

Tracking swimming *Lefua echigonia* to assess the impact of crayfish introduction

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Data needed for monitoring and assessment



- More evidence (data) are needed for better decision support for sustainable development.
- Advanced (smart) sensing and measurement methods are key technologies for deeper understanding of target systems.

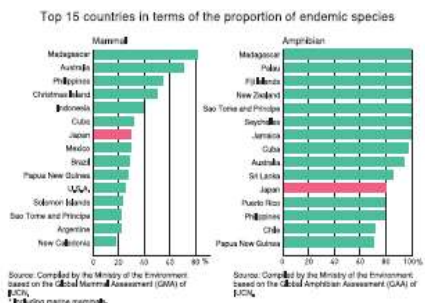
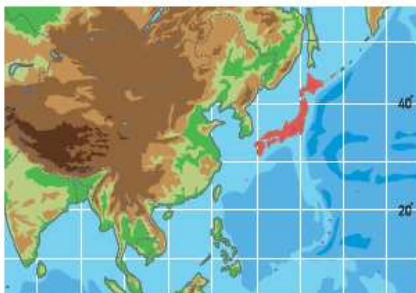
Biodiversity is the basis of ecosystem services

– Japan – Islands where people live side by side in harmony with nature

Consisting of several thousand islands that vary greatly in size, Japan is a long archipelago stretching for approximately 3,000 km from north to south located in the mid latitudes (20–45 degrees) of the northern hemisphere. It extends from the subtropics to the sub-frigid zones, so a wide range of ecosystems have evolved. With forests accounting for about two thirds of the area of the country, it has a complex topography from sea coasts to mountain ranges with considerable differences in elevation and the four seasons are clearly defined due to the effects of the monsoon climate. All of these factors combined have created diverse habitats and environments for the growth of plants and animals. At present, more than 90,000 species have been confirmed as existing in Japan and if those yet to be confirmed are included, it is estimated that Japan is home to over 300,000 species.

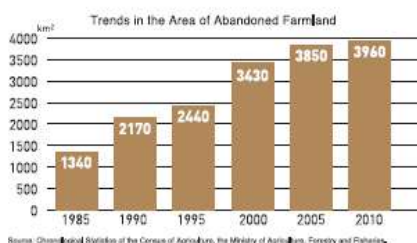
Compared to other developed countries, Japan has an extremely high proportion of endemic species; around 40% of its terrestrial mammals (30% if marine mammals are included) and about 80% of its amphibians are found nowhere else. The fact that Japan is the only developed country where wild monkeys still live is further evidence that it still has a rich natural environment. In addition, extensive areas where unique habitats have been created by humans, such as Satochi-Satoyama areas (rural landscapes formed by sustainable use of natural resources) and agricultural land, have also contributed to the country's rich biodiversity.

Japan also has especially strong biological ties with Asia. As a result of the Japanese islands having been repeatedly connected to the Asian continent by land and then separated from it by sea areas, there are rare species that have survived or evolved in unique ways in Japan after migrating from the continent during one of the glacial periods when land bridges formed between them. Furthermore, migratory birds that mainly travel across the borders of Asian countries use Japan as a breeding or wintering ground.



Reduced intervention in nature
 The negative impact on biodiversity of reduced human intervention in nature has become a problem in Japan. Due to changes in resource use such as the decline in the use of wood as a fuel and the decreasing and aging population of people managing forests and farmlands, the Satochi-Satoyama agricultural complex is no longer being maintained as it once was. Consequently, species that live specifically in this secondary natural environment that has been maintained by human intervention are now in danger of extinction. In contrast, the populations of wild deer and boar have been expanding rapidly and are having an adverse effect on ecosystems and are causing severe damage to the agriculture and forestry industries.

Efforts to reintroduce the crested ibis to the wild
 Although the wild-born crested ibis (*Nipponia nippon*) became extinct in Japan in 1981, ibises of the same species were presented to Japan for breeding by the Chinese government in 1995. With the gradual increase in the population, the birds started to be released on Sado Island, Niigata Prefecture, in 2008. In 2012, the released ibises successfully hatched eggs in the wild and it was confirmed that a chick had left its nest, becoming the first one born in the wild to do so in 38 years. The crested ibis is a bird that lives in the Satochi-Satoyama habitat, which consists mainly of paddy fields. The project, which was aimed at the reintroduction of the crested ibis into the wild in Japan, was carried out in collaboration with the local residents and has become a symbol of the development of a region existing in harmony with nature.

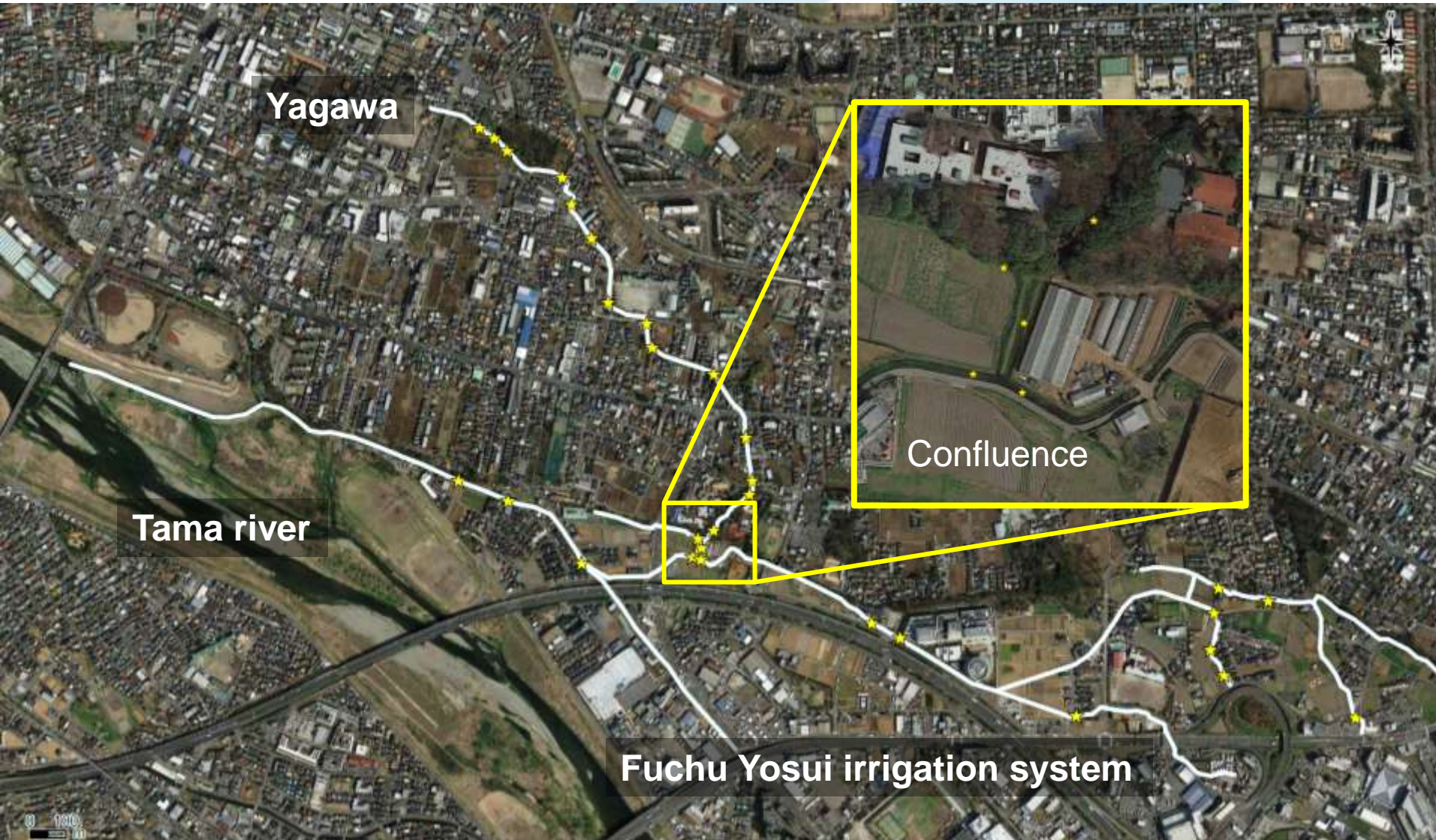


The Ogasawara Islands were registered as a World Natural Heritage site in recognition of the fight against the introduction of alien species
 The impact on biodiversity of the increasing spread of invasive alien species has also been identified as a serious problem in Japan. The Ogasawara Islands, which were registered as a World Natural Heritage site in 2011, are a group of oceanic islands that have never been connected to any other land area and are thus habitats to a great number of endemic species that have evolved in unique ways. However, non-native species such as green anoles (*Anolis carolinensis*) have had a significantly detrimental impact on the biodiversity of these islands. The designation of the islands as a World Natural Heritage site was partly due to the efforts of a range of actors such as local residents working together to maintain and manage the natural environment through the control of these alien species and these and other measures have been bearing fruit and are evaluated highly.



Studying natural & regulated flows

Yagawa: spring-fed stream (permanent flow; Temp $\approx 18\text{--}20\text{ }^{\circ}\text{C}$)



Fuchu Yosui: irrigation channel (irrigation in May-Sep; Temp $\approx 5\text{--}30\text{ }^{\circ}\text{C}$)

Physical habitat & fish fauna (monthly since 2014)



Native and non-native (incl. trans-located) species



Are non-native species all bad?

Native, endangered *Lefua echigonia*



Non-native, invasive *Procambarus clarkii*



- ✓ Red swamp crayfish (*P. clarkii*) is popular as an invasive species in Japan
- ✓ Crayfish occurs in nearly entire Yagawa stream
- ✓ *Lefua* habitats seems to be similar to crayfish but they rarely co-occur.

- ✓ Do these species use a similar space?
- ✓ Does *crayfish* introduction affect the swimming behaviors of *Lefua*?

Laboratory experiment



Equipment

Glass cylinder:

- Diameter: 25 cm
- Water depth: 5 cm
- Substrate: small gravel (D: 1–3 mm)
- Opaque screen to cover outside

Camera

- QBiC MS-1 (ELMO Co. Ltd.)
- Video format: 1080p/30fps



Experimental condition

Water temperature: 14.7–16.1 °C

Time: 30 min (5 min acclimatization)

Block (10 cm × 10 cm × 6 cm) (2 cases)

-Presence/Absence

Number of individuals (6 cases)



Species	Length (mm)	Weight (g)	Number of individuals					
Crayfish	34.0–55.0 (41.2 ± 5.9)	0.9–3.5 (1.6 ± 0.7)	0	1	2	3	4	5
Lefua	42.0–57.0 (52.3 ± 4.9)	0.6–1.6 (1.1 ± 0.3)	5	4	3	2	1	0

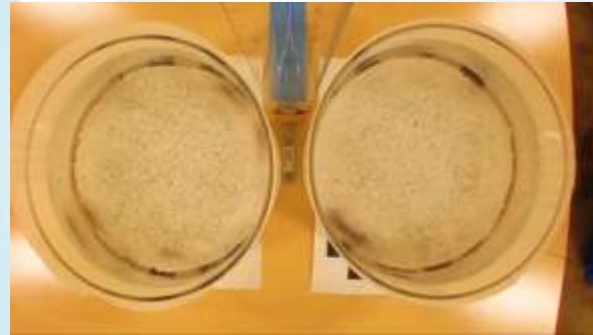
Image analysis

❖ MoveTr/2D (Library Co. Ltd., Japan)

- Background substitution
- Calibration (pixel-length relationship)
- Tracking



Original image



Background extraction



Background substitution

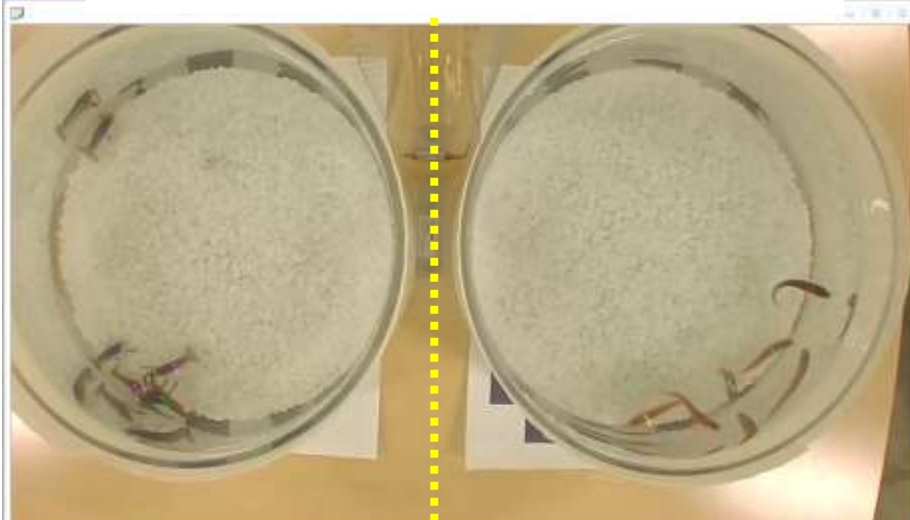
❖ Data analysis

- Movement distance (cm)
- Movement speed (cm/s)
- Movement acceleration (cm/s²)

Movement tracks (8 cases)

C-5 // L-0

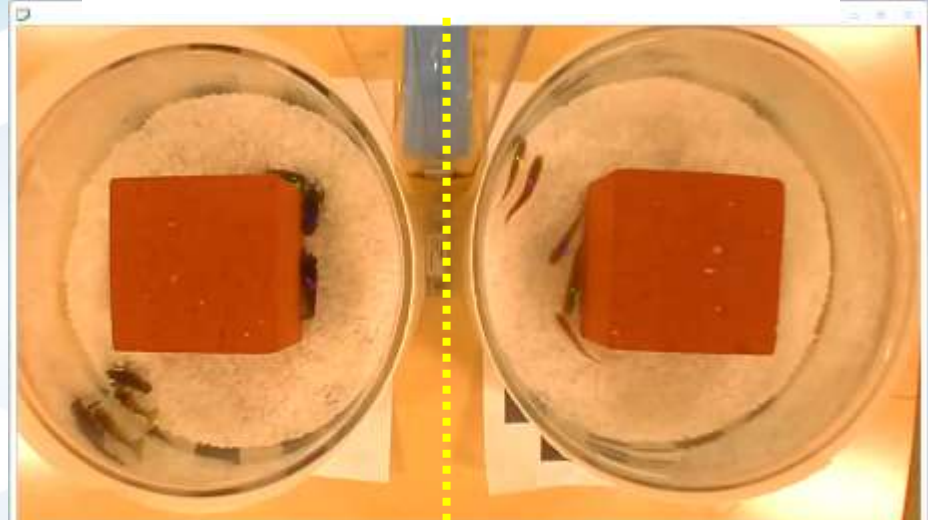
C-0 // L-5



Without block

C-5 // L-0

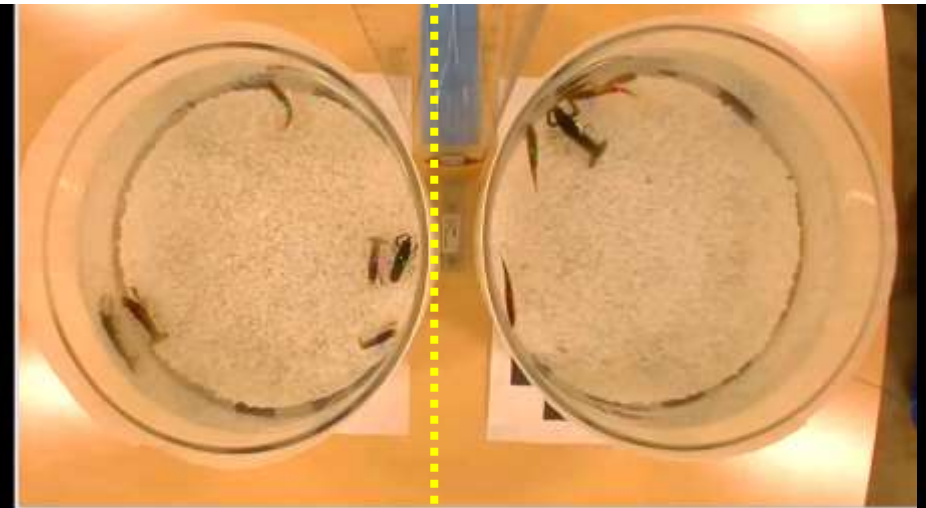
C-0 // L-5



With block

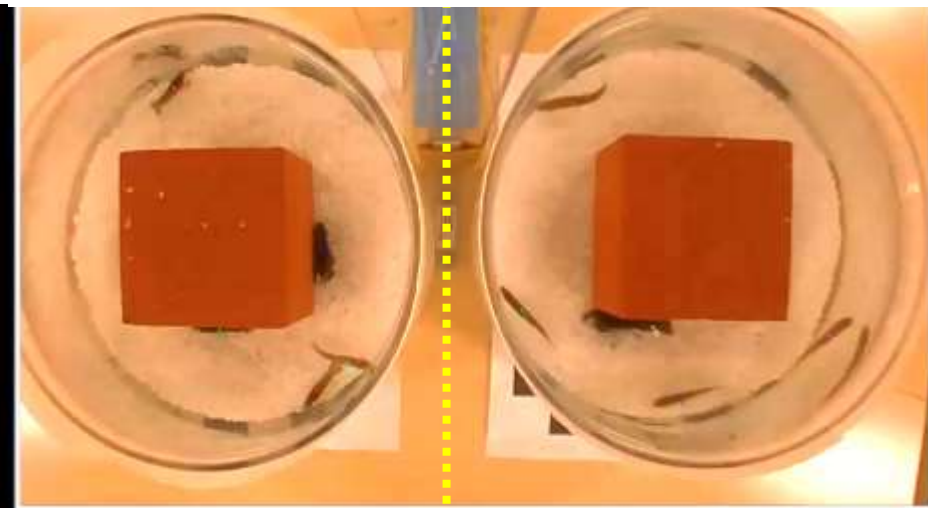
C-4 // L-1

C-1 // L-4



C-4 // L-1

C-1 // L-4



Movement distance (cm)

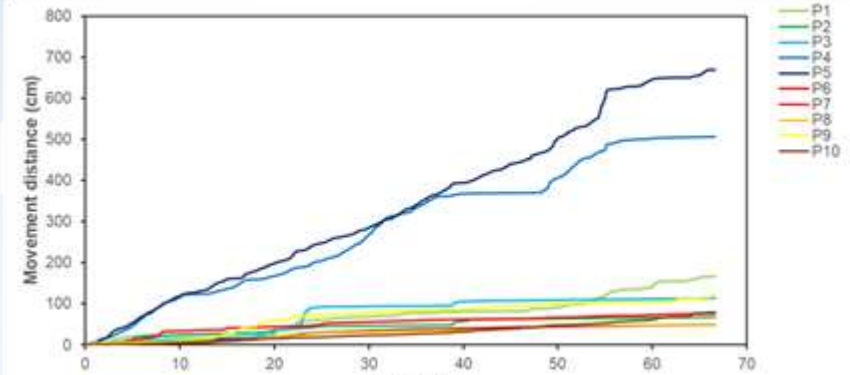
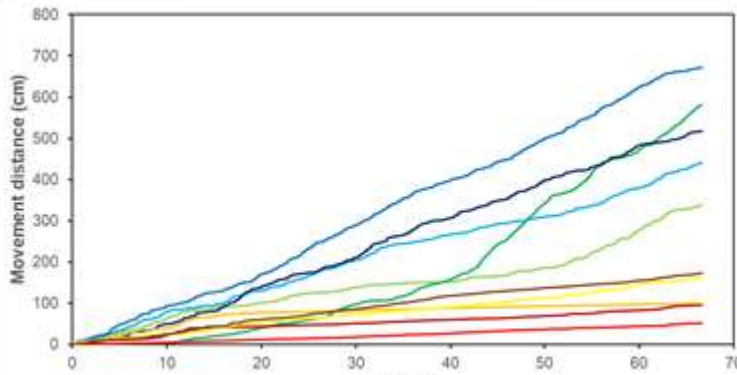
Warm color: Crayfish
Cold color: *Lefua*

Conditions

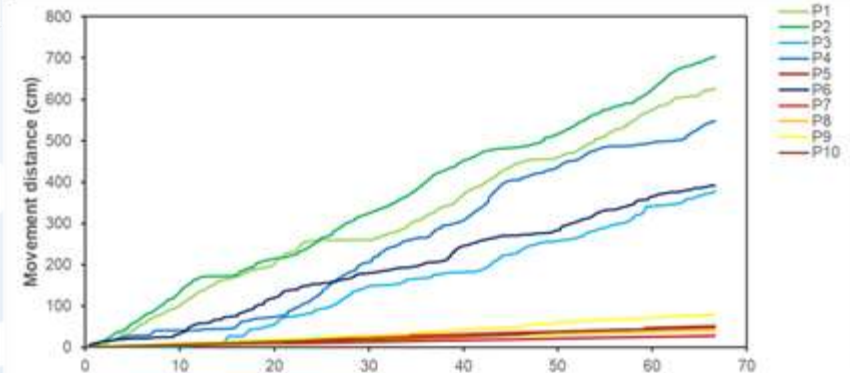
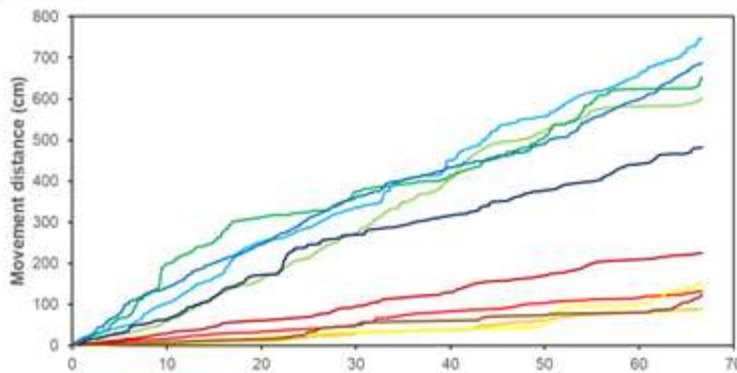
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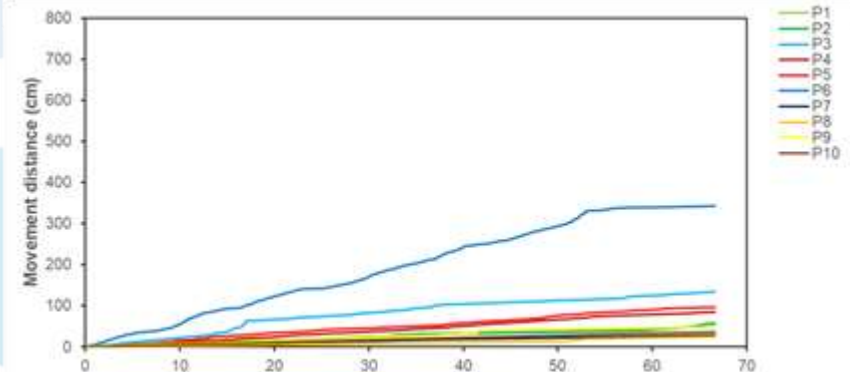
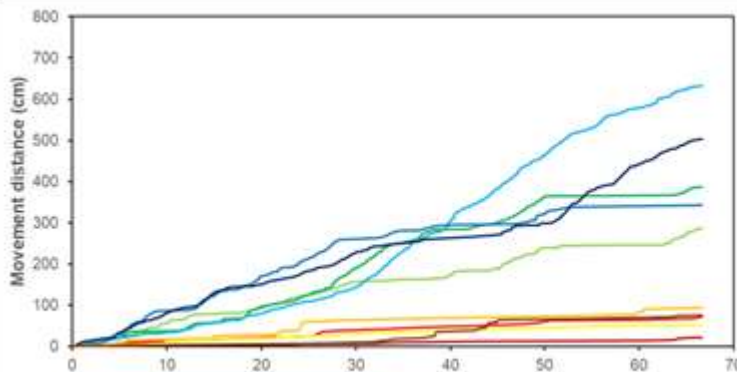
L0-C5
L5-C0



L1-C4
L4-C1



L2-C3
L3-C2



Time (s)

Time (s)

Movement speed (cm/s)

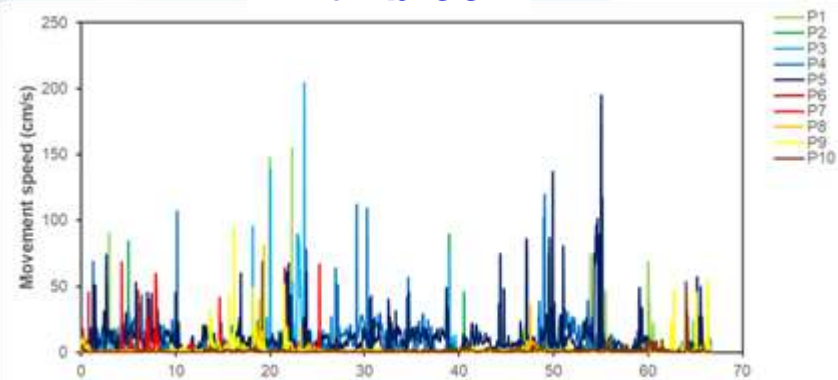
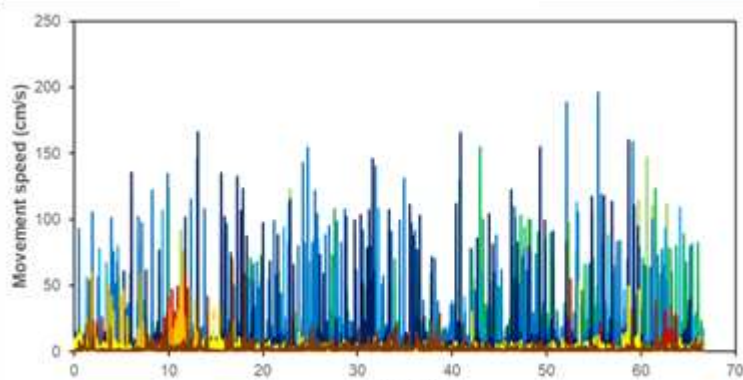
Warm color: Crayfish
Cold color: *Lefua*

Conditions

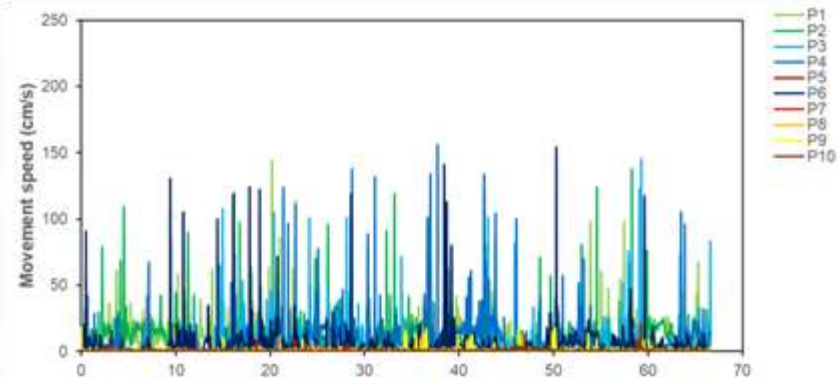
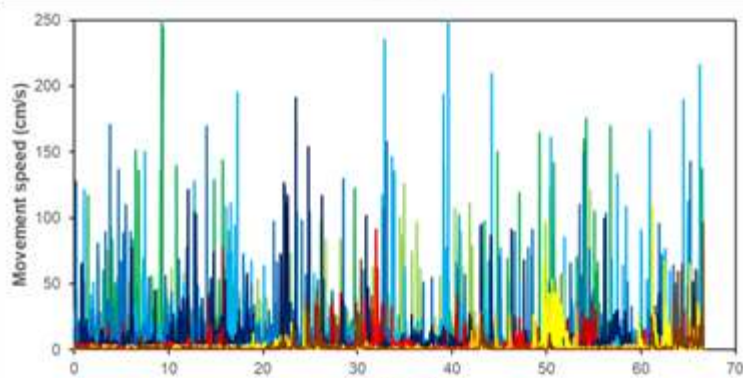
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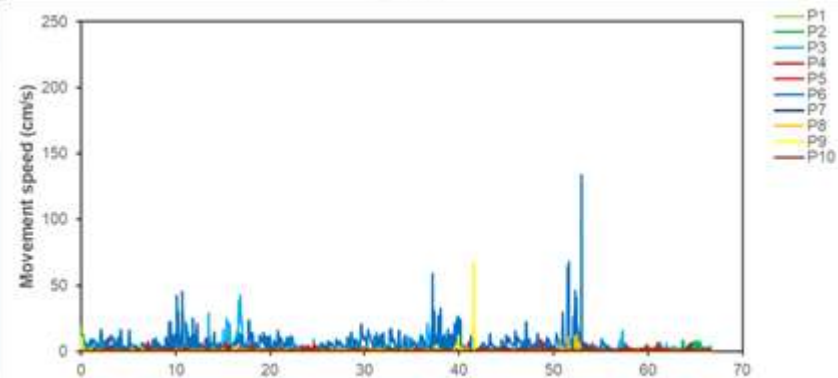
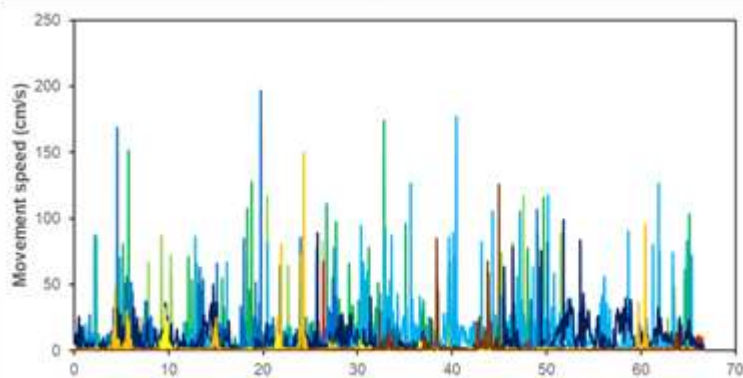
L0-C5
L5-C0



L1-C4
L4-C1



L2-C3
L3-C2



Time (s)

Time (s)

Movement acceleration (cm/s^2)

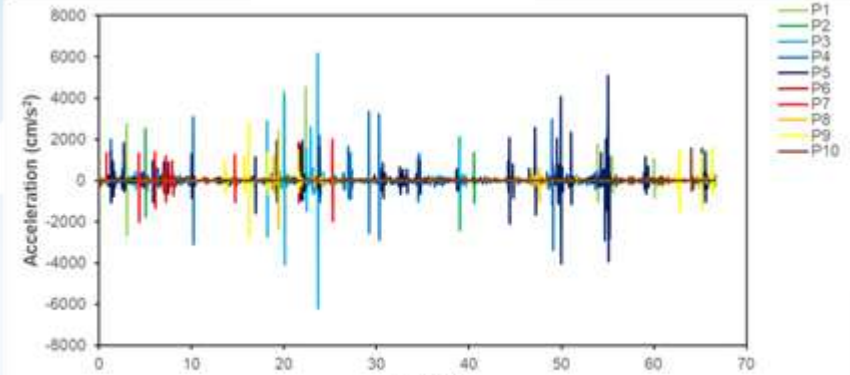
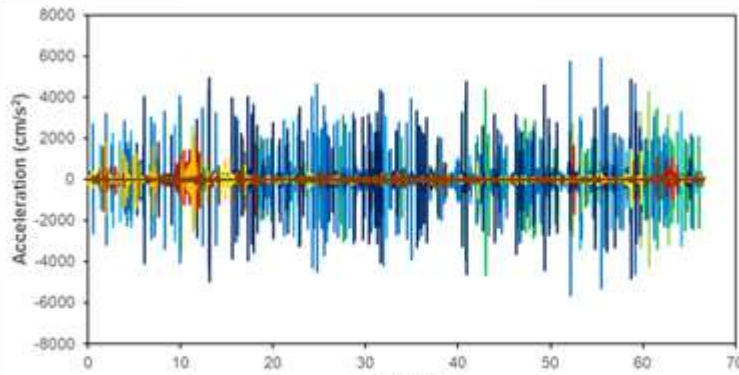
Warm color: Crayfish
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Conditions

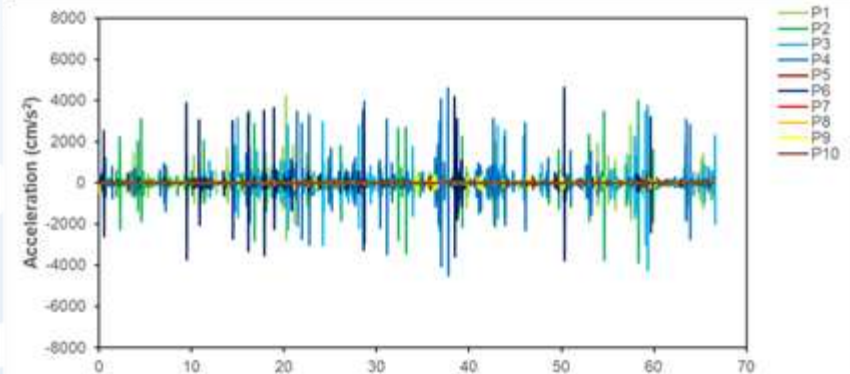
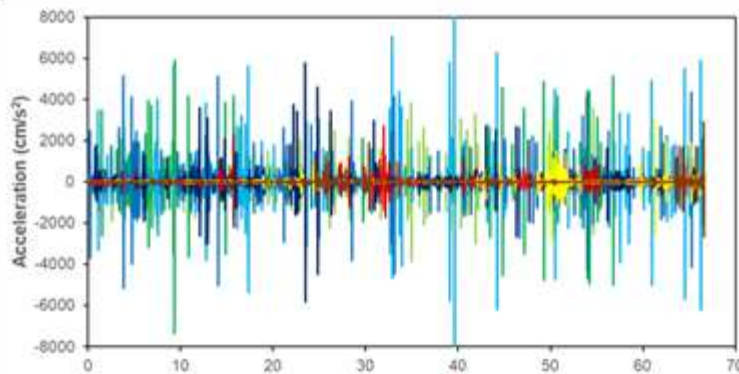
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With block

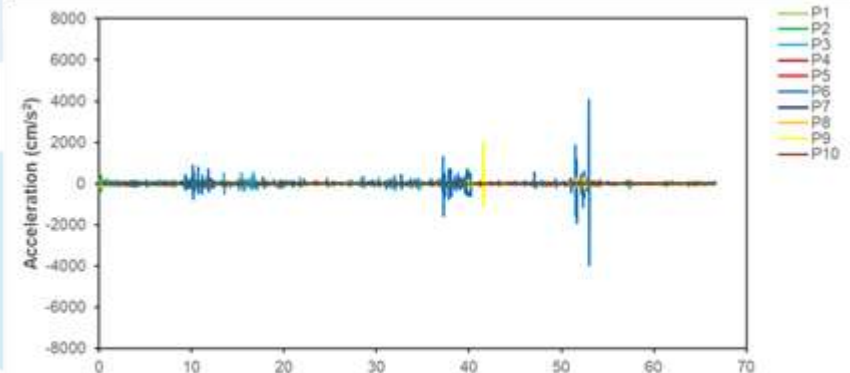
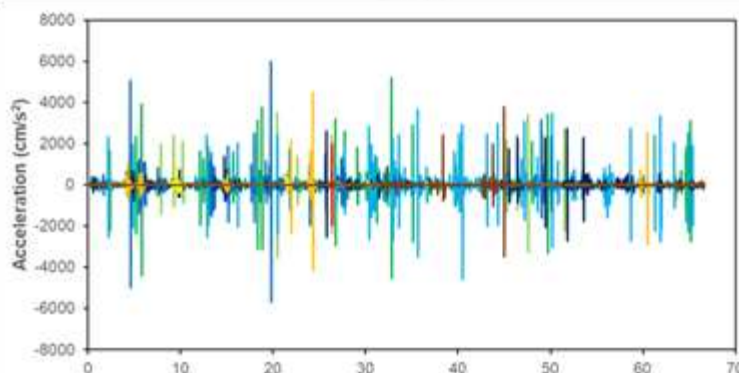
L0-C5
L5-C0



L1-C4
L4-C1



L2-C3
L3-C2



Time (s)

Time (s)

***L. echigonia* and *P. clarkii* presented different behaviors**

❖ Lefua moved more than crayfish

- Water temperature might have affected ecophysiology
- *Lefua* is known to be found near spring-fed streams and is tolerant to lower temperature
- Block seems to be used as a shelter kind of habitats

❖ Tracking schooling fish is challenging

- Automatic tracking of multiple individuals is not easy
- But fish position is highly correlated in space & time
 - ✓ Statistically sound assessment is needed

❖ Future works

- Experiments under different temperature conditions
 - effects of behavioral modes such as feeding
- Improved algorithms for image analysis
 - multiple individuals are difficult to track simultaneously

Balancing Water, Agriculture & Ecosystems

Innovative
measurement and
advanced data
analysis are the keys
for sustainable
development in near
future

