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Note

Observations on the influence of temperature on the length of embryonic development in *Octopus vulgaris* (Senegal)

Alain Caverivière [a*], François Domain [a], Anis Diallo [b]

[a] *Institut de recherche pour le développement (IRD), BP 1386, Dakar, Sénégal.*

[b] *CRODT, BP 2241, Dakar, Sénégal.*

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Abstract – Observations were made in Senegal between 1997–1998 on the length of embryonic development in *Octopus vulgaris*. The data were from eggs which had been laid by two females in the open sea and fourteen females in concrete tanks. The observations in natural surroundings are the first concerning this species. Hatching occurred after 15–42 d at 27 °C, 29–49 d at 22–23 °C, 57–65 d at 21 °C and 80–87 d at 17 °C. These values are higher than the few data previously recorded in European aquariums, particularly for temperatures under 20 °C. © Ifremer/Cnrs/Inra/Ird/Cemagref/Elsevier, Paris

Cephalopod / spawning / embryonic development / embryos / hatching / West Africa

1. INTRODUCTION

It is well-known that length of the embryonic development for each cephalopod species varies in an inverse relationship with environmental temperature which in turn varies with season and/or the water depth at which the eggs are laid [1, 8, 9]. However, few data are available for *Octopus vulgaris* and the present note provides new information from lower latitudes than previously recorded [6, 8, 9, 11, 16, 18] and the first observations in natural surroundings.

2. MATERIALS AND METHODS

The data concern fourteen females captured in the sea and raised in concrete tanks in two places (CRODT and Oceanium) in Dakar (Senegal) and two females observed by scuba-diving in the bay of Dakar.

The experiments had for first target the test of different types of tags before tagging the octopus at sea. They took place between December 1996 and March 1998. Octopuses captured by trawling off Dakar were kept in two 15-m^3 and one 10-m^3 tanks where the quality of the seawater was maintained by a closed circuit filter system and was checked every week. Water temperature was measured daily. Tanks were in open areas, but well protected against the sun. Stones and several octopus pots were put on the bottom of the tanks to provide shelters for the octopuses, in order to limit aggressive behaviour among them. The octopuses were fed once a day with pieces of fish and were weighed once a week to check their growth. Captivity did not appear to provide an obstacle to reproduction and thus we have been able to observe mating several times, followed later by females laying eggs in strings attached on the ceiling of octopus pots. The weight of each female before egg laying was between 600 and 2 400 g. In the tanks, male and female were in the same proportion and their weights were generally comparable; nevertheless, some males were bigger.

In natural surroundings, we have been able to observe closely by scuba-diving the length of embryonic development of the eggs of two females. One female and its eggs were observed under a piece of metal stuck in sandy ground at a 24-m depth. The piece of metal was 2 m away from an octopus pot attached to a line of pots that was visited every week, or some-

* Corresponding author, e-mail: caverivi@orstom.sn

times more frequently, and three days before the first observation, no eggs were present. The other female was observed inside a shelter located in rocky ground at a 13-m depth. A male had been occupying a shelter near it. Egg laying occurred several weeks after the first observation of this female. The two females were estimated to weigh about 2 kg each.

3. RESULTS

Table I gives the length of embryonic development for each female, and includes laying and hatching dates and the average water temperature during the embryonic development period. The evolution of temperature in the tanks during all the experimental period is shown in *figure 1*. A minimal and a maximal value are given for each length of embryonic development because two factors of imprecision exists: i) a period between the first observation of egg strings and the previous observation where the eggs were not yet in the pot or shelter; and ii) a period between the last egg observation with embryos in chorions and the statement that the hatching is over (all the egg chorions are empty). Hatching occurred after 15–42 d at an average temperature of 27 °C (range 26–27.6 °C), embryonic development time was 29–49 d at around 22–23 °C (range 20–26 °C), 57–65 d at 21 °C (range 20–22.5 °C), 65–74 d at 18.8 °C (range 14–23 °C) and 80–87 d at 17 °C (range 14–19 °C).

Table I gives also the maximal weight of each female and the weight at death when it was possible to record before decomposition began or before consumption by cannibalism. It is worth noting that the females brooding eggs were not eating at all and that fasting could begin before laying. In the tanks, female losing weight have been recorded until two weeks before laying. Weight loss could reach 50 % at death of the female, which usually occurred in the first three days after the end of hatching. On some occasions, we have observed females taking the string of eggs out the pot at the time of hatching, possibly to make it easier for the new paralarvae to reach open water.

Figure 2 shows embryonic development time versus water temperature for the present study and the curve given by Mangold [6] from previously recorded data for *Octopus vulgaris* in other countries. For temperatures above 21 °C, Senegalese values lie near the curve, although embryonic development is a little longer. At temperatures less than 20 °C, the two embryonic development times recorded in Senegal are markedly longer.

Table I. Length of embryonic development (time) for sixteen females *Octopus vulgaris*, with date of laying and hatching, average water temperature, maximal weight of the female and weight at death (if known).

Observation type	Laying date	Hatching date	Time (d)	T °C (mean)	Max. weight (g)	Weight at death (g)
in situ	1997 Feb. 1–2	1997 April 23–27	80–87	17.0	(2 000)	–
Tank	1997 April 3–6	1997 May 6–7	31–35	21.7	2 420	1 910
Tank	1997 April 3–9	1997 May 13	35–41	21.7	1 850	950
Tank	1997 April 4–9	1997 May 14	37–42	22.5	2 070	–
Tank	1997 April 11–16	1997 May 15–17	30–37	23.0	1 650	1 040
Tank	1997 April 18–24	1997 May 22	29–35	23.3	2 040	1 150
Tank	1997 July 4–10	1997 Aug. 14	35–42	26.8	790	–
Tank	1997 Aug. 1–7	1997 Aug. 28–31	22–31	27.1	890	–
Tank	1997 Aug. 1–7	1997 Aug. 21–28	15–28	27.2	775	–
Tank	1997 Aug. 14–19	1997 Sept. 9–11	22–29	26.6	705	–
Tank	1997 Nov. 15–19	1997 Dec. 24–26	36–42	22.6	995	735
Tank	1997 Nov. 15–19	1997 Dec. 18	30–34	22.8	1 095	–
Tank	1997 Nov. 15–19	1997 Dec. 24–26	36–42	22.6	1 345	–
Tank	1997 Nov. 21–26	1998 Jan. 6–8	42–49	21.6	600	515
Tank	1997 Dec. 19–25	1998 Feb. 19–21	57–65	21.0	665	–
in situ	1998 April 8–13	1998 June 16–20	65–74	18.8	(2 000)	–

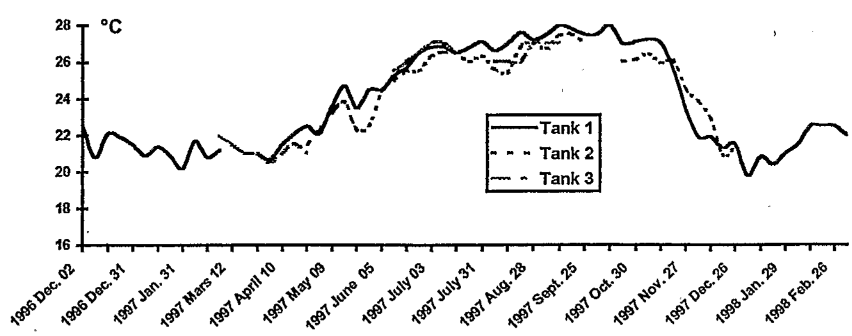

Figure 1. Evolution of temperature in the tanks during the experimental period.

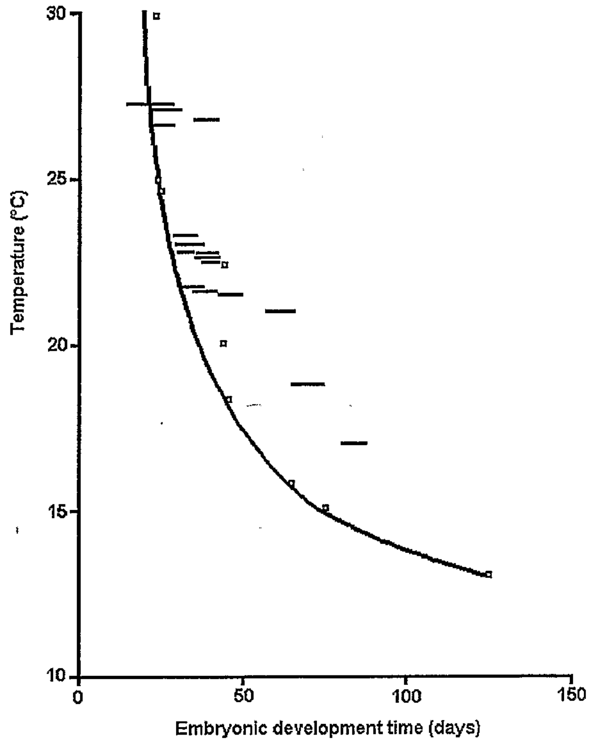

Figure 2. *Octopus vulgaris* embryonic development time as a function of temperature. Curve and spots according to Mangold [6] (spots data in [8, 9, 11, 16, 18]). Bars correspond to present data (minima to maxima values).

4. DISCUSSION

Embryonic development times in *Octopus vulgaris* are in inverse relationship with temperature and appear to be longer in Senegal than in European countries where the previous studies on this topic were carried out. In particular, differences are recorded for low temperatures. Several hypotheses could explain this last point. i) A difference in embryonic development times could be representative of separate species or sub-species; recent studies show that *Octopus vulgaris* may in fact represent a species complex [5, 7]. ii) *Octopus vulgaris* populations in lower latitudes have a poorer adaptation to low temperatures than high latitude octopuses. iii) In the present study, the two lower average temperature values of seawater during embryonic development were recorded in natural surroundings. All the other data in previous and present studies concern observations in aquariums. Maybe the seawater conditions in nature (depth, aeration or others) are less favourable to embryo development. At present, we can only note the difference.

As already mentioned, the inverse relationship between environmental temperature and duration of embryonic development is known for all cephalopod species. Considerable variations exist between species depending on the species order and within an order upon the size of eggs: embryonic development is longer in octopods than in decapods and increase with egg size [2, 6, 8]. Paralarvae of *Octopus vulgaris* are planktonic before settlement. For Mangold [7], the duration of the planktonic phase is also dependent upon temperature: between 33 d and 3 months according to previous studies [12, 13, 17]. Concerning the relationship between temperature and duration of embryonic development, a recent study [2] on the embryonic development of cephalopods at low temperatures makes some hypotheses. Adaptative mechanism could exist, lengthening the pre-hatching phase and acting as a regulatory function where food supply shows seasonal fluctuations, i.e. hatching is postponed when the planktonic food for paralarvae is poor. In Senegalese and Saharian waters, such a mechanism could be favourable. Mature females of *Octopus vulgaris* are present throughout the year, but two spawning seasons exist ([4] and our data). For the secondary season in cold waters, lengthening the embryonic phase could permit hatching at the end of the upwelling season, when the planktonic food is the highest, but particularly when water turbulence and offshore larvae dispersion decrease [3, 10, 14, 15]. Nevertheless, it is difficult to explain why in octopus the planktonic life would be lengthened in cold water, even though this stage is a critical period. Then, the lengthening of the embryonic phase and the paralarvae period in cold water can be seen just as a simple physiological process, without regulatory function on population dynamic.

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