Revealing an unknown EAAF shorebird migration: The Wood Snipe

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All the photos in the report was taken by the authors of the report unless otherwise noted. Cover photo was taken by Tong Mu.

Contents

1. Objectives and background of this project

1) Objectives

1: Identify the migratory route and wintering grounds of the Wood Snipe population that breeds in the EAAF in the Hengduan Mountains. See Chapter 3.
2: Investigate the population size and distribution of Wood Snipes in the Hengduan Mountains. See Chapter 2.
3: Characterize the habitats and threats to Wood Snipe at breeding site in the Hengduan Mountains. See Chapter 4.

2) Background

The Wood Snipe (*Gallinago nemoricola*) is a threatened and extremely poorly known long-distance migratory shorebird in the EAAF. It breeds in SW China (and also west to the Himalayas), and in winter, it has been observed in India, Bangladesh, Myanmar, N & C Laos, N Vietnam and N Thailand (Gils et al., 2020). It is arguably the least known of all EAAF migratory shorebirds: the information on this species is so sparse that the only peer-reviewed research article about it is a report of observations of its population and breeding in one national park in Nepal (Basnet et al., 2021). It has never been formally studied in the EAAF and there is no information about the population size or breeding habitat of the breeding population in Hengduan mountains. The Wood Snipe is currently classified as Vulnerable by the IUCN Red List, with a population estimated to be less than 10,000 mature individuals with a decreasing trend (BirdLife International, 2017). It is suggested that high grazing pressure and tourism, both lead to habitat degradation and disturbance, are important threats at its breeding site, while hunting and habitat loss at non-breeding sites might be also key threats (BirdLife International, 2017). Thus, the study and conservation on breeding population of Wood Snipe in Hengduan mountains are important for the survival of this species.

There is no information on migratory routes for the Wood Snipe. It was historically considered rare and local across most of its range. It is assumed that birds breeding in the Himalayas travel to south India in the non-breeding season, and possibly that there is also some altitudinal migration in the region (BirdLife International, 2017). However, migratory connectivity in the EAAF population is impossible to assess, and there is no information on the non-breeding destinations of the birds breeding in the Hengduan mountains of SW China. All the sighting records by Chinese birders (Birdtalker and Birdreport databases) are from the breeding season (April to August) as are almost all the eBird records from SW China, except one at Potatso National Park in December and a possibly erroneous record at Balang Shan in October. Sightings in SE Asia, central and southern India, Sri Lanka and Bangladesh are only from the non-breeding seasons (September to March), suggesting that the EAAF population is predominantly a long-distance migrant rather than a short distance altitudinal migrant. Given that this species is rare and possibly highly threatened, **resolving the migration routes of Wood Snipe with tracking is an urgent issue so that threats throughout the species annual cycle can be identified and conservation efforts can be directed toward the most pressing issues**.

2. Breeding population size and distribution of Wood Snipe in the project site

1) Preliminary survey and survey design

In order to determine the specific scope of the project for the current year, the project team members (Dr. QUE Pinjia, REN Xiaotong, HUANG Ke) and consultant expert (Dr. MU Tong) conducted a preliminary survey from April 24th to 26th, 2021 in Huya Township, Pingwu County, Sichuan Province, China. The preliminary survey included preparing for the project with the Xuebaoding National Nature Reserve, exploring the accessibility of the areas where there were historical records of Wood Snipe breeding, and determining the habitat condition and whether the Wood Snipe had arrived for breeding in the designated areas during the spring survey period. Through this preliminary survey, we confirmed that the areas of Tudiliang, Wuguishi, and Damachang (referred to as Damachang in total in the following text) had records of Wood Snipe breeding and were accessible during the scheduled survey period. The majority of the habitat in the area consisted of alpine meadows with a certain proportion of shrub coverage, with an elevation of approximately 3400-3800m. Although no traces of the Wood Snipe were found during the daytime survey, their mating calls were heard during the nighttime survey, confirming that they had already arrived in the breeding area.

Based on the preliminary survey results, we have determined that the main survey area for this project is Damachang. The previously planned Muguaping area was excluded from the survey range due to its distance and the difficulty in accessing it due to weather and snow accumulation for most of the year. Based on initial observations, the Wood Snipe is elusive during the day and difficult to detect. While their mating calls at sunset are relatively easy to detect, it is difficult to estimate the number and location of individuals since the calls are made during flight. Therefore, we have designed a population survey method that combines transect surveys and territory mapping surveys. As the Wood Snipe has already arrived at the breeding site during the preliminary survey and exhibited obvious mating behaviors, we have decided to start the field work as soon as possible, advancing the scheduled work from the second week of May to the very beginning of May.

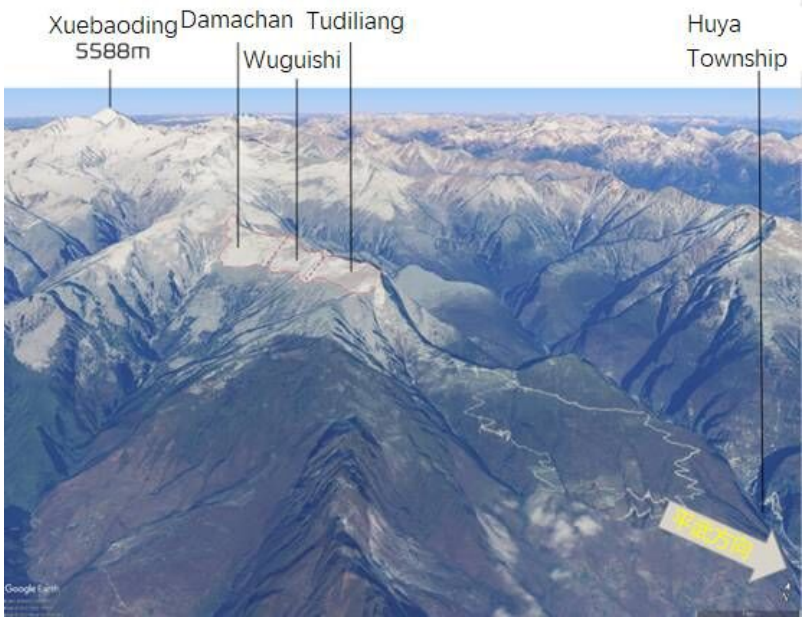

Figure 2.1 Location map of the study site.

Figure 2.2 Camp site in the field.

2) Fieldwork

The field survey of Wood Snipe breeding site for the year 2021 officially started on May 1st and ended on July 26th. A team of 20 people, including project members, reserve staff, and volunteers, worked continuously in the field for 87 days. We established and maintained a field camp (Figure 2.2) and completed various tasks, including population size and distribution survey, preliminary observation and description of breeding biology, call survey, individual capture and banding (see section 1 of chapter 3), survey for habitat characteristics and food resource (see chapter 4).

During the fieldwork, we conducted a semi-structured survey of the Wood Snipe population for 7 rounds. The survey was conducted by walking at a speed of about 1 km/h, covering all the recording locations (see details below) as one round. During the survey, the GPS coordinates were used to accurately locate and mark each Wood Snipe individual observed (either seen on the ground or flushed) or heard, and the number of Wood Snipes observed (single or in pairs) was recorded as individual activity. Each survey lasted approximately 2-3 days, covering all areas of Damachang, Wuguishi, and Tudiliang.

In addition, the project team deployed Wildlife Acoustics Song Meter Mini recorders (Figure 2.3) in a grid pattern (Figure 2.5 for recorders distribution in green dots, also refer to Figure 4.1) within the study area. The recorders were installed every 100 meters of elevation along the contour lines (approximately 400 meters apart horizontally) at 25 locations. Recording started on May 6th, 2021, and lasted 24 hours a day for about 80 days, resulting in a total data volume of approximately 12TB.

3) Data analysis and preliminary results of breeding population survey

We recorded a total of 123 Wood Snipe occurrence sites during field survey in 2021. Based on the recorded site information and on-site observations (such as whether two individuals were seen together or if an individual was consistently seen in the same area), we provided a preliminary estimate of Wood Snipe home range as shown in Figure 2.4. There are approximately six home ranges in the Damachang area, one in the Wuguishi area, and approximately two in the Tudiliang area. Based on field observations, each home range represents the activity area of 1-2 adult Wood Snipe individuals.

The project team used Kaleidoscope Pro software to automatically extract Wood Snipe calls from all recordings and created a call heatmap (Figure 2.6) for spatial analysis. Wood Snipe distribution is relatively more biased towards the lower altitude parts of the study area. Among them, the most detected Wood Snipe calls were found in the Damachang area, the least in the Wuguishi area, and the Tudiliang area was in the middle. This trend is consistent with the results obtained from our semi-structured human survey, indicating that our survey results are reliable. In terms of temporal rhythm, Wood Snipe calls mainly occur during night-time display flights, with only a few instances of singing during dawn, dusk, when startled, or on rainy days.

Figure 2.3 Recorder used in this project.

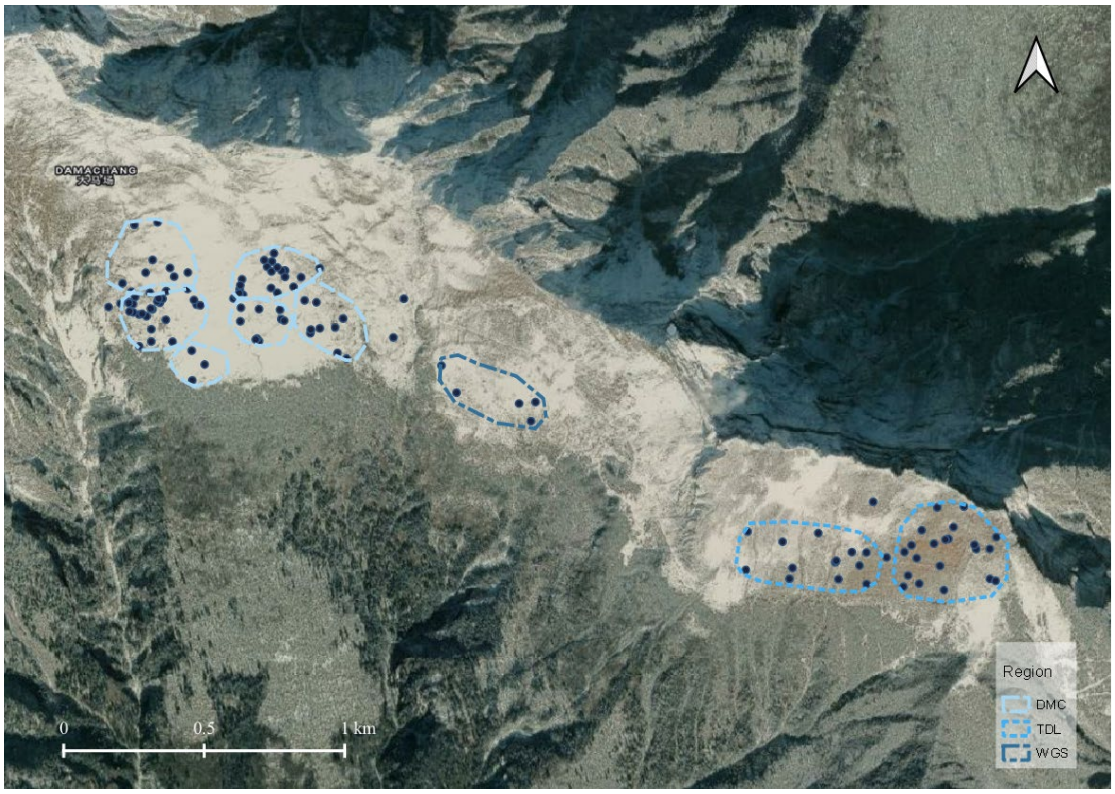

Figure 2.4 Wood Snipe occurrence sites and preliminary estimate of Wood Snipe home ranges.

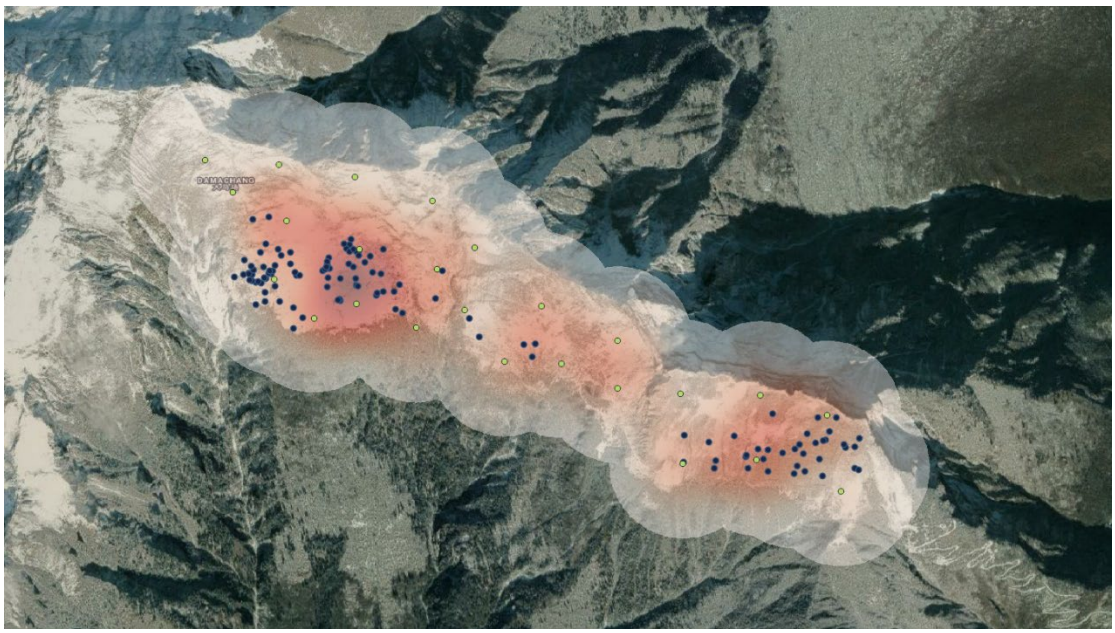

Figure 2.5 Wood Snipe occurrence sites (blue), recorder points (green) and song heat map (the darker the red, the higher the song activity intensity). The concentration of calls in Damachang (west side) and Tudiliang (east side) is consistent with the surveyed Wood Snipe activity areas.

3. Habitat preference and migration route of Wood Snipe in the non-breeding season

1) Banding

Based on observations of Wood Snipe behavior and literature on trapping methods for other *Gallinago* species, we attempted to capture individual Wood Snipes using mist nets (at sunrise and sunset), traps, and torch lights with hand nets at night. Throughout the capture process, the team members ensured the safety of the Wood Snipes and conducted various attempts to capture them. After successfully capturing Wood Snipe individuals, the team members performed ringing, measuring, sampling, and tracker placement work. Due to the difficulty of capturing Wood Snipes, except for a few days of breeding habitat surveys, the project team made continuous capture attempts throughout the entire fieldwork period. The first individual was captured on May 11, 2021, and the last individual was captured on June 20, 2021. During this period, a total of 7 individuals were ringed, as shown in Table 3.1.

The banding work involves attaching a metal band (as required by the National Bird Banding Centre of China) and a colored band (used for individual identification) to the wood snipe, as well as measuring the individual's weight, culmen length, head length, tarsus length, wing length, and tail length, and making a preliminary determination of the wood snipe's sex. This was the first banding work conducted on this species worldwide, which filled in the basic biological measurement information on the population of this species breeding in the Hengduan Mountains.

The sampling work involves collecting fecal samples (using cotton swabs to collect feces expelled during the banding process and preserving them in Eppendorf tubes containing 75% ethanol), feather samples (including 1-2 covert feathers of some individuals and feathers dropped during the banding process), and blood samples (using a standard blood sampling method for small and medium-sized birds and preserving the collected blood in anticoagulants). To ensure the health of the Wood Snipe individuals and the safety and success rate of subsequent tracker deployment, we only collected feather and blood samples from a portion of individuals after assessing the physical condition of each banded individual. The sampling work provided basic samples for subsequent molecular biology study. By analyzing the blood and feather samples, we determined the sex of the wood snipe, which was consistent with our preliminary observations in the field. In addition, we will collaborate with Professor Yang Liu's team from Sun Yat-sen University to conduct population genetics research on the Wood Snipe using these collected samples.

During the satellite tracker deployment, in order to increase the success rate of tracking, we used two different tracking devices (Figure 3.1), which were HQBG0804 from HQXS Inc., China and PinPoint GPS Argos from Lotek Wireless Inc., Canada. The HQBG0804 from HQXS weighed 4.5 grams and was powered by solar energy. We set the initial recording frequency to one location point recorded every 6 hours, and data was transmitted back every 5 points recorded. The PinPoint GPS Argos from Lotek weighed 3.5 grams and was powered by a built-in battery. The recording frequency was set to approximately one location point recorded every 5 days, and data was transmitted back every 3 points recorded. The battery could provide power to record and transmit data for approximately 60 location points (i.e., provide 300 days of recorded information). During

the entire ringing work, we fitted tracking devices to a total of 7 Wood Snipe individuals and ensured that the weight of each tracking device was less than 5% of the corresponding individual's body weight. The specific tracking device models and weights are shown in Table 3.1. Both types of tracking devices were attached to the back of the birds (Figure 3.1), and some of the HQBG0804 devices were raised in position to prevent the solar charging panel from being covered by feathers.

Figure 3.1 Attaching HQSX(upper) and Lotek tracking tags on banded individuals.

Ring No.	Tracking tag type	Tracking tag No.	Weight of tag/g	Weight of individual/g	Gender	Culmen length /mm	Bill length/ mm	Tarsus length /mm	Wing length/ mm	Tail length/ mm	Date of banding
G126175	HQXS	PAN013	5.0	215.8	F	67.94	101.15	37.01	161	61.5	2021/05/11
G126173	Lotek	214884	3.8	170.4	M	68.46	102.6	39.18	155	56	2021/05/18
G126181	Lotek	214881	4.1	163.6	M	65.26	98.03	37.41	151	56	2021/05/20
G126176	HQXS	PAN012	5.3	163.3	M	68.00	102.42	40.31	157	57	2021/06/01
G126180	HQXS	PAN010	5.3	141.1	M	67.67	100.77	38.2	154	56	2021/06/04
G123182	Lotek	214883	4.3	207.4	F	67.37	101.53	38.56	162	60	2021/06/05
G126174	Lotek	214882	4.2	160.0	F	71.39	107.66	39.54	150	54	2021/06/20

2) Migration patterns and choice of stopover sites

We analyzed the migration pattern and habitat selection of Wood Snipes using the tracked data during the migration season, along with corresponding satellite remote sensing images and land use information (Figure 3.2). Two out of seven Wood Snipes had successfully transmitted the information of their wintering sites back; thus we had the southward migration route for two individuals and northward migration route for one individual. Due to the use of different tracking devices, data recording and transmission of these two Wood Snipes were different.

The individual wintering in Qinglong County (Band No. G126176, details in the next section, blue dot in Figure 3.2) took 5 days (approximately 126 hours) to complete the migration. Besides the points logged at the departure site in Damachang and the wintering site in Qinglong County, it recorded 13 stopover points (we considered GPS locations with speed of 0 as stopover points and retained only those with A-level GPS accuracy to investigate habitat use), distributed among 6 different locations. Among the stopover sites, one was located in an orchard with dense herbaceous plants (Figure 3.3, observed on site), while the other four were determined by analyzing satellite remote sensing images of the land use type, located in herbaceous habitats (grassland or farmland), and one was located at the edge between herbaceous habitat and forest (Gong et al., 2019). The average distance between resting sites was 119 ± 62 km, totaling 832 km. During migration, this individual spent more time flying at night (between 18:00 and 6:00 the next day). It has arrived at each stopover site at noon and 6 p.m., suggesting that it rested during the day. We recorded three data points during its flight, with more than 13 satellites available for each location, and the positioning accuracy was at the A-level. Two of the data points recorded a flight speed of 34 km/h, while one recorded a flight speed of 41 km/h.

Northward migration started from Apr. 22, 2022, and took 3 days (less than 72h, light blue track in Figure 3.2). Two stopover sites were identified, and mean speed in flight (3 points) was 50.5+-0.8 km/h.

The individual wintering in Hoang Lien Son (Band No. G123182, details in the next section, orange dot in Figure 3.2) recorded only one data point on September 29, 2021, at 12:01, which we inferred to be a resting point based on its behavior. The resting point was located in a forest area at the interface between forest and herbaceous habitats (Gong et al., 2019).

3) Habitat preference in wintering grounds

The wintering sites of the two individuals were identified through satellite tracking, located in Qinglong County, Guizhou Province, China, and the southern part of the Hoang Lien Son National Park, Lao Cai Province, Vietnam, with a straight-line distance of about 400 km (Figure 3.2). Among them, the individual wintering in Qinglong County is marked with ring code G126176, wearing a Transmitter manufactured by HQXS, and is male (hereafter referred to as the Qinglong individual). This record is the first time that the activities of the Wood Snipe have been recorded in Guizhou Province and is a new discovery of a wintering site not documented in existing literature. The distance from this wintering site to its breeding site is about 770 km. The individual wintering in Hoang Lien Son is marked with ring code G123182, wearing a Lotek PinPoint GPS Argos

Transmitter, and is female (hereafter referred to as the Hoang Lien Son individual). This area has been recorded as a non-breeding site for Wood Snipe in existing literature (BirdLife International, 2001). The distance from this wintering site to its breeding site is about 1,150 km.

In addition to the differences in wintering sites, the two individuals also differ in their migratory rhythms. The Qinglong individual left the breeding area between 0:00 and 6:00 on August 15, 2021, and arrived at the wintering site between 0:00 and 6:00 on August 20, 2021. The Hoang Lien Son individual left the breeding area between September 24 and 29, 2021, and arrived at the wintering site between September 29 and October 24, 2021 (with poor time precision). The two individuals differ in their migration time by more than a month.

Figure 3.2 Map of Wood Snipe tracking in non-breeding season. Individuals marked by colors: orange indicates south-ward migration of Hoang Lien Son individual; dark blue and light blue indicate south-ward and north-ward migration of Qinglong individual respectively.

Figure 3.3 Habitat of Wood Snipe stopover site (photo by QUE Pinjia).

4) Vegetation and Wood Snipe habitat use in wintering grounds

Table 3.2 Vegetation and Wood Snipe habitat use in wintering grounds

Individual	Area of wintering MCP/ha	Percentage area of grassland	Percentage area of woodland	Percentage area of scrubland	Percentage of tracking point on grassland	Percentage of tracking point on woodland	Mean elevation/m
Qinglong	875.7	83%	16%	0%	95%	5%	1670±45
Hoang Lien Son	79.7	33%	59%	5%	86%	14%	1279±44*

*Elevation from ASTER GDEM v3

The wintering site in Qinglong County (see Figure 3.4) is located at 25.7°N, 105.1°E. The area has a complex topography and is dominated by karst landforms, with undulating hills and valleys. Wood Snipe's main wintering home range is on a relatively flat plateau in the area. This region is mainly covered by herbaceous vegetation (see Figure 3.5), and there is currently no agricultural activity. Based on the land-use type data processed from satellite remote sensing images (Gong et al., 2019) and field surveys, the habitat types and habitat use within Wood Snipe's wintering home range are shown in Table 3.2 (see Figure 3.6). The wintering home range at wintering site in Table 3.2 refers to the minimum convex polygon (MCP) area that includes all recorded points. The elevation of the occurrence sites is based on the altitude recorded by the tracking device.

The land-use type data obtained from remote sensing images include grassland and cropland, but according to our on-site survey, cropland should be a misclassification. Therefore, these two land-use types are combined in this statistic to represent the herbaceous vegetation area. As shown in Table 3.2, the wintering home range of Wood Snipe individuals are relatively fixed in their wintering site for over seven months, from late August to the end of March (at the time of writing this report). We observed that even though there is already abundant herbaceous cover in the area, Wood Snipe still shows greater prefers to choose the herbaceous vegetation within the wintering home range, as the remaining occurrence points in the forest are located at the forest edge. Although this may be due to the birds' preference for the forest edge or the tracking device's precision error.

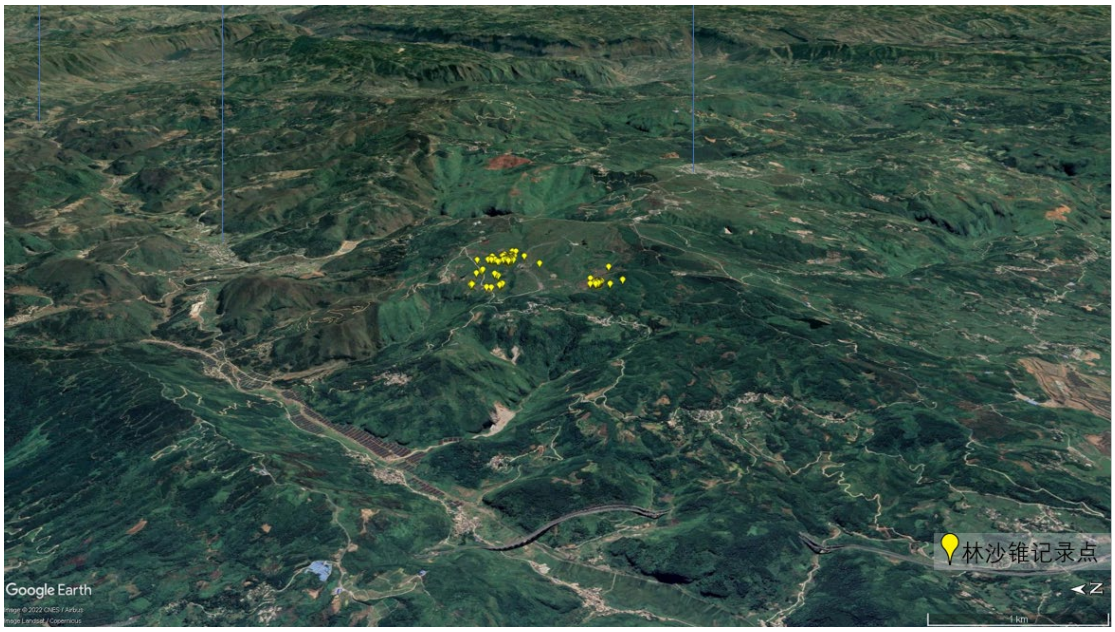

Figure 3.4 Topography of Wood Snipe wintering site in Qinglong (Background: Google Earth).


Figure 3.5 Wood Snipe wintering habitat in Qinglong (photo by: HUANG Ke).

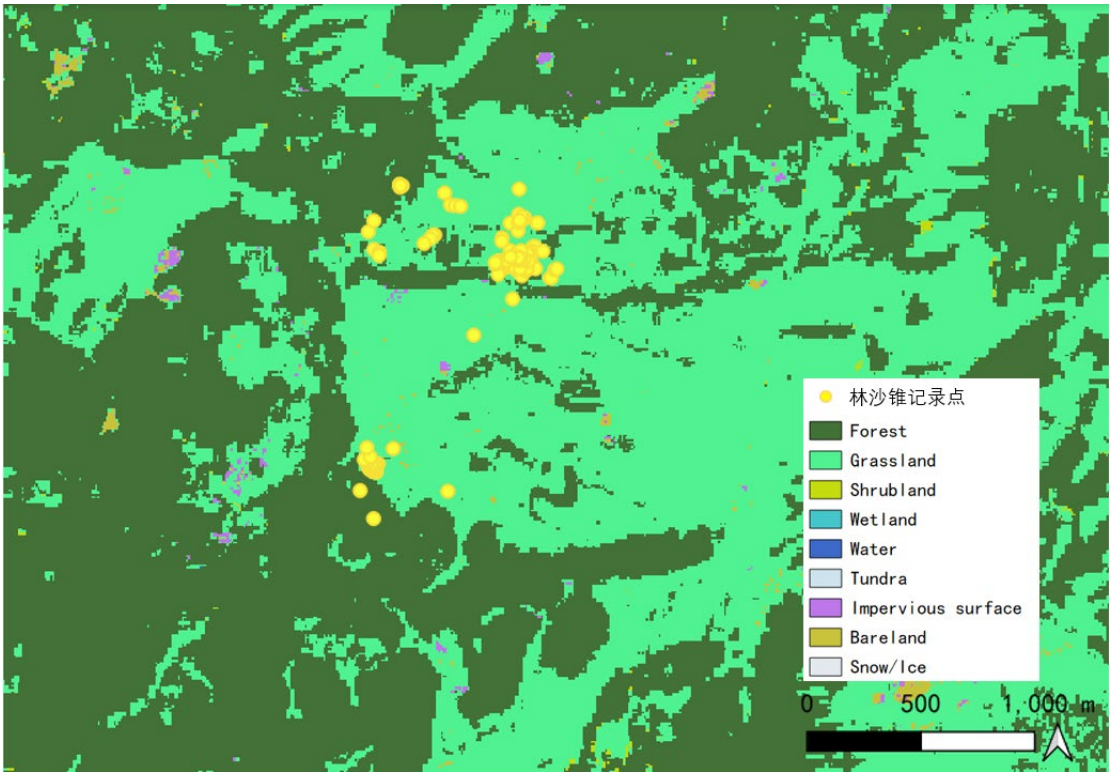

Figure 3.6 Land use types of Wood Snipe wintering ground in Qinglong (modified from Gong et al., 2019)

The Hoang Lien Son wintering ground (Figure 3.7) is located at 22.0°N, 104.0°E. This area is situated in the southern part of the Hoang Lien Son Mountains, 36 km from Fansipan Peak, the main peak of the Hoang Lien Son Mountains, which is the highest peak in Vietnam. The vegetation is dominated by subtropical evergreen mountain forests. The Hoang Lien Son Mountains are located on the right bank of the Honghe River and extend from Honghe Prefecture in Yunnan Province, China, to Lao Cai Province in Vietnam. In this area, Vietnam has designated the Hoang Lien Son National Park, an important natural protected area and scenic spot. Based on the tracking data of Wood Snipe in this area and the land use type data (Gong et al., 2019), the main vegetation type within the Wood Snipe's wintering home range (MCP) is trees (Table 3.2, Figure 3.8). However, looking specifically at the Wood Snipe's occurrence sites, it can be seen that Wood Snipe mainly inhabits scattered grassland habitats within the terrain. A detailed examination of the terrain shows that this area is actually located within the landslide bodies on both slopes of the mountain (refer to Figure 3.9), with an average slope of 41°±10° calculated using the 30m resolution ASTER GDEM v3 digital elevation model (NASA/METI/AIST/Japan Space systems and U.S./Japan ASTER Science Team, 2019). Combined with high-resolution satellite images, we believe that the vegetation in this area is mainly composed of rapidly growing grasses. The use of the MCP method to estimate the activity range has limited reference significance for these relatively steep terrain on both slopes; Wood Snipe does not make much use of the surrounding forest habitat.

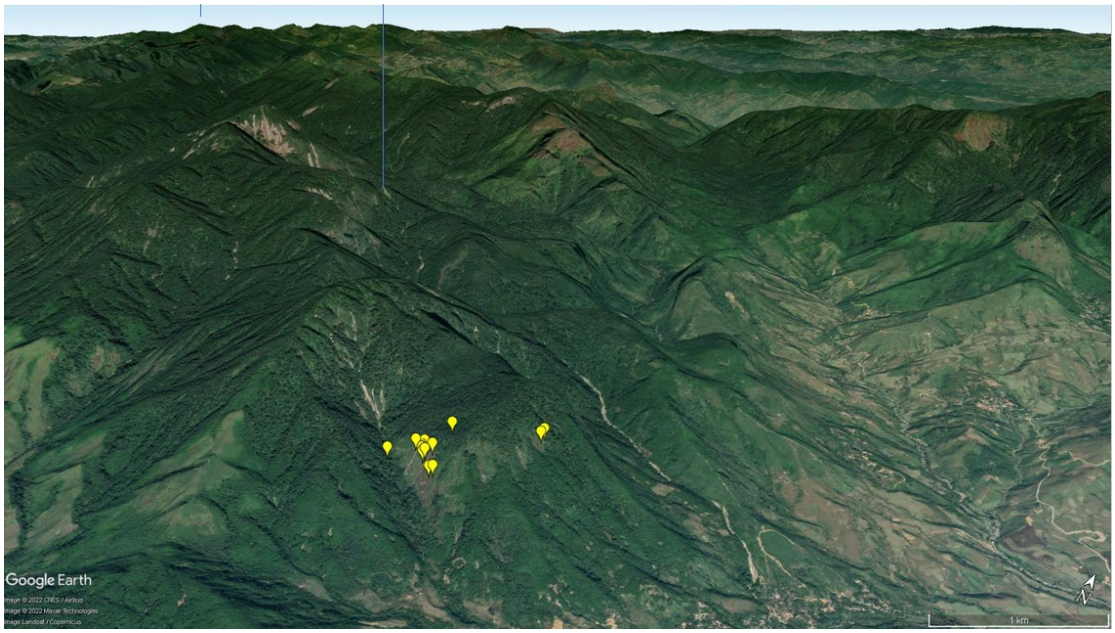

Figure 3.7: Topography of Wood Snipe wintering site in Hoang Lien Son (Background: Google Earth).

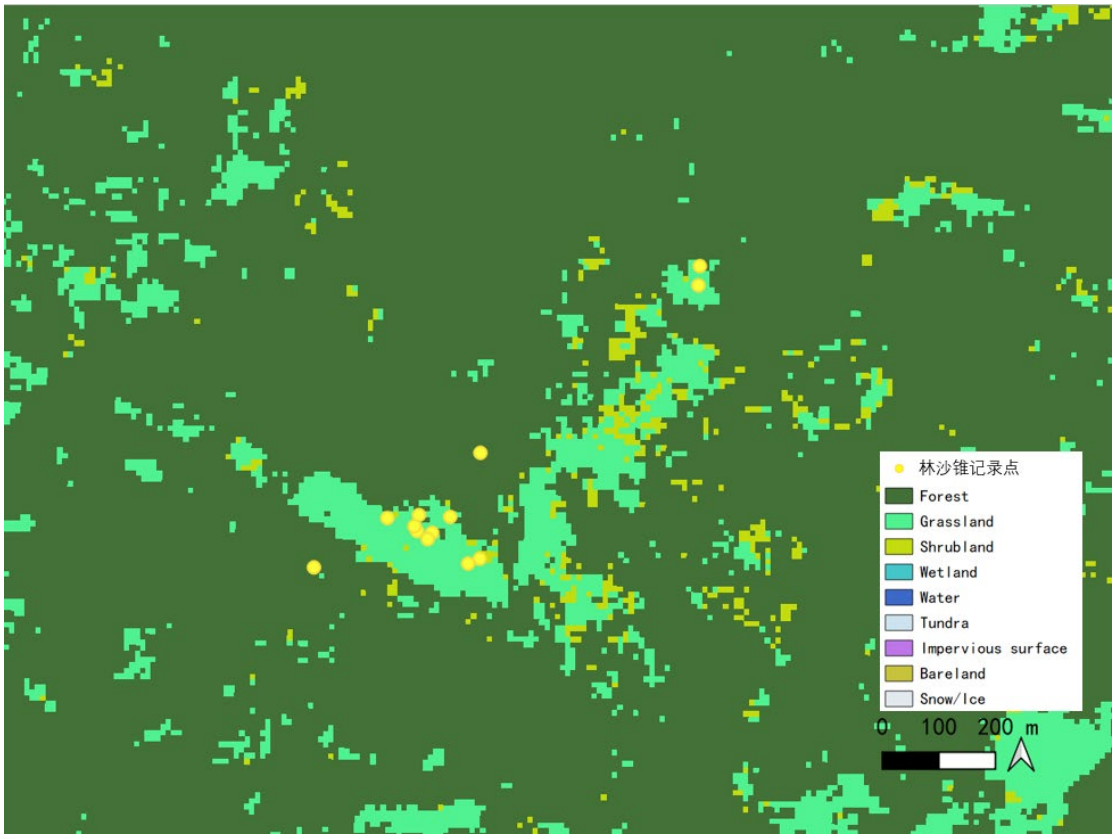

Figure 3.8: Land use types of Wood Snipe wintering ground in Hoang Lien Son (modified from Gong et al., 2019)

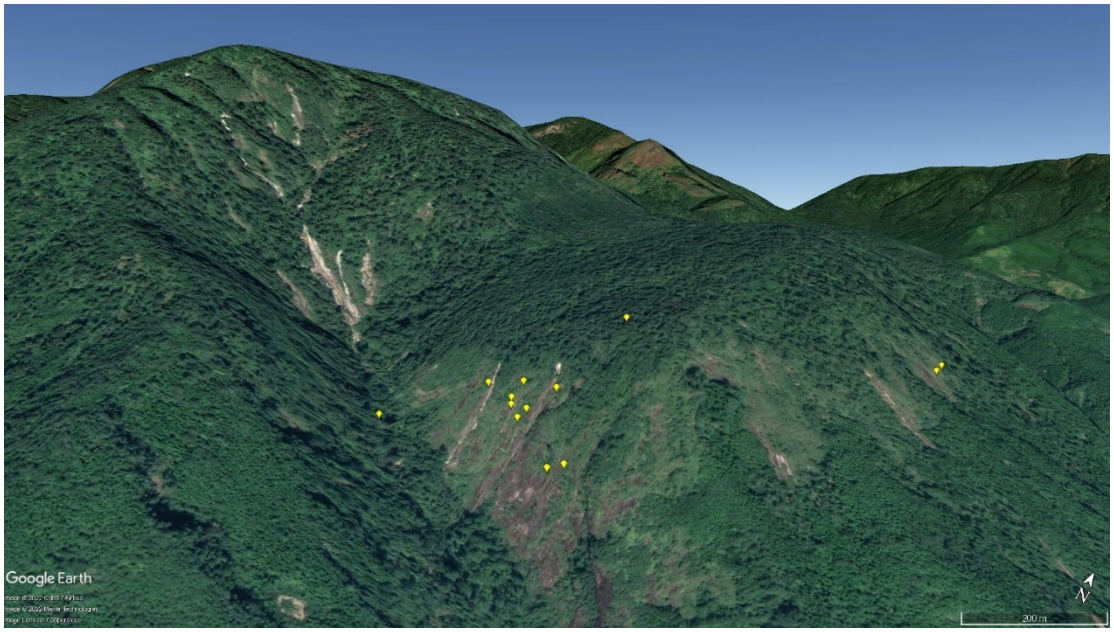

Figure 3.9: Topography of Wood Snipe wintering ground in Hoang Lien Son (Background: Google Earth, the visual effect does not represent the actual slope)

Based on the non-breeding season tracking records of the two individuals mentioned above, it can be seen that Wood Snipes primarily select mountain habitats for their activities. The radius of the wintering home range is around 400-800m, and they prioritize the use of grassland habitats within their wintering home range, which is consistent with their preference for grassland plants as breeding habitat. Even in areas with higher forest cover, Wood Snipe still prefers narrow and steep herbaceous habitats, possibly because this habitat type is more similar to their breeding habitat. It is worth noting that Wood Snipes only occasionally appear at the edge of forests. Furthermore, the current tracking results do not show any preference for altitude, slope, or other conditions in their wintering habitat.

4. Characteristics and potential threats of Wood snipe breeding habitat

In order to understand the habitat preferences of Wood Snipe in their breeding grounds, we designed and conducted a corresponding habitat survey. Based on the 123 Wood Snipe observation points described in Chapter 2, we selected 34 sites for habitat modelling analysis after sparse sampling based on the proportion of different regions, covering the areas of Damachang, Wuguishi, and Tudiliang. In addition, we also randomly sampled background points for direction and distance based on a grid of 25 placed recording devices (see details below, location shown in Figure 2.3), using the background points as potential locations that Wood Snipe may use in the study area but have not been observed.

Furthermore, during the field survey in late June, we recorded an additional 19 sites where Wood Snipe were observed foraging. After individual Wood Snipe left the site, we immediately marked the foraging point with a flag and conducted a survey of potential food sources in early July, together with the 25 background points.

1) Design of breeding habitat survey

As there is very little field research information available on the Wood Snipe, we have referred to studies on other snipe species (primarily the well-researched Common Snipe and Great Snipe) to investigate their preference (Hoodless et al. 2007, Mongin 2006, Korniluk et al. 2021, Løfaldli et al. 1992). Based on literature review and field investigations of the project site, we have designed the following plan for investigating the breeding habitat of the Wood Snipe, with the aim of collecting as comprehensive information as possible on environmental variables that may influence the selection of their breeding habitat.

1. Selection of sampling sites

Occurrence sites of Wood Snipe: Based on the results of previous field surveys, sampling will be conducted at all GPS locations where one or a pair of Wood Snipes have been clearly recorded taking flight or foraging (without considering spatial accuracy) (Hoodless et al., 2007). Actual sampling points will be randomly selected from all recorded locations or thinned out, with a total of 30 sample points expected.

Background sites: Systematic sampling will be conducted based on the location of each recording device, including food resources. A specific distance within 0-10m (randomly selected) from the recording device in a direction randomly selected between 0 (due north) and 360 degrees will be chosen as the sampling point. A total of 25 sample points are expected.

Foraging sites: Sampling will be conducted at all recorded exact foraging locations (marked on-site after observing foraging behavior), with a total of 20 sample points expected.

2. Survey targets and methods

   We conducted surveys to investigate the habitat characteristics of the Wood Snipe. The following information was collected:

   a) Terrain Features:

      Latitude, longitude, and elevation (same as survey point selection), slope (average of 5 meters, measured by pulling a tape measure straight down and using a smartphone app to measure the average slope), aspect (measured using a compass or smartphone app, with reference to the slope tape measure and a 2-meter tape measure extended horizontally on the ground perpendicular to the slope direction).

   b) Vegetation characteristics:

Quadrats (0.5m * 0.5m, see Figure 4.2): species name (including both herbs and shrubs, life form/ecological functional group to be added later), relative cover (estimated by species, mosses listed separately), and the height of horizontal vegetation cover (measured with a Robel pole at 4m distance in four directions at a height of 1m, see Figure 4.2; Robel R. J., et al., 1970). Average height could be measured using two methods: Method 1 records the average height of each species in the quadrat; Method 2 records the average count of individuals within a 10cm radius, with the quadrat center serving as the measurement center point (Hoodless et al., 2007). The highest individual height and species of herbs and shrubs were recorded within the quadrat (Herrick et al., 2017).

Shrubs: Using the center point quartile method, we recorded the species, height (measured from the base of the shrub), distance (measured in a straight line), length of the longest axis, and the length of the axis perpendicular to it (to calculate the area of the shrub cluster) for the nearest shrub individual in each of the four quadrants. We repeated these measurements at five points located 5 meters apart in the north, south, east, and west directions from the sampling center point.

c) Soil Features

Moisture (sampled at the quadrat center point using a soil moisture meter), hardness (measured by dropping a 6 mm diameter and 80 g weight steel nail to record the penetration depth three times and taking the average) (Mongin, 2006).

d) Disturbance

Livestock feces (counted in a 5m x 5m quadrat).

e) Food Resources:

Only visible soil macroinvertebrates (earthworms and other invertebrates) were investigated as food resources in the habitat. Sample locations were within the selected quadrats (Valckx et al., 2011). Quadrat size was 15cm x 15cm x 10cm (deep). All visible soil animals within the quadrat were collected and preserved in 75% alcohol (see Figure 4.1 on the left).

2) Conducting breeding habitat survey

Based on the above survey plan, we conducted a habitat survey at the breeding sites. We surveyed 34 Wood Snipe occurrence sites and 25 background sites, recording the environmental variables as descripted above. In addition, we investigated the abundance of Wood Snipe potential food (soil macroinvertebrates) at 17 foraging sites where Wood Snipe were observed and at the 25 background sites. We preserved all collected individuals as specimens and subsequently measured their body length in the laboratory and identified them to the level of genus or family based on morphological characteristics (Figure 4.3).

Figure 4.1 Investigation of Wood Snipe food resources (left); investigation of environmental variables and vegetation (right)

Figure 4.2 Herbaceous vegetation quadrat (upper); Vegetation horizontal cover height (Robel pole)

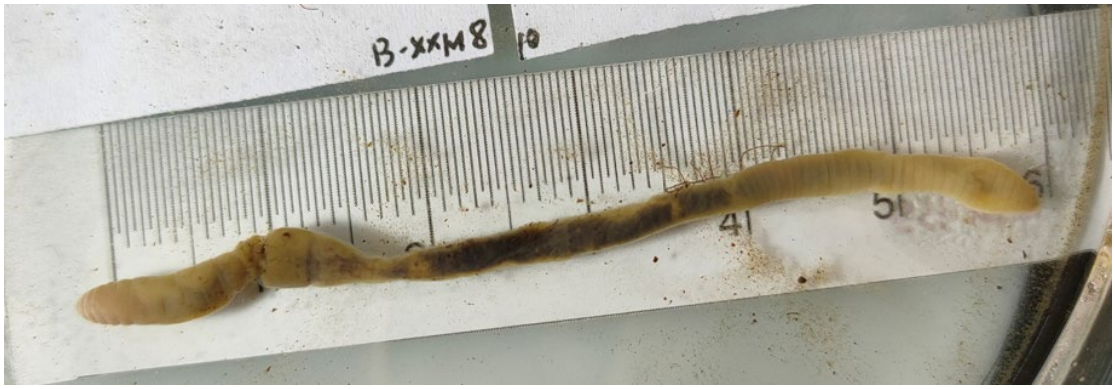

Figure 4.3 Measuring the body length of soil macroinvertebrate samples.

3) Results

The detailed result of this breeding habitat survey was accepted for publish in *Bird Conservation International* under title “Habitat selection and population status of breeding Wood Snipe *Gallinago nemoricola* at an alpine meadow in Sichuan, China”, and can be accessed through its website when it is online.

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7. References

BirdLife International. (2001). WOOD SNIPE *Gallinago nemoricola*. In *Threatened birds of Asia: the BirdLife International Red Data Book*. Cambridge, UK: BirdLife International.

Basnet H., Shrestha M. B., Thakuri D. C., Pun T., Chaudhary D., Baral H. S., Ecology and status of Wood Snipe Gallinago nemoricola in Lamtang National Park, Nepal. *Wader Study*, 128: 220-225. https://doi.org/10.18194/ws.00243

Gong, P., Liu, H., Zhang, M., Li, C., Wang, J., Huang, H., Song, L. (2019). Stable classification with limited sample: transferring a 30-m resolution sample set collected in 2015 to mapping 10-m resolution global land cover in 2017. *Science Bulletin*, 64(6): 370-373. https://doi.org/10.1016/j.scib.2019.03.002

Gils, J. V., Wiersma, P., & Kirwan, G. M. (2020, March 4). Wood Snipe (*Gallinago nemoricola*), version 1.0. In *Birds of the World* (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.woosni1.01

Hoodless A.N., Ewald J.E. & Baines D., (2007), Habitat use and diet of Common Snipe *Gallinago gallinago* breeding on moorland in northern England. *Bird Study*, 54: 182–191.

Herrick et al., (2017), *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems.* 2nd Edition

Korniluk, M., Bialomyzy, P., Grygoruk, G., Kozub, L., Sielezniew, M., Swietochowski, P., Tumiel, T., Wereszczuk, M. & Chylarecki, P. (2021). Habitat selection of foraging male Great Snipes on floodplain meadows: importance of proximity to the lek, vegetation cover and bare ground. *Ibis*, 163: 486-506.

Løfaldli, L., Kålås, J. A. & Fiske, P. (1992). Habitat Selection and Diet of Great Snipe Gallinago Media during Breeding. *Ibis*, 134: 35-43.

Mongin E., (2006), Breeding biology and habitat selection of the Common and Great Snipe in Belarus, Sixth European Woodcock and Snipe Workshop – *Proceedings of an International Symposium of the Wetlands International Woodcock and Snipe Specialist Group*, 25 – 27 November 2003, Nantes, France. *International Wader Studies* 13, Wageningen, The Netherlands, vi + 114 pp.

NASA/METI/AIST/Japan Space systems and U.S./Japan ASTER Science Team. (2019). ASTER Global Digital Elevation Model V003. Retrieved from: https://lpdaac.usgs.gov/products/astgtmv003/

Robel R. J., et al., (1970), Relationship between visual obstruction measurements and weight of grassland vegetation, *J. Range. Manage.*, 23:295-297.

Valckx J., Govers G., Hermy M., Muys B., (2011), Optimizing Earthworm Sampling in Ecosystems, in Karaca A. (ed.), *Biology of Earthworms*, *Soil Biology*, 24.