Asexual Reproduction, Diet, and Anomalies of the Anemone *Nematostella vectensis* in Nova Scotia

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Observed population increases in two aquaria containing the anemone, *Nematostella vectensis*, from Minas Basin, Nova Scotia were thought to be the result of asexual reproduction. This hypothesis was supported when 20 vitally stained and 10 unstained anemones produced 13 new individuals, 7 of which were stained. The enteron contents of 555 anemones revealed nine kinds of ingested items, *Hydrobia* and copepods being the most common. Several anomalous forms of the anemone were found but no one reason for the anomalies could be demonstrated.

Key Words: *Nematostella vectensis*, anemone, Nova Scotia, asexual reproduction, transverse fission, diet, anomalies.

Nematostella vectensis is a small rare anemone of the family Edwardsiidae, first described from the Isle of Wight. It has since been found in salt marshes in other localities in England, the Atlantic coast of North America, and the Pacific coast of the United States (Crowell 1946; Robson 1957; Hand 1957; Bailey and Bleakney 1966; Williams 1976). The English populations appear to be threatened with extinction, caused mainly by pollution and evaporation of their ponds (Williams 1976).

Over the last few years several papers have appeared dealing with *Nematostella vectensis* (Williams 1973a, b, 1975, 1976; Frank and Bleakney 1976) and a popular account has been written (Lindsay 1975). The purpose of this paper is to describe some further aspects of the asexual reproduction, diet, and anomalies of the anemone. Specifically, we hoped to show that *Nematostella vectensis* did in fact reproduce asexually and this could account for a rapid increase in the population. The diet of *N. vectensis* has not been reported previously. We also looked for anomalous forms of the anemone in field collections and laboratory experiments and compared them with those found by Williams (1975).

Methods and Materials

Anemones were collected from salt marsh pools at Kingsport, Nova Scotia and transported to the laboratory where they were kept at room temperature in two small aquaria. The aquaria had been prepared by providing a substrate of salt-marsh pool-bottom material (fine flocculent mud and plant detritus), as previous experience had shown that the anemones would not live long on clean glass-bottom containers.

Some of the anemones were stained with vital stains, Brilliant Cresyl Blue, Nile Blue A, and Safranin O, by injecting the stain into the enteron by hypodermic needle through the mouth. Usually two or three injections were needed to produce a color dark enough to be readily seen. The color persisted for about 2 wk.

To obtain direct evidence of asexual reproduction we placed 30 anemones in 10 finger bowls, each of which had mud and detritus on the bottom. Each bowl contained two vitally stained (one red and one blue) and one unstained anemone. The anemones were stained so that we could identify which anemones produced any fragments that might be found in the bowls. After the substrate had been added to the bowls, and before the experimental anemones were added, the bowls were left for 2 or 3 d and inspected regularly to make certain that any anemones inadvertently introduced with the bottom material were captured and removed. Therefore, any small anemones in excess of the three originally placed in a particular bowl would be the result of a reproductive process, and the sudden appearance of a stained fragment would strongly suggest asexual reproduction.

Diet items were determined by dissecting preserved anemones and analyzing the enteron contents.

Results

Asexual Reproduction

Collections had been made during October and November 1972, and every month in 1973 except February, March, and December prior to the experiment reported here. In many of these collections there were what appeared to be small pieces of anemones but lacking tentacles and pharynx. The pieces varied in size from 2 mm to 5 mm. It was suspected that these pieces might be the result of asexual reproduction.

Anemones kept in two aquaria were counted every day and several times there were more anemones than had been counted the previous day. Almost all of the new anemones were identified and all appeared to be pieces similar to those found in the field collections. After 3 wk, all of the anemones that could be seen in the two aquaria were removed and in both cases more anemones were taken out than had been put in. From one aquarium, to which only 20 anemones had been added, 29 were removed; and from the other which started with 18 anemones, 39 were removed.

It seemed evident that the new anemones were the result of asexual reproduction but, to go beyond circumstantial evidence 10 finger bowls were set up, with 30 anemones 10 to 20 mm long, as described. Fragments began to appear within the first few days but they were all unstained, so the possibility that anemones had been buried in the mud could not be completely ruled out. After 17 d, on 27 September, however, a red fragment was found in one of the bowls, and more colored fragments were found up to the end of the experiment. From 10 September to 15 October, 13 fragments were produced by the 30 anemones, and 7 of these were stained. Most of them were 3 to 5 mm long, and the same diameter as the parent anemones. The fragments all produced tentacles and a pharynx within about 2 d, thus conclusively showing asexual reproduction of *N. vectensis*. The actual process was not witnessed and in every case took place at night.

Diet

Two hundred forty-two anemones collected in 1965, 1966, and 1971 were dissected by Joan McCracken and the enteron contents were examined (unpublished report, Acadia University). Of these, 32 contained 42 items: 21 *Hydrobia* snails, 18 chironomid larvae, and 3 corixid adults, suggesting that insect adults or larvae make up a substantial part of the anemones' diet.

In the present study, 313 anemones were dissected with somewhat different results. In the 74 with enteron contents, there were 114 items of eight categories, including 15 *Hydrobia* snails, 13 ostracods, 40 copepods, 2 chironomid larvae, 11 "worms," 18 egg masses, 14 unidentifiable animals (mostly crustaceans), and what appeared to be 1 rotifer test. Most of the "worms" were nematodes; however, some were polychaetes; the egg masses were probably from copepods. Although it is possible that some of these items were ingested accidentally, almost all of them showed signs of digestion and there were sufficient quantities of most of them in the anemones dissected to consider them regular prey. These data are summarized in Table 1.

Nematostella vectensis in the Minas Basin were usually found in pools with most of the column buried but also occurred stretched out on the bottom or floating in surface algae. They "hunted" by stretching out the tentacles until something made contact. Although usually stationary, they would sometimes tip the body in different directions or appear to explore the surroundings with several tentacles.

The tentacles of *N. vectensis* are extremely responsive to tactile stimulation and immediately wrap around anything that touches them, including metal probes, and draw these objects toward the mouth. This process was observed with a chironomid pupa which was placed on the tentacles of an anemone in the laboratory. The pupa was captured and drawn to the anemone's mouth, but it took 2 h 40 min before ingestion was completed. Digestion involved another 23 h, after which the exoskeleton was ejected.

Anomalies

Several aberrant forms of *N. vectensis*, such as double-headed anemones and forked tentacles, have been discussed by Williams (1975) for anemones found in England. Similar forms were found in the Minas Basin. The double-headed anemones (having a tentacled oral region at both ends of the body column) were more common in the late summer and fall, which is similar to Williams' findings in England (personal communication). Of nearly 1300 anemones collected from the Minas Basin in 1972 and 1973, 17 had

TABLE 1—Food items from enteron of *Nematostella vectensis*. Collections were not available for February, March, and December. The bracketed figures are from Joan McCracken's unpublished report

Month	*Hydrobia*	Copepods	Chironomid larvae	Egg masses	Unidentified	Ostracods	"Worms"	Corixids	Rotifer	No. of anemones examined	Subtotal
January	0	0	0	0	0	0	0	0	0	12(8)	20
May	0	1	0	5	0	2	0	0	0	18(0)	18
June	11	2	0	3	3	0	1	0	1	81(0)	81
July	3(5)	0	0	1	3	0	0	0(1)	0	20(27)	47
August	9	29	1	7	7	0	5	0	0	59(14)	63
September	3	12	0	0	3	12	6	0	0	78(0)	78
October	2(15)	2	1(16)	0	0	0	0	0(2)	0	27(123)	150
November	0(1)	0	0(2)	0	0	0	0	0	0	18(70)	88
Subtotal	28	46	2	16	16	14	12	0	1	313	
	(21)	(0)	(18)	(0)	(0)	(0)	(0)	(3)	(0)	(242)	
Total	49	46	20	16	16	14	12	3	1	555	

tentacles and pharynx at both ends of the body column, with sizes ranging from about 1 mm to 47 mm. One Y-shaped anemone, with two adjacent tentacle crowns and one physa, was collected, and several anemones with forked tentacles were also found. Anemones, such as Williams' (1975), found lacking tentacles or with a single tentacle crown and two opposing oral cones were not observed in the Minas Basin population.

Several of the apparently normal anemones kept in an aquarium developed a second oral cone and tentacles at the physa end, and one double anemone placed in an aquarium resorbed one tentacle crown and developed a normal physa.

Figure 1 shows an anemone that is just developing a second tentacle crown; the second set of tentacles is still quite small. In all other double anemones found, the tentacles at both ends of the column were of approximately equal sizes. Also note in Figure 1 that the larger tentacle crown is composed of 20 tentacles, the largest number recorded for *N. vectensis*. Previously, the maximum number reported was 18 (Stephenson 1935).

Discussion

Lindsay (1975) described the transverse fission process for *N. vectensis* as beginning with elongation of the parent, followed by the development of a transverse constriction in the posterior portion of the column. About 24 h later, a new individual was formed, and tentacles were produced after about 2 d. Although the process was not actually witnessed during the present study, the fragmented pieces did develop tentacles and a pharynx within 2 d. The anemones in the bowls were inspected frequently throughout the day but persistent constrictions, as described by Lindsay, were not observed. Apparently in our study, the complete process took less than 24 h; in fact, the longest period the anemones went unobserved, excluding most weekends, was about 14 h.

Asexual reproduction undoubtedly plays a major part in the population dynamics of *N. vectensis* in the Minas Basin. To date, evidence of sexual reproduction has been reported only in the late summer and fall (Frank and Bleakney 1976), but collections from pools in early spring and into the summer frequently contained small anemones and fragments, the latter identical to those produced in the laboratory. Williams (1976) observed transverse fission in January 1975 and speculated that the process might continue through the year. It is certainly probable that asexual reproduction by fission is responsible for the general increase in the population during the spring and early summer months.

Nematostella vectensis is unique in that it is

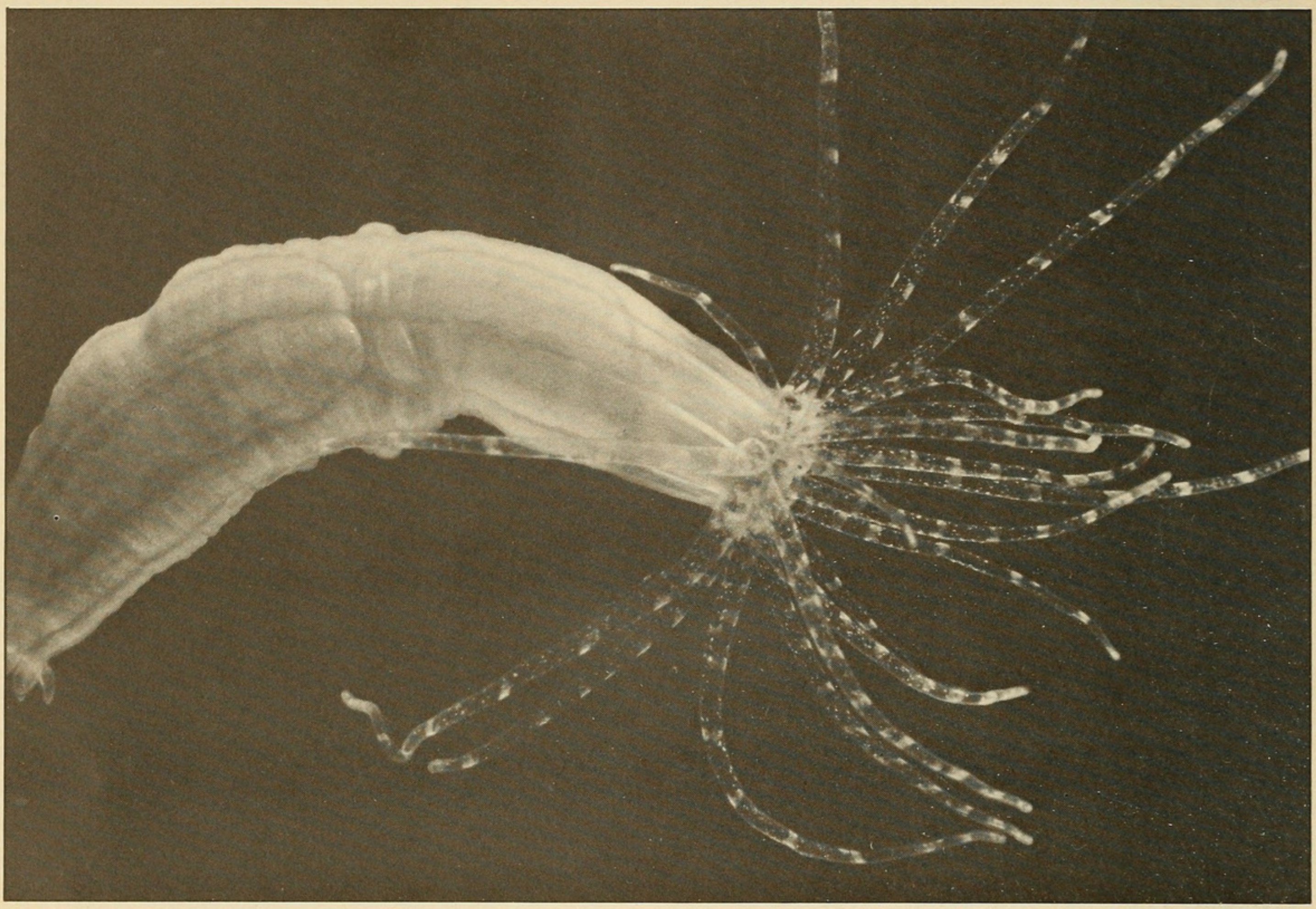

FIGURE 1. *Nematostella vectensis* from Minas Basin, Nova Scotia. Note the tentacle buds in addition to the 20 full-sized tentacles.

the only anemone known to feed on insects. Minas Basin anemones fed on chironomid larvae and corixids, and Lindsay (1975) also reported them feeding on midge larvae. Anemones in Half-Moon Pond, Norfolk, England feed on the larvae of *Chironomus salinarius* and on harpacticoid copepods (Williams 1976). Insects, however, did not make up a sizeable portion of the anemones' diet in the Minas Basin, even though chironomids were especially abundant. The major prey were *Hydrobia minuta* and copepods (Table 1) which were also the most abundant animals in the pools. This is what one would expect for an animal that is basically sessile and opportunistic and that cannot actively pursue its prey.

Anemones collected in 1972 and 1973 had not ingested numbers of chironomids and corixids comparable to the numbers taken in the earlier collections of anemones. This is not really surprising since chironomids and corixids are comparatively large active animals and when they came in contact with a tentacle they were usually observed to break away easily. *Hydrobia* are also large but they are relatively slow, and their reaction to attack may be simply to withdraw into their shell and thus give the anemone an opportunity to ingest them without any trouble.

Anemones examined from 1965, 1966, and 1971 apparently did not ingest any of the smaller animals such as copepods. They are often difficult to distinguish in dissected anemones, however, and it is possible that these smaller food items were present but were overlooked.

No explanation could be found for the anomalous anemones. Williams (1975) suggested three possibilities: imperfect asexual fission, regeneration of a damaged animal, or a genetic defect in the zygote. All of these possibilities are reasonable, but as yet, no evidence has been found to single out any of them. It is worth noting, however, that in our aquaria none of the anemones that eventually developed a second set of tentacles appeared to be damaged. Whatever the reason, the transformation from normal to double anemone can be quite rapid. Our anemones developed second oral regions, complete with pharnyx and tentacles only slightly shorter than normal in about 2 d. Only one anemone collected from the marsh (Figure 1) appeared to be in the process of developing a second oral end, and its second set of tentacles was considerably smaller than the original set.

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Correction to page 262 (July-September issue)

The complete photograph of Figure 1 was not printed. It is reproduced below as it should have appeared in the article.

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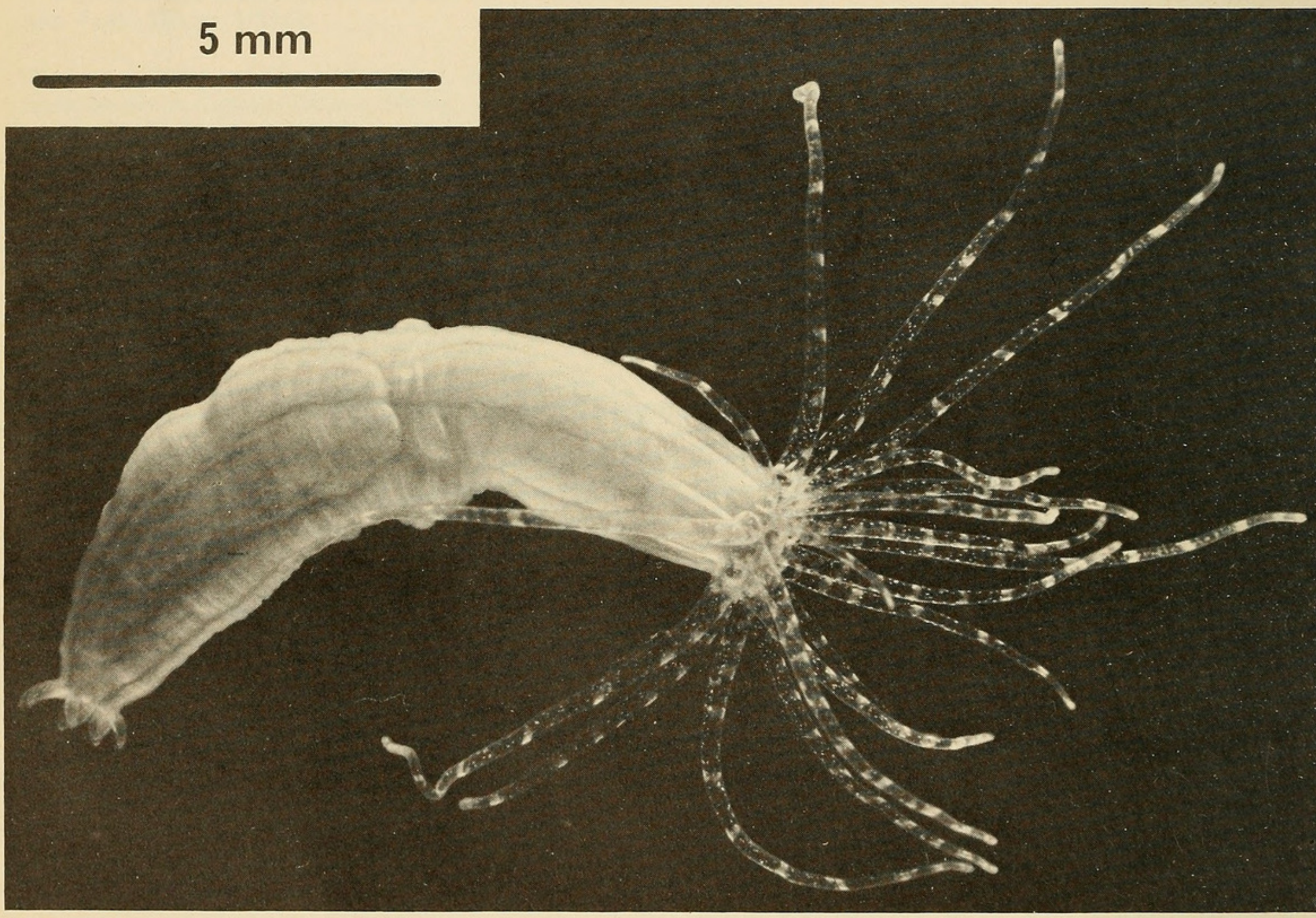

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