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Complex Social Systems:
THE BEHAVIOURAL SINK

CSS Project's Presentation -
Alessio Melone, Henrique Ranieri, Francesco Rosano

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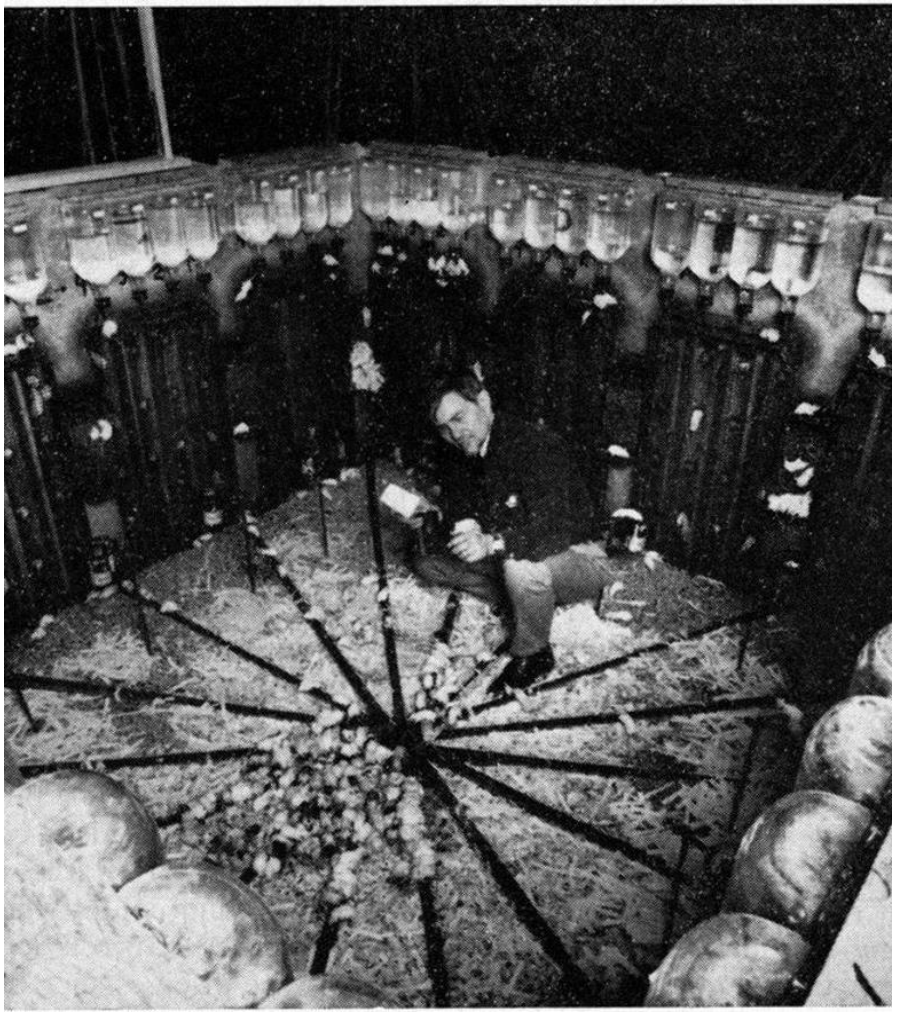
Universe 25 Experiment – John B. Calhoun, 1968

SETTING

- Four mice couples at t_0
- «Rat Utopia»:
  - Unlimited food and water
  - Protection from predators
  - Protection from weather
  - Protection from external diseases
- Four pens in a «U» shape, one food dispenser each
- Habitat built for 4000 mice
- Only one scarce resourse: **space**



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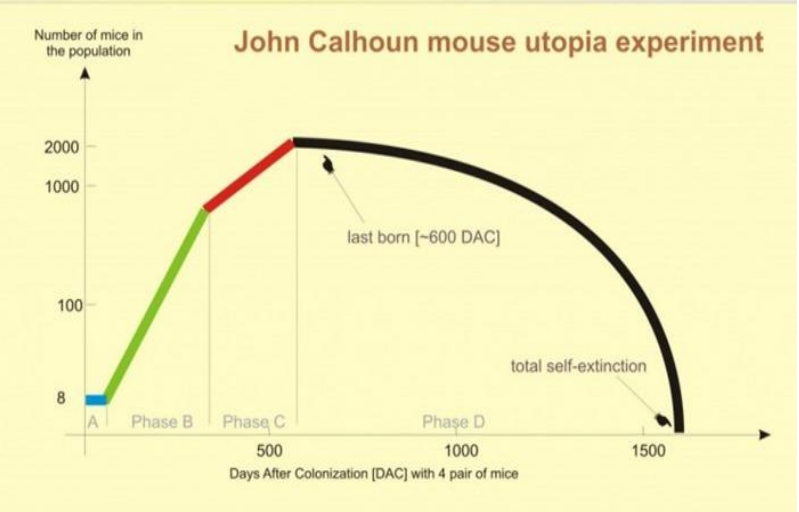
Universe 25 Experiment – John B. Calhoun, 1968

EMERGING BEHAVIOURS

- Population peaked at 2200 mice (habitat for 4000)
- Antisocial emerging behaviour:
  - Mothers abandoning «mothership», infant mortality
  - Cannibalism
  - Increased aggresivity
  - Sexual deviation
  - Self-isolation/«togetherness» necessity
  - Hyperactivity/laziness
  - Strict social hierarchy
- High density lead to extinction

➡ "BEHAVIOURAL SINK"



Too many complex emerging behaviours for a single model?

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Universe 25 Experiment – John B. Calhoun, 1968

EMERGING BEHAVIOURS:

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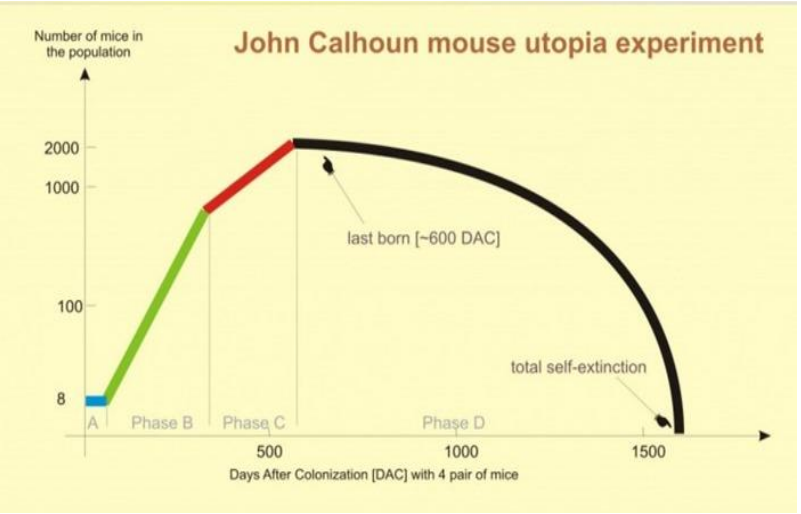

➡ **OUR FOCUS:** Explored using 3 different agent-based models

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Agenda

Models

1. Social Togetherness
2. Social Dominance and Fights
3. Infant Mortality and Mothership

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1. Social togetherness

Speaker: Henrique Ranieri

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«Gradually the social aspect of the activity (of eating - editor's note) became determinant: the rats would rarely eat except at hopper already in use by other animals.

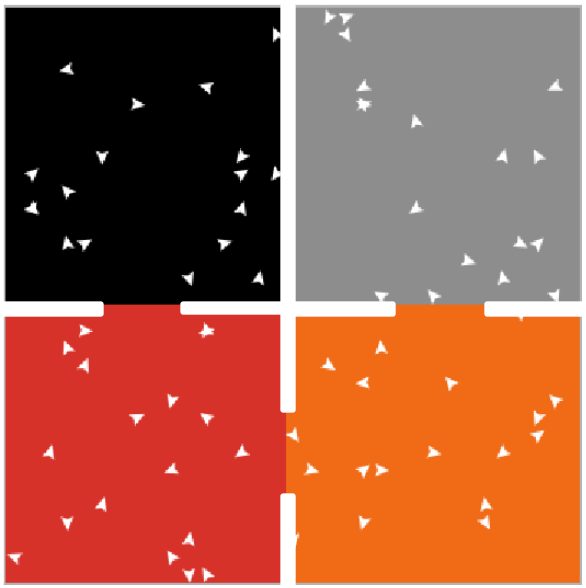
…

the same pathological "togetherness" tended to disrupt the ordered sequences of activity involved in other vital modes of behavior such as the courting of sex partners, the building of nests and the nursing and care of the young

Population Density and Social Pathology,
John B. Calhoun

Social togetherness - Model

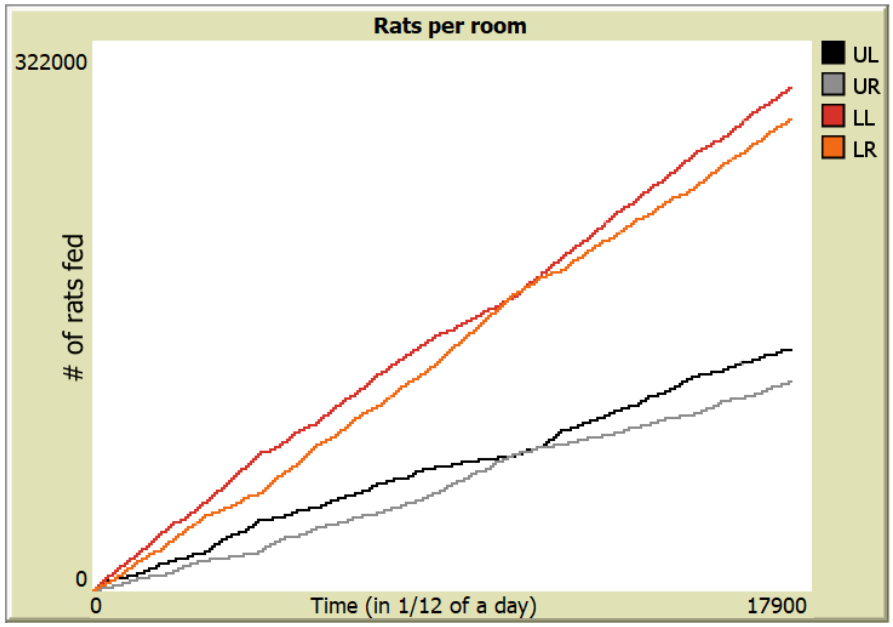
- Focus: ”Eating and other biological activities were thereby transformed into social activities in which the principal satisfaction was interaction with other rats.”
- Environment:
  - Four rooms with three bridges in between.
- Agent behaviour:
  - Each rat tries to feed on a unique feeding window. Fixed size, random interval.
  - Prioritize adjancent rooms that meet their social togetherness necessities.
  - Social togetherness dynamically changes with the amount of rats each specific rat ate with. Eating with more rats conditions the rat to seek more social togetherness.
  - Generational dynamic: Rats die and new ones are born. Always constant population size.

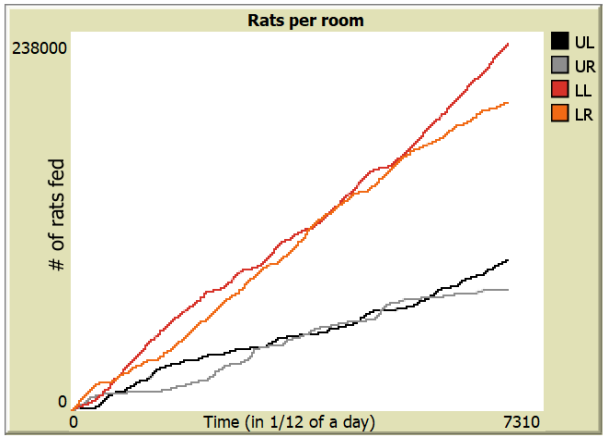


https://gwern.net/doc/sociology/1962-calhoun.pdf

Social Togetherness - Population distribution

- Lower rooms are consistently more populated.
- Total room population emerges in vertical pairs.
  - Self-reinforcing social hub.





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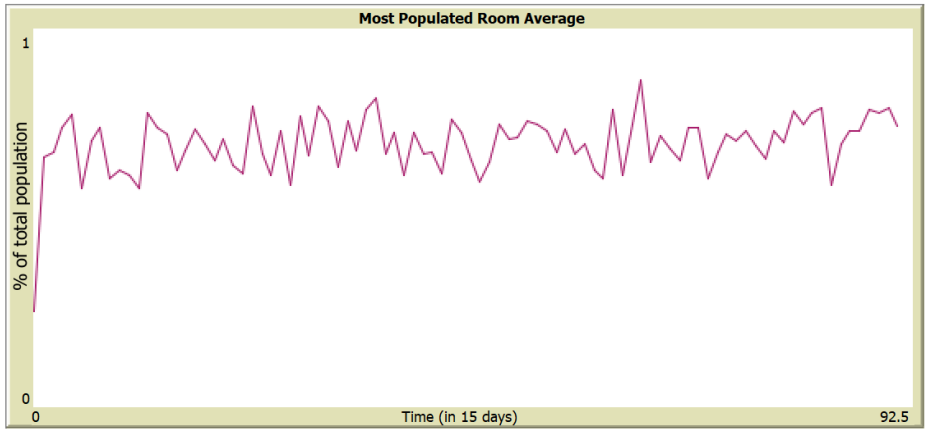
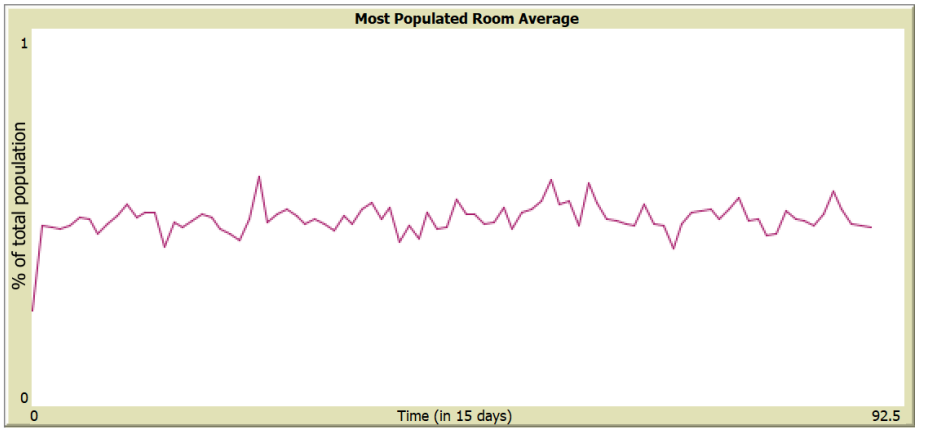
Social Togetherness - Beneficial enviroment conditions

- The ease of environmental conditions allows social behaviours to thrive, leading to clustering.
  - More flexible feeding time.
  - More food available.



feeding windows of size 90% of the day



feeding windows of size 25% of the day

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Social Togetherness - Additional observed behaviors

- New generations have little influence over an established environment.
- Conditioning coefficient values become irrelevant over time.

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2. Social Dominance and Fights

Speaker: Alessio Melone

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«… a dominant male was usually able to expel all other males and possess a harem of females. The sex ratio approximated equality only in those groups that fell within the expected size range. In the larger groups, on the other hand, there were many more males than females.

…

The more fights a male initiated and the more fights he won, the more likely he was to establish a position of dominance.

Population Density and Social Pathology,
John B. Calhoun

https://gwern.net/doc/sociology/1962-calhoun.pdf

Social dominance and fights – Moving

Seeking Food:

- **Dominant Males:** Claim and hover around a dispenser.
- **Non-Dominant Males:** Avoid dispensers near dominant males.
- **Females:** Go to the nearest dispenser.

Seeking Mates: appx. 5 attempts per lifespan.

- **Dominant Males:** Avoid mating if stronger males are nearby.
- **Non-Dominant Males:** Avoid females near dominant males.

Random Movement: Bias towards the center when idle.

Social dominance and fights – Mating and fighting

Fighting

- Happens among males under overcrowded conditions.
- Outcomes depend on social status and energy; can lead to death.

Reproducing

- Fertile females reproduce based on energy and overcrowding.
- After gestation, they give birth to a random number of offspring.

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Social dominance and fights – Mouse attributes

- `sex` : Mice can be male (“M”) or female (“F”).
- `energy` : Represents the health of a mouse. A mouse dies if its energy goes to 0. It is decreased at every tick and in case of fight, the winner has a lower decrease than the loser.

It is necessary for females in order to give birth (they only mate if their energy is higher than 50% of the maximum energy. Can be brought back to `max-energy` when eating.

- `age` : Increases each tick, influences fertility (a mouse is considered fertile in a certain range of age).
- `social-status` : For males, a value between 0 and 1 indicating dominance. Affects the probability of winning fights and a mouse is considered dominant and marked in red if its social-status goes over a certain threshold `dominance-threshold` .
- `behavior` : Can be “normal” or “beautiful”, affecting movement and interactions. Setting `behavior-change-probability` to 0 allows not to take behavioral change to “beautiful” into account, made for simplicity.
- **Reproduction**: Females can become pregnant and give birth after a gestation period.

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Social dominance and fights – Model parameters

- `initial-population` of mice. **Changing** in analysis.
- `max-age` and `death-probability-factor` : after a certain age, the mice start dying with a probability proportional to the exceeding and the death probability factor. Both fixed for simplicity.
- `max-energy` and `energy-loss-rate` are fixed for simplicity and indicate respectively the maximum energy and the energy lost per tick by each mouse.
- `overpopulation-threshold` indicates the number of mice present in a radius of 5 from a certain mouse or patch to be considered overcrowded.
- `pregnancy-duration` , `min-offspring` and `maximum-offspring` for each birth.
- `dominance-threshold` is the threshold after which a mouse in considered dominant by other mice. **Changing** in analysis.
- `fight-probability-factor` affects the probability of males fighting when overcrowded. Setting it to 1, we force the male mice to fight whenever it's overcrowded.

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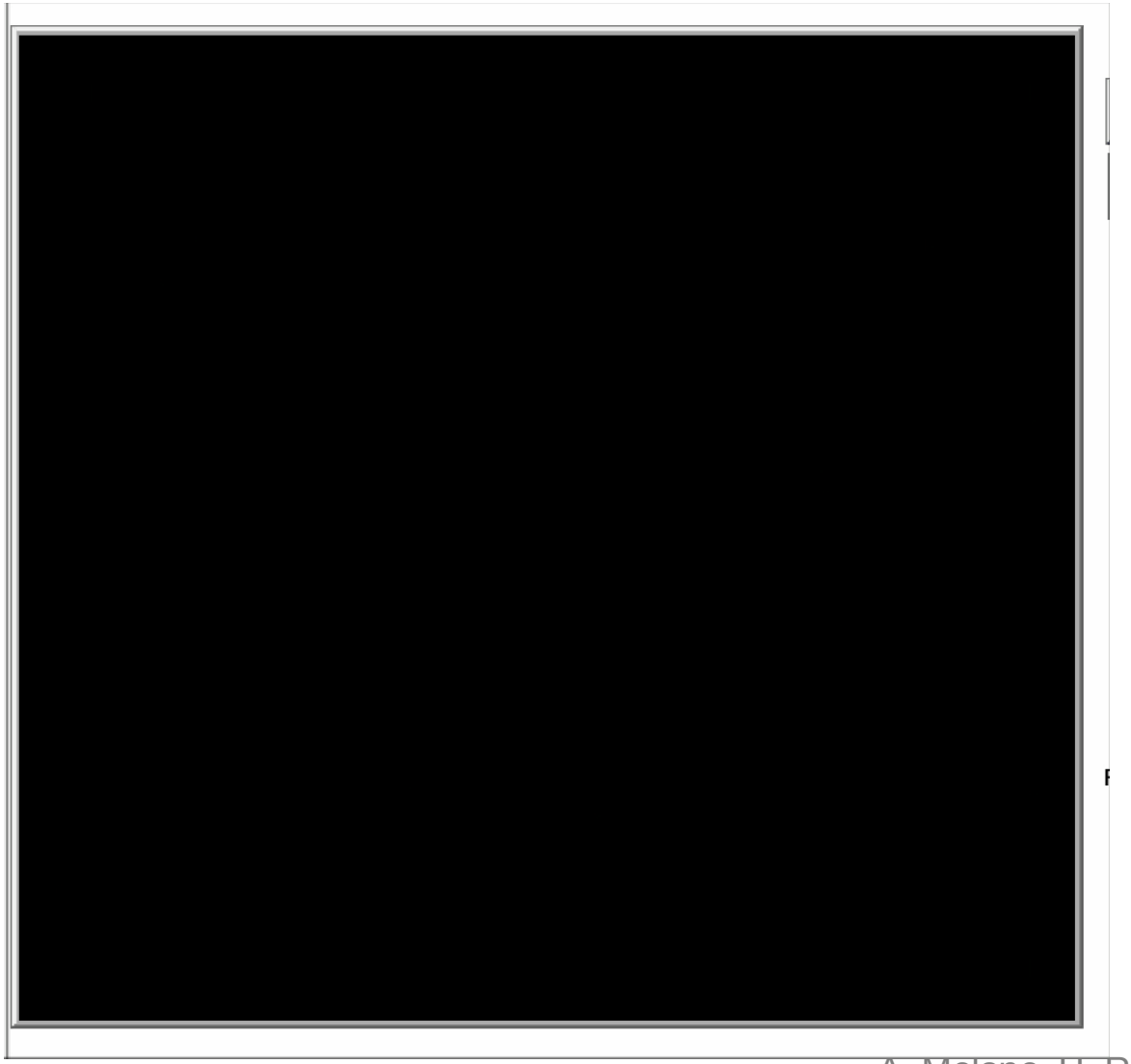
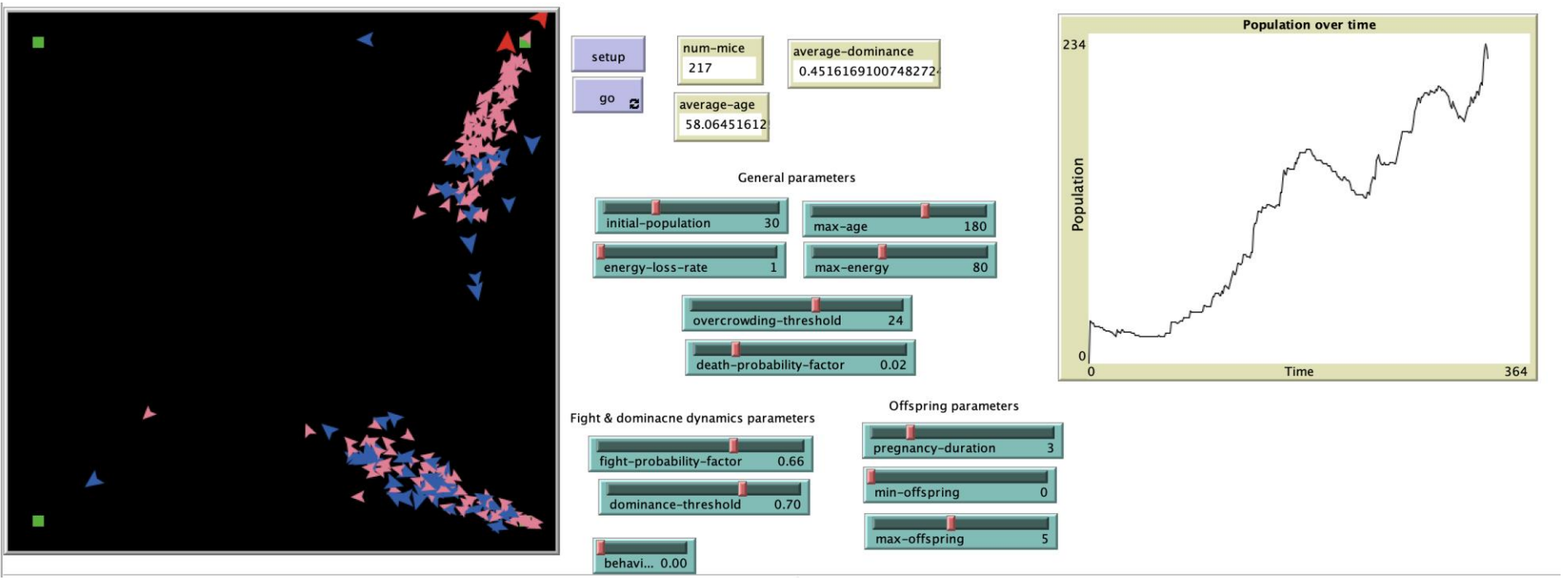
Social dominance and fights



Social dominance and fights – Clustering



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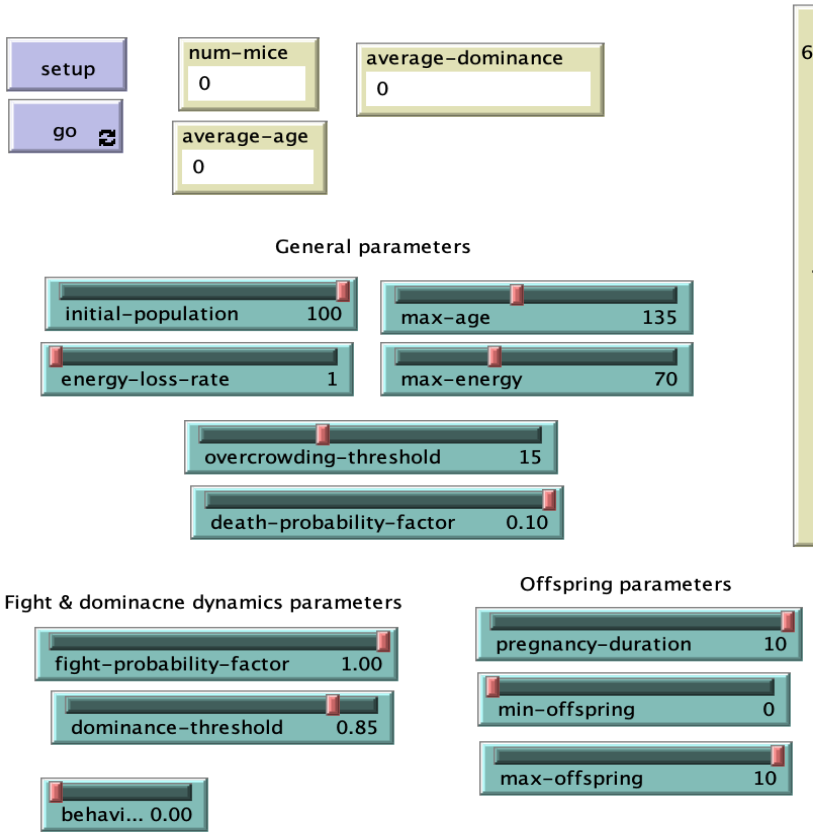
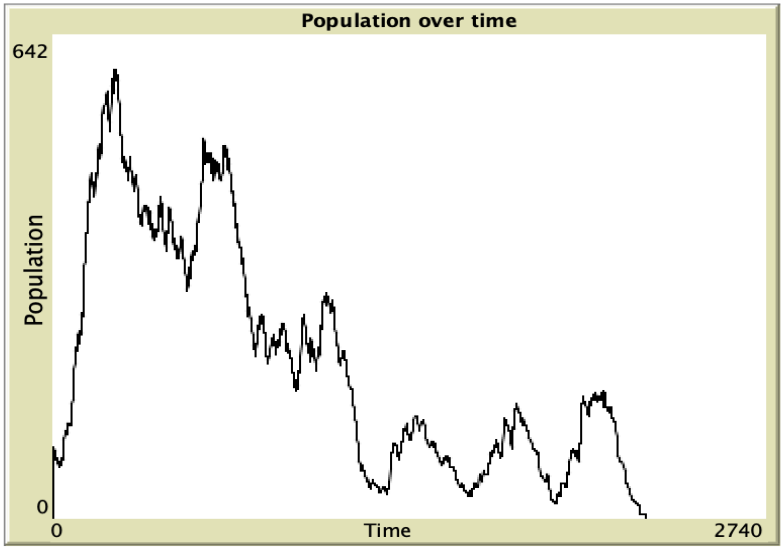
Social dominance and fights – 100 initial population





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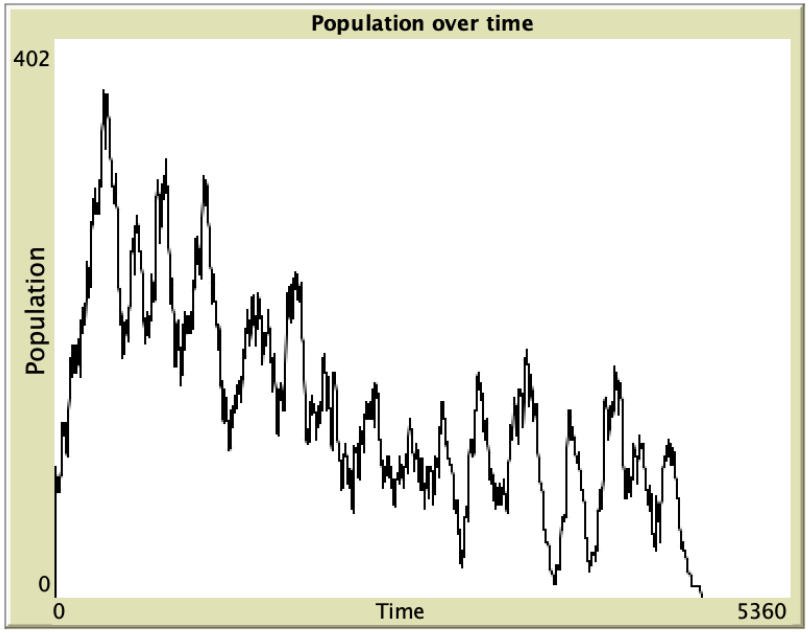

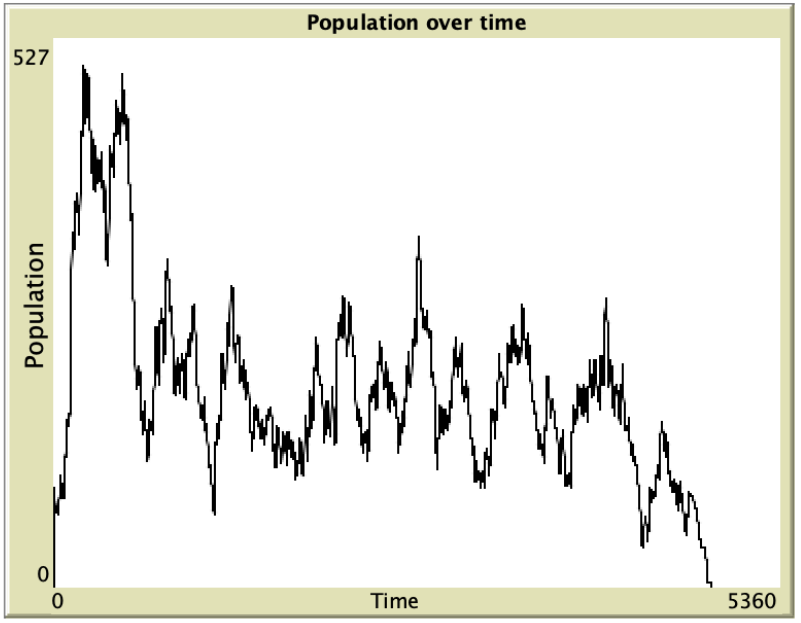

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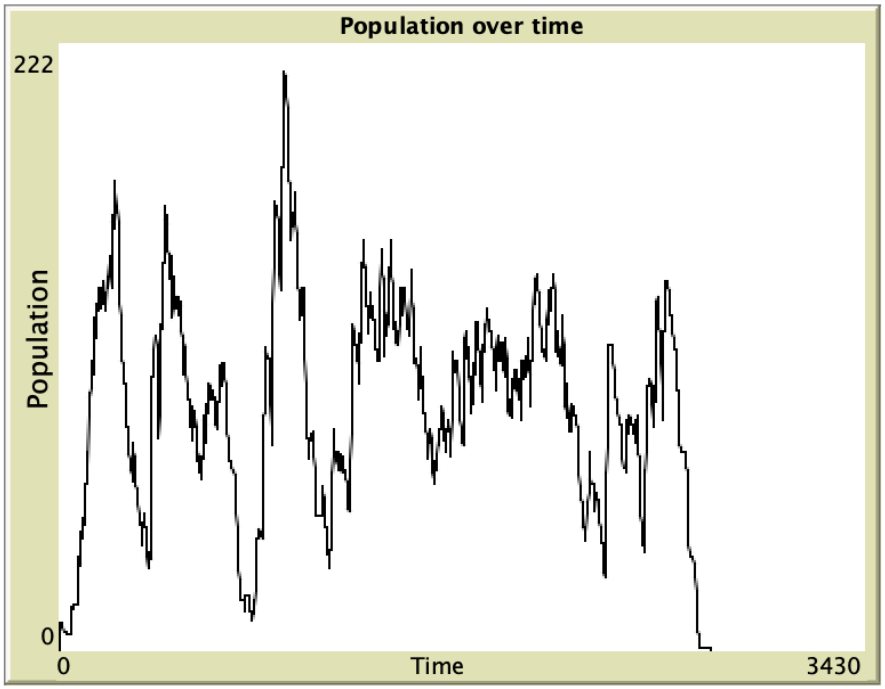
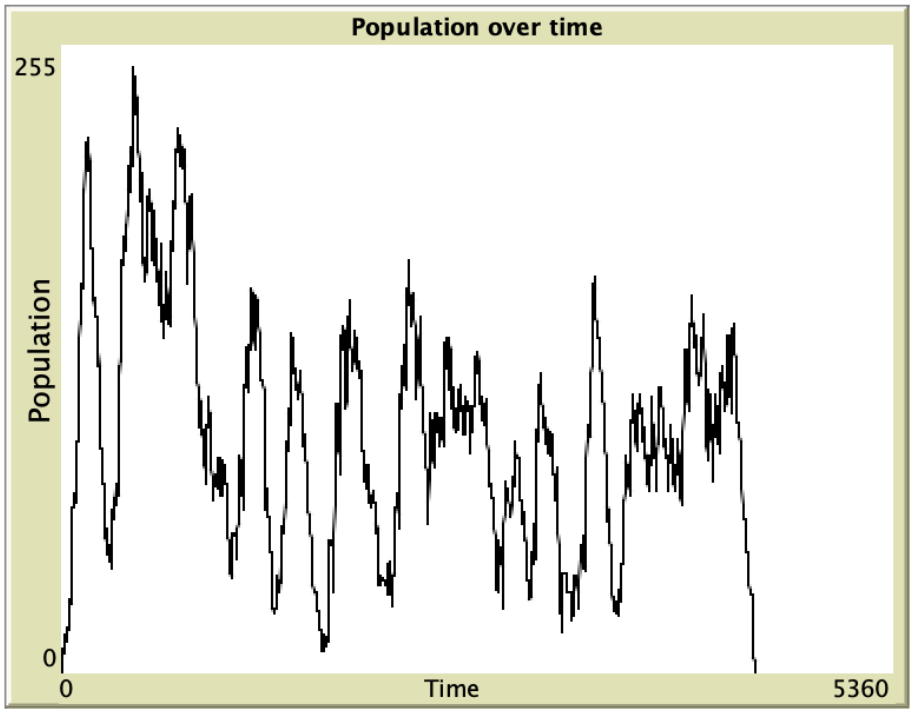
Social dominance and fights – 10 initial population





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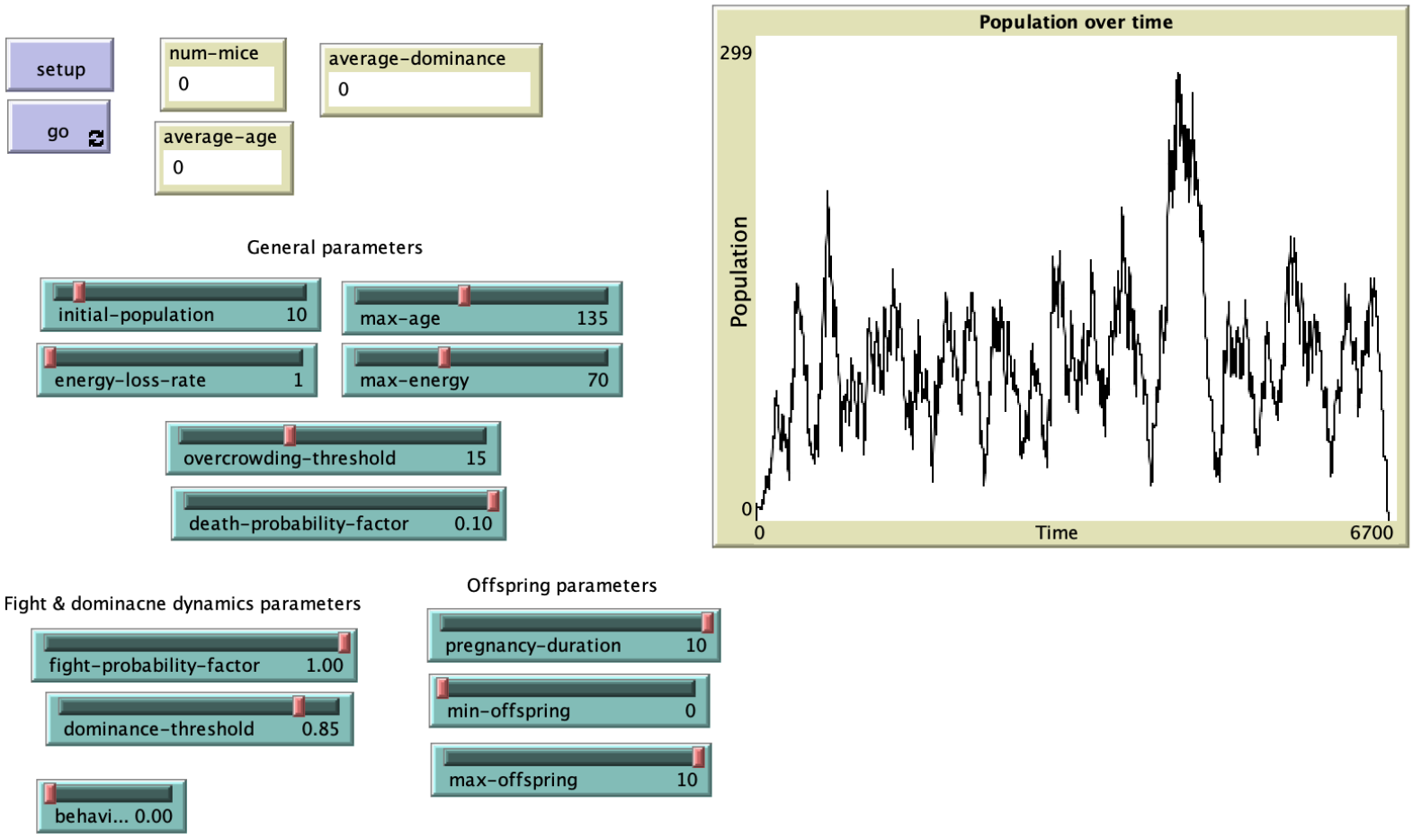

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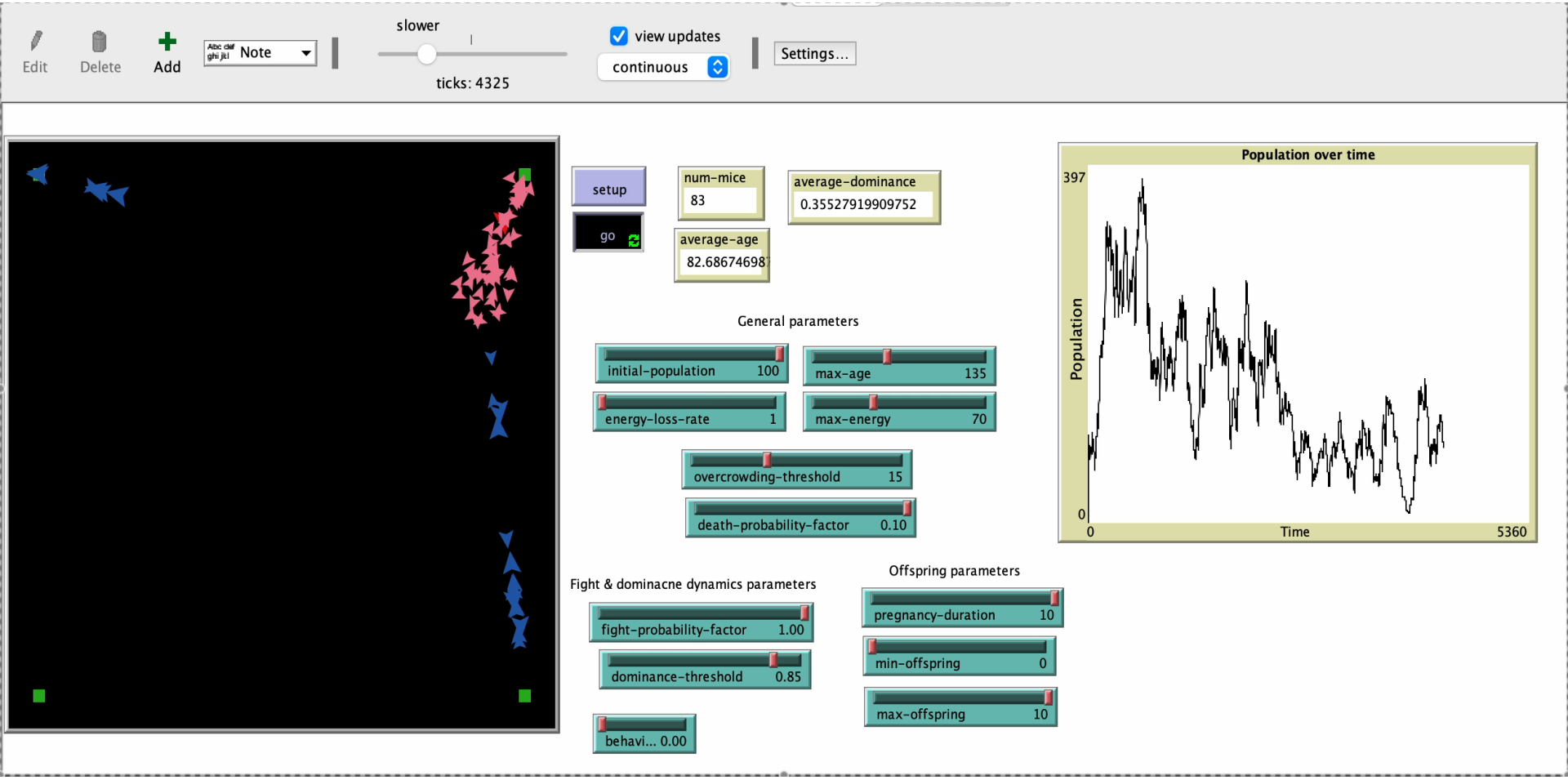
Social dominance and fights – Why extinction?



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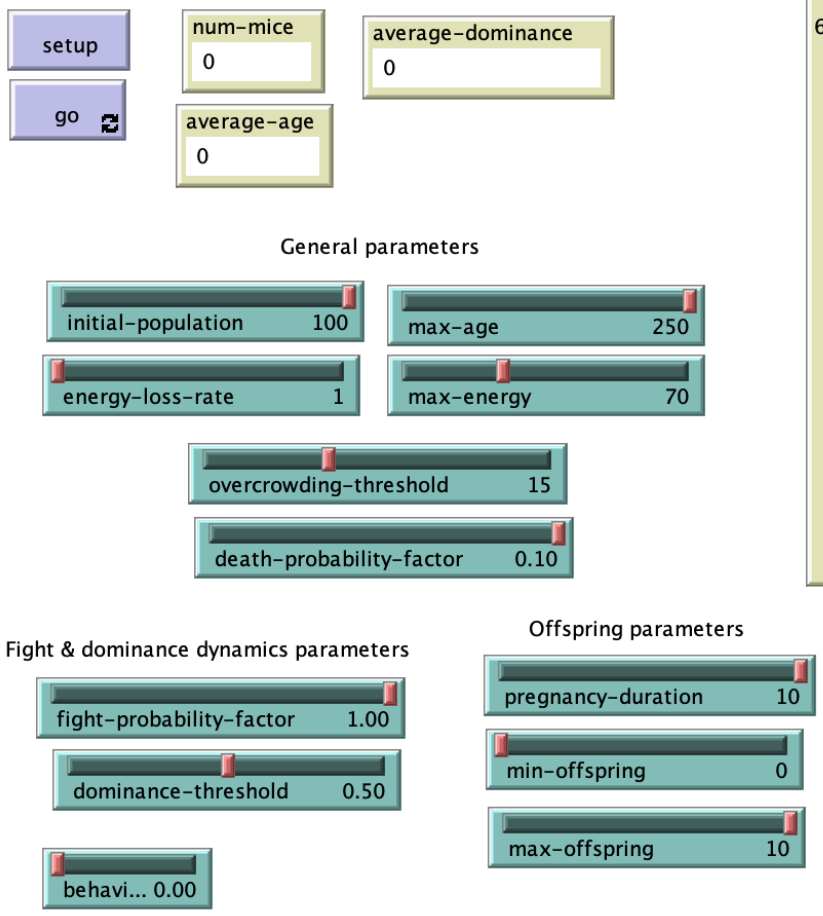
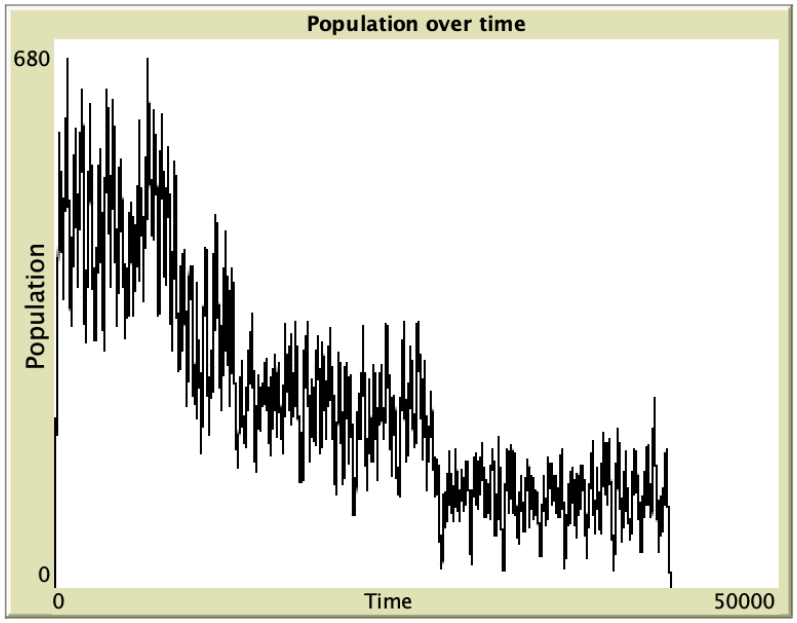
Social dominance and fights – Changing max-age





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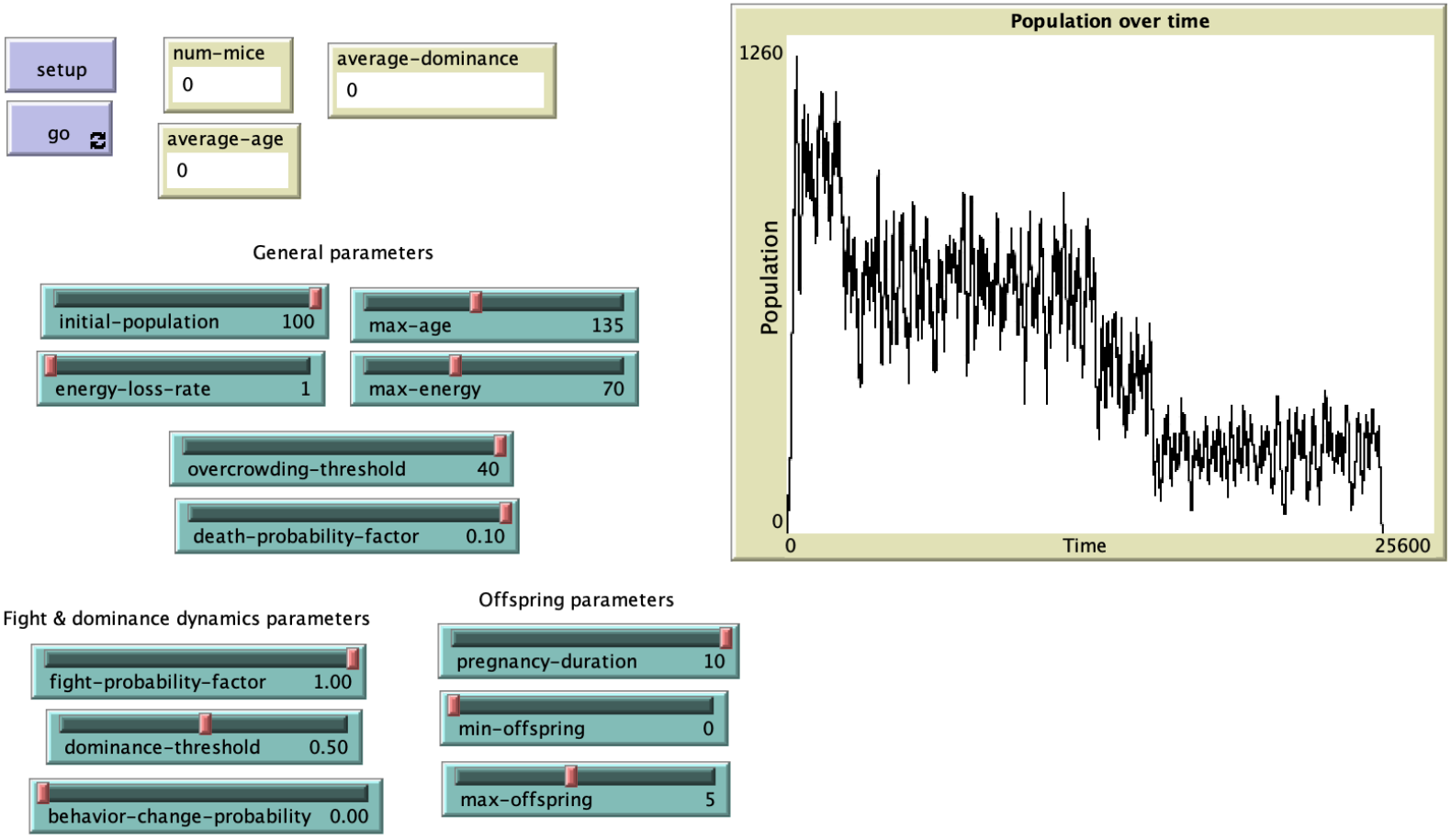
Social dominance and fights – Changing Overcrowding Threshold



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3. Infant Mortality and Mothership

Speaker: Francesco Rosano

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«… An even greater number (of females - editor's note), after successfully giving birth, fell short in their maternal functions.
... stress from social interaction led to such disruption of maternal behavior that few young survived.

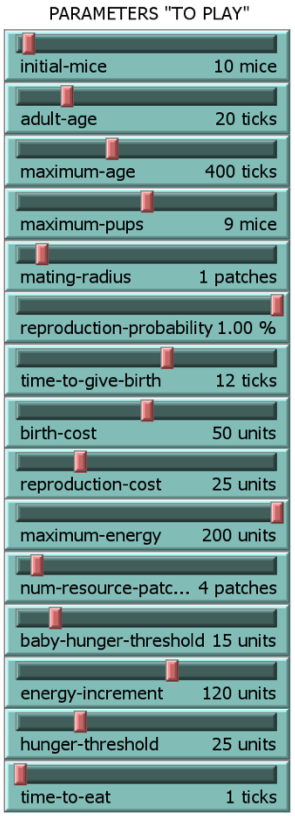
Population Density and Social Pathology,
John B. Calhoun

https://gwern.net/doc/sociology/1962-calhoun.pdf

Infant Mortality and Mothership

MODEL RULES:

- Finite number of infinite energy sources
- Agents move randomly until when they need resources, then towards sources
- Time to eat proportional to the number of agents in the radius of the source
- Only «adult» mice get pregnant (coupling with another mouse)
- Pregnancy takes time
- «Young» mice can get fed only by their parents



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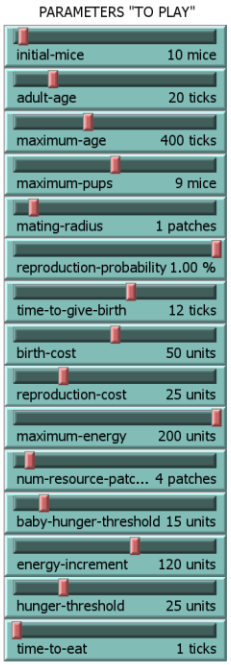
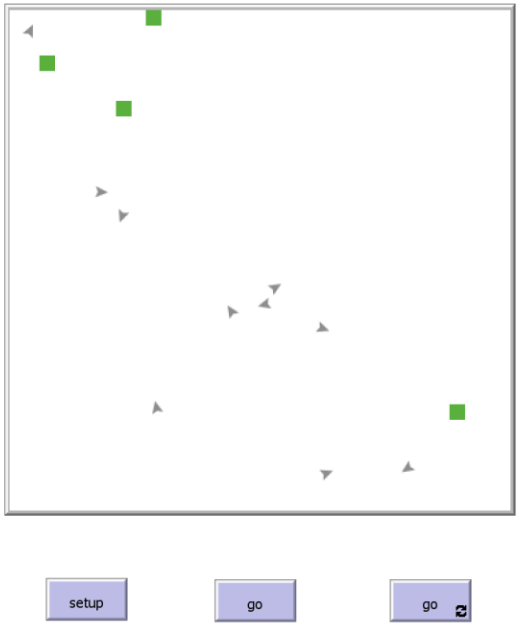
Infant Mortality and Mothership

MODEL SETTING:





MAIN PARAMETER

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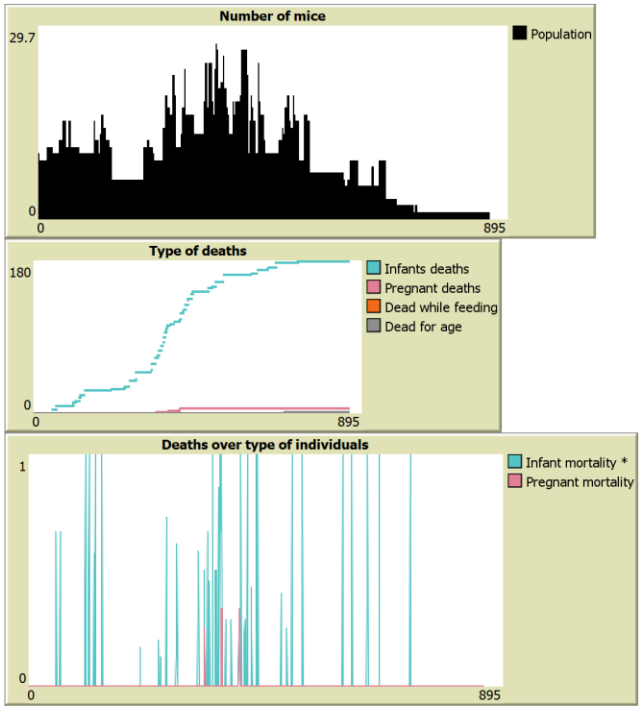
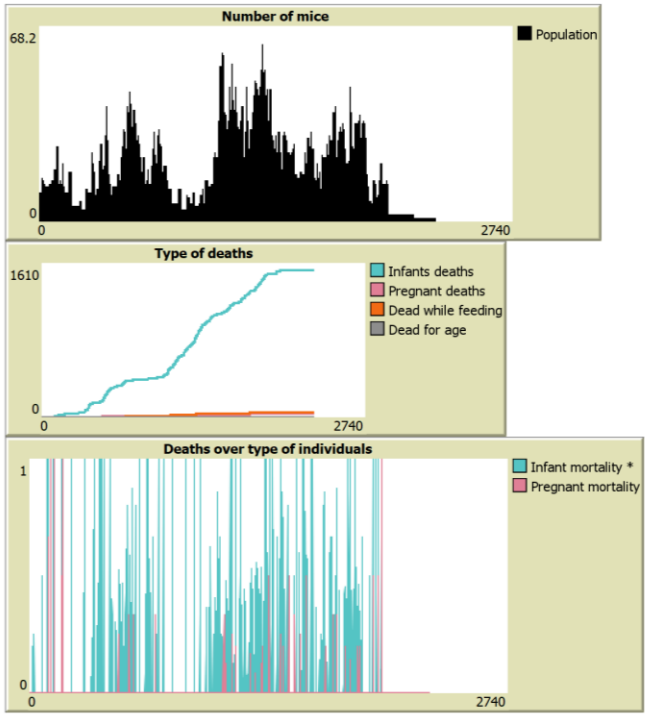
Infant Mortality and Mothership

LOW «MOTHERSHIP» → EXTINCTION

VERY LOW PEAKS OF POPULATION





CORRELATION BETWEEN POPULATION PEAKS AND INFANT MORTALITY

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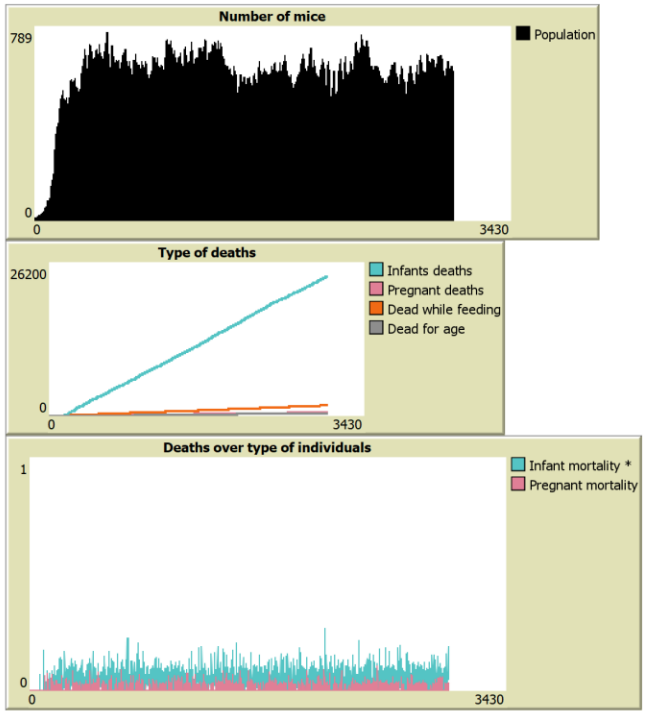
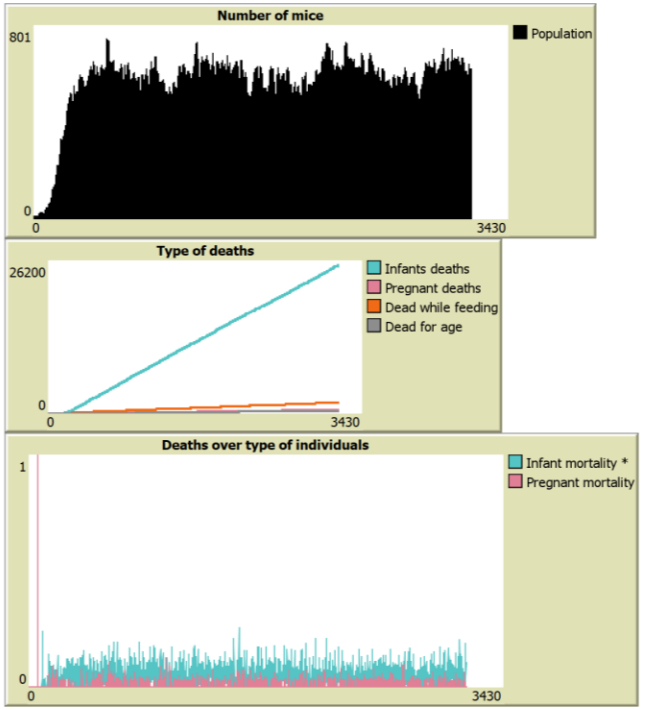
Infant Mortality and Mothership

HIGH «MOTHERSHIP» → STABILITY

AVERAGE POPULATION IS WAY HIGHER





INFANT MORTALITY IS STABLE, AND OVERALL LOWER

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Thank you for your attention!

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