Title

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

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Publication Date

2003

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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

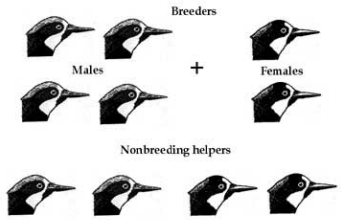

Fig 2 Mating system of the Acorn Woodpecker

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

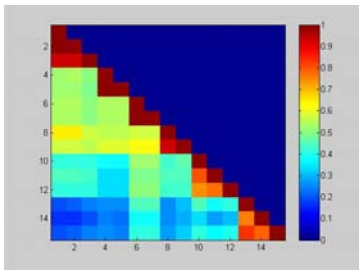

Fig 3. Similarities between calls of acorn woodpeckers. 1-3. *waka* calls; 4-5. *garrick* calls; 6-7, 8-9, 10-12. three groups of different *karrit-cut* calls; 13-15. *trtrtr* calls. Similarity values are indicated by different colors.

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 signeller
- 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 signeller
- Environmental sensors collect the environmental parameters
- Visual sensors record the visual displays accompanied with the vocal signals

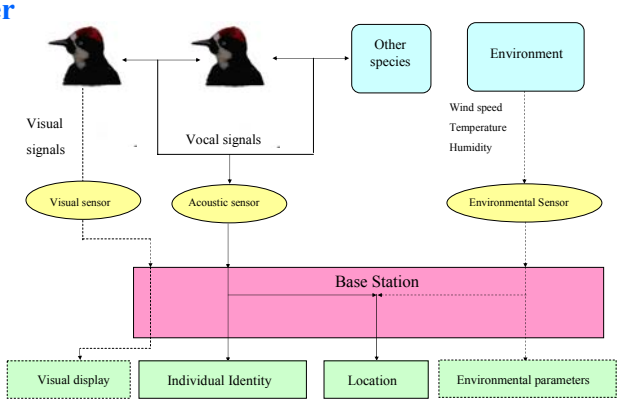

Fig. 4 Structure of the sensor network

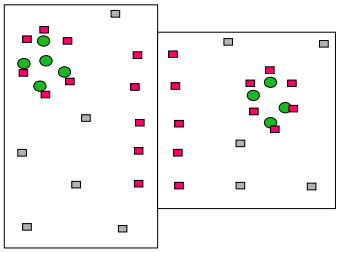

Fig 5 Placement of the sensors. Big squares: two territories. Green round dots: Granary trees. Red square dots: sensors in the "hot spot" of the study. Grey square dots: sensors evenly distributed in the habitat.

- **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