A Possible Relationship between Size and Reproductive Behavior in a Population of *Aplysia punctata* Cuvier, 1803

BY

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INTRODUCTION

As part of a comparative study of the behavioral adaptations of *Aplysia* (Tobach, *et al.*, 1965; Lederhendler, *et al.*, 1975; Lederhendler, *et al.*, 1977; Lederhendler & Tobach, 1978; Tobach, 1978), a study of *Aplysia punctata* was carried out in the intertidal waters of Concarneau, France (47°53′22″ N, 3°54′10″ W). From June 21, 1979, through July 28, 1979, observations were conducted approximately 800 m W of the Laboratoire de Biologie Marine, Collège de France. The field site measured approximately 240 m² and was enclosed by large rocks covered primarily by *Fucus serratus*. The basin consisted of coarse sand, scattered rocks of different sizes covered with several species of algae. These were, in addition to the *F. serratus, Palmaria marina, Enteromorpha* spp., *Lomentaria articulata, Laminaria digitata, Ulva* spp., and *Chondrus* spp. The rocks were usually covered by more than one algal species; the most abundant were *Fucus, Enteromorpha* and *Ulva*. The maximum tidal range was approximately 4.3 m and during periods of extreme low tides, the entire area became exposed. Surface water temperature ranged from 15° to 20° C with a fairly constant salinity of 34‰.

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PROCEDURES

Vegetation, substrate and rocks were systematically searched by sight and touch for animals, for one half hour before and after the lowest point of the

Table 1

Field observations of *Aplysia punctata*.

Date (1979)	Number of animals found[1]	Median Weight (g)	Range From	Range To
6/21(AM)	18	48	30	75
6/21(PM)	15	35	15	55
6/22	18	38	10	53
6/23	18	42	30	70
6/24	24	40	25	65
6/25	20	45	25	65
6/26	4	45	30	<50
6/27	21	40	<30	65
6/28	14	38	<30	50
6/29	14	48	25	70
6/30	1	55	–	–
7/1	10	45	>25	75
7/4	1	50	–	–
7/7	15	45	35	75
7/8	14	40	>20	70
7/9	10	40	25	75
7/10	12	40	30	65
7/12	23	40	25	50
7/13	30	40	20	65
7/15	10	40	30	65
7/16	3	45	25	45
7/22	5	35	25	50
7/24	12	40	25	65
7/25	4	30	20	40
7/27	1	40	–	–

[1]Only animals found for the first time are listed.

tide. Once animals were located, records were made of type of contact and weights by volumetric measurements in graduated cylinders to the nearest 5 mL. A Hartner Balance, model LP105, was used to determine the net weights of animals which were also measured volumetrically. The difference in measurements by the two methods was not noteworthy (± 0.5 g) and it was assumed that mL = g. Animals were tagged according to methods developed by Tobach (Lederhendler *et al.*, 1975). Given the restrictions of time and tidal conditions, the data obtained can only be understood within this context. As Table 1 shows, there was a considerable variation in the number of animals found on any day.

RESULTS AND DISCUSSION

Table 1 lists the days on which observations were made, the number of animals tagged and their weights. It should be noted that during the month of August, on 15 days of searching, 2-6 animals were found on only 4 days. Between the 11th and 26th of August (last observation date), no animals were found.

Table 2 shows the number of times animals were found in contact or copulating. In addition, 194 sea hares were found not engaged in either activity.

Table 2

Aplysia punctata copulating or in contact: Number of times seen.

	Number of animals			
A. Copulating	2	3	4	
	89	7	3[2]	
B. Contact	2	3	4	7
	22	9	5	2

[2]Weights of one chain of 4 not obtained.

Table 3 shows that a significant number of copulating pairs found during the observation period were composed of sperm donors which were smaller than sperm recipients (one-sample Chi-squared test (Siegel, 1956), $p < 0.001$). Given the results of this statistical analysis, pairs in which donors were smaller than recipients were classed as "typical," and others as "atypical."

Table 4 shows that the donor in the most frequently found relationship, *i.e.*, "typical" donor (D^t), is, indeed, smaller than the recipient in the "typical" relationship (R^t). R^t is smaller than either of the other animals in the "atypical" pairing, that is, R^a; where "t" stands for "typical" and "a" stands for "atypical." The recipient in the typical pairing (R^t) is also larger than the recipient in the atypical pairing (R^a).

The lack of a significant difference in weight between R^t and D^a would seem to indicate that at a certain weight, these sea hares are as likely to be found acting as sperm donors as sperm recipients.

In the laboratory, 2 sea hares (*Aplysia punctata* Cuvier, 1803), weighing 3 g and 8.7 g were seen copulating, the smaller being the sperm donor. The smaller sea hare was seen acting as sperm donor until it weighed 7.1 g two weeks later. Subsequently both animals assumed both roles and laid eggs. The sea hare that acted as recipient in the early copulations first laid eggs when it weighed 11.6 g. Lederhendler (1978) reported that a pair of *A. dactylomela* first copulated when weighing 58 g and 53 g, the former being the sperm donor. However, subsequent to this first copulation, the smaller of the 2 was the sperm donor on the 3 occasions when copulation took place. The size relationship seems to be similar in the *A. dactylomela,* which appear to attain greater size than *A. punctata* (see Carefoot, 1967 for *A. punctata* and Tobach, unpubl. data for Bimini; and Lederhendler *et al.*, 1977, for Puerto Rico for *A. dactylomela*).

The weights of the laboratory *Aplysia punctata* are in a very different range from those observed in the field. However, in the pair described above which was followed daily in the laboratory, the size relationship was consistent with the field data.

These data are preliminary in that the sampling technique was restricted to a particular field population at only one point in their daily activity under one tidal con-

Table 3

Patterns of copulation and individual weights of *Aplysia punctata*.

A. Paired Animals

		Donor smaller than recipient	Donor larger than recipient	Donor equal to recipient
Number of pairs[3]		56[4]	25[5]	8
Weights (g)	Donor:			
	Median	30	50	43
	Range from	20	25	30
	to	70	75	60
	Recipient:			
	Median	50	35	See above
	Range from	30	25	
	to	75	65	

B. Chains of 3 and 4 Animals

Copulatory relationships[6]		Donor	Donor and recipient	Recipient
Typical				
	Chain of 3	20	30	40
	of 3	25	30	40
	of 4	30	35	60
			40	
Atypical				
	Chain of 3	45	40	35
	of 3	60	40	30
Mixed				
	Chain of 3	40	30	40
	of 3	25	40	35
	of 3	35	35	65
	of 4	30	30	70
			44	

[3]$X^2 = 37.8$; $p < 0.001$.

[4]This relationship, i.e., donor (D) < recipient (R) in weight, is classed as "typical" ("t"), because of the significant X^2.

[5]This relationship, i.e., donor > recipient is classed as "atypical" ("a"), for the same reason.

[6]Categories "typical," and "atypical" based on statistical analysis of data for paired animals in "A" above. "Mixed" indicates that donor/recipient was "typical" for one part of the chain and "atypical" in another part.

dition. These findings suggest, however, that the commonly held belief that *Aplysia* assume both roles soon after metamorphosis needs to be re-examined, and that further study is warranted.

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Table 4

Analysis[7] of weights of copulating pairs of *Aplysia punctata*.

	Distribution according to median weight (40g) for combined groups			
	$D^t < R^t$[8]		$D^a > R^a$[8]	
Copulatory role	D^t	R^t	D^a	R^a
Number of animals				
Below median	43	5	3	13
At median	6	7	5	6
Above median	7	44	17	6

[7]Median test (Siegel, 1956).

[8]D = donor; R = recipient; t = "typical" relationship; a = "atypical" relationship.

$D^t < R^t$; "p" < 0.001

$D^t < D^a$; $0.10 >$ "p" > 0.05

$D^a < R^a$; "p" < 0.02

D^a and R^a; do not differ: "p" > 0.10

$R^t > R^a$; "p" < 0.001

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