

## An application of acoustic and visual information to monitor activities of sika deer

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After the extinction of sika deer (*Cervus nippon*) population in the wild in Taiwan, a restoration program has been in place in Kenting National Park since 1984. To evaluate the effectiveness of restoration program and to address the issue of deer impacts on the environment, the population status and activities of sika deer should be monitored. In addition to conventional methods, such as line transects and camera traps, soundscape monitoring represents an alternative tool for monitoring sika deer population during their breeding season. From November 7 to December 21, 2017, we deployed 9 sound recorders and 9 camera traps to acoustically and visually, respectively, investigate the behavior pattern of sika deer. In the acoustic part, we measured the difference between the mean spectrum and the median spectrum to detect high-intensity transient sounds. A clustering algorithm was employed to further identify rutting vocalizations of sika deer. In the visual part, we calculated a relative activity level, i.e. the number of independent photographs per survey effort, for male sika deer at each camera trap. In addition, we estimated the diel activity pattern of male deer by applying a kernel density estimation. The acoustical analysis shows that 9 acoustic clusters were identified from 3,124 hours of effective recordings. Among them, two clusters were highly associated with deer's rutting vocalizations. The occurrence of deer's rutting vocalizations varied among different recorder locations and recording months. The rutting vocalizations are crepuscular in a diel period at every recording location. In addition, we collected 506 independent photographs of male deer from 392 trap nights of all camera traps. Male deer's relative activity level varied among the traps. Their diel activity pattern was crepuscular. On the basis of camera traps and sound recorders, the dynamic pattern of space use and diel activity of sika deer can be effectively detected. Each of camera trap and sound recorder has pros and cons, such as detection range, efficiency of data process, data precision, restriction of season, cues for animal behavior...etc. Therefore, a combination of acoustic and visual information are potential to be employed to monitor the population status of wild sika deer in the future.

**Co-authors:** LEE SHANER, Pei-Jen (National Taiwan Normal University); Dr LIN, Tzu-Hao (Japan Agency for Marine-Earth Science and Technology)

**Presenter:** Dr YEN, Shih-Ching (National Tsing Hua University)

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