**Avifauna in Arctic Tundra: Acoustic Monitoring of Migratory Birds in Northeastern Siberia**

Yi-Chin Tseng1 and Sergei M. Sleptsov2

1Department of Forest Resources Management, Faculty of Forestry, University of British Columbia, Canada

2Institute of Biological Problems of Cryolithozone, Siberian Branch of the Russian Academy of Sciences, Sakha Republic, Russian Federation

**Background and Relevance**

Located in northeastern Russia, Siberian arctic tundra is favored by numerous migratory bird species (Pearce et al., 1998b) because ?. Indigirka River Delta (IRD, 5,000 km2) is one of the most productive tundra areas in Siberia that supports 40 – 60 breeding species each summer (Goryachkin, 1994; Pearce et al., 1998a). This delta is the main breeding ground for many rare species, such as Siberian Crane (*Leucogeranus leucogeranus*), which is listed as critically endangered in the IUCN Red List (IUCN, 2017). Other rare species include Yellow-billed Loon (*Gavia adamsii*), Ross’s Gull (*Rhodostethia rosea*), and Steller’s Eider (*Polysticta stelleri*). It is not exaggerate to say IRD is the most important breeding grounds of the world for migratory birds.

There is no doubt that IRD deserves continued monitoring and conservation, however, only few research expeditions had been conducted and the quantitative data for bird community are lacking (Pearce et al., 1998a). Researchers are not able to get access to the IRD until the Indigirka River channel is open, around late May to early June. The lack of transportation and the short summer (i.e., 50 to 60 days) substantially constrain both the spatial and temporal scale of the bird study. Large area and long-term detection of birds in tundra is not possible with conventional survey methods (i.e., point counts, transects, and mist-nets). Thus, a new method must be introduced to enhance the scale of monitoring of birds in tundra.

In this study, we propose to introduce automatic recording systems to monitor the bird community in the IRD area. Autonomous recording system has been applied in diverse ecosystems to remotely and non-invasively monitor bird community (Blumstein et al., 2011). Species richness, abundance, composition, and other quantitative data can be derived. With the permanent recordings, automatic recording systems are proved to have the same or even better detection ability than conventional field survey (Celis‐Murillo et al., 2009). Given the progressive vocal activity of the breeding birds in arctic tundra, applying autonomous recording systems in tundra is promising.

This study will be the first attempt of applying automatic recording systems in Siberian arctic tundra for monitoring migratory breeding? birds. We will continuously monitor the vocal activity in different habitats of tundra along the breeding season (i.e., May to July). By comparing the quantitative data from recordings (i.e., species richness, abundance, and composition), we will be able to investigate the activity patterns of birds in Siberian arctic tundra. Furthermore, the audio recordings for different species will provide important data for future study. The introduction of autonomous recording systems will pave the way for large spatio-temporal scale monitoring of birds in the Arctic tundra.

**Goals and Objectives**

\*Goal 1: Monitoring the activity patterns of birds in Siberian arctic tundra

Objective 1-1: Understanding the diurnal? rhythm of birds in tundra.

We will investigate the circadian rhythm of the birds under the midnight sun by comparing the species detected in the recordings within 24 hours. Since the concept of “night” does not exist in the Arctic, we expect different daily activity patterns as birds in tropical or temperate area.

Objective1-2: Understanding the dynamic of breeding activity tundra.

The long-term dynamic of breeding activity will be examined by comparing the species richness, abundance, and composition during whole breeding season. We will know when the breeding activity starts, to the peak and ends in tundra.

\*Goal 2: Sharing bird sound recordings in public database

Objective 2-1: Increasing the collection of bird sounds on Xeno-Canto. In Xeno-Canto, the world’s biggest bird sound database, there are only 55 recordings of how many species in Siberian arctic tundra. We will provide all the recordings from our study in this public platform and thus provide materials for other studies in the future.

**Methodology Detail**

***Study area***

The recording systems will be set in the arctic tundra of Indigirka River Delta (IRD) area, specifically around the Dzhyukarskoe Lake (70˚56′37.0′′N, 148˚00′22.3′′E). Typical vegetation in the area is composed of dwarf shrubs, grasses, lichens, and mosses. The subsoil is permafrost. In summer time (i.e., breeding season), the temperature ranges from -4 to 22˚C, with an average of 5˚C. Three habitats will be selected for monitoring based on the distance to the Indigirka River to monitor riverine and upland habitats? Or why? How many replicates within each habitat? . Each location will be monitored with a set of recording system with each of the locations separated at least one kilometer in distance.

There is a research station located by the Dzhyukarskoe Lake that we will use during the fieldwork. Food supply and fuel will be purchased from the nearest village, Chokurdakh ([70°38′N 147°54′E](https://tools.wmflabs.org/geohack/geohack.php?pagename=Chokurdakh&params=70_38_N_147_54_E_region:RU-SA_type:city(2,367))). The IRD area is within the Kytalyk Reserve. We will request the required permit from Siberian Branch of the Russian Academy of Sciences, one of the collaborators of this study.

***Bird species***

The updated species list of IRD area consists 93 species and 57 of them are migratory birds (species list: <https://goo.gl/Ma9q7Y>). We are interested in monitoring all the migratory species especially for the following target species:

* Siberian Crane (*Grus leucogeranus*): One of the rarest species breeding in tundra. The Siberian Crane is listed critically endangered in the Red List of IUCN and only 3,750 individuals were left in the wild.
* Sandhill Crane (*Grus canadensis*): A species has intraspecific competition with Siberian Crane.
* Rough-legged Buzzard (*Buteo lagopus*): A migratory raptor staying in south Asia during winter time. The population of Rough-legged Buzzard is decreasing due to the agriculture management in the south Asia (i.e., hunting poisoned rats).
* Ross’s Gull (*Rhodostethia rosea*): a migratory gull, that is unstudied in Indigirka River

***Recording equipment***

The type of Autonomous Recording Unit (ARU) we plan to use is the Song Meter SM4 Acoustic Recorder provided by Wildlife Acoustics. Two built-in microphones in SM4 are omnidirectional (i.e., capture sound equally from all directions) with sensitivity at -28dB +/- 3dB at 1kHz. The frequency response of the microphones ranges from 20Hz to 48kHz, which fully covers the frequency of bird sounds, ranging from 1kHz to 8kHz. The SM4 features on its low power consumption, large data storage (i.e., more than one terabyte total capacity), and malleable operation environment (i.e., during rain and low temperature down to -20 ˚C). Furthermore, it provides the flexibility in powering system so that the external solar panels can be connected to provide extra electricity. The combination of these features makes SM4 a suitable acoustic recorder in our study.

We will use the scheduled recording function of SM4 to record 10 minutes per hour, 24 hours a day from May to July in the tundra.

***Audio interpretation***

The analysis of collected audio recordings can be broken into two stages: signal detection and signal classification. Signal detection involves the extraction of structured sounds of interest while signal classification involves the identification of bird species. We will apply occupancy model to detect the presence of birds in each audio file, then identified the species by comparing the recordings with the bird sound database: Xeno-Canto. For each audio file we will then be able to derive the species richness (i.e., the number of species), abundance (i.e., the number of individuals of each species), and composition.

**Methodology Justification**

In the summer of 2017, I cooperated with Dr. Sergei M. Sleptsov from Russian Academic of Sciences to record tundra birds in the Indigirka river delta (IRD) area. Based on the experience, I listed two potential constraints in this study and the reasons why I am optimistic in achieving the goals.

\*Location selection and accessibility

The IRD area is one of the most productive tundra delta consisting 57 breeding species, including the majority of the population of several rare species. The IRD is no doubt the best location to apply long-term acoustic monitoring to understand the Arctic birds. My local cooperator, Sergei M. Sleptsov, is an ornithologist from Russian Academy of Sciences. He is an experienced researcher working in tundra and visits IRD area every summer. He will help to apply the permit to get to the Kytalyk Reserve and arrange all the local transportations.

\*Recording system

Recording bird sounds in the tundra is a challenging task due to the extreme weather conditions (i.e., low temperature, limited electricity source, and strong winds). In my 2017 visit in IRD area, I used Telinga SM2 parabolic microphone system and successfully got high quality recordings (https://www.xeno-canto.org/contributor/SPMWIWZKKC). According to this experience, I listed possible challenges for the SM4 we are going to use in this study.

-Low temperature: The lower limit of SM4 operation temperature (i.e., -20˚C) is lower than the lowest temperature of summer in the IRD area (i.e., -4˚C), so the system will operate well. However, the low temperature will substantially reduce the battery life, which we will discuss in the next paragraph.

-Limited electricity source: The SM4 build-in batteries can support 300 hours of recording. The SM4 also supports external power so we will connect the SM4 with extra solar panels.

-Strong wind: The wind speed in tundra is around 70 km/hr. We will use extra windshield layers on the SM4 microphones to prevent noise due to the wind.

**Works Cited**

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