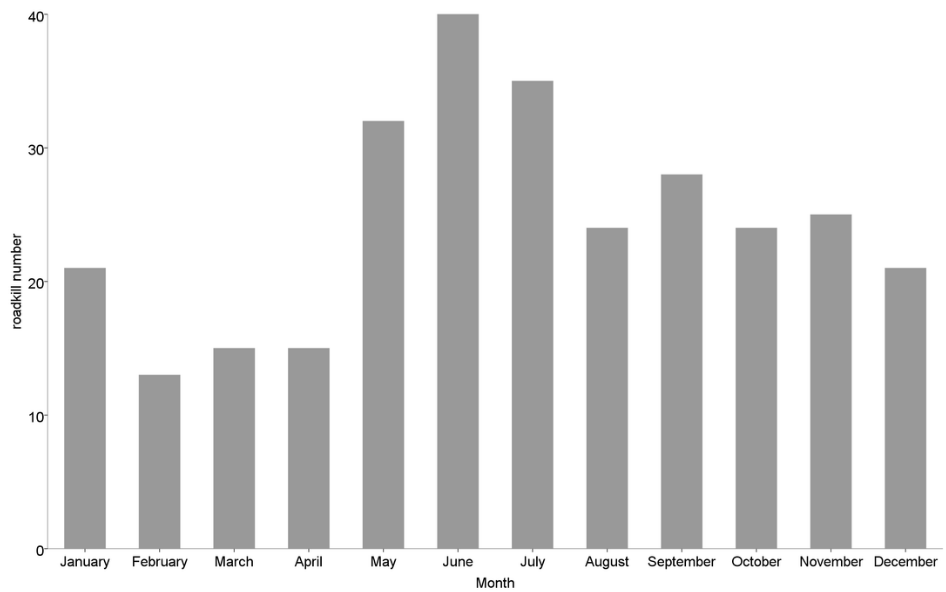
Figure1 Sample lines and roadkills for roadkill survey of small vertebrates in Nanjing

The 224.27 km road section is in bold, including the National Highway (90.60 km, blue), the Provincial Highway (84.74 km, green) and the Rural Highway (48.93 km, yellow)


118° 15'0"E
118° 30'0"E
118° 45'0"E
119° 0'0"E
119° 15'0"E
32° 30'0"N
32° 15'0"N
32° 0'0"N
31° 45'0"N
31° 30'0"N
31° 15'0"N
31° 0'0"N
Survey road
County Highway
Provincial Highway
National Highway
Location of roadkill
0 8 16 24 32
km
Jiangsu
Nanjing

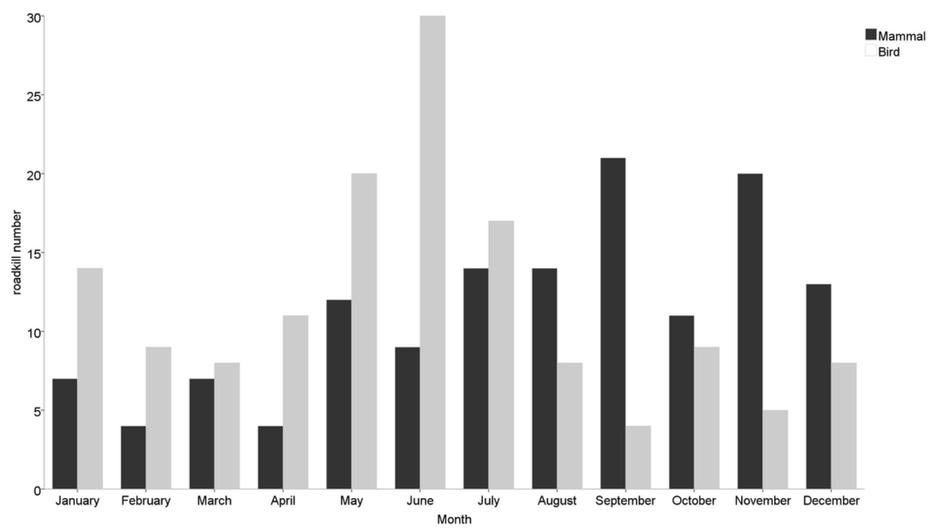
# Figure 2

Figure 2. Monthly number of small vertebrate roadkills in Nanjing, November 2020 - October 2021



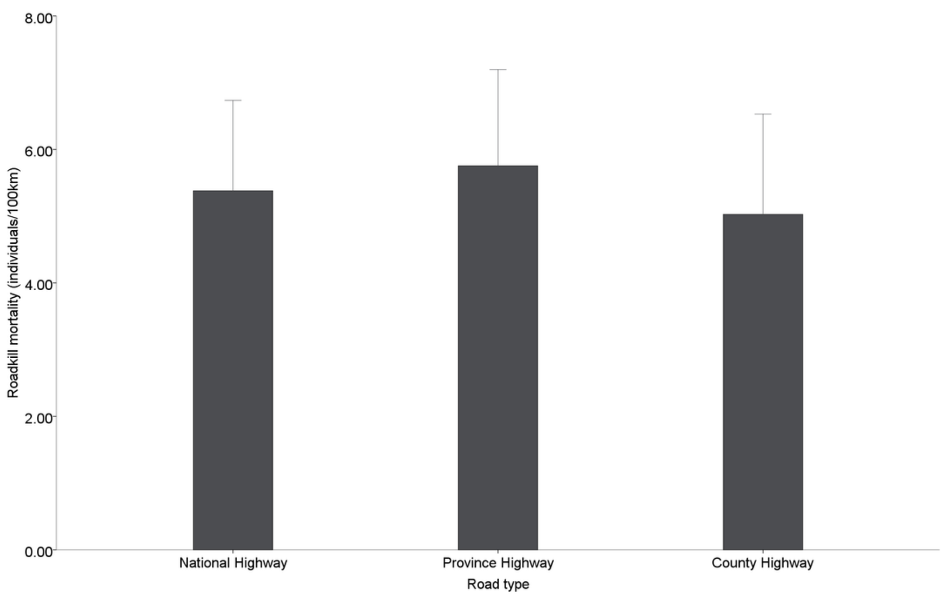
# Figure 3

Figure 3. Monthly roadkill number of mammals and birds in Nanjing, November 2020 - October 2021



# Figure 4

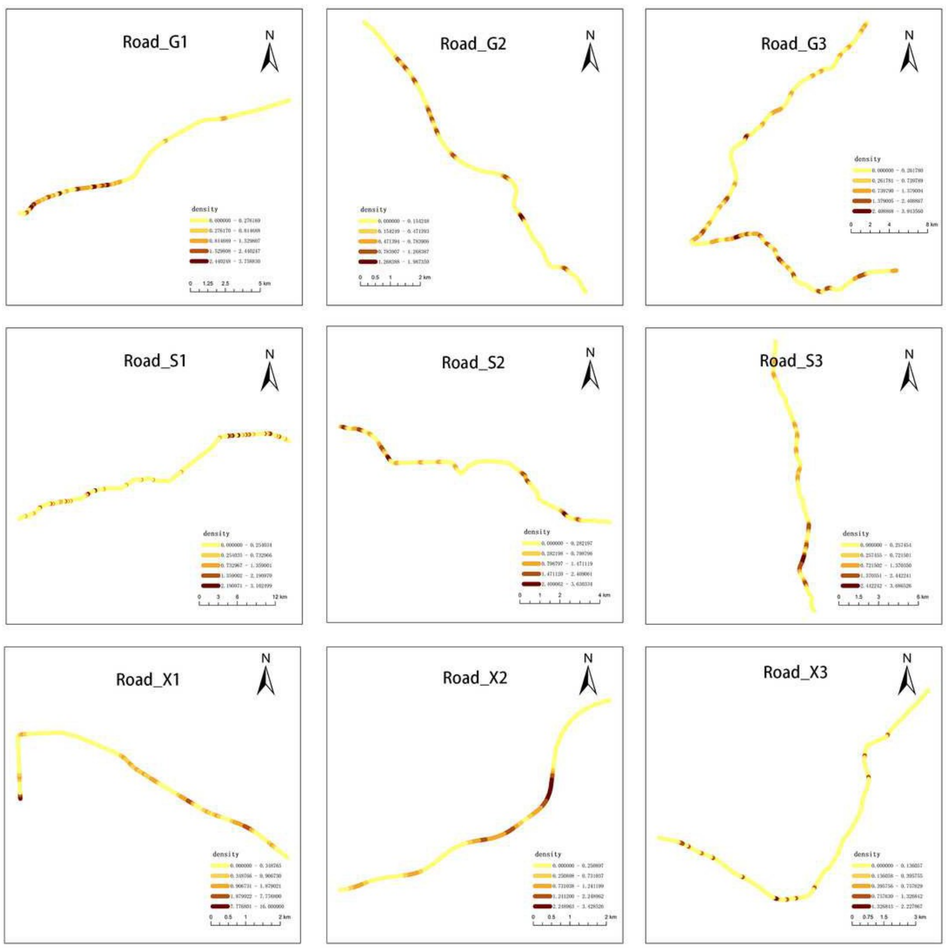
Figure 4. Roadkill mortality rates on diûerent administrative levels road



# Figure 5

Figure 5. Results of network kernel density estimation

Darker colors represent higher roadkills densities.



# Figure 6

Figure 6. Network K-function analysis

The blue line is the observed curve, the red line is the expected curve, the green line means the upper limit of the 95 % conûdence interval and the pink line means the lower limit of the 95 % conûdence interval. If the observed curve is above the conûdence interval, the spatial distribution pattern is clustered; below, it is dispersed; within, it is random.