

# A Study of Vocalization and Social Behavior of the Acorn Woodpecker (*Melanerpes formicivorus*) Based on the Remote Sensor Network

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## Introduction

### Acorn Woodpecker (*Melanerpes formicivorus*)

- **Nonmigratory, group-living picid**
- **Common residents in the oak woodlands of California**
- **Acorn storage habit**  
 Acorns are stored in the holes drilled on the granary trees (Fig. 1)
- **Extreme sociality**  
 Each group contains 1-4 breeding males, 1-2 breeding females, and 0-10 nonbreeding helpers. Group members are engaged in social activities every day. (Fig. 2)



Fig 1 An Acorn Woodpecker

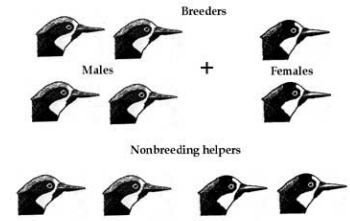


Fig 2 Mating system of the Acorn Woodpecker

## Problem Description: How are social behaviors of acorn woodpeckers organized by vocal signals?

### Study of vocalization and Social Behavior of the Acorn Woodpecker

- Social behaviors of the acorn woodpecker are mediated by communication
- Sociality drives the evolution of communicative complexity
- A complex vocal communication system is expected in the acorn woodpecker due to its high level of sociality
- Vocal signals in the acorn woodpecker are thought to transmit more information indicating the social events and social relationship between the signaller and the receiver
- This study will help us to understand the vocalization system of the acorn woodpecker and how the social behavior is organized through vocalization

## Proposed Solution: Monitoring vocal activities by the sensor network

### Vocal individual recognition by the sensor network

- **Call Features and Call Variation Analysis:** dominant frequency, call duration, frequency bandwidth
- **Sound-spectrographic Cross-correlation(SSCC) Analysis:**
  - A Matlab program has been developed to calculate the SSCC value between two calls of acorn woodpeckers.(Fig. 3) A preliminary study demonstrates that SSCC has the potential to recognize the woodpeckers individually if the variations between individuals exist
- **Hidden Markov Model (HMM):**
  - More efficient than SSCC method
  - A program has been developed to build the HMMs for frog calls with a superb recognition rate
  - The program will be modified to recognize the acorn woodpecker individually

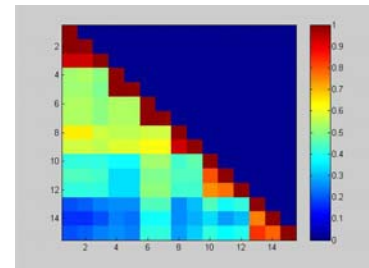


Fig 3. Similarities between calls of acorn woodpeckers. 1-3. waka calls; 4-5. garrick calls; 6-7, 8-9, 10-12. three groups of different karrit-cut calls; 13-15. trrrr calls. Similarity values are indicated by different colors.

### Application of the Remote Distributed Sensor Network on Monitoring and Localization of the Acorn Woodpecker

- **Advantages of the sensor network in the acorn woodpecker study:**
  - monitor more than one signaller simultaneously
  - localize the object out of sight
  - a passive study method: avoid the disturbance on focal animals
  - allow a long-time continuous monitoring
- **How the sensor system works (Fig. 4):**
  - Sensors are distributed in the territories of acorn woodpecker family (Fig. 5)
  - Acoustic sensors collect the vocal signals emitted by the signaller
  - Vocal signals are sent back to the base station, where the vocal signals are analyzed to illustrate the individual identity and the location of the signaller
  - Environmental sensors collect the environmental parameters
  - Visual sensors record the visual displays accompanied with the vocal signals

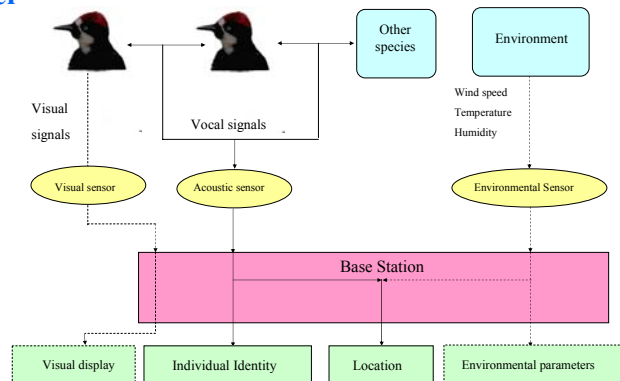


Fig. 4 Structure of the sensor network

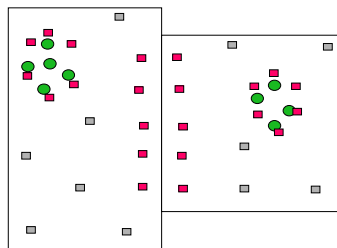


Fig 5 Placement of the sensors. Big squares: two territories. Green round dots: Granary trees. Red square dots: sensors in the "hot spot" of the study. Grey square dots: sensors evenly distributed in the habitat.

- **Biological studies of the acorn woodpecker based on the sensor network:**
  - Variability in the Vocalization of the Acorn Woodpecker
  - Contexts and Patterns of Vocal Communication in the Acorn Woodpecker
  - Individual Recognition through Vocal signals in the Acorn Woodpecker
  - Territorial Defense through Vocal Communication by the Acorn Woodpecker
  - Many other studies related with the ecological, behavioral, evolutionary characteristics of the Acorn Woodpecker