

Laboratory Studies of Shrimp Tolerances to Salinity and Temperature

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Abstract

Two types of study—24-hour survival and 30-day growth—have been used to test the combined effects of salinity and temperature upon acclimated grooved postlarval penaeids (brown or pink shrimp). The 24-hour survival tests, conducted over ranges of 45 to 98F and 2 to 40 parts per thousand (ppt), indicated that postlarvae had wide tolerance limits to both factors. One hundred per cent of the postlarvae survived all combinations of 68 to 90F temperatures with salinities of 5 to 37 ppt. However, 100% mortality occurred at salinities of 5 ppt or below when temperatures were above 95F or below 60F.

Survival in growth studies using four temperature levels (52, 65, 77, and 90F) combined with five salinities (2, 5, 15, 25, and 35 ppt) was quite similar to that seen in the 24-hour work except for somewhat greater mortality at 90F. Postlarvae held at 2 ppt died within 20 days at all temperatures below 90F. The greatest observed growth of 1.0 to 1.1 mm per day was attained by postlarvae held at 90F. Postlarvae at 77F grew approximately 0.8 mm per day and those at 65F only 0.3 mm per day. Essentially no growth was observed in postlarvae held at 52F. Measurement of food intake indicated that rapid growth required 2 to 3 grams of food for each gram increase in weight.

Survival data indicate that these grooved postlarval penaeids were able to withstand wide fluctuations of both salinity and temperature. Growth also occurred within a wide salinity range, but was restricted to a much narrower temperature zone than that at which good survival was observed. Although growth rate was apparently affected more by temperature than salinity, higher salinities may be more favorable than lower ones as the temperature limits are approached. Both the tolerances and the food requirements would seem to be of considerable importance to the animals in the estuarine phase of its life history.

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Effects of Light and Moon Phase on the Behavior of Pink Shrimp¹

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Abstract

This particular study deals with responses of the pink shrimp to light of low

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intensity. Two separate patterns were found and described. The first was a response to the light which appeared as a simple attraction of the shrimp to the light. This was measured by determining the percentage of tested animals that moved toward the light. The second pattern was concerned with the strength of the attraction of the animals to the light. This was measured by determining the percentage of specimens that were able to cross a standard obstruction to get to the light.

INTRODUCTION

SCIENTISTS and commercial shrimp fishermen have been concerned with the effects of light on shrimp for a long time. Science is interested in the academic implications of the problem, while the fishery is interested in the economic aspects.

Many reports are available showing the effects of light on different marine animals, and others show the effects of moon phase on the biology of other animals. However, nothing is available to show the effects of naturally cyclic phenomena on the photic behavior of the pink shrimp, *Penaeus duorarum* Burkenroad. This paper presents the results of preliminary work to define the photic response of the pink shrimp as correlated with various natural phenomena.

The studies were conducted on dark-adapted specimens of *P. duorarum* measuring from 60 to 80 mm between the leading edge of the blades and the spine of the telson. The light used in the experiment was a white beam with about 2% divergence and an intensity of 0.3 foot-candles for the first phenomenon studied and 1.1 foot-candles for the second phenomenon. The light-beam was horizontal.

The two phenomena just mentioned were separated statistically from a common procedure, and both were easily observed as separate phenomena. The first of these was termed "photoactivation" and was measured by the percent of a sample of specimens that was activated toward the light source when exposed to the light. The second of these phenomena was called "phototactic drive" and was measured by the percentage of activated specimens that passed a standard obstruction (an AC field) while attempting to reach the light source. Photoactivation can be thought of as the degree of response, and phototactic drive can be pictured as the force of the motivation once the response has occurred.

A general picture of the technique should help clarify the distinction between photoactivation and phototactic drive. Specimens were tested individually according to the following scheme: (1) The specimen was placed at the end of a long trough and exposed to the light entering the opposite end of the trough. (2) The shrimp was allowed a two minute time limit to respond to the light. If the animal moved toward the light within this time, a rating of "active" was recorded; if the animal did not move within the time limit, a rating of "inactive" was recorded. The specimen was then removed from the trough. (3) As the "active" animal moved down the trough, it encountered the AC field that completely obstructed the pathway. If the animal moved through the AC field, a rating of "passing" was recorded; if not, a rating of "not passing" was recorded. All specimens were removed after their contact with the AC field.

RESULTS

Movement of the shrimp toward the light source was studied and consequently attributed to the existence of a positive phototaxis rather than to the result of random movement. Although this conclusion was based on

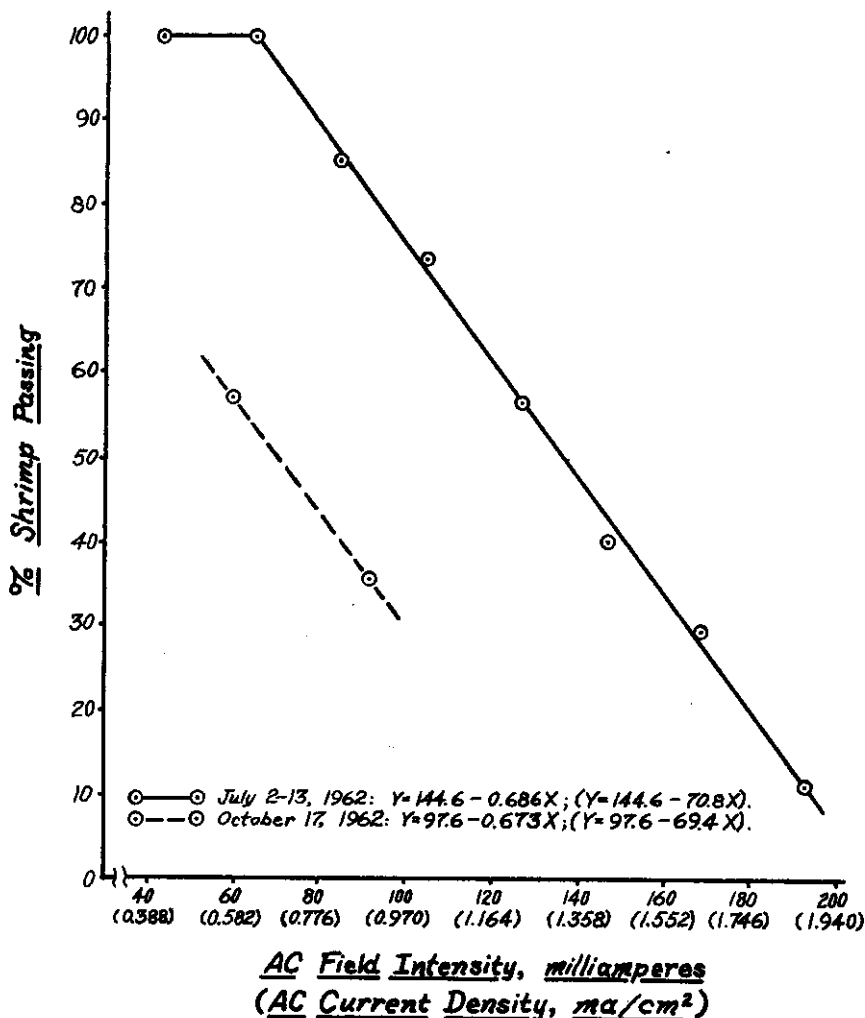


FIG. 1. Per cent of activated specimens of *P. duorarum* passing through the AC field (when attracted by a light of 1.1 foot-candle intensity) for various field intensities tested in early July and in mid-October. All information in parentheses pertains to expression of the data in terms of current density. The per cent passing is an indication of the intensity of the phototactic drive of the animal.

statistical analysis, the difference is evident on a purely observational basis.

The response of the activated specimens to the AC field was proportional to the intensity of the field within a narrow range. Fig. 1 is the curve of this relationship.

No differences in photoactivation or phototactic drive were found between the sexes. Size of the specimens did play an important part in the photic responses of the shrimp. Fig. 2 shows that photoactivation was greatest in

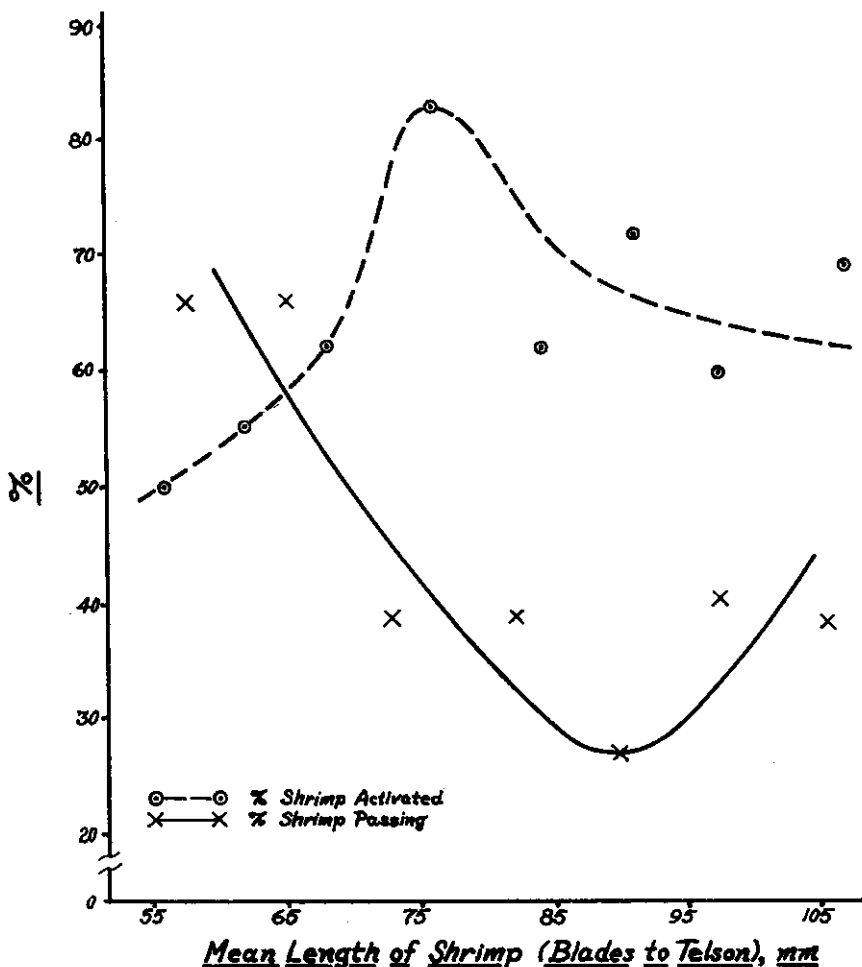


FIG. 2. Effects due to size of *P. duorarum* on (1) the per cent of tested specimens activated to a phototactic state by 0.3 foot-candle light within two minutes after the beginning of the test and on (2) the per cent of activated specimens passing through the AC field when attracted by light of 1.1 foot-candle intensity. This per cent passing is an indication of the intensity of the phototactic drive of the animal.

specimens measuring 75mm from blades to telson, while the phototactic drive was least in 90mm specimens.

The effects of the naturally cyclic phenomena were studied and some significant results were obtained. The photoactivation of the shrimp was lowest during the times of the nocturnal low tides; this is shown in Fig. 3. Phototactic drive, however, was significantly higher during the times of the nocturnal low tides, as seen in Fig. 4.

Moon phase had a significant effect on the photoactivation of the shrimp.

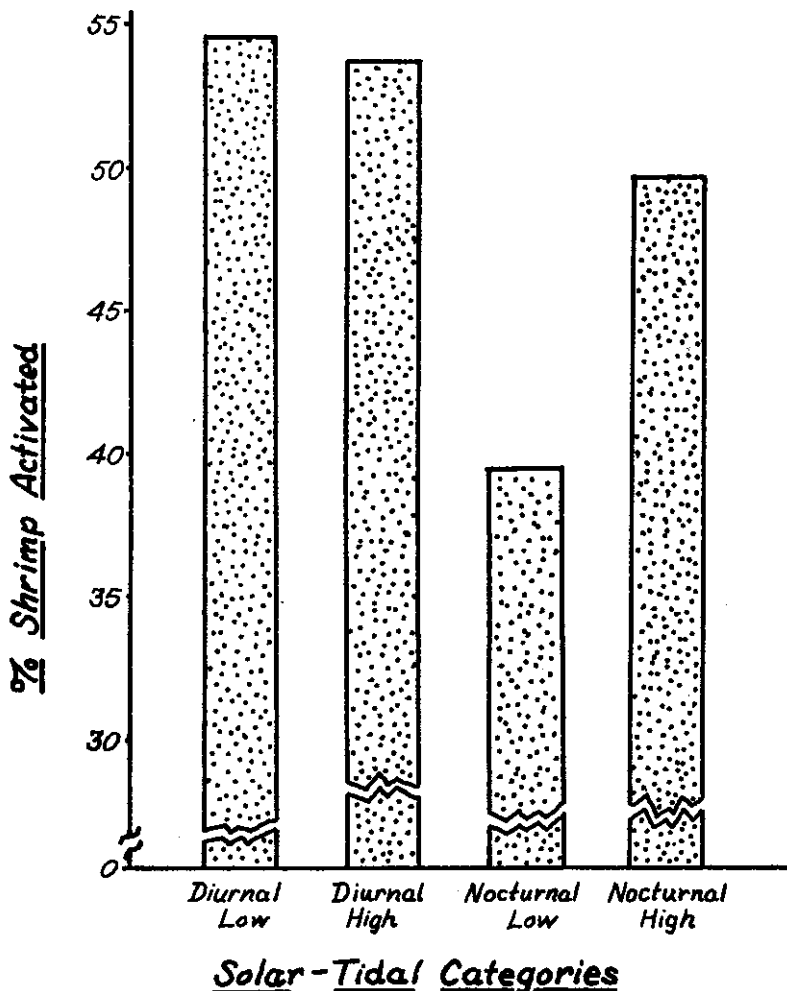


FIG. 3. Solar-tidal variations in the per cent of tested specimens of *P. duorarum* activated to a phototactic state by 0.3 foot-candle light within two minutes after the beginning of the test.

Maximum photoactivation was observed during the full moon, and the minimum was observed during the new moon. This is shown in Fig. 5. Variations in phototactic drive with respect to moon phase were not significant, but the trend is presented here as Fig. 6 to complement the studies.

Photoactivation was found to be at a maximum at about noon and at a minimum at about 2000 hours; see Fig. 7. Phototactic drive was maximum at about 0200 hours and minimum at about 1400 hours. Fig. 8 shows this.

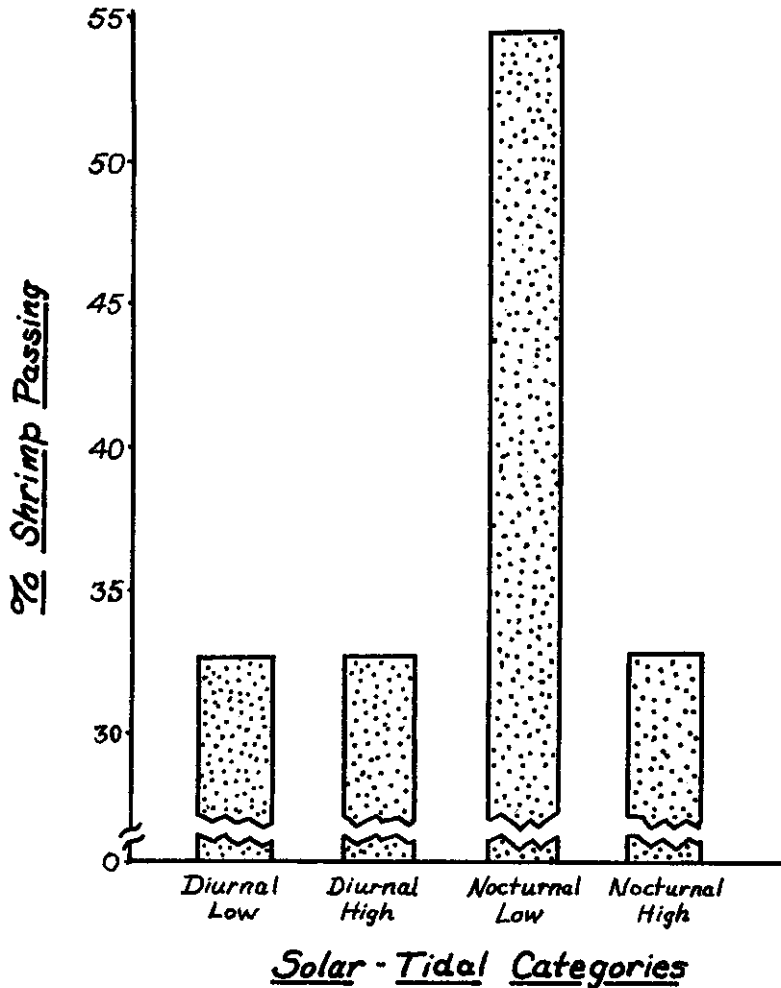


FIG. 4. Solar-tidal variations in the per cent of activated specimens of *P. duorarum* passing through the AC field when attracted by light of 1.1 foot-candle intensity. This per cent passing is an indication of the intensity of the phototactic drive of the animal.

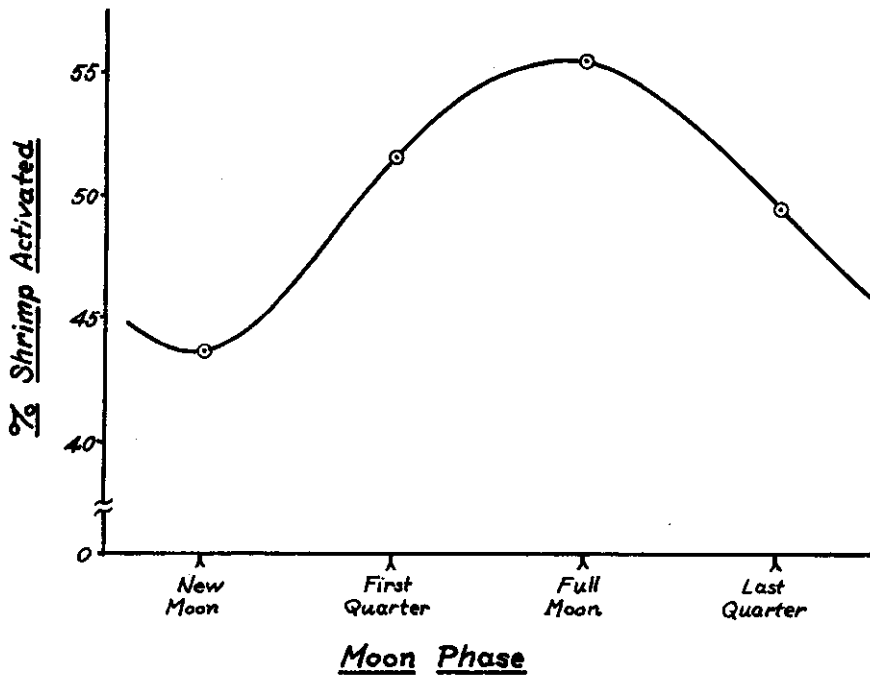


FIG. 5. Lunar variations in the per cent of tested specimens of *P. duorarum* activated to a phototactic state by 0.3 foot-candle light within two minutes after the beginning of the test.

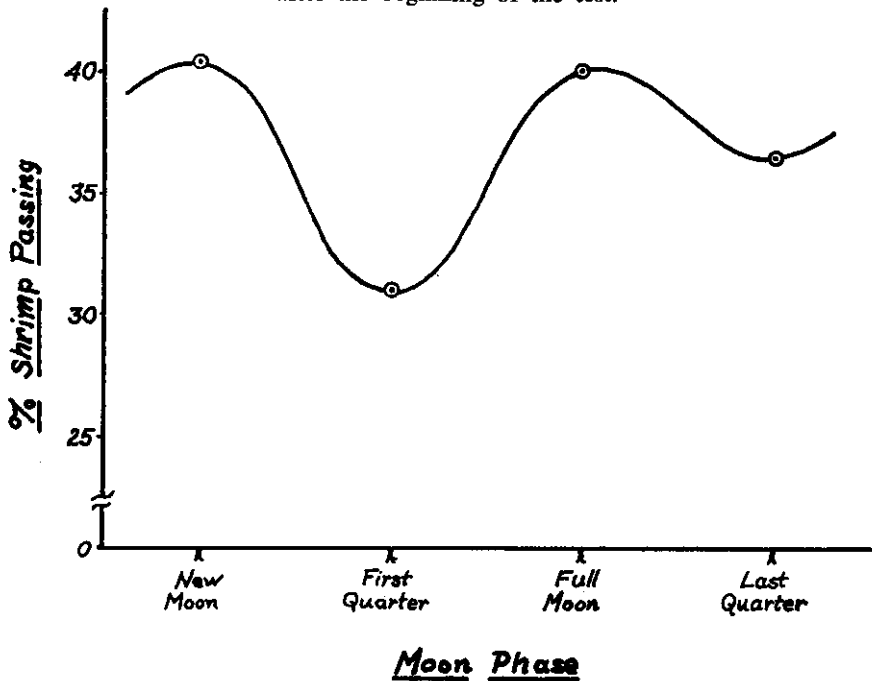


FIG. 6. Lunar variations in the per cent of activated specimens of *P. duorarum* passing through the AC field when attracted by light of 1.1 foot-candle intensity. This per cent passing is an indication of the intensity of the phototactic drive of the animal.

Significant tidal effects were not observed for photoactivation, but phototactic drive was found to be higher during low tides than during high tides.

It might appear on first observation that the two phenomena treated in this study are inseparable. Attempts to correlate the values for these phenomena, however, showed that they apparently operate independently. The correlation coefficients for the two phenomena for various times of day are as follows: about 0200, -0.94 ; about 0800, -0.92 ; about 1400, -0.82 ; and about 2000, -0.33 .

DISCUSSION

The two phenomena treated in this study are separable, and no definable association could be found. The significance of the phenomena is not clear; at present no biological significance could be assigned to the pattern described in this study.

It might be speculated that the phenomenon of photoactivation has its origin in the channeling of the optic nerve impulse to the locomotory appendages. Variations in photoactivation might possibly stem from variations in the intensity of the optic nerve impulse; such variations in impulse intensity were reported in five species of beetles by Jahn and Crescitelli (1940). Variations

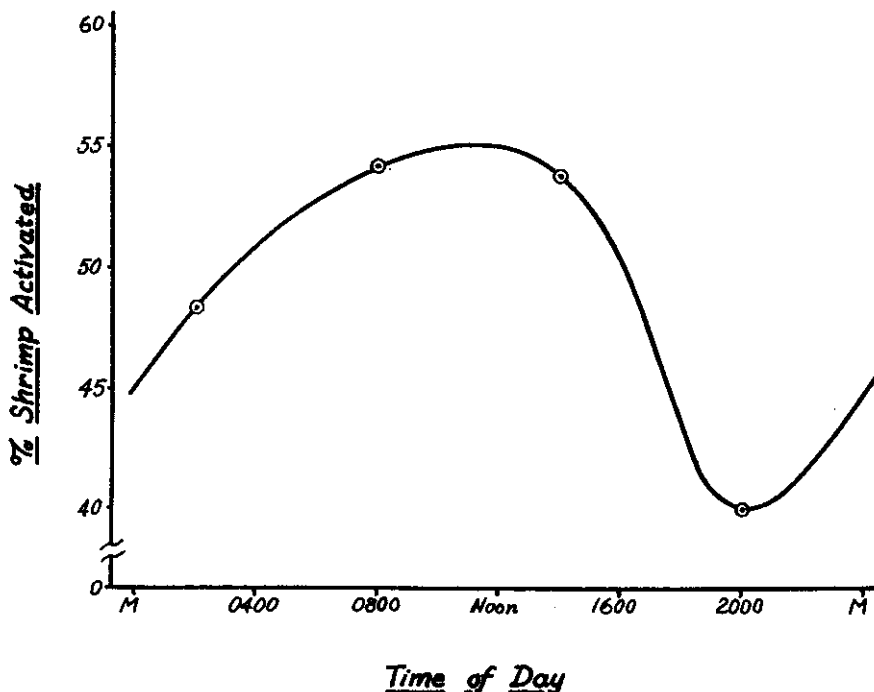


FIG. 7. Solar variations in the per cent of tested specimens of *P. duorarum* activated to a phototactic state by 0.3 foot-candle light within two minutes after the beginning of the test.

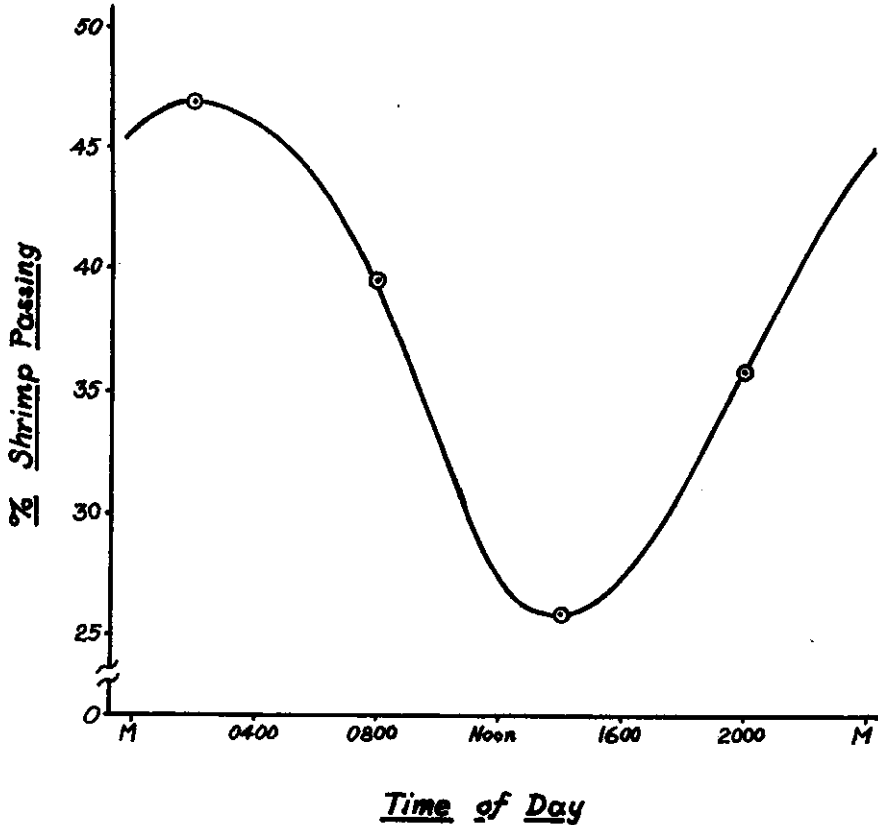


FIG. 8. Solar variations in the per cent of activated specimens of *P. duorarum* passing through the AC field when attracted by light of 1.1 foot-candle intensity. This per cent passing is an indication of the intensity of the phototactic drive of the animal.

in the impulse intensity probably result from variations in the amount of light stimulating the photoreceptors of the eye. Variations in the amount of light reaching the photoreceptors might result from variations in the positions of the various eye pigment cells of the shrimp eye. Bennitt (1932), Horstman (1935), Kleinholz (1937), and Welsh (1930, 1935, 1936, and 1938) have reported rhythmic migrations of eye pigment cells in various arthropods, some of which were decapod crustacea.

Phototactic drive variations can best be explained in terms of the concept of Specific Action Potential (SAP). SAP is, as the name implies, the potential for an organism to react in a specific way to the appropriate stimulus. This potential is a function of the physiological state of the animal. Variations in phototactic drive probably stem from variations in the SAP for phototactic drive, which in turn stem from rhythmic variations in the physiological state of the animal.

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