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SEASONAL VARIATIONS OF LUMINESCENCE IN PHOTOPHORES OF *PORICHTHYS NOTATUS* (TELEOSTEI : BATRACHOIDIDAE)

by

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SUMMARY

The present observations demonstrate the seasonal variation of luminescence in light organs isolated from the epipelagic fish *Porichthys notatus.* The light production is maximal at the end of the summer and at the beginning of the autumn; it is minimal during the winter. This fish breeds in the summer (from June to August). The role of the bioluminescence in courtship and nestguarding by the male is discussed.

Variations saisonnières de la luminescence des photophores de *Porichthys notatus* (Teleostei : Batrachoididae)

RÉSUMÉ

Les présentes observations décrivent la variation saisonnière de la photogénèse des organes lumineux isolés du poisson épipélagique *Porichthys notatus.* La production de lumière est maximale à la fin de l'été et au début de l'automne; elle est minimale durant l'hiver.

Ce poisson se reproduit en été (de juin à août). Le rôle joué par la bioluminescence dans l'accouplement et dans la garde du nid par le mâle est discuté.

INTRODUCTION

Porichthys notatus is very common in the shallow waters of the Californian Pacific coast during the spring and the summer (Greene, 1899). According to Warner and Case (1980) there are two geographically separated populations, but only the specimens of the southern population (from Santa Monica to San Francisco) can luminesce. These fishes are presumed to feed on the ostracod *Vargula* (Warner and Case, 1980), which are supposed to provide them luciferin, the substrate of luminescence (Tsuji *et al.*, 1971; Barnes *et al.*, 1973; Warner and Case, 1980). Although the existence of noradrenergic control of the photophore luminescence has been established (Anctil *et al.*, 1981; Gariepy and Anctil, 1983; Christophe and Baguet, 1983) all authors agree that the amplitude of the light response to noradrenaline is extensively variable among specimens.

The aim of the present work is to describe the periodic variation in the response of isolated photophores to noradrenaline.

MATERIAL AND METHODS

The observations were performed on photophores of 32 specimens of *Porichthys notatus* (standard length, 124 to 282 mm; 19 males, 8 females and 4 not sexed) air-shipped (24 to 48 hours) over a period of three years by groups of 4-6 fish (Pacific Biomarine Laboratories, Venice, California). The photophores were isolated with fine scissors and forceps on anaesthetized fish and the light response to noradrenaline was recorded with a photomultiplier (International Light) adapted to a small chamber as described previously (CHRISTOPHE and BAGUET, 1983). The light response to 1 mM noradrenaline recorded on a series of photophores isolated for the first time from a fish, corresponded to a standard light response. Such a response was a mean value calculated on the activity of 3-9 photophores. The amplitude of the light responses was corrected for the lapse of time between dissection and stimulation (CHRISTOPHE and BAGUET, 1983). From the results, a mean value is calculated on all the specimens of each sample and represented with its standard error of mean (S.E.M.).

RESULTS AND DISCUSSION

Figure 1 shows the mean value of the standard light responses of photophores isolated from specimens of *Porichthys notatus* at different periods of the year from

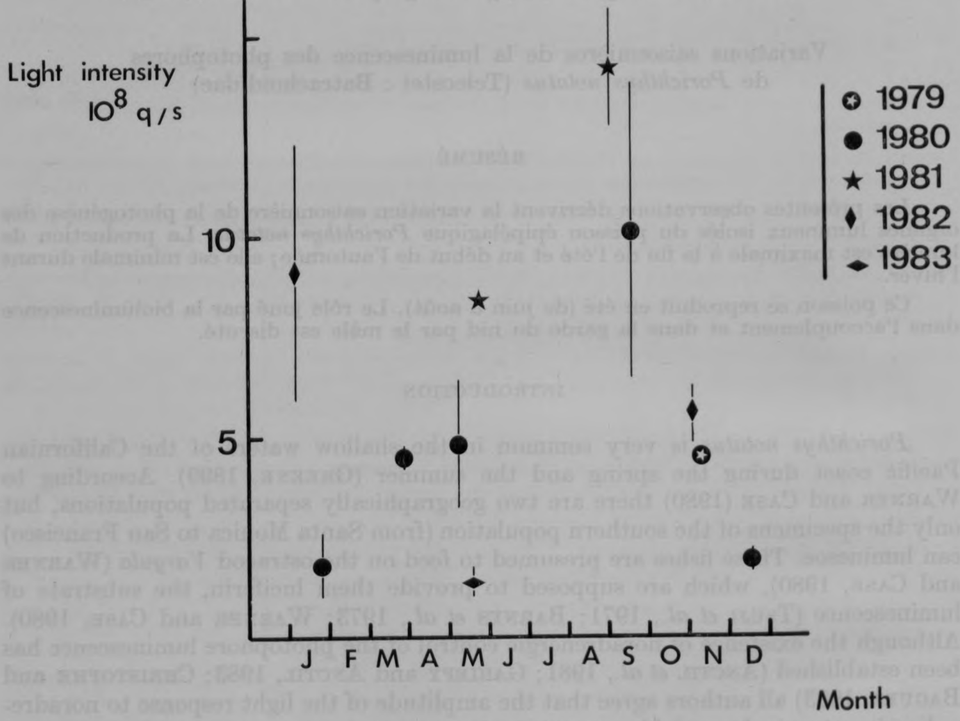

Fig. 1. — Variation in the light response amplitude of isolated photophores from *Porichthys notatus* to 10^{-3}M noradrenaline (1979 to 1983). Each point corresponds to the mean value of the light response calculated on all the specimens of each sample.

November 1979 to May 1983. Maximal amplitudes were similar in September 1980 and 1981 and minimal amplitudes were similar at the end of January 1980 and at the end of December 1980.

In 1982, we only observed two groups of fish : the response of photophores from January-specimens is high when compared with the response recorded in January from previous years. However, nothing is known about the photophores response in September 1982. Although the period of observations is restricted to

TABLE 1

Data recorded on 32 specimens of *Porichthys notatus*. Fish : numbered 1 to 32; Sex : M = male, F = female, ? = not sexed; Length : standard length in mm; Light response : maximal intensity in Mq/s; n : number of photophores used for the determination of the mean value of the light response; Month : month of capture and of experimention.

Fish	Sex	Length	Light response	*n*	Month
1	M	190	453.4 ± 42.7	9	November 1979
2	M	176	94.4 ± 10.9	9	January 1980
3	M	185	257.8 ± 36.4	9	January 1980
4	F	185	458.9 ± 28.8	3	March 1980
5	M	198	475.7 ± 87.2	3	March 1980
6	M	205	409.7 ± 30.7	3	March 1980
8	M	178	362.8 ± 14.9	3	May 1980
9	F	185	957.7 ± 21.1	3	May 1980
10	F	177	283.6 ± 112.6	3	May 1980
11	M	180	306.7 ± 95.8	3	May 1980
12	F	190	744.2 ± 99.4	3	September 1980
13	M	145	133.9 ± 25.5	3	September 1980
14	M	215	1708.1 ± 606.1	3	September 1980
15	M	252	1612.6 ± 55.4	3	September 1980
16	?	175	226.5 ± 99.6	3	December 1980
17	M	172	155.9 ± 45.5	3	December 1980
18	F	175	844.7 ± 365.9	3	May 1981
19	F	168	1195.4 ± 133.4	3	September 1981
20	F	124	1548.9 ± 187.3	3	September 1981
21	F	162	1721.0 ± 149.3	3	September 1981
22	?	147	959.8 ± 206.9	3	January 1982
23	M	154	325.4 ± 18.5	3	January 1982
24	M	172	1457.1 ± 267.2	3	January 1982
25	M	176	425.9 ± 119.8	3	November 1982
26	M	170	791.7 ± 177.9	3	November 1982
27	M	160	636.4 ± 201.5	3	November 1982
28	M	185	477.4 ± 279.1	3	November 1982
29	M	190	478.3 ± 76.6	3	November 1982
30	M	215	74.5 ± 3.0	3	May 1983
31	?	240	12.8 ± 1.8	3	May 1983
32	?	282	293.9 ± 2.9	3	May 1983

three years, one can draw a trend for a periodic variation in the amplitude of the light response which is maximal at the end of the summer or at the beginning of the autumn, and minimal in the winter. The magnitude of the light response does not seem to be dependent on the length or the sex of the specimens (Table 1).

The course of the light production does not change significantly in the three years : the values of the parameters characterizing the course are similar to the values reported for the fast light response to noradrenaline by CHRISTOPHE and BAGUET (1983). *Porichthys notatus* spends the autumn and the winter at depths below 200 m in the coastal waters of California (WARNER and CASE, 1980). At the end of the spring and throughout the summer, *Porichthys notatus* occurs in the intertidal area (CRANE, 1965). These seasonal vertical migrations are associated with the spawning of the fish which occurs from June to August (CRANE, 1981). The courtship display of *Porichthys notatus* is well known (GREENE, 1889; HUBBS, 1920; CRANE, 1965) and has been observed in the laboratory aquarium (ANCTIL, 1977). The authors reported that it is a complex activity in which grunting and flashing play an important role. The male is the nest guardian during a period of 40 days; it guards the brood until the young become free-swimming. It is likely that grunting and flashing are used to keep predators away from the nest. According to CRANE (1981) the glow of luminescent male observed in the absence of any stimulus, might attract food organisms to the vicinity of the nest.

Our results show that the response to noradrenaline increases from May to September, *i.e.*, during the spawning period. Cyclic bioluminescent activity has also been reported in the Euphausiacean *Thysanoëssa raschii* (TETT, 1972) : the response of the luminescent organs is maximal here from March to June corresponding to the period of the spermatophore transfer. It is suggested that the luminescent capability of *Porichthys notatus* exemplified by the response of its isolated photophores to noradrenaline shows a seasonal variation synchronous with the breeding activity.

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