Finding Nemo: Impact Of Change In The Social Environment On The Behaviour And Physiology Of Clownfish

PART A – Research Question (20 Marks)

Does change in the social environment have a long-lasting impact on the behaviour and physiology of clownfish?

The question incorporates theory regarding reproductive system of fish (Module 2), evolution and behavioural adaptation (Module 3). This is an inquiry question which could be tested in different ways to obtain an answer.

PART B – Literature Review (100 Marks)

Biology is a study which explores the several mysteries in living organisms. Biology can be seen in several places, ranging from the smallest of cells that can't be seen by the naked eye to an entire ocean ecosystem. Various biological ideas and concepts are prevalent in Pixar's 2003 animation Finding Nemo. The story revolves around the life of a clownfish named Marlin who loses his son to a diver and takes to great lengths to retrieve his son. The animation clearly highlights the relationships between various fish species and their biotic and abiotic features and represents the interactions within an underwater ecosystem. Although the film includes multiple biologically accurate elements, there are inconsistences film in the accuracy of portrayal of fish and their environment. Clownfish are species which are ruled by a strict social hierarchy and change sex based on their social environment. D

Sequential Hermaphroditism in Clownfish

Clownfish are hermaphrodites, which means that they possess both testicular tissue as well as ovarian tissue. There are two types of hermaphroditism – simultaneous where both sexes are present at the same time, and sequential, where the organism first develops as one sex and later it switches to the other sex. Clownfishes are sequential hermaphrodites. Clownfish display a strong hierarchy based on size and this hierarchy functions as queues for breeding. All clownfishes are first developed as males, and then switch to female if the social environment requires it to. In any clownfish community, the female fish is the largest fish, the breeding male is the second largest, and the rest of the fish living in that community are sexually immature males. If the dominant female of a community dies, all smaller subordinates attempt to claim the vacant position, while the largest male fish of the community becomes a mature male to complete the breeding pair. This allows for the formation of a new breeding pair without the need of traveling for reproduction but requires smaller sexually immature male fish to complete the sex change. Once the female is dead, the behaviour of the male clownfish alters. A male clownfish who prior to the female fish was gone, was once receiving orders, then shows power, dominance and aggression over the smaller fish. Although there is little research to back up the neurological aspect of clownfish, it can still be said that the brain mediates these behavioural changes.

In Finding Nemo, the film opens with two clownfish (male and female) in an anemone before a barracuda attacks the female and the several eggs that the couple had. The father wakes up, and after discovering that his partner and all the eggs were gone, he sees one remaining cracked egg, and raises the clownfish. This is one of the biological inaccuracies in the movie. Firstly, no other fish can be seen in the anemone apart from the mother and father, which does not properly represent the community that a clownfish lives in. If the movie were to consider the concept of sequential hermaphroditism, then Marlin would become the dominant female, and would need a sexually immature male to reproduce with, but there are no fish apart from nemo. These would mean that Nemo is meant to grow up to mate with his own ‘mother’ to repopulate the clownfish population.

An experiment was conducted by a group of four individuals which aimed to assess how social interaction influenced blood cortisol values and brain aromatase genes in the clownfish. Under the theory that each animal which lives in a social group experiences a different level of social stress in accordance with its social rank, the group hypothesised that the stress situation of individual clownfish influenced its sex determination. Groups of three sexually immature clownfish were Groups of three sexually immature anemonefish were placed into each of five experimental tanks and kept for 10 days to allow for social rank formation and behavioural observation. Then after the fish had been euthanised, blood and brain samples were taken from each fish. Aggressive behaviours were most frequent and blood Cortisol values were higher in dominant individuals. The transcription of mRNA for stress-related genes, i.e., those encoding for glucocorticoid was higher in the brains of dominant individuals than in other social ranks. Furthermore, a higher level of transcription of gonad and brain aromatase genes had been detected, which encode the enzyme that converts androgens into estrogens, in the brains of dominant individuals. These quantitative results suggested that social rank reflects the blood Cortisol value, which in turn leads to sex differentiation by manipulating transcription of genes, including aromatase genes, in the brain.

Acoustic Behaviour in Clownfish

Clownfish produce sounds during agnostic interactions that help maintain the size-based hierarchy of clownfish social groups. Larger clownfish, particularly the larger females, produce distinct “chirp” and “pop” sounds while charging and chasing smaller subordinates. The sounds are produced when the jaw teeth clash, as the jaw rapidly slams shut. Chirps on average last 89 milliseconds and contain multiple pluses of different durations. Subordinate males do not produce chirps or pops. Instead, subordinates produce hydrodynamic sounds generated by continuous head shaking. It is thought this shaking behaviour serves as a way to avoid physical injury during agonistic interactions. Clownfish hearing studies have revealed that these fishes can detect sounds between 75 and 1800 Hz, with best hearing sensitivities between 95 and 240 Hz. The dominant frequency of sounds produced by clownfish ranged from 370-00 Hz. Dominant frequency of sound is strongly correlated with clownfish size as larger individuals produce lower frequencies than smaller individuals do. According to researchers, these acoustic signals are vital for clownfish given the size-based hierarchy of their social structure, which means that they use their sound to assert their dominance if they are larger in size. This overall change in the way their hierarchy operates, resulted in clownfish using acoustics to effectively prevent conflict between other members of the community, to reinforce individuality and to maintain their rank in the hierarchy.

Evolution of Clownfish

Clownfish species have evolved a specific adaption which allows them to live in symbiosis with sea anemones. They have adapted to their environment, and are able to resist the stings of the anemone. This helps to drive off the anemone's predators and provide it with food, and in exchange the anemone provides protection with its stinging tentacles. A study by a researcher from the UQ School of Biological Sciences said that predators have been identified as the "shaping force behind mutually beneficial relationships between species such as clownfish and anemones". Deakin University Centre for Integrative Ecology Research Fellow Dr. Rohan Brooker said the team found that fish-anemone mutualisms had evolved at least 55 times across 16 fish families over the past 60 million years. Through the use of quantitative data, this study suggests that predation can explain the independent evolution of cooperative behaviours between clownfish, and impacting their behaviour and physiology.

This is seen in Finding Nemo in the scene where the female clownfish attempts to fight off the barracuda is accurate as female fish generally tend to fight off predators whereas male clownfish are responsible for looking after the eggs.

Source Analysis

Using a wide variety of sources and implementing information from various areas of research was crucial to determine whether change in the social environment has a long-lasting impact on the behaviour and physiology of clownfish or not.

Social Interaction

Formation and maintenance of social rank in a group are considered key requirements for the induction of sex change.

Size of a clownfish

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