**Simulation & Results**

In all our simulations and . The reason for this is explained in the section of interpretation of the parameters.

1. Trivial case, no predator

In this case the equation of the motion of preys simplify to:

Since there are no predators there is no need to take them into account.

In this trivial case with 8 preys, m0 = 0.1 and b0 = 0.1, the preys eventually form a stationary equilibrium depicted in the figure x. Further it is to note that there exist different stationary equilibriums for only preys. The only case where they do not form a stationary equilibrium is when the friction is removed in the above equation i.e. the term . That follows from the fact that the energy is conserved which implies that there is no stable equilibrium anymore.

The results obtained in this case equal the results of the paper proposed the model.

1. Single predator

This cases uses the equation (x) for preys and (y) for predators. In general there is no stable equilibrium anymore like in case 1 with no predators. However, with the configuration m0=0.1, b0 = 0.5, mx = 0.5, bx = 1 the predator gets trapped in the middle of the preys. The situation is depicted in figure x. This is an unrealistic result and therefore is not discussed further in this paper. Nevertheless it is the same result as in paper [1]. A lot of configurations in the single predator case result in an unrealistic behaviour of the swarm.

Analysis of the parameters in the section above and several test with those parameters we found out that the parameters of figure (x) are the most realistic in case of a single predator. The predator follows the swarm and split it mostly into two parts. As soon as the predator is some distance away from the preys, he again meet each other and build a swarm. This increases the chance of survive of the preys as they try to stay close together. Sometimes the predator is able to chase a prey away from the swarm but instead trying to chase the prey further away, as it mostly would appear in nature, the predator turns into the direction of the swarm. This is caused by the multiple preys having a stronger attractive force on the predator as a single prey. It is not possible to change this behaviour of the predator without changing the model, since the predator always gets attracted by the most predators. This also could be seen as the case where the predator is able to eat/kill a prey and turning around to chase more preys in the swarm.

1. Multiple predators

This scenario is the most complicated one, because the equation of the predator needs to be considered as well. Therefore this part is divided into three subsections: First of all the situation with no force between the predators will be considered. Secondly this paper will consider an attractive force between the predators and thirdly the case with a repulsive force.

In all of the parts mentioned above the equation (x).will be used for the preys.

In the first case with no interaction between the predators the equation (x) is used to compute the force of the predators.

Although this scenario corresponds to the case where the predators do not interact with each other, they stay close together in the most of the configurations, which looks similar to the scenario with only one predator. The reason for this is that once they come close enough together the acting forces on them will be nearly the same.

The next option is an attractive force between the predators which is expressed in the equation (x). In contrary to the above case where the predators sometimes behave exactly the same, they stay at least at a certain distance due to the near distance repulsive force.

With a configuration of bx = 0.1, mx = 1, b0 = 0.5, m0 = 0.5, three predators and seven preys, it first looks that the predator do some random walk with the preys in the middle. But after some time the predators form a group and circulate together around the prey swarm in their middle which is depicted in figure x.

Another interesting behaviour is given by the configuration mx = 0.2, bx = 0.2, b0 = 0.2, m0 = 0.1, 2 predators and 7 preys. This is more realistic scenario in which the predators try to stay together, but after a while mostly chase the preys alone. They do often separate the swarm and go after some preys which lost the connection to the swarm. Anyway after a while the swarm again finds together and the scenario starts from the beginning.

The last option is to choose a repulsive force between the predators which leads to the equation x. In this scenario the predators avoid each other. With this kind of interaction they often attack the swarm from different sides what is close to realistic behaviour, where the predators tries to surround the preys. The predators often rush through the swarm and divide them for a short time into multiple smaller swarms until the swarm eventually finds together. This outcome can be observed with the following configuration: mx = 0.3, bx = 0.2, m0 = 0.1 and b0 = 0.2. Also remarkable in this configuration is that the swarm finds together relatively quickly after a predator divided them into two parts. In contrast to a configuration: mx = 0.2, bx = 0.2, m0 = 0.1 and b0 = 0.2 where the preys need a long time to find together when they got separated. In some cases the latter configuration leads to separated swarms chased by the predators.