Verifying the efficacy of passive acoustic monitoring for sika deer populations

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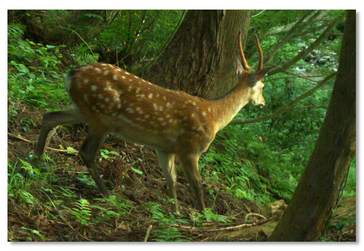
Highlights

- ✓ We introduce a bioacoustic method—passive acoustic monitoring (PAM)—for the detection of male sika deer, *Cervus nippon*.
- ✓ PAM could detect males with greater sensitivity than existing methods using spotlight counts and camera traps.
- ✓ The detection range of PAM was 6 ha in forests, which was >200-times wider than that for commonly used camera traps.

Introduction

- ✓ A precautionary measure is strongly urged to avoid biodiversity loss caused by the expanding distribution of sika deer.
- ✓ We invented PAM to detect males with a high sensitivity using their howl, *i.e.*, a loud call during the rut.
- ✓ The detection of males is required because the male-to-female ratio is remarkably high in the initial stage of invasion.



The aim of this study

To define the efficacy of PAM for sika males in ranging sites with different population densities, by comparing with the existing approaches of spotlight and camera-trap surveys.

In particular, we verified:

- ✓ **feasibility**—determine how the density of males and the time of day influence the frequency of loud calls
- ✓ **efficiency**—identify the detection range of the loud calls using a sound recorder
- ✓ **sampling optimization**—clarify the minimum sampling efforts required to obtain proof of the presence/absence of males

Methods

Study area

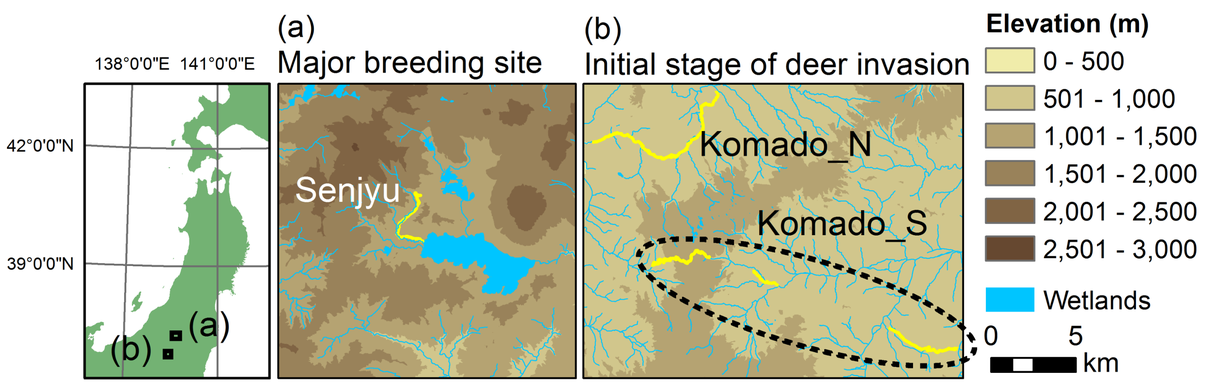


Fig. 1. Study area located in Japan. Yellow lines show the survey routes. The route lengths were 5 km, 13 km, 15 km in Senjyu, Komado_N, and Komado_S, respectively.

1. Spotlight and camera trap surveys

- ✓ Estimating the population density by repeatedly conducting spotlight counts of deer on each survey route, based on the distance sampling
- ✓ Measuring relative abundance index (RAI) by using camera traps (HC 500, Reconyx; or D444, Moultrie), set on the routes at 100-m intervals

2. PAM

- ✓ Making continuous recordings by using Song Meter SM2+ (Wildlife Acoustics, Inc.), placed at the survey routes at >1-km intervals, during 4 consecutive days in Oct. 2015 (Senjyu) and Oct. 2016 (Komado)
- ✓ Counting the howl frequency by reviewing the respective recordings using a sound spectrogram software, Song Scope 4.1.3A
- ✓ Estimating the minimum sampling effort required to determine the occurrence of males at respective sites, based on the lower limit of the bootstrapped 95% CI of the howl frequency

3. Detection range of PAM (= Evaluating the attenuation of howls)

- ✓ Playing the recorded howl at its theoretical SPL (96.4 db) with a loudspeaker and recapturing the playbacks from 10 to 150-m apart at 10-m intervals using Song Meter in defoliated beech forests
- ✓ Defining the detection range as the distance at which the sound patterns of howls could be automatically detected in audio files using the sound recognizer of Song Scope 4.1.3A

Results & Discussion

1. Spotlight and camera trap surveys

Table 1. Abundance of male sika deer by spotlight and camera-trap surveys

Sites	Spotlight survey: # observed on routes (ind./km)	Spotlight survey: Mean density (ind./km²)	Spotlight survey: 95%CI Lower	Spotlight survey: 95%CI Upper	Spotlight survey: *N*	Camera-trap survey: RAI (ind./CN)	Camera-trap survey: 95%CI Lower	Camera-trap survey: 95%CI Upper	Camera night (CN)
a) Senjyu	1.1	12.9	9.2	18.1	8	0.4	0.3	0.5	279
b) Komado_N	0.0	–	–	–	8	0.0	0.0	0.0	248
b) Komado_S	0.0	–	–	–	7	0.0	0.0	0.0	372

The existing methods could not be used to estimate the deer population in the initial stage of invasion!

2. PAM

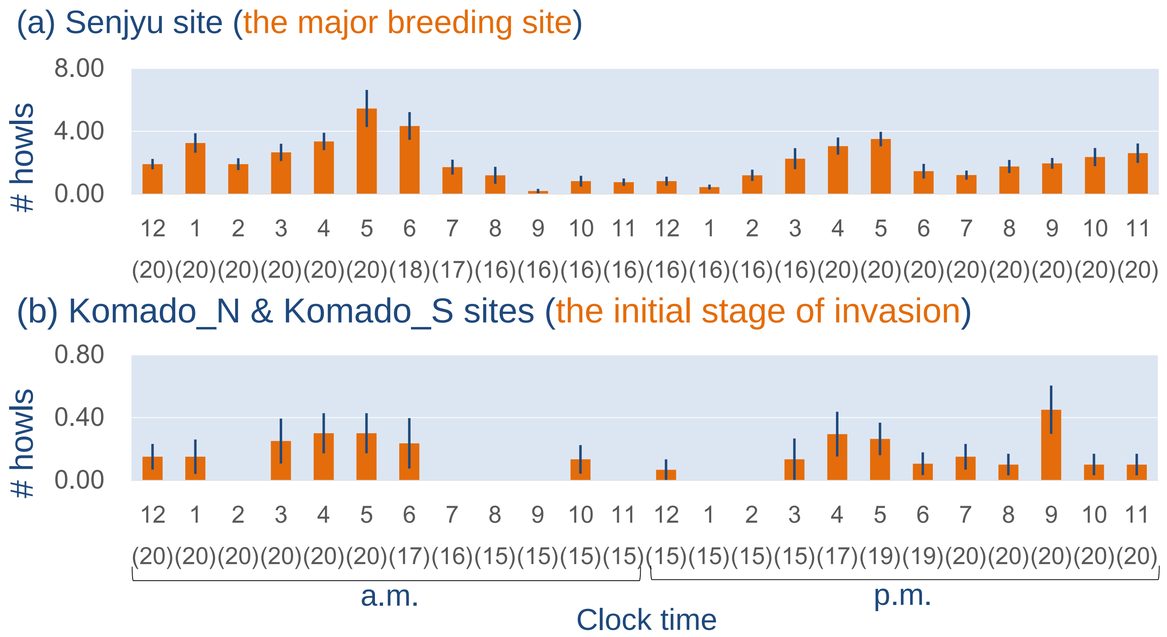


Fig. 2. Hourly variation in the frequency of howls emitted by male deer. Values in parentheses and blue bars represent *N* and *SE*, respectively.

PAM could detect the presence of males in every site!
The frequency showed bimodal peaks occurring at dawn and dusk.

Table 3. Mean frequency of howls per peak period during both dawn and dusk

Sites	#howls /period	95%CI Lower	95%CI Upper	*N*
a) Senjyu	20.7	**15.9**	25.5	20
b) Komado_N	0.8	**0.1**	1.4	8
b) Komado_S	2.0	**0.9**	3.1	11

The minimum sampling efforts are estimated at:
- *0.1 recorders × periods*
- *10.0 recorders × periods*
- *1.1 recorders × periods*

3. Detection range of PAM

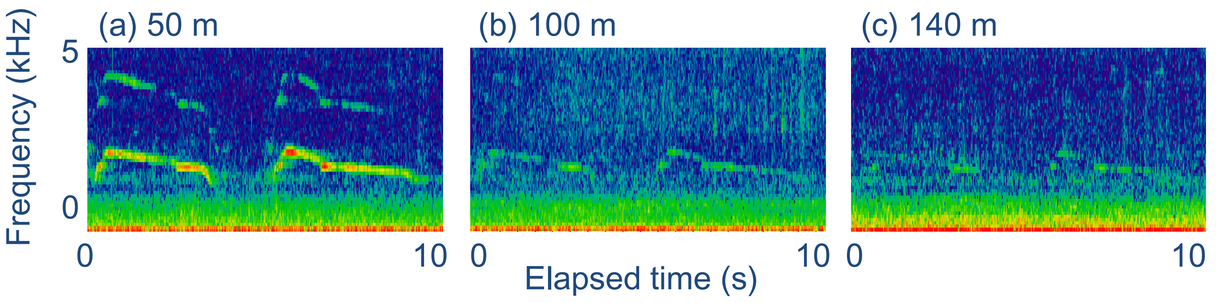


Fig. 3. Sound spectrograms of the playbacks of howls. The signal becomes stronger from green to red within the spectrograms.

*The sound recognizer showed that howls could be correctly detected up to a distance of **140 m** !*

Acknowledgements

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