

In the name of God

Course Title:  
**Bio-Inspired  
Robotics**

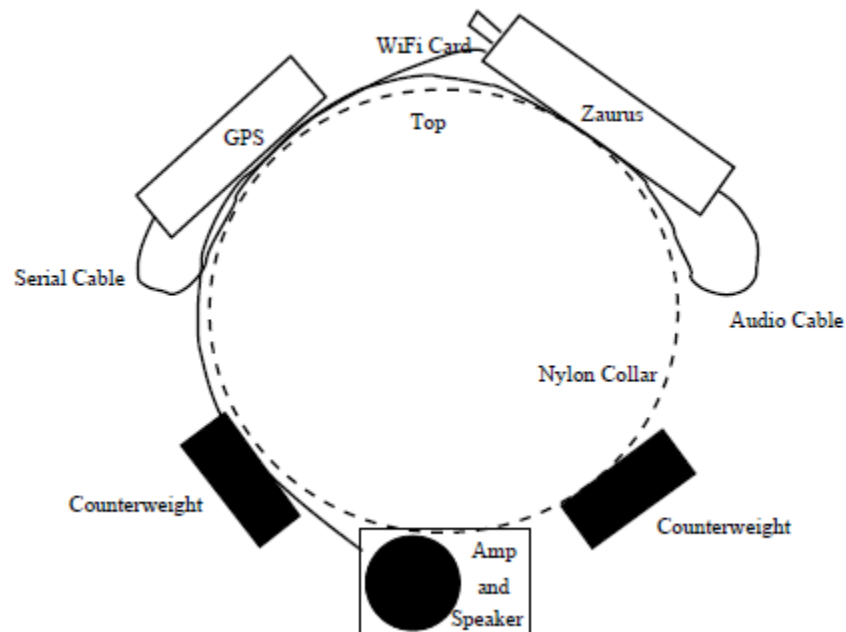
Mohammad Iqbal

(Thanks to Masoud Asadpour)

Lecture: **Control of Collective Behavior**

# Smart Collars and Virtual Fences

- Centralized Control of collective behavior



# Distributed Control with Informed Agents

- In many collective behaviors, **only a few** individuals among a group that, e.g. forage or travel, have pertinent information, such as knowledge about the location of a food source, or of a migration route.
- Couzin et al (Nature 433, 2005) showed that the **larger the group, the smaller the proportion** of informed individuals needed to guide the group, and that only a very small proportion of informed individuals is required to achieve great accuracy.
- Potential applications in human society: Education, Dialog between cultures, Government, Stock market, Fashions.





# LEURRE Project: Realization of Collective Behavior Control

- Cockroaches tend to aggregate in **dark** places.
- Can we **change** their behavior and force them in some way to select bright places?
- Solution: Use some robot which seem like cockroaches (**in their eyes!**)

# Experimental protocol

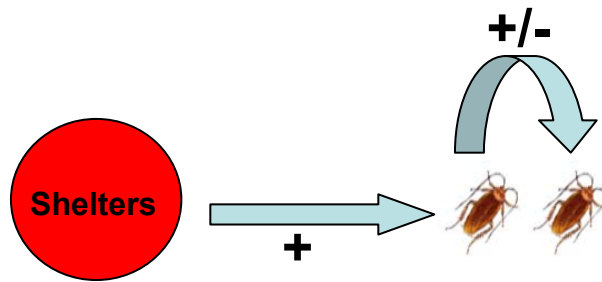


Camera: Panasonic WV-BP330

Polyethylene ring (diameter: 100cm, height: 20cm, thickness: 1cm)

Plexiglas shelters covered by red filters

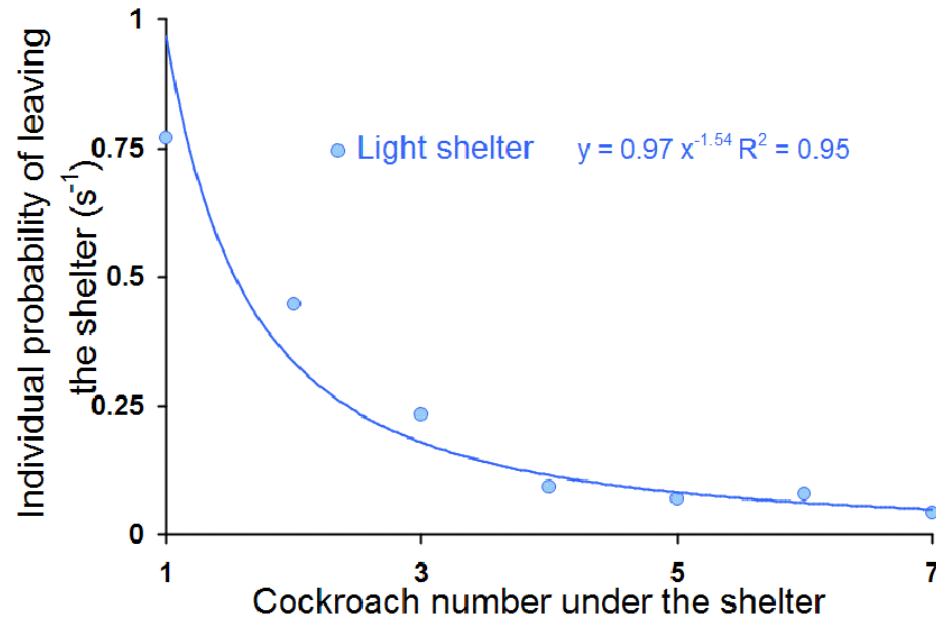
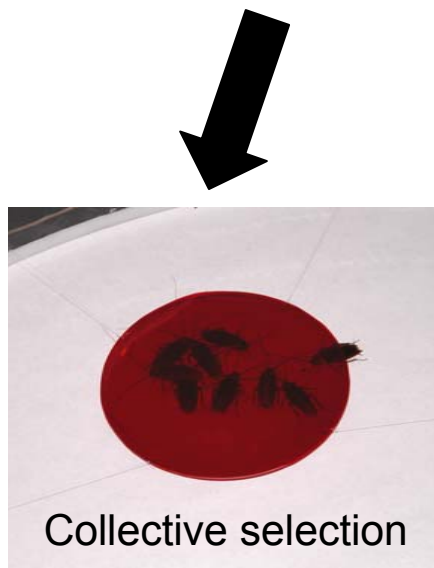
# Modulation of cockroach's behaviour



	Probability of leaving	
	Light shelter	Dark shelter
Cockroach	0.030	0.006

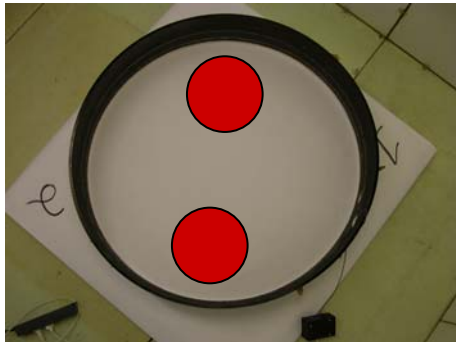
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Influence of shelter **darkness** on P of leaving



Central role of the **number of neighbors** on cockroach behavior:  
P of leaving shelter decreases with increasing number of neighbors.

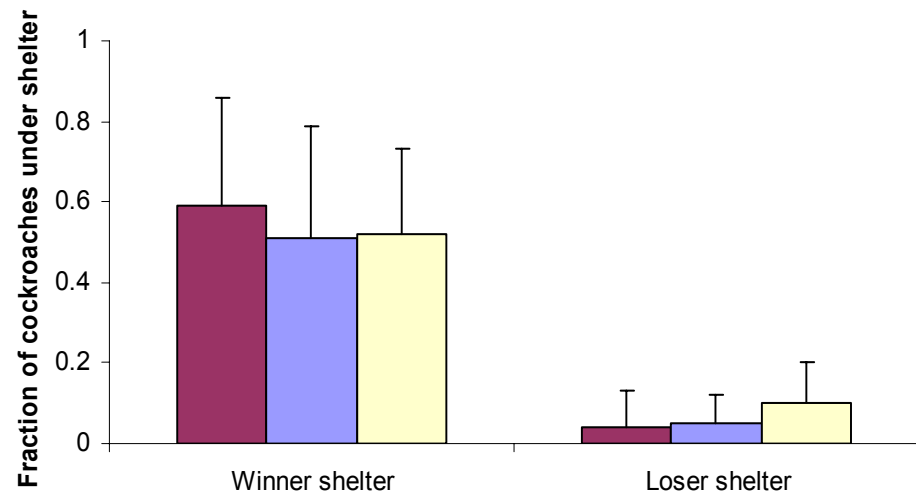
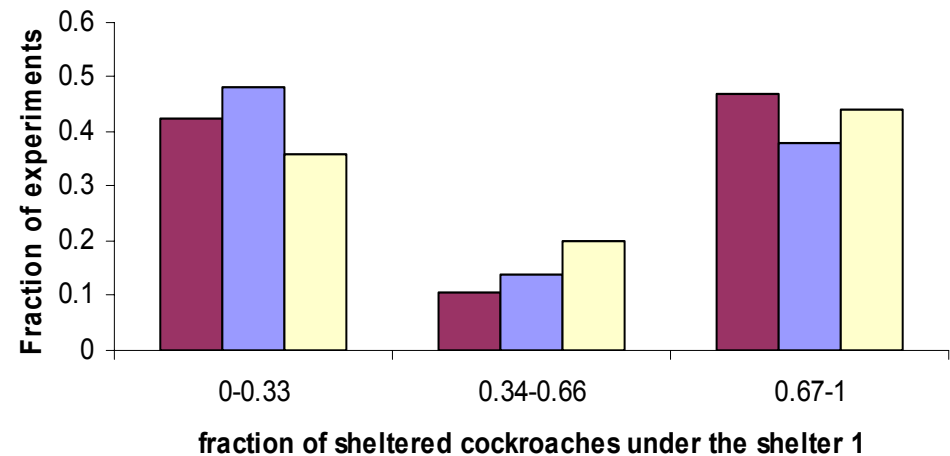
# Selection between 2 identical shelters



- 10 cockroaches/light shelters
- 10 cockroaches/dark shelters
- 30 cockroaches/dark shelters

→ Symmetry

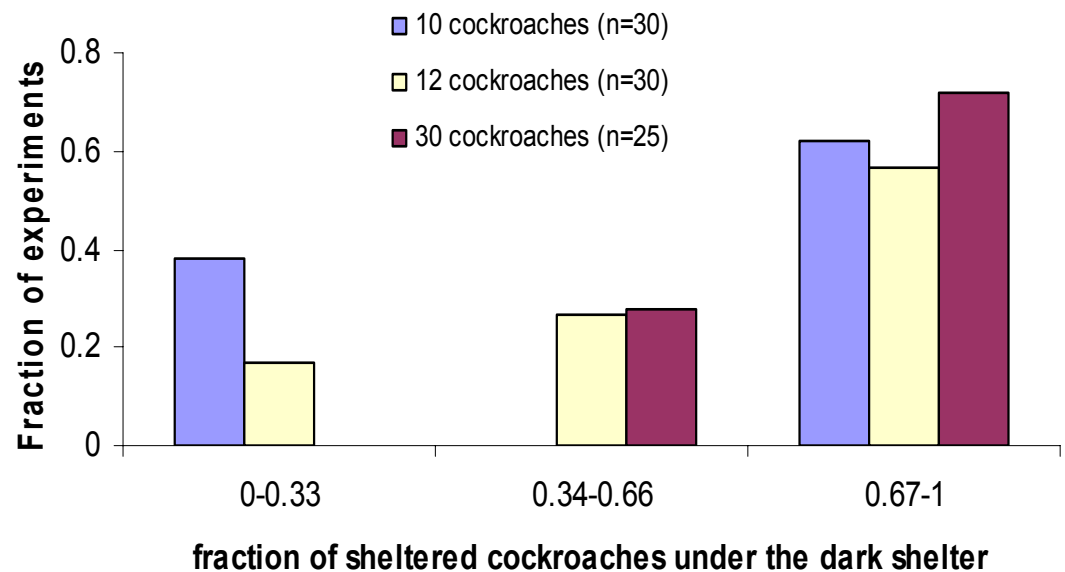
→ Collective selection of only ONE resting site





# Collective selection between 2 different shelters

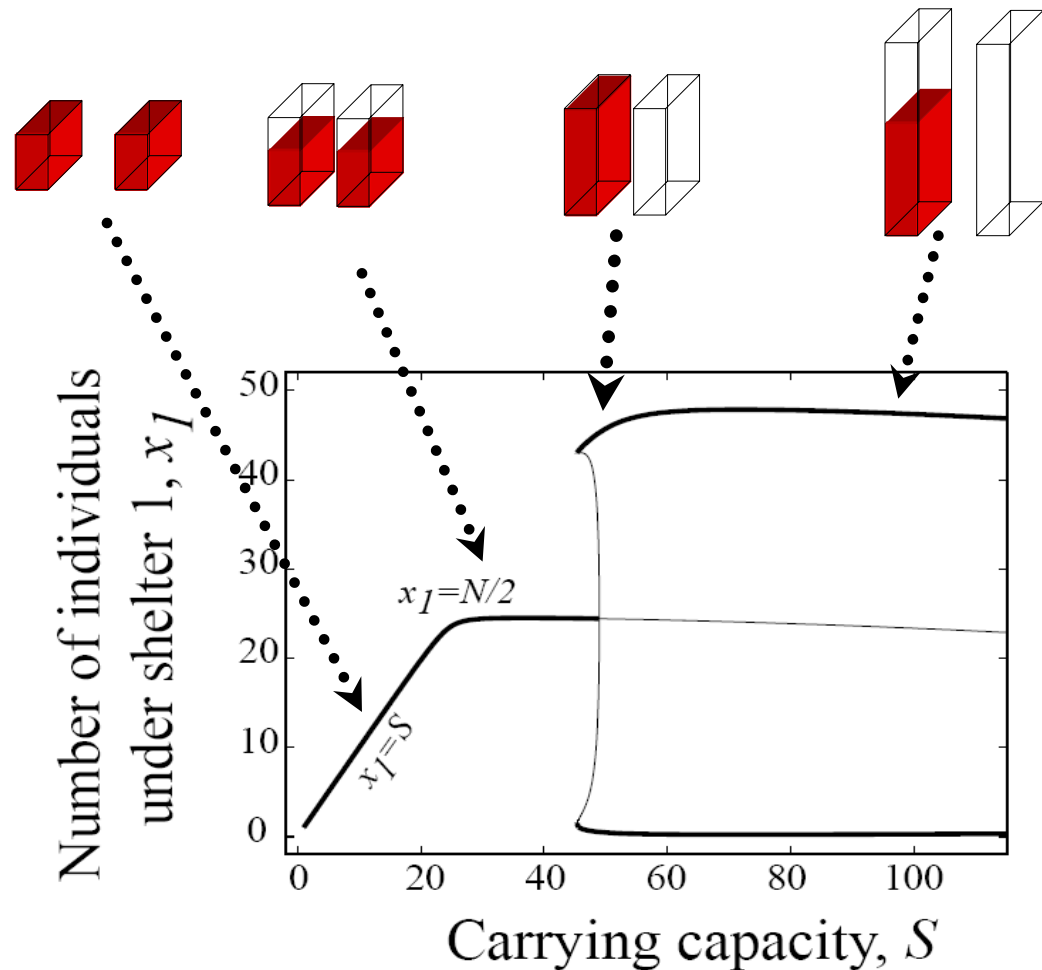
- Collective selection of the darkest shelter
- Discrimination increases with group size



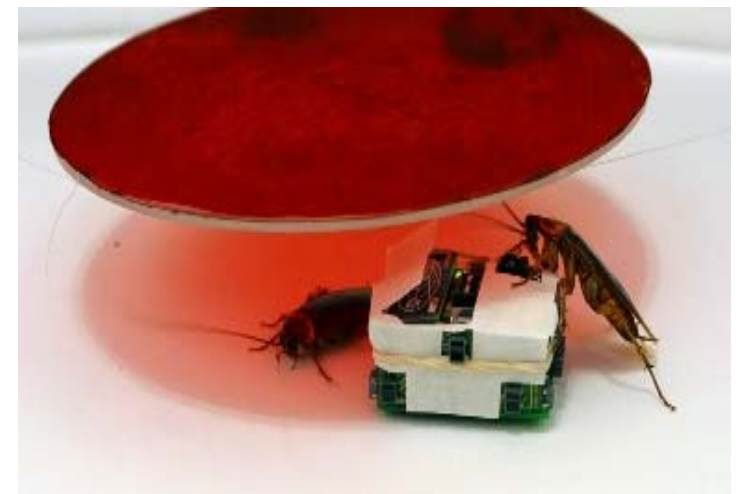
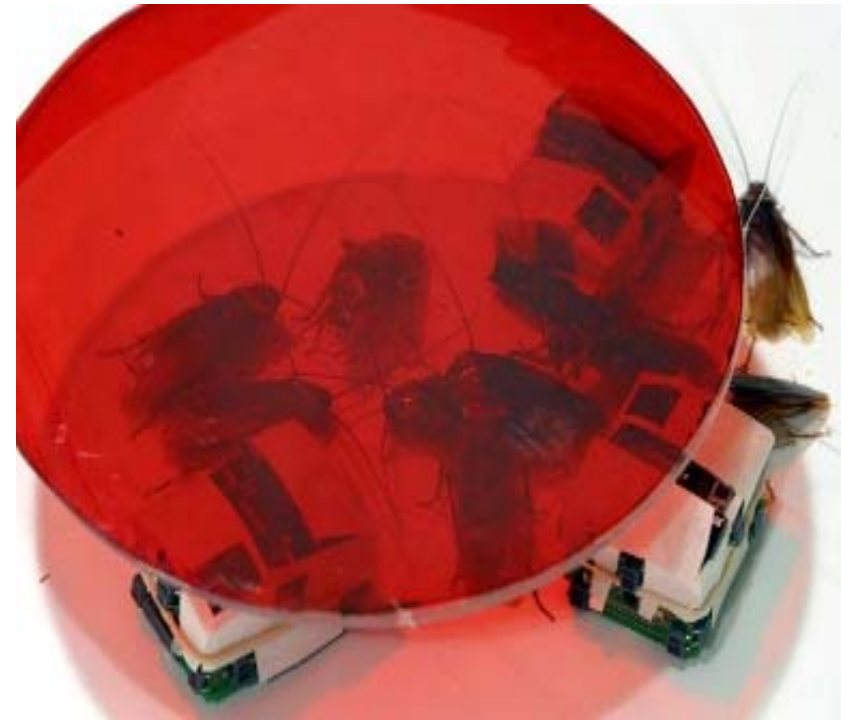
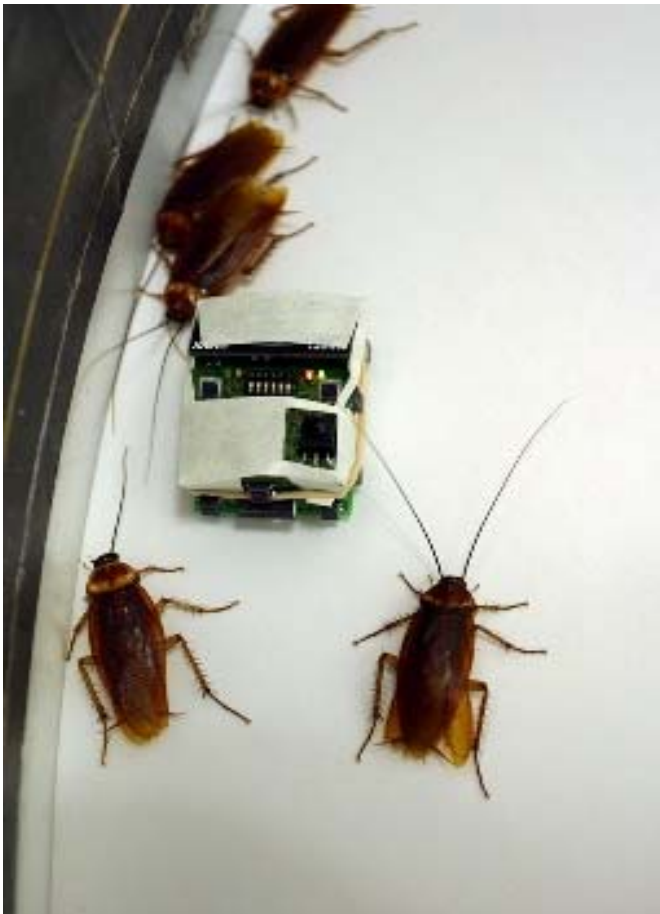


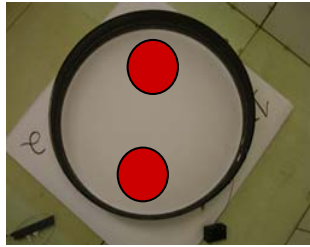
# Collective decision making in cockroach group

- bifurcations leading to multiple steady states



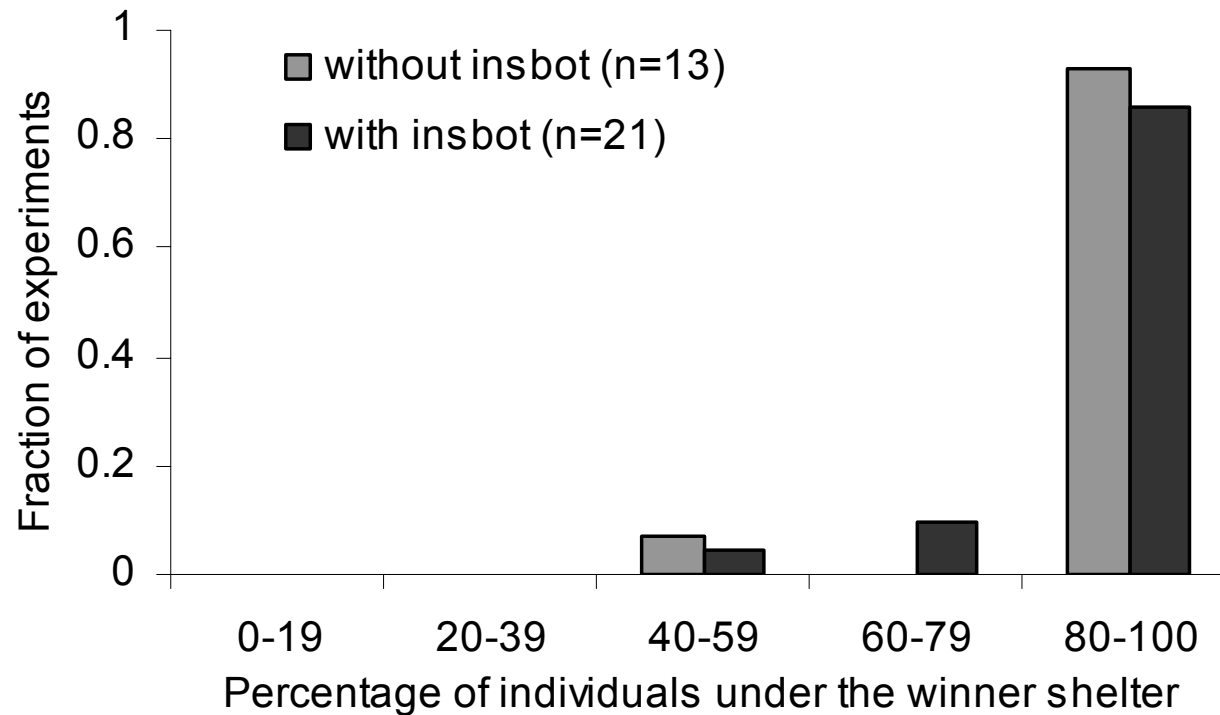
# Mixed Society



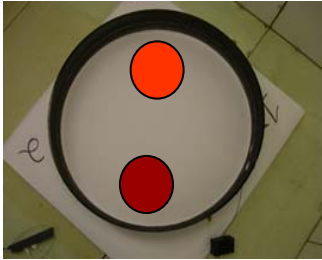


# Collective choice in mixed-society

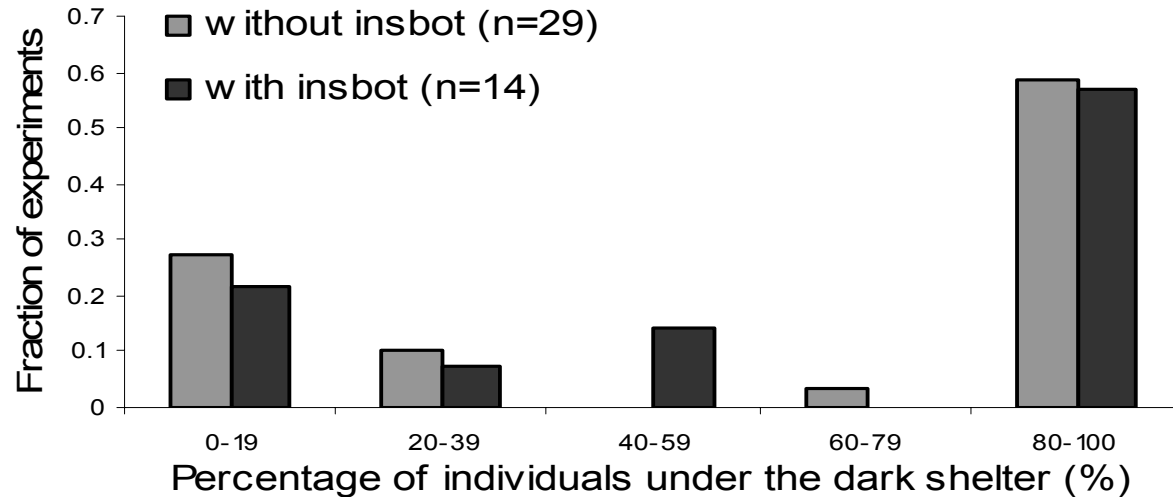
## Homogeneous shelters



Mixed groups are as **selective** as pure cockroaches groups



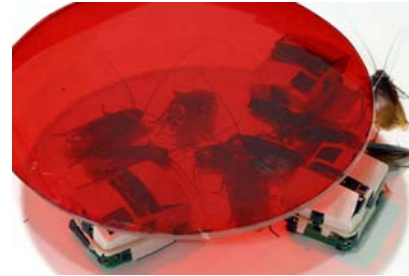
# Collective choice in mixed-society Heterogeneous shelters



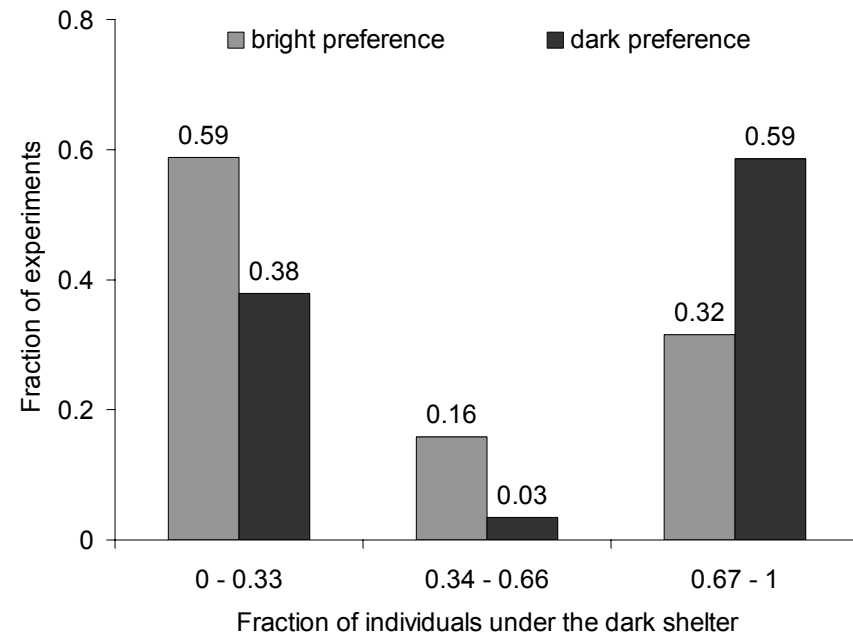
**The proportion of experiments choosing either the dark or the light shelter is **same** in pure cockroaches and mixed societies**

# Change in collective choice

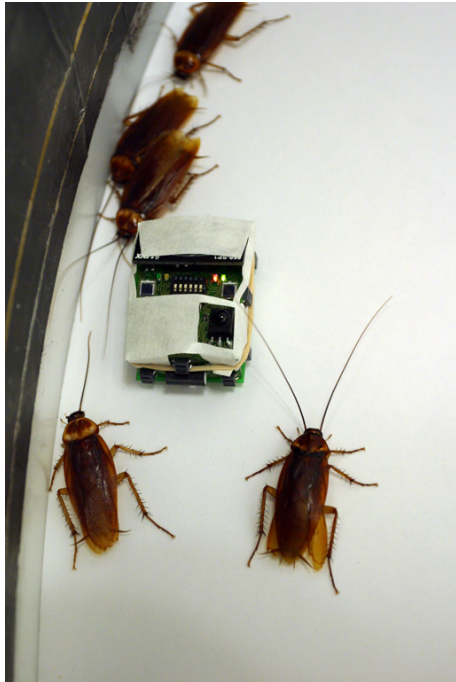
- Preference of the robots for dark and light shelters is **swapped**. So they prefer the light shelter instead of the dark one
- The robots are able to **induce a change** in the global pattern by reversing the collective shelter preference.



Insects prefer dark  
Robots prefer light

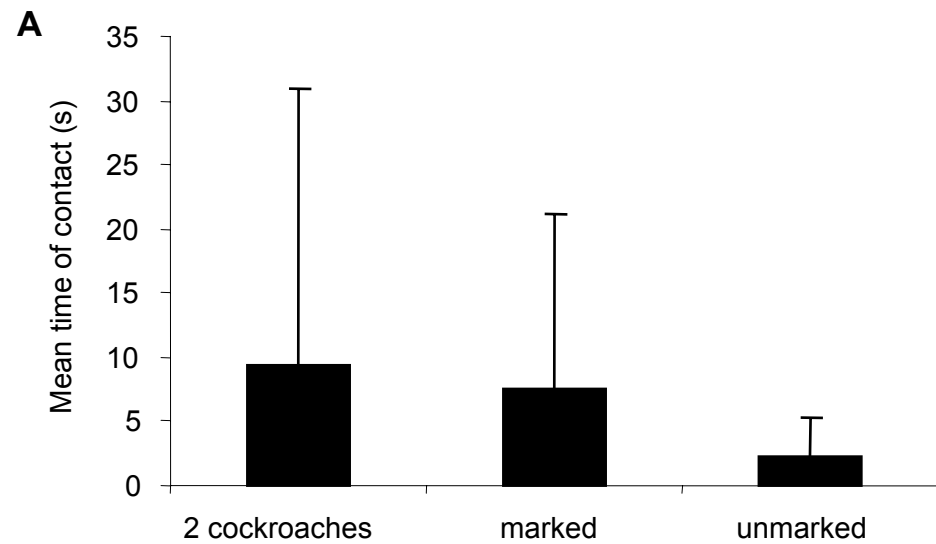


# Importance of chemical marking



10 x 

1 x  Marked or unmarked





# Summary

- Cockroaches perform group choice that is a form of self-organized collective decision. It emerges from the local interactions between individuals.
- Both machines and insects are capable, independently of each other, to perform such collective decision.
- The robots are accepted by the cockroaches groups and actively take part in the collective choice.
- Most of the time, they gather with the cockroaches under the same shelter.
- When the robots are programmed to have an opposite preference compared to insects, they are able to induce a change in the global pattern by reversing the collective shelter preference.
- The mixed group of robots and insects gather in the less preferred shelter by the insects.
- These experimental results demonstrate the existence of shared and controlled collective choice between machines and animals.