A dominant–subordinate relationship underlies the phototactic behaviour in male *Clarias batrachus*

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Phototactic behaviour in male *Clarias batrachus* was studied in a choice chamber consisting of a photic and an aphotic zone. It was observed that the fish with the maximum weight showed the highest frequency to the photic zone. This behaviour seems to be independent of time, as the frequency of photic visits of the heaviest fish remained the highest, irrespective of the time of observation. Thus it can be concluded that a dominant–subordinate relationship might underlie the phototactic behaviour. Could it be that the heaviest fish is better equipped than others, in a social group, to fend the predators off and to bear the rigours of the photic zone?

THE phenomenon of social hierarchy or pecking order is widespread in the animal world. In organism living in groups, a dominant hierarchy is an efficient organization as it reduces aggression, protects the young and weak, orders access to scarce resources, helps in fending-off predators and also leads to division of labour. Leadership on the basis of body colour[1] has been documented. The role of dominance-determining factors such as age[2], sex[3], prior territoriality, dominance experiences[4] or individual recognition, and experimental manipulations[5] has been studied. Dominance behaviour is well known in fishes. Dominance on the basis of body size has been studied in *Lepomis megalotis*[3,6], *Trichogster trichopterus*, *Macropodus opercularis*[7,8], *Poecilia reticulata*[9] and *Mollienesia latipinna*[10]. Influence of body weight in acclimation to water temperature in comet goldfish has been reported[11]. Thus, it seems that weight or body size can affect the different physiological behaviour of the animal. This has been amply demonstrated in *Labroides dimidiatus*[12], in which the degree of size difference between two individuals is a powerful factor determining the social relationships between them. Equal-sized fishes perform territorial behaviour without overlap of their home ranges, while fish of different body size have size-based dominance relationships in their overlapping home ranges. The sex reversal in *L. dimidiatus* is also dominance-dependent, as only the largest females have the possibility to become males. Dominance of the largest individual, in the shelter-seeking behaviour, in *C. gariepinus* juveniles has been investigated[13]. The dominant–subordinate relationship may be due to fighting capacity or increased hardiness of the heavier and larger individual. The pecking order or the dominace in *Clarias batrachus* is not well-studied. The present study was aimed to investigate the dominance–subordinate relationship in phototactic behaviour of *C. batrachus*, the Indian walking catfish.

C. batrachus was chosen as the experimental model. Individuals were purchased from a local fish-market and transferred to the laboratory.

The animals were sexed and released separately in two cement tanks. They were subjected to acclimation for a week, under dark (DD) conditions. Only males of the species were chosen for experimental purpose. The room temperature was recorded and was found to be relatively constant (mean: 27.7°C with standard error of 0.6°C) during the period of acclimation. The feeding regime consisted of minced goat liver given thrice a week. Water was changed a day after each feeding during the acclimation period.

The experiment was conducted in a choice chamber (30 cm × 12 cm × 13 cm) consisting of two parts, a photic zone and an aphotic zone. The aphotic zone was a closed black box made of acrylic sheet and had a small opening that provided a passage to the photic zone, thus allowing free movement of animals from one zone to the other. Both the photic and aphotic zones were of equal dimensions. The light intensity in the aphotic zone was approximately zero lux. The experimental apparatus was kept on a wooden stand. To avoid any sort of disturbances, both visual and auditory, the wooden stand was covered by curtains on all sides. A small slit in the curtain provided an access to non-invasive manual observation. The source of monochromatic white light in the photic zone was an ordinary tubelight. The diffracted light in the dark chamber was found to be negligible. The aquarium was filled three-fourth of its volume with tap water. Four male individuals having varying body weights were selected randomly from the stock cement tank. The fishes were weighed in an electrical weighing balance, with a least count of 1 g. The method of tagging was resorted to, for the purpose of identification. The tag consisted of plastic coloured beads. They were attached to the pectoral fins of the animal using thin nylon threads. Each fish carried a tag of different colour. On the basis of bead colour, different codes were assigned for different fishes. These codes were helpful in identifying a fish having a particular body weight; for example, pb for a fish tagged with pink bead. The four tagged individuals were then released in the photic zone of the choice chamber. Within ten minutes of being transferred to the photic zone, all the fishes showed a predilection for the aphotic zone. They were further subjected to acclimation for 2–3 days inside the choice chamber. One day prior to the commencement of experiment, feeding was stopped. The experiments were carried out between February and March.

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In the first experiment, after acclimation, the photic response of the individual fishes was gauged in the choice chamber. The number of fishes in the photic zone was counted every five minutes, in a session of 90 min. Each individual was identified by its coloured tag and its corresponding weight was recorded. During the course of experiment, the frequency of a particular tagged individual in the photic zone was also recorded. Observations were taken in two sets, each having three sessions (morning session from 0930 to 1100, noon session from 1200 to 1330, and finally, afternoon session from 1430 to 1600) on each day for two consecutive days. Thus, in all, there were 12 sessions of observations in the two sets.

In the second experiment, the basic procedure remained the same as that of the first experiment, except that new individuals from the cement tank were recruited. However, observations were recorded in five sets. Thus the total number of sessions were 30 in this experiment.

Different sets of data were pooled separately for both the experiments, and were subjected to ANOVA and Duncan's multiple-range tests. Further, the data were analysed using correlation analysis to detect the relationship between body weight and frequency of visits to the photic zone.

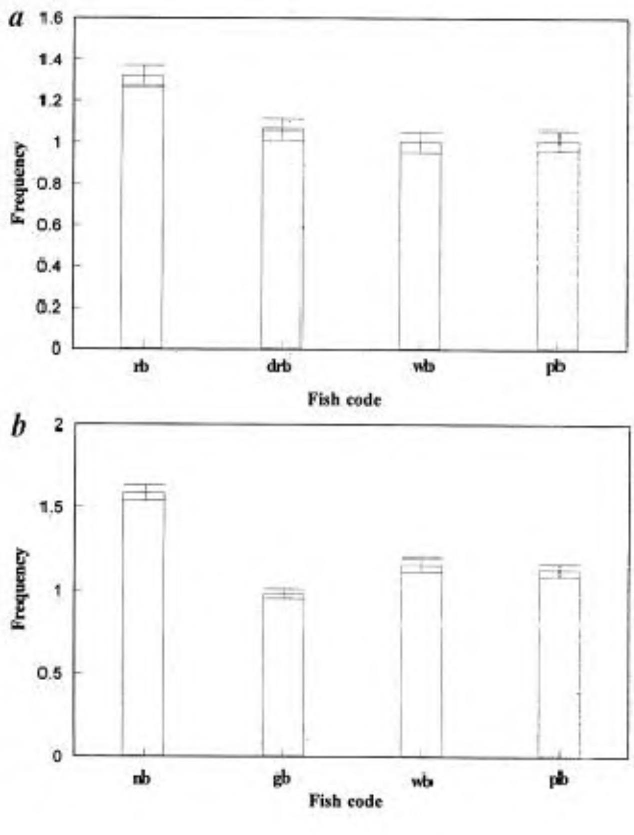

Figure 1. Frequency of visits to the photic zone in all the four fishes when data from the three sessions are pooled. ***a***, rb, the heaviest fish exhibits maximum photic frequency in the first experiment. ***b***, nb, the heaviest fish exhibits maximum photic frequency in the second experiment.

Results of the first experiment show that rb, the fish with the highest weight makes the maximum visits to the photic chamber, irrespective of the experimental sessions. Finally, when the data from all the 12 sessions in the first experiment were pooled and analysed, rb once again emerged to be the most frequent visitor to the light zone (Figure 1 *a*). In the second experiment the results indicate that nb, the fish with the maximum weight was the most dominant visitor to the photic zone. As in the first experiment, this dominant behaviour shows uniformity irrespective of the timings of the experimental sessions. Data from the 30 sessions were combined and analysed, with the results once again indicating nb to be the leader (Figure 1 *b*). A significant positive correlation between weight and frequency was observed in both experiments, when data were analysed separately or in combination (Figure 2 *a*–*c*).

The results reveal that there is a strong dominant behaviour in the experimental groups of *C. batrachus*. In both the experiments, consisting of four individuals each, the fish with the maximum body weight and size exhibited the highest frequency to the photic zone. The largest fish also showed aggressive behaviour towards the other members of the group, when they encroached on its niche. The dominant behaviour in the photic zone was independent of the timing of different study sessions. This corroborates indirectly with the findings reported in *M. auratus*[14]. It has been speculated that in *M. auratus*, the body size may be one of the factors that confers the dominance capacities to an individual among the conspecifics, when the dominance relation in a group has to be established. The effect of weight in acclimation to water temperature has been demonstrated in comet goldfish[11]. It has been reported that the heavier subjects are more active at lower temperatures and the lighter subjects are more active at higher temperatures. Dominance on the basis of body size has been established in *M. latipinna*[10] and in *Xiphophorus helleri*[15]. In *C. gariepinus* juveniles, the distribution of fish in the light gradient experiment has been documented to be size-dependent, in that the dark compartment (denoting the refuge area) is always monopolized by the largest fish[13]. The African catfish, *C. gariepinus* is nocturnal[16,17]. The juveniles of *C. gariepinus*, which has been demonstrated to be photonegative[13], exhibit the occupancy of prime shelter (dark) on the basis of size. In the present study, the most common reason for the heaviest individual to pay maximum visits to the photic zone might be its fighting capacity or hardiness. It is known that the *C. batrachus* is nocturnal and negatively phototactic. Generally, the fishes tend to prefer the darkness of a shelter than the lighted zone, which might be a predator-avoidance behaviour. In the present experiments it is seen that all other members of the group, except the largest one, made lesser visits to the photic zone. The largest fish, also being the heaviest, must be better equipped than the others to fend-off a

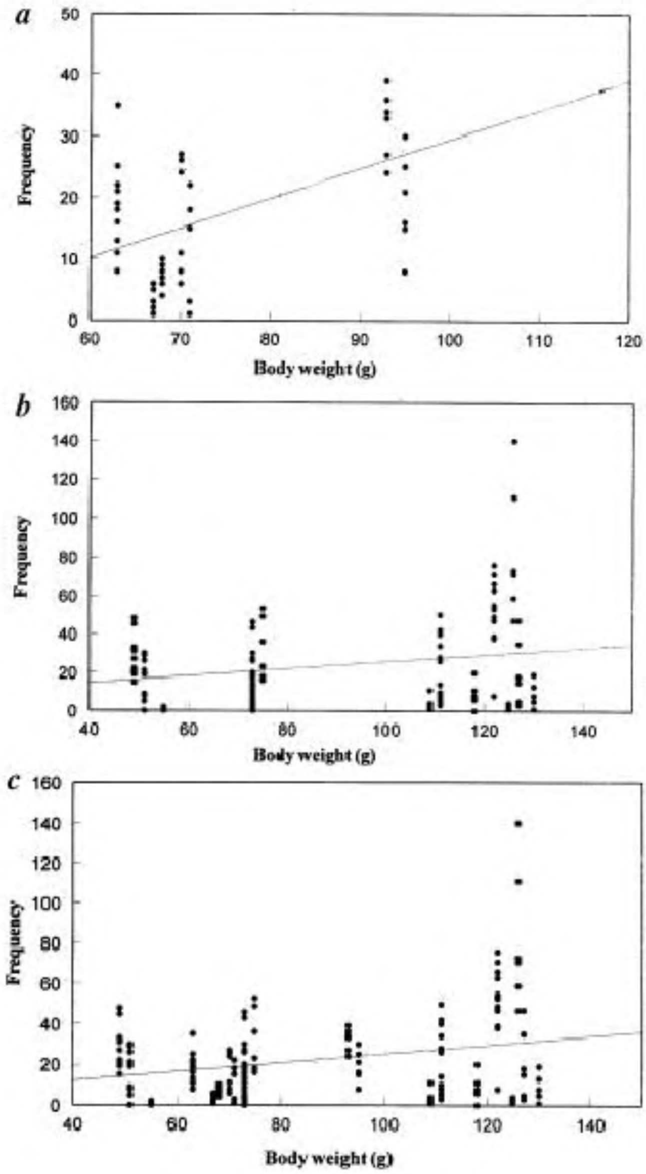

Figure 2. Correlation between body weight and frequency of visits to the photic zone (***a***) in fishes of the first experiment; (***b***) in fishes of the second experiment; and (***c***) when data from both experiments are combined. A positive correlation is detected between the two variables.

predator. Hence it dares to venture more often to the lighted zone. Another reason might be that being hardy, the largest fish is also better-suited to bear the rigours of the photic zone, which might be considerable for a nocturnal fish. This behaviour could not be attributed to the phenomenon of photoperiod preference, because experimental fishes were not provided with such an option. Further, the phototactic responses of the members of each group having lesser body weight were significantly different from those exhibited by the heaviest ones. In conclusion, it can be said that the phototactic behaviour in *C. batrachus* exhibits a dominant–subordinate relationship, being a function of body size, and that the frequency to the photic zone is directly proportional to the size and weight of the fish.

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Elephant temporal gland ultrastructure and androgen secretion during musth

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We have investigated the ultrastructure of the temporal gland of the Asian elephant (*Elephas maximus*) in the musth condition. We find that the organelles are highly evolved for the production of the androgen, testosterone which is reported to be very high in the Asian male elephant in full musth. The mitochondria bear cristae which are profuse and tubular, and occur along with many Golgi bodies. There is hypertrophy of smooth endoplasmic reticulum. All the structures involved in the production of androgen, as in the Leydig cell or the cells of the adrenal cortex, are thus

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