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QUALITATIVE AND QUANTITATIVE BEHAVIOUR STUDIES IN STARVING AND FEEDING TURBOT (SCOPTHALMUS MAXIMUS L.) LARVAE.

by

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ABSTRACT

A computer aided video system was used to register three dimensional movement and behaviour patterns in starving and feeding turbot larvae. The feeding larvae were kept and were monitored beyond metamorphosis in the observation chamber. The results are discussed. The observation system concept is described and discussed.

INTRODUCTION

The use of threedimensional registration technique is the best way of getting proper data for the movement of fishes. Until now, measurements from photographs have been the basis for threedimensional observations. Two different methods are used: stereophotographic methods (Cullen et al. 1965, Pitcher 1973, 1975, Lawrence et al. 1981) and the "shadow method" (Patridge et al. 1980, Batty 1983).

In this experiment a computer aided video system for movement observation of fish larvae and small aquatic invertebrates is applied in a study of turbot larvae (Scophthalmus maximus) from hatching to beyond metamorphosis.

MATERIALS AND METHODS

The observation system is outlined in figure 1. The basic unit is a low light video camera mounted on a modified dawing board ruler holder. The camera is moved horizontally and vertically by two servo motors and a simple belt drive system. The servo motors, and thus the camera movement are controlled by a joystick on the operator´s table. The camera lens has motorized focusing which is operated by two pushbuttons on top of the joystick.

On the axes of each of the two servo motors, and on the focusing ring of the camera lens there are mounted precision potmeters. When the camera is moved or focused the resulting resistance alterations in the potmeters cause corresponding voltage variations which are read and digitized by an attached microcomputer. The microcomputer is programmed to log position data at chosen intervals down to 0.5 seconds, and also to receive behaviour pattern entries from the keyboard and log them with the corresponding time. A file from an observation period will thus contain threedimensional coordinates with corresponding time lapse from the start point of the observation period, and also behaviour patterns with time of occurance. The data are stored on diskettes.

The video camera is placed in front of an observation chamber with a temperature control unit. A video casette recorder is also included in the system.The camera lens either has to have a macro function, or an extension ring has to be used to get a proper magnification and focusing range.

The resolution of the position data is 0.5 mm in each dimension.

Two groups of turbot larvae were investigated. One group of 200 starving larvae and one group containing 600 feeding larvae. Turbot eggs were delivered from the Ardtoe Research Station, Scotland and hatched in the observation chamber. The observation period started the first and the second day after 50% hatching for the starving and feeding group respectively. The starving group observation period was brought to an end when the larvae died at the seventh day. The feeding group observation period was ended when 2/3 of the larvae had metamorphosed day 26 after hatching.

The observation chamber measured 20X60X70 cm and held a volum of 70 liters of 34 o/oo salinity filtered (5µ) seawater. The temperature was kept at about 18°C and the observation chamber was continously provided with light from a fluorescent tube. The light intensity at the surface was close to 1000 lux. Fifteen per cent of the water volum was replaced daily.

After the third day of observation, algae (Nannochloris atomus) were added to the feeding group. The algae were supposed to act both as a water conditioner and as a potential feed enhancer (Scott & Middleton, 1979). The main food was rotifers (Brachionus plicatilis), copepode (Tispe sp.) nauplii and adults. The prey density was always kept above 1 per ml. One observation section included tacking twelve larvae. The larvae were randomly picked out for tracking (Fig. 2). Each larva was tracked for five minutes. Behaviour patterns were entered during tracking. The excact position and occurring behaviour patterns were logged every second. The total behaviour of the larvae were categorized into behaviour patterns as follows:

1 No activity - the larvae is inactive.

2 Searching - the larvae is swimming around searching for prey. All swimming activity apart from "Attack" is included in this behaviour pattern.

3 "S" posture - a pre attack mode typical for larvae of many species (Schumann, 1965, Hunter,1972). When sighting prey they form their body into a "S" posture. This feeding behaviour is typical for larvae of flatfishes (Jones, 1972).

4 Attack - driving the body forward to capture the prey.

5 Shake - several rapid lateral movements with head and body. Turbot larvae show this behaviour pattern after catching a prey.

The later used term "activity period" comprises the behaviour patterns 2, 3, 4, and 5.

In this study the volume searched was calculated with the formula:

$$2/3 \cdot \pi \cdot X^2 \cdot \bar{v}$$

where x is the perception distance and v is mean velocity. This relationship was derived from Blaxter & Staines (1971).

RESULTS

Activity

Fig. 3 shows activity as mean percentage of total observation-time. The first three days after hatching the larvae were inactive more then 95% of the time. At day three the activity period increased to about 70% in the feeding group and to about 50% in the starving group. After day three the activity of the starving group decreased, and the larvae died at day 6 and 7. The feeding group increased their activity period gradually to almost 100% of the time after 11 days, and kept this level for the rest of the experimental period.

Swimming speed

The two curves shown in figure 4 indicate the mean swimming speed of the larvae. The figure shows both the mean speed for the whole observation periodes and the swimming speed of the active periodes only.

Search volume.

Search volume calculation are show in fig.5. The perception distance of the turbot larvae was estimated by watching the larvae in relation to their food. The perception distance is in this article definded as the measured length from the snout of the larvae to the pray. The perception distance was found to be 3.5mm for 3 day old larvae, and 5 mm when the larvae were 7 days old.

This is about the same as for sole (Solea solea) larvae (Rosenthal 1966) and herring yolk sac larvae (Rosenthal & Hempel 1969)

Behaviour.

The first two days after hatching the larvae were located in the upper 10 cm zone of the observation chamber. Later they dispersed throughout the whole chamber volume. the larval attack frequency was nearly constant throughout the experiment.

DISCUSSION

The behaviour of fish larvae is an adaption to the environment. Right after hatching there is no competition for food and the behaviour is mainly a question of adjustments to avoid predation. When the larvae are motionless they are difficult to detect and when they move, they move rapidly. This is reflected in fig. 4, and means that a predator has to respond accordingly. Rosenthal and Hempel (1969) found the perception ranges of fish larvae being dependent on swimming speed. Ranges were greater during slow swimming than during fast swimming. This indicates that the larvae of the present experiment were unable to see very far when swimming the first three days due to the high swimming speeds. Accordingly larvae were often seen to collide at this stage.

The behaviour changed when the larvae started to eat. The activity periods were much longer and the swimming speed much slower. After the larvae began to eat, no collisions between larvae were detected except for larvae which were located close to the surface.

Westerhagen & Rosenthal (1980) found that laboratory reared herring larvae swam more slowly, and the fraction of active time was lower than for wild ones. A larger search volume might thus be expected of turbot larvae in nature than in the laboratory, and accordingly laboratory reared turbot larvae might need higher prey density than wild turbot larvae.

However, from the search volume data and feed particle density in this experiment it is clear that the larvae encountered far more feed organisms than is required for consumption. Already at day four more than 200 potential prey were visible to the larvae per hour, increasing to 7-800 by day 9. Even with a very limited feeding success it is clear that the number of prey within the search volume must have been well above requirements. This might indicate that the normally high prey density requirements of laboratory reared fish larvae are due to other causes than prey availability within the search volume.

It is known that larval perception distanse increases when larvae are growing (Blaxter & Staines 1971). The same tendency was observed for the turbot larvae in this study.

Throughout the activity period, the starving larvae swam faster than the feeding larvae but had shorter active periods. Blaxter and Ehrlich (1974) could not find any strict relationship between reduced feeding and activity level for herring and plaice larvae. The results in this work, however, correspond to the observations on plaice done by Wyatt (1972). He stated that the speed appears to be inversely correlated to prey density.

The larval attack frequency was nearly constant throughout the experiment, but the volume searched increased. Andersen & Ursin (1977) found that larvae generally are more selective in their choice of prey, and increased feeding success when the larvae get older was found by Braum (1964), Rosenthal & Hempel (1969), and Blaxter & Staines (1971).

The observation logging/system had its advantages, but also some limitations. Position data were very effectively aquired with good presicion in the camera movement plane. the third dimension position data which were aquired through focusing were dependent on depth of field, and thus on iris aperture and lighting conditions. Generally it was possible to adjust these settings so that also focus related position data had approximately the same accuracy as the data aquired through camera movement. It did, however, require som practicing by the operator to follow fast swimming larvae.

Observing and logging behaviour patterns while tracking the larvae also proved to be quite a demanding task. Ideally one person should observe and log behaviour patterns while another person track the larvae.

Feed organisms were also quite difficult to detect, especially rotifers. This may be helped by enhancing contrast conditions in the observation chamber.

The greatest advantage of the system is that large amounts of position data may be aquired, stored and computer treated with very little effort. Thus , investigations which would be almost impossible with traditional methods can be carried out.

The camera rig and observation chamber should be placed in a room with temperature control. Othervise local thermic convection in the observation chamber may distort the results, especially if the room temperature is very different form the observation chamber temperature.

The price on the system would be in the order of magnitude of £ 7000.

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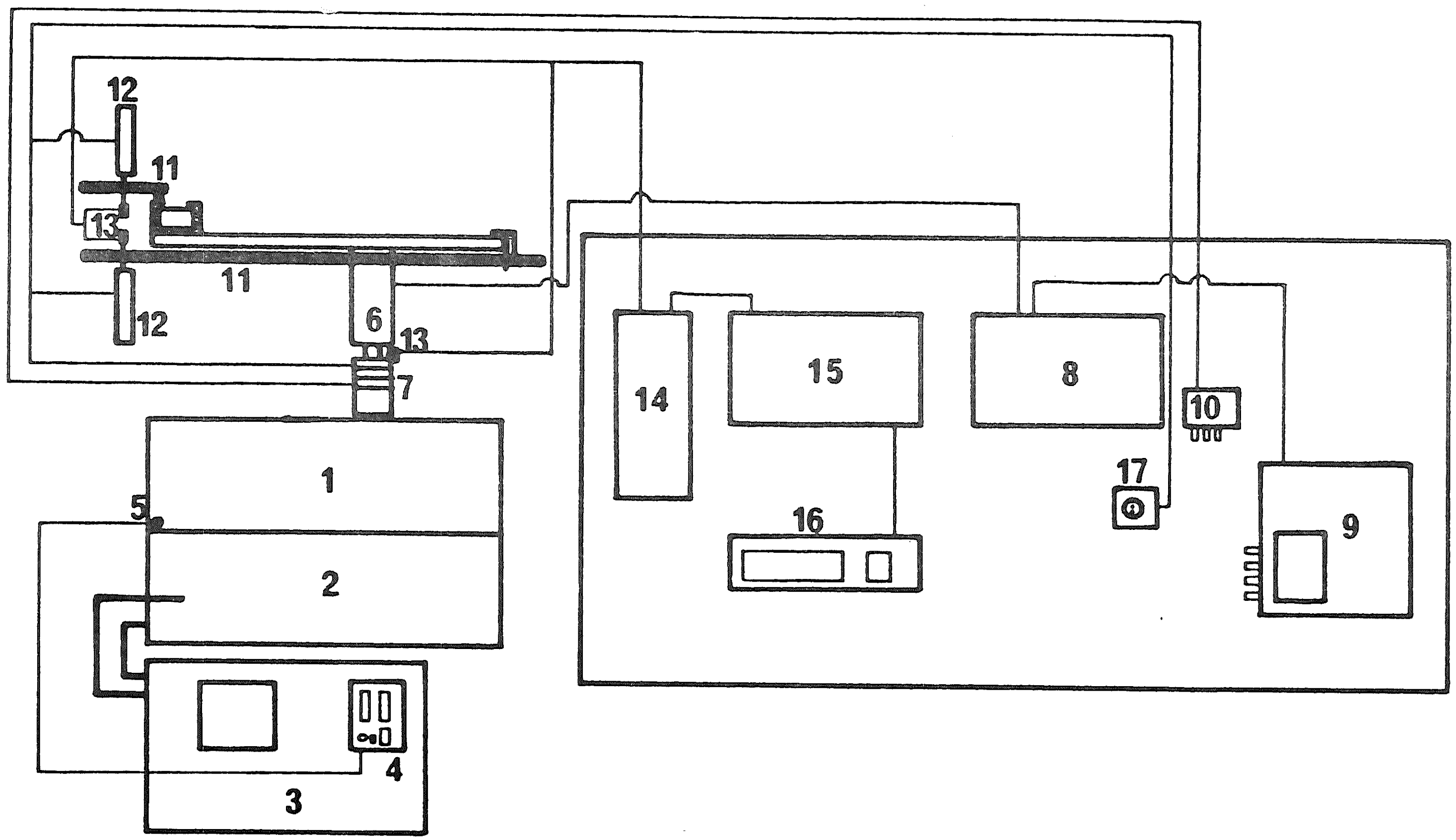

Figure 1. Schematic wiew of the behaviour observation system. 1) Observation chamber. 2) Temperature regulation chamber. 3) Temperature regulation unit. 4) Temperature display. 5) Temperature sensor 6) Video camera. 7) Lens with motor focus and motor iris. 8) Video monitor. 9) Video casette recorder. 10) Iris control. 11) Belt drives for camera movement. 12) Servo motors. 13) Potmeters. 14) Analog/digital converter and diskette drive. 15) Microcomputer monitor. 16) Keyboard. 17) Joystick.

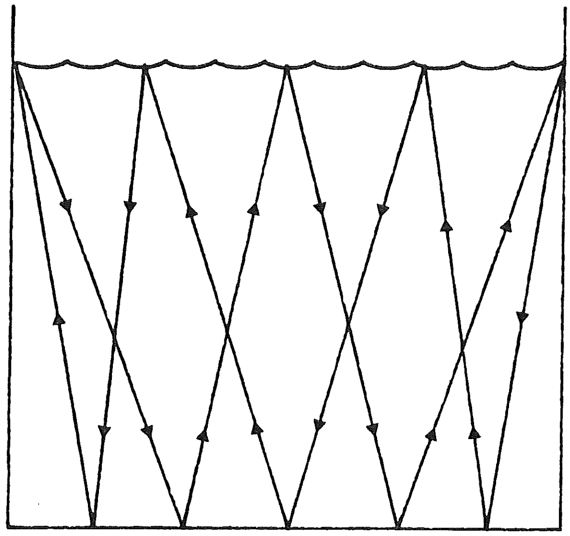

Figure 2. Sampling path of video camera in the observation chamber to randomize election of larvae for observation. The third larva encountered was elected. Start point of sampling path was where previous tracking ended.

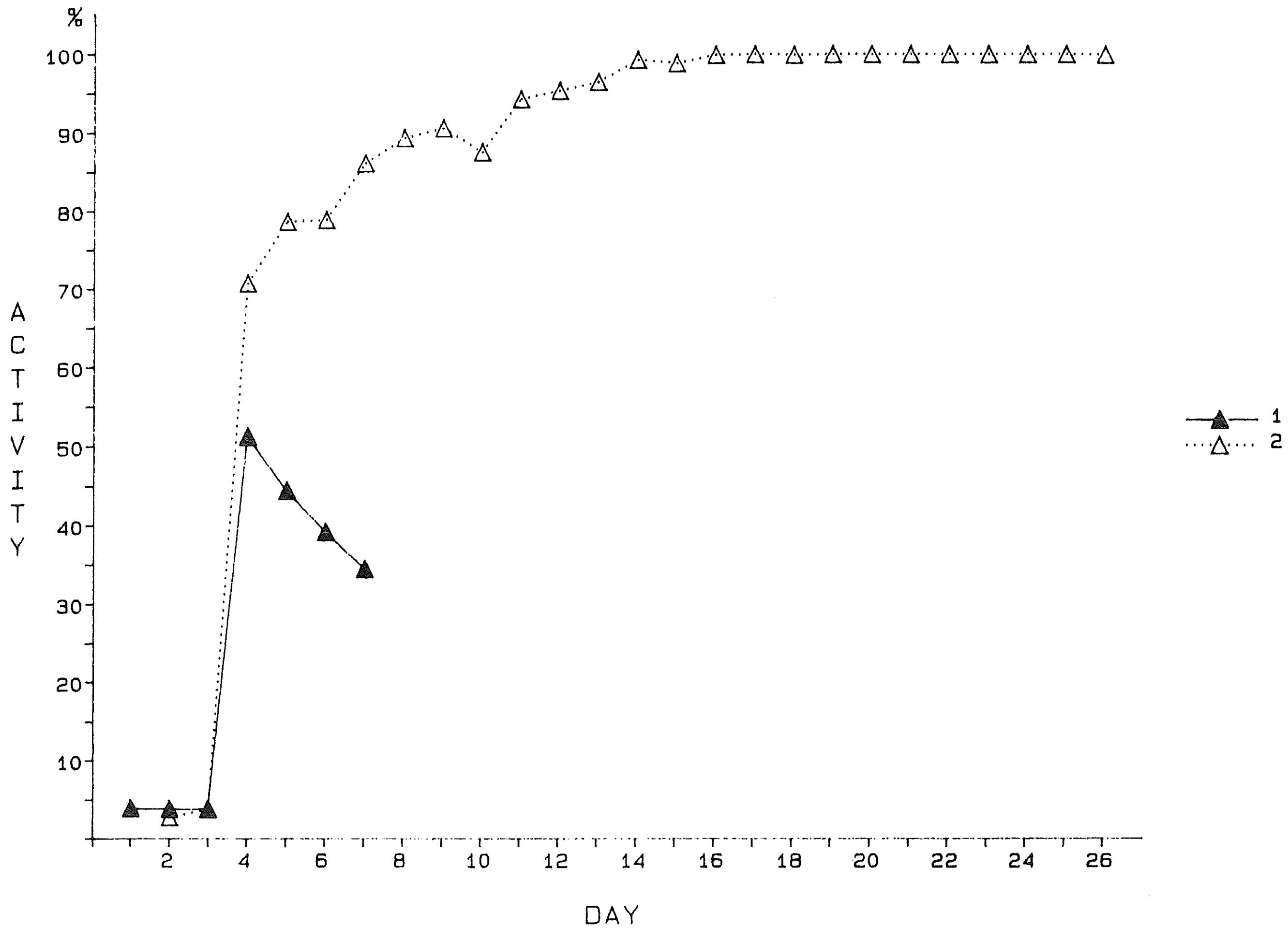

Figure 3. Activity period in per cent of observation time. 1) Mean activity of starving larvae. 2) Mean activity of feeding larvae.

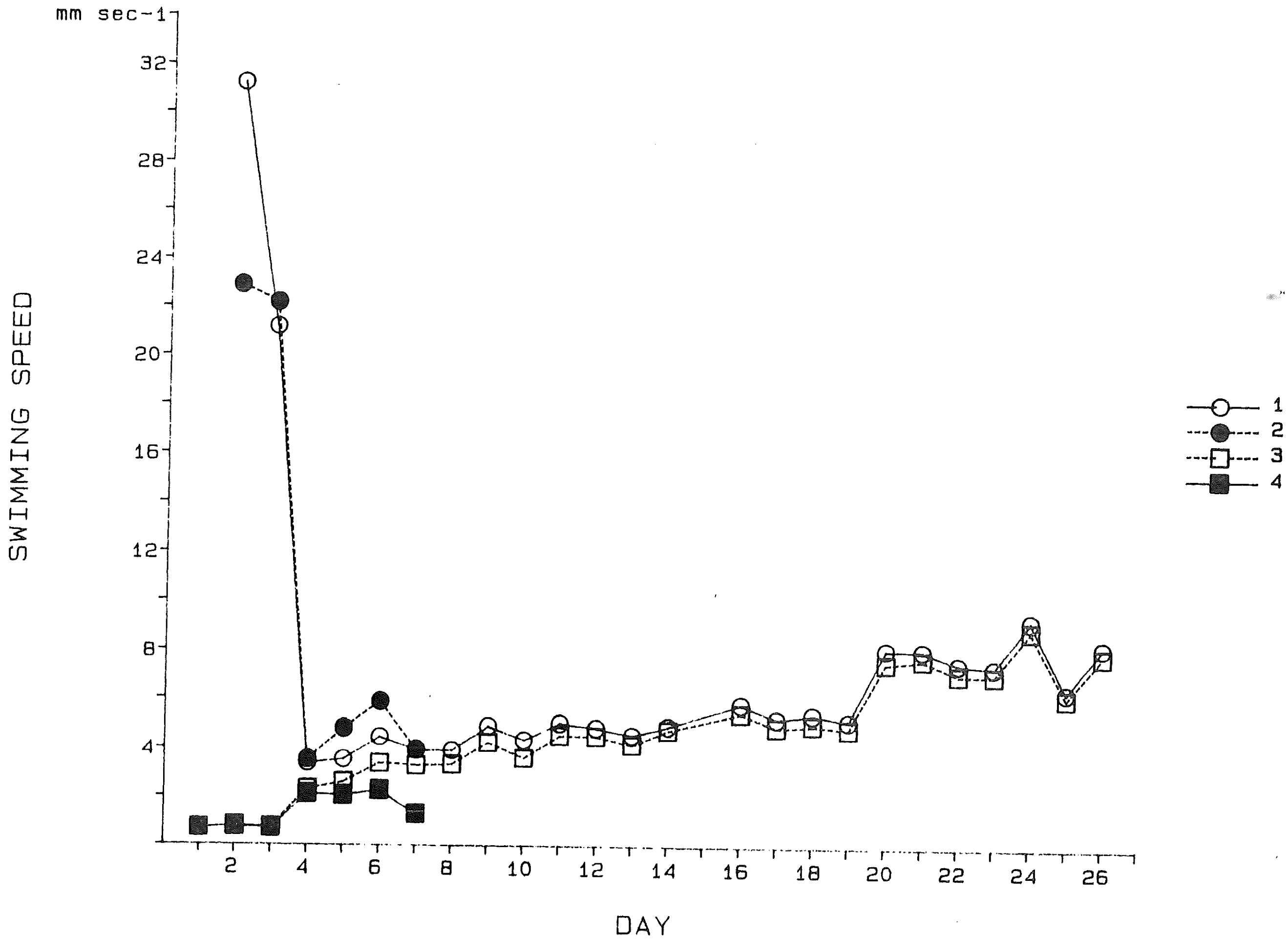

Figure 4. Swimming speeds. 1) Activity period mean swimming speeds of feeding larvae. 2) Activity period mean swimming speeds of starving larvae. 3) Total mean swimming speeds of feeding larvae. 4) Total mean swimming speeds of starving larvae.

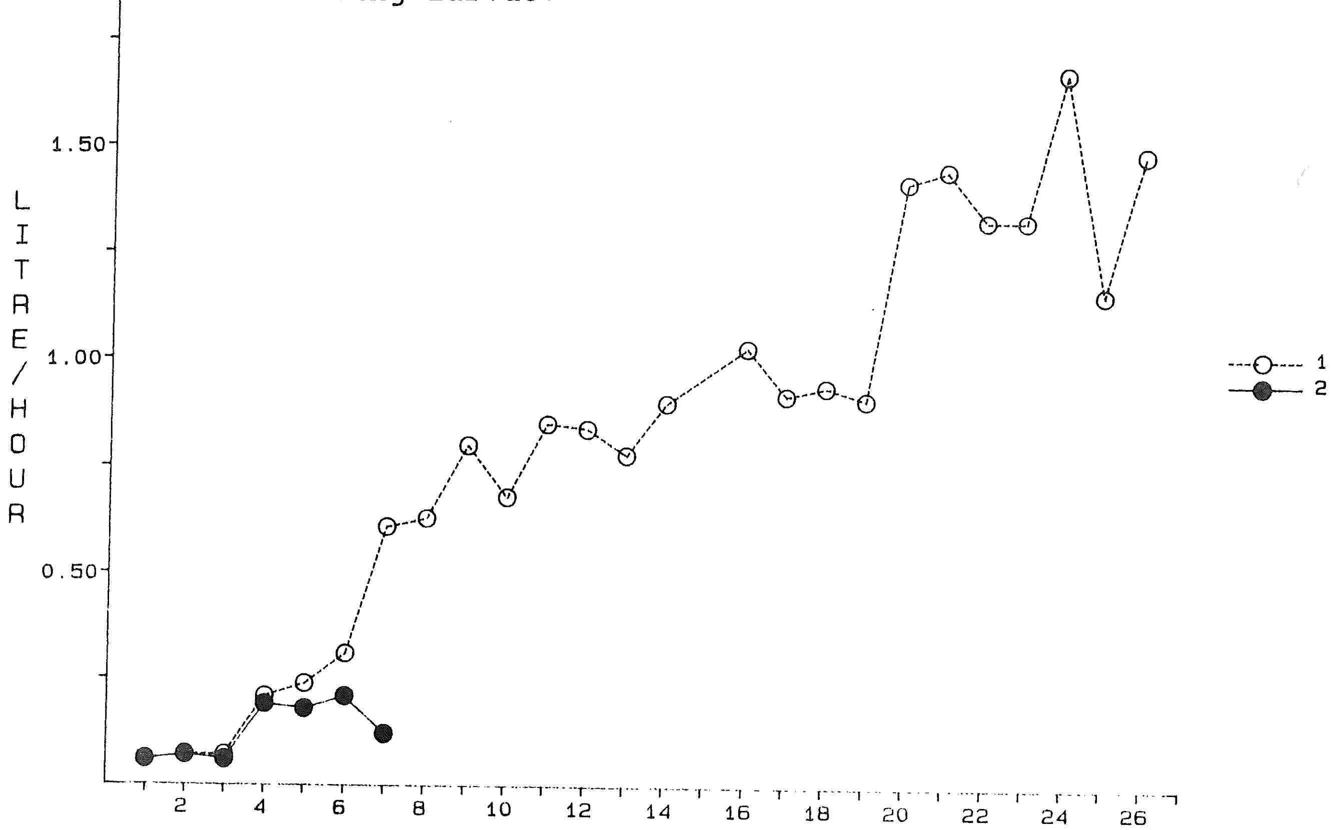

Figure 5. Search volume. 1) Mean search volume of feeding larvae. 2) Mean search volume of starving larvae.