https://doi.org/10.24199/j.mmv.1983.44.16 30 June 1983

LABORATORY OBSERVATIONS ON THE VISUAL ATTACK OF THE SQUID, *TODARODES PACIFICUS*

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Abstract

Observations on the visual attack of the squid, *Todarodes pacificus*, were made in concrete holding tanks. A 35 mm SLR camera with a motor drive recorded the squid visual attack. Using sardine fillet attached to a monofilament nylon or to the plastic body of a jig as bait, the attacks observed were fast and continuous which terminated with the squid grasping the bait with its arms. As observed also in other cephalopods (*Sepia, Illex* and loliginid squids) by other workers, prey capture using the arms instead of the tentacles were exhibited when the prey was stationary or slow moving. This similar behavior exhibited by *T. pacificus* may also be due to the slow introduction of bait into the tank. This behavior may be verified in actual squid fishing operations where the hauling speed of the jigging machine is reduced. Seizure of the jigs using the arms may lessen the chances of the hooked squid lost off the jig.

Introduction

Information on the visual attack of the squid may help in the design of the jigs. Murata (1978) reported a problem in jig fishing for the squid, *Ommastrephes bartrami* locally called "baka-ika" or "aka-ika". During rough weather, hooked squids are often lost off the jigs when brought out of the water. This may account for a considerable loss in the fishing operation. The cause of the loss of hooked *O. bartrami* was not clearly known. Both *Todarodes pacificus* and *O. bartrami* are ommastrephid squids and appear to have close ecological similarities. If their mode of life is not very different then their attack behavior also may be closely related. Information on the attack behavior of *T. pacificus* may thus be used to help understand the problem with fishing for *O. bartrami.*

Observation on locomotion on a closely related squid, *Illex illecebrosus illecebrosus*, were made by Bradbury and Aldrich (1969). Working with confined squid they analyzed general locomotions such as "lift-off", hovering, free swimming and turning. Williamson (1965) also made general observations on *I. illecebrosus* in Newfoundland waters. His work analyzed swimming, reconnaisance and attack, color and behavior of the squid after capture. Messenger (1977) reported details of the attack or "prey capture" in the cuttlefish *Sepia*. Messenger divided the attack into three phases: (1) *attention*, turning of the body axis towards the prey which may be accompanied by changes in body coloration, (2) *positioning*, an approach towards the prey till it is at attacking distance where it pauses for up to 10 seconds, and (3) *strike*, the whole animal lunges forward slightly and the tentacles are ejected at high speed to seize or capture the prey. Kier (1982) described the attack behavior of *Loligo pealei* and *L. plei* in the laboratory in his study of the musculature of squid arms and tentacles. He divided the attack pattern into three phases as employed by Messenger (1977).

First hand information on squid attack behavior in the natural environment and the results on aquarium studies by other workers will be referred to for comparison with observation presented here on *T. pacificus.*

Materials and Methods

General observations on the attack behavior of *T. pacifica* were taken from squids in concrete holding tanks of the Hokkaido Hakodate Fisheries Experimental Station, Hakodate, Japan, while the author was developing maintenance technique for squid in laboratory confinement (Flores, *et al.*, 1976, 1977). Detailed observations were made in summer of 1978 using squids in the holding tanks which were later used in the simultaneous discrimination tests for light intensity and color (Flores, 1983).

Feeding of squid in confinement allowed repeated observations on its visual attack on the bait introduced. The squids were maintained in concrete tanks (230 cm × 180 cm × 120 cm) and

fed daily with sardine fillets. With this size of tank, the bait when introduced can be seen from all parts of the tank.

The squid visual attacks were recorded using a 35 mm SLR camera with a motor drive where the maximum film advance was at five frames per second. Using this method, a rough estimate of the squid attack speed can be calculated. Daily observations were noted during feedings and are included here in describing the attack behavior of *T. pacificus*.

Results

General swimming behavior. Healthy squids maintained in laboratory confinement when not disturbed swam quietly back and forth or moved from one side of the tank to the other without hitting the walls. Most animals spent considerable time just hovering or suspended at mid-water depth with little forward and backward movements. The arms and tentacles were "relaxed" and drawn together, but not tightly (Figure 1). The fins beat with a short vertical motion and at times a horizontal component was also present which took the form of a wave moving headward at the periphery of the fins.

Strong dorso-ventral beating of the fins together with jet propulsion were observed when a squid moved away from a disturbance such as the quick introduction of a scoop net into the tank or the sight of an attacking squid. When the disturbance was great, the escape was in most cases accompanied by a release of ink. During the escape, which was fin first, the arms and tentacles were drawn tightly together to form a cone. This was presumably to reduce the drag force.

Weak squids either constantly hit the plastic sheet bumper lining the walls of the holding tank or settled to the bottom. These behaviors were discussed in detail in previous papers (Flores *et al.*, 1976, 1977).

Feeding. The squids described in Flores *et al.* (1976) that were subjected to a 10-day survival test without feeding immediately began to feed on sardine fillets when first introduced on the 11th day. Attacks were fast and the detailed movement could not be resolved by the unaided eye. The same fast attacks were also observed when the plastic body of a squid jig was introduced. Squids with empty stomachs seized any object smaller than itself when presented.

Squids used for behavioral studies (Flores *et al.*, 1978, Flores 1983) were fed with sardine fillets on the second day after being transported from the fishing boats to the holding tanks in the laboratory. The same fast attacks were also observed for these squids.

Analysis of the visual attack. The fast and continuous attack was the most commonly

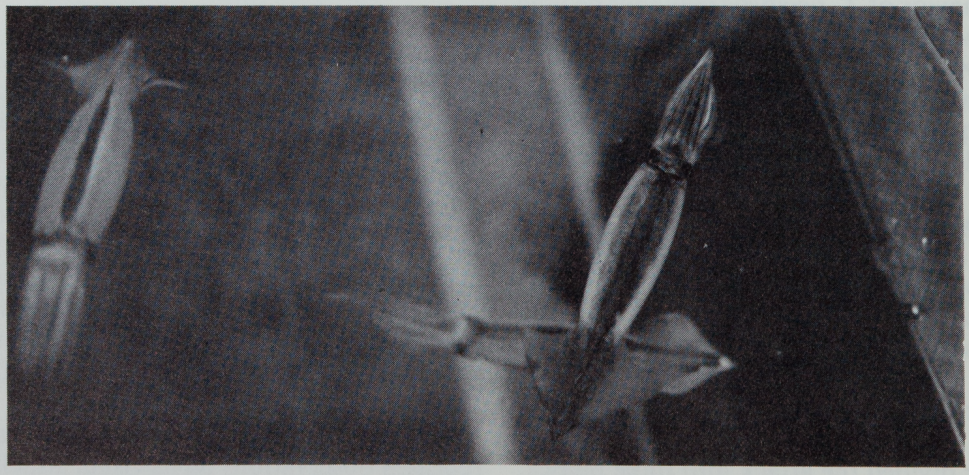


Figure 1. Squid, *Todarodes pacificus*, after six days in confinement shown undisturbed.

observed attack behavior. The components of this attack was (1) attention, (2) approach and (3) seizure. Attention was shown when the squid turned towards the direction of the bait. The yawning plane was horizontal when the squid was at the same level with the bait. When the bait was either above or below the swimming level of the squid, horizontal and vertical components were observed. In most cases, attention was accompanied by a display of dark body coloration and the arms and tentacles were drawn tightly together to form a cone. In this posture, binocular vision was attained when the eyes converged towards the body axis.

The approach started when the squid swam head first towards the bait. Figure 2, frame A shows the squid at the end of its approach to a bait attached to the lower portion of the plastic body of a squid jig. The arms and tentacles are still drawn tightly with the eyes directed towards the bait. During a tail first approach, a squid usually swam obliquely towards the bait, passed it by about 40 cm and then went back head first for the seizure.

Seizure started when the tentacles were spread laterally (Figure 2, frame B). The distance between the bait and the tip of tentacles at this moment varied. In this Figure, the tentacles with suckers exposed were extended laterally without touching the bait while the arms were opened (frames C and D) for the seizure. The tentacles appeared to cover the lateral escape of the bait as they would probably do in nature with a live bait. The bait was then seized using the arms and brought to the oral region. Once the bait was secured by the arms the tentacles were relaxed but not retracted (see also Figure 3 frame B and 4 frame D). Seizure took about 0.8 to 1.2 sec depending on the distance between the squid and bait at the start of seizure. In Figure 2 the mantle length of the squid is about 20 cm. The attack speed calculated here at frame interval of 0.2 sec, would be roughly 50 cm/sec.

When the bait was secured in the oral region, the squid started to retreat with strong dorsoventral beating of the fins (see Figure 5, frames F to J). In most cases the dark body coloration

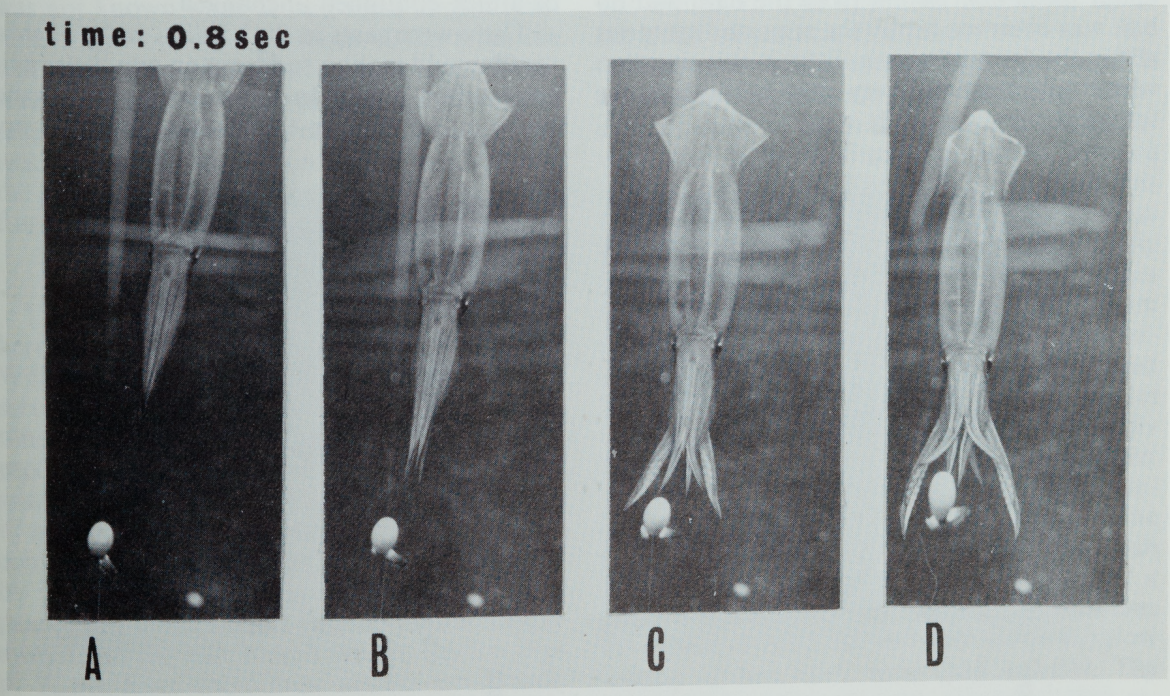


Figure 2. Squid attacking a bait attached to jig. A sequence of postures clearly showing binocular vision.

disappeared leaving only a dark streak extending from mid-dorsal to the tip of the fins. Using the film advance speed of the motor drive as reference, a squid attack took about 3 to 4 sec depending on the distance of the squid from the bait at start of approach and at start of seizure.

Although the majority of attacks fit the fast and continuous description some showed slight variation. An example of one variation is shown in Figure 3 where the arms were spread wide open in all directions like an open umbrella. In this type of seizure, the bait passed the arms and hit the oral region before the arms closed. This probably represents a case where the distance to the bait was not clear to the squid. Again, in this type of seizure, the tentacles were not used.

Figure 4 shows part of a sequence of attack postures similar to Figure 2 except for the start of seizure (frame B) which was very close to the bait. The variations in distance of squid to bait at start of seizure suggests that the determination of distance was approximated within a given range. No seizure started at a distance of about more than 20 cm from the bait, and no bait was observed hit by the arms and tentacles still in the form of a cone. Even in this situation where seizure started very close to the bait, the tentacles were not used.

A sequence of postures in Figure 5 shows clearly the eyes of the squid directed to the bait maintaining binocular vision at seizure (frames A to E). With the bait secured by the arms, the squid shift back to monocular vision (the eyes at laterally directed position) while starting to retreat with strong dorso-ventral beating of the fins (frames F to J). In this Figure, the squid seized first the body of the jig with its arms and then the lower end of the jig where the bait was attached was turned towards the oral region (frames H, I, J). The body of the jig was held close after contact and then tightly which may be due to the presence of the natural bait at the lower end of the jig.

Figure 6 shows two squids attacking the same bait from one direction. The presence of a second squid attacking the same bait did not disturb the attack pattern. Other similar attacks would be two squids approaching the same bait at right angles to each other. The attack pattern could be disrupted while a squid was still approaching the bait, but once the seizure phase began, even if the bait was moved, the direction of attack continued unchanged.

There were cases in the holding tanks where a squid would make a sudden stop or a pause as it approached a bait. In rare cases a squid would make a full stop in the middle of a fast ap-

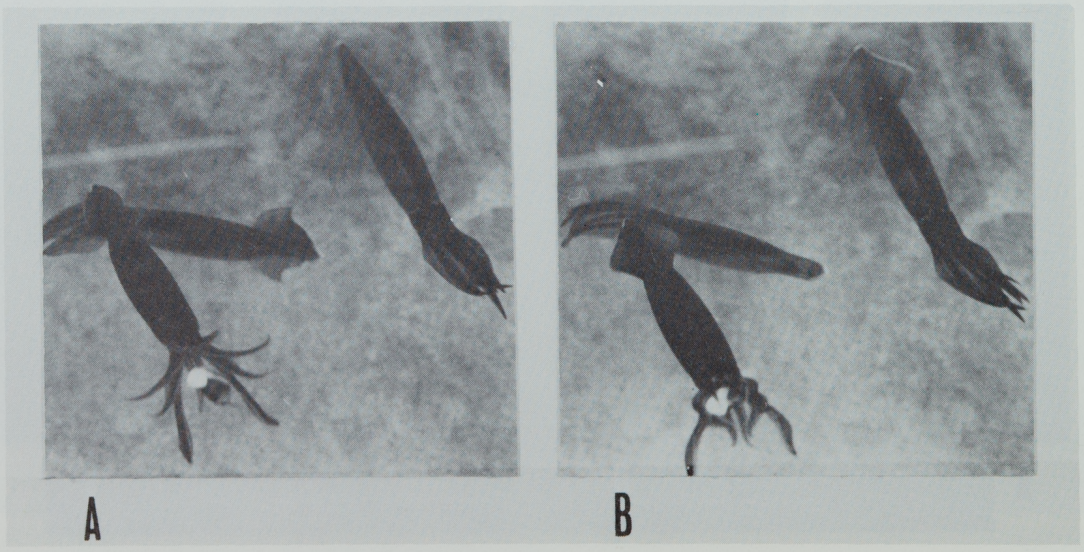


Figure 3. A fast and continuous attack with arms spread out in all directions at seizure.

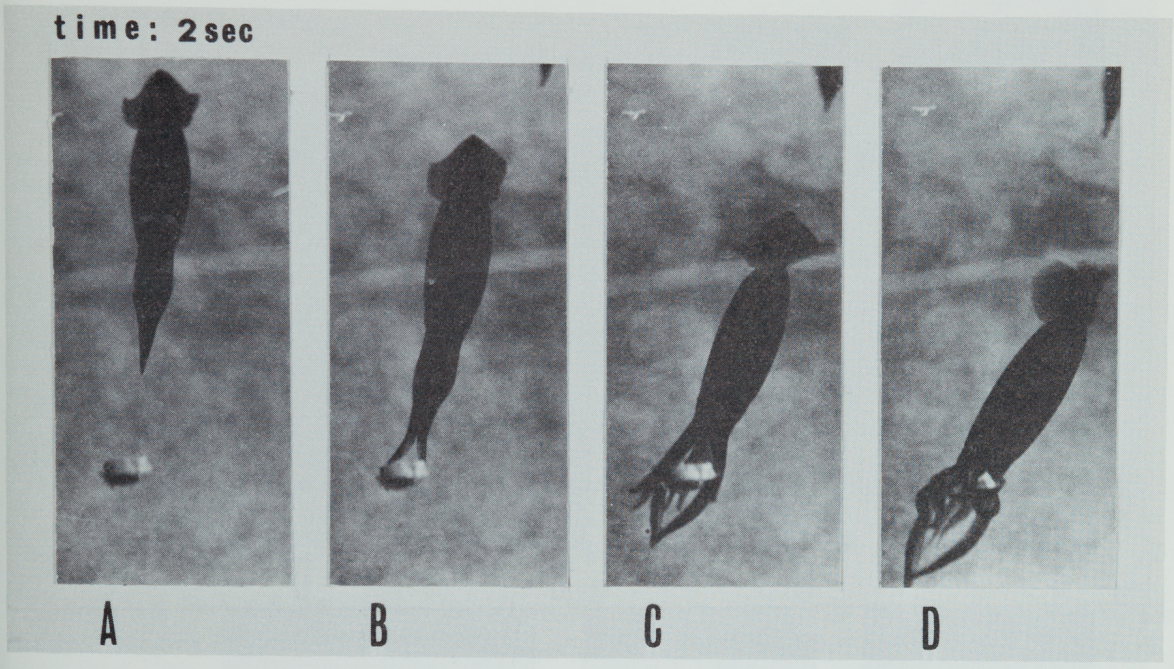


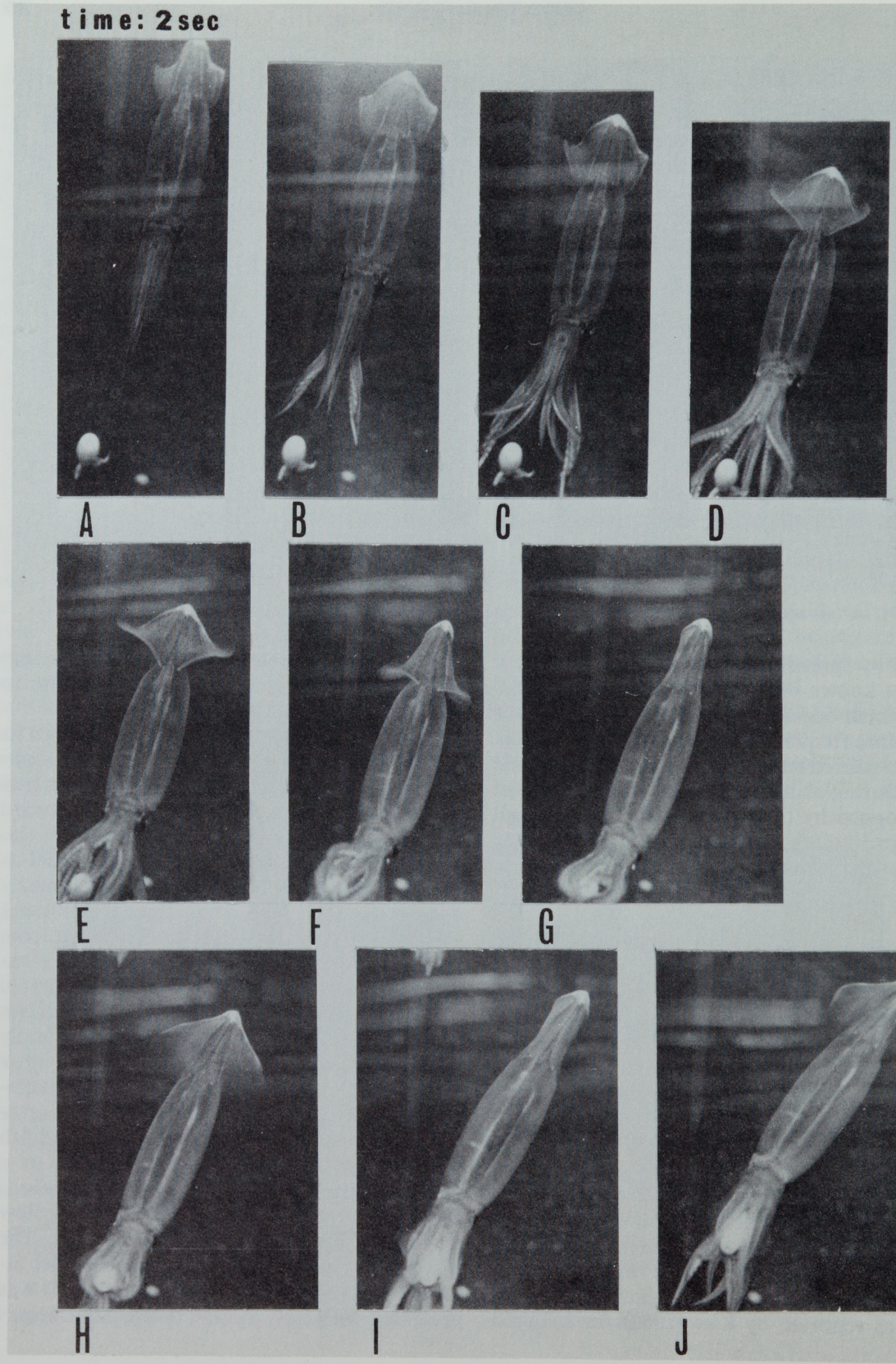
Figure 4. A fast and continuous attack with tentacles starting to spread at bait position, Frame B.

proach by spreading all its arms wide open. It was not known what caused these abrupt reactions which occurred at about 40 cm from the bait. More frequently, when a new form of bait was introduced for the first time, a squid would pause during a slow approach. This movement was stopped by the action of the fins and not the arms, though it may have been aided by the funnel which was not visible from above.

Discussion

The general swimming behavior observed here was the same as those described by Williamson (1965) for *Illex*. Williamson observed multiple squid attacking a jig at the same time and also a case where the squid approached the jig tail first and then turned to seize the jig after passing it. He called this type of approach a "reconnaissance". The approach component of attack was called "positioning" by Messenger (1968) since his *Sepia* always paused at a distance less than its mantle length away from the bait before seizure. In the case of *T. pacificus* where most attacks were made without a pause before seizure this component is best termed as "approach". Similar observation was reported by Kier (1982) for loliginid squid where also the pause before seizure was not exhibited. The approach continued up to the point of tentacle ejection.

Messenger (1968) reported that *Sepia* used its arms when catching slow moving crabs. However, in order to catch live prawn, the tentacles were used by projecting them rapidly forward ahead of the arms. Kier (1982) described this final phase of the attack for loliginid squid as when the tips of the tentacles are approximately 4 to 6 cm from the prey, the squid lunges towards the prey, the arms are flared out from the previous cone, and the tentacles are extended rapidly. However, Kier further stated that when the prey is stationary, the tentacles are sometimes not used and the squid simply lunge forward and grasp the prey with their arms. Bradbury and Aldrich (1969) in maintaining *Illex illecebrosus* reported the same behavior when feeding the squid with dead fish (*Mallotus villosus*) suspended by means of a monofilament nylon line. Similar observations were made here for *T. pacificus* where the slow sinking sardine fillets were used as baits. The plastic body of the jig with a sardine fillet attached at its lower portion (Figures 2 & 5) was presented with slow up and down movement.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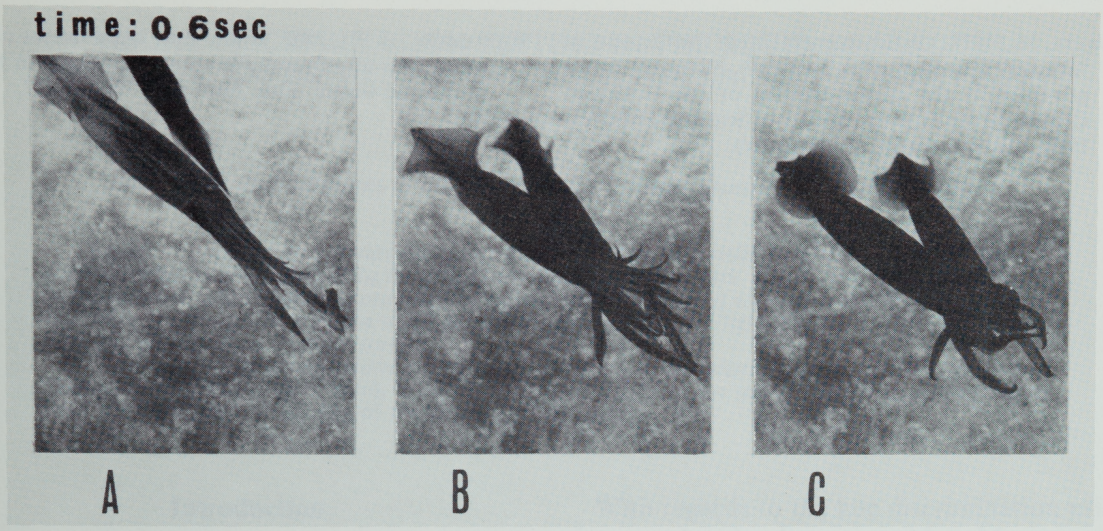

Figure 6. Two squid attacking the same bait from the same direction.

Out of the 175 squid observed in the present study, only one was observed to seize the sardine fillet with its tentacles. In this case, the tentacles were ejected at about the time the tentacles were spread laterally just prior to seizure. As in *Sepia*, the tentacles were ejected together and parallel. The suckers on the tentacle clubs seized the bait which was then brought to the oral region.

Seizure of the jigs using the arms may lessen the chances of the hooked squid lost off the jig. Four pairs of arms produce a better hold than a pair of tentacles. From the findings in this present study, arm seizure is exhibited when the bait or prey is slow moving. This behavior may be verified in actual fishing operations where the hauling speed of the jigging machine is reduced.

Acknowledgement

I thank Dr S. Igarashi and T. Mikami of the Faculty of Fisheries, Hokkaido University for their encouragement and assistance. I also thank the Director and Staff of the Hokkaido Hakodate Fisheries Experimental Station for the facilities. I am most grateful to Drs C. Roper and R. Hanlon for their valuable suggestion and criticism. This work was supported in part by a Japanese Ministry of Education Scholarship.

Figure 5. Squid attacking a bait attached to jig. A sequence of postures showing binocular vision at seizure (Frames A to E) and shifting to monocular vision at retreat (Frames F to J).

References

Bradbury, H. E. & Aldrich, A., 1969. Observations on locomotion of the short-finned squid, *Illex illecebrosus illecebrosus* (Le Sueur, 1981) in captivity. *Canadian J. Zool.* 47: 741-744.

Flores, E. E. C., Igarashi, S., Mikami, T., & Kobayashi, K., 1976. Studies on squid behavior in relation to fishing I. On the handling of squid, *Todarodes pacificus* Steenstrup, for behavioral study. *Bull. Fac. Fish. Hokkaido Univ.* 27: 145-151.

Flores, E. E. C., Igarashi, S., & Mikami, T., 1977. Studies on squid behavior in relation to fishing II. On the survival of squid, *Todarodes pacificus* Steenstrup, in experimental aquarium. *Ibid.* 28: 137-147.

Flores, E. E. C., Igarashi, S., & Mikami, T., 1978. Studies on squid behavior in relation to fishing III. On the optomotor response of squid, *Todarodes pacificus* Steenstrup, to various colors. *Ibid.* 29: 131-140.

Flores, E. E. C., (this volume). Visual discrimination testing in squid, *Todarodes pacificus*: Experimental evidence for lack of color vision.

Kier, W. A., 1982. The functional morphology of the musculature of squid (Loliginidae) arms and tentacles. *J. Morphology* 172: 179-192.

Messenger, J. B., 1968. The visual attack of the cuttlefish, *Sepia officinalis. Anim. Behav.* 16: 342-357.

Messenger, J. B., 1977. Prey capture and learning in the cuttlefish, *Sepia*. In Nixon, M. and Messenger, J. B. (eds.), The Biology of Cephalopods, 615 pp. Academic Press, London.

MURATA, M., 1978. On the regeneration of the tentacles in "aka-ika" (*Ommastrephes bartrami*). Summary report presented at the annual meeting of the Hokkaido Chapter of the Japanese Society of Scientific Fisheries, 1978, Kushiro, Japan. (In Japanese).

WILLIAMSON, G. R., 1965. Underwater observations of the squid *Illex illecebrosus illecebrosus* Le Sueur in Newfoundland waters. *Can. Field Nat.* 79: 239-247.