Studies on Olividae XVII. Data on depth of burrowing, motion and substrate choice of some *Oliva* species.

C. VAN OSSELAER (*), J. BOUILLON (**) and B. TURSCH (*)

* Laboratoire de Bio-Ecologie, Faculté des Sciences,
** Laboratoire de Zoologie, Faculté des Sciences,
Université Libre de Bruxelles,
50 av. F.D. Roosevelt, B-1050 Brussels, Belgium.

ABSTRACT. The depth of burrowing of several *Oliva* species has been measured. The influence of several parameters (size and colour of the shell, nature of substrate, day-night effect) on movement has been tested and discussed. Substrate choice experiments have been performed on adult *Oliva* of different species.

RESUME. La profondeur d'enfouissement de plusieurs *Oliva* a été déterminée. L'influence de plusieurs paramètres (taille et couleur de la coquille, nature du substrat, effet jour-nuit) sur le mouvement a été testée et discutée. Des expériences de choix de substrat ont été effectuées sur des *Oliva* adultes de plusieurs espèces.

KEYWORDS: Mollusca, Gastropoda, *Oliva*, behaviour, depth of burrowing, choice of substrate, motion.

1. PURPOSE

The purpose of the present work was threefold:

1. We needed to establish the burrowing depth of *Oliva*, in order to optimize our sampling methods for a quantitative field investigation on the distribution of species.

2. "Substrate preferences" have been reported for some species by several field collectors (HEMMEN, 1981; WIDMER, 1981 and WITTIG-SKINNER, 1981) as well as GREIFENEDER (1981) and PETUCH & SARGENT (1986). We wanted to determine whether habitat specificity could be explained by an active choice of the substrate by adult *Oliva*.

3. *Oliva* are widely reported to be "particularly active at night" (see for instance ZEIGLER & PORRECA, 1969; PETUCH & SARGENT, 1986). Such information is not very informative about the nature of that activity and we wished to obtain comparative day and night data on a specific action, in this case mobility.

2. MATERIAL AND EXPERIMENTAL CONDITIONS

All experiments were carried out at King Leopold III Biological Station at Laing Island (4°10'30"" S, 144°52'47" E), in Hansa Bay, Papua New Guinea. White painted (epoxy) marine plywood aquaria, equipped with an open circulation of natural seawater flowing slowly from a storage tank, were placed under an open corrugated iron shelter shaded with curtains of fishing net. The light uniformity was checked with a luxmeter and the water

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temperature was close to that in the bay. Specimens were individually tagged as in previous experiments in Brussels (see TURSCH, 1991) by numbering them with red nail varnish (Bourgeois, Pourpre). *Oliva* appear unaffected by this treatment and the tags lasted several weeks. Olives were fed once a week with meat morsels. All specimens were acclimatized more than 4 days before observations. Two different sediments (one black, terrigeneous, fine sand of volcanic origin and one white, coarse coral sand, both typical of the two general classes of sediments found in Hansa Bay) were utilized for substrate effect experiments.

For estimation of the burrowing depth we have utilized the common species *O. carneola* Gmelin, 1791, *O. coerulea* Röding, 1798, *O. longispira* Bridgman, 1906, *O. reticulata* Röding, 1798 and *O. sericea* Röding, 1798 in order to examine species with very different sizes.

For experiments on night/day mobility we have utilized: *O. carneola* (very largely represented on different types of substrate) and *O. longispira* (restricted to sandy beaches). As we wanted to see if activity varies with size within a given species *O. carneola* of two size classes were utilised (small specimens from 9.3 mm to 11.2 mm and large ones from 14.3 mm to 18.9 mm). The same was done for *O. longispira* (small specimens from 13.3 mm to 22.8 mm and large ones from 31.3 mm to 42.0 mm). It is to be noted that *O. longispira* is represented in Hansa Bay by two populations: one lives on white sand and all specimens are white; the other lives on black sand and 75% of the specimens are black. Black and white specimens of this species were compared, in order to see if activity is correlated with shell colour.

For experiments on substrate choice we have utilized: *O. carneola*, *O. coerulea* and *O. longispira*. All *O. carneola* and *O. coerulea* in these experiments were collected during March and April 1991 in the coarse white coral sand from Laing Island lagoon and all *O. longispira* in the black sand of Sisimangum beach, excepted for the large white specimens, collected on white sand at Boro Beach.

3. EXPERIMENTS ON THE BURROWING DEPTH OF *OLIVA*

3.1. Method

Experiments were performed in daylight in small aquaria (26 cm x 14 cm x 13 cm). Both black and white substrates were tested. Preliminary experiments established that a 8 cm bottom layer of sand was sufficient. 2 to 5 specimens (depending on size) were placed on the substrate, in which they soon burried. When burried specimens were close enough to the glass plate of the aquarium, one could measure without disturbance the distance separating their metapodium from the sand surface.

After these observations and while the olives were still burried, we lowered the water level (to 2 or 3 cm under the surface) by tilting the aquarium without disturbing the sand layer, in order to very roughly simulate a receding tide. The reaction of each animal was then observed for more than 30 minutes.

3.2. Results

Depth of burial was similar in both substrates but for most tested species was significantly deeper in white coarse sand. None of the species burried in the substrate by more than 5.5 cm. Observations in both sediments were thus grouped and are reported in Table 1. Lowering the water level does not seem to cause deeper burial but on the contrary appears to trigger a tendency to emergence.

4. EXPERIMENTS ON MOBILITY

4.1. Purpose.

The experiments were designed to answer four questions, for each of which the null hypothesis (H_0) is given hereunder.

Question 1: **Substrate effect**. $H_0$1: Motion is the same whatever the nature of the sediment where motion begins (comparison of substrate effect within each category of shell size and color).

Question 2: **Size effect.** $H_0$2: Motion is the same for small and large specimens.

Question 3: **Day/night effect.** $H_0$3: Motion is the same during the day and the night.

Question 4: **Color effect**. $H_0$4: Motion is the same whatever the colour of the specimens in the case of *O. longispira* (presenting a colour polymorphism).

These null hypotheses have been tested with the usual non-parametric χ^2(2x2) tests.

4.2. Material and method.

Aquarium: 50 cm x 34.5 cm. Water height: 25 cm. The bottom of the aquaria were divided in eight equal rectangular compartments separated by small plastic walls (22 mm height and 3.5 mm width). Sediments tested: black and white sand (see section 2). Each compartment was filled with a 2 cm layer (enough to allow specimens to bury) of substrate, in such a way as to divide the bottom of the aquarium into two halves, each being covered by one type of sediment.

At the start of each experiment half of the specimens are placed in each type of substrate. Evey recorded passage of an animal from one compartment to another is considered a motion. For 8 days the location of the *Oliva* was recorded twice daily: once in the morning (6 - 7.00 a.m., to observe night activity) and once in the evening (18.00 p.m, for day activity). Burried *Oliva* are hard to find and occasionally some specimen(s) (especially of small size) could not be located. All calculations are therefore made on the basis of the number of specimens for which motion could actually have been observed, this is the number of specimens located both before and after each time lapse (called "Σ observations" in the tables). Non parametric Chi square tests were performed on the number of animals that moved and the number that did not. As we are dealing with small figures, we only consider the 0.01 significance level, for the sake of precaution.

4.3. Experiment on *O. longispira.*

4.3.1. Experimental conditions. 12 small (see section 2) and 5 large (see section 2) specimens of each colour (black and white) were utilised. Water current resulted from two water flows: a weak one in the white sediment and another, somewhat stronger, between the two sediments.

4.3.2. Results. The results of this experiment are summarized in Table 2. One sees that:

a. The nature of the substrate does not influence the motion of *O. longispira*. For the following χ^2 tests, this result allows to group the counts for each category of animals, irrespective of the nature of the substrate in which motion originates.

b. Motion varies with the size classes of the specimens. During the day small olives are active while large ones are totally motionless. No significant difference between the size classes is noted during the night.

c. All categories of olives are more mobile during the night than during the day.

d. Motion is not related to the colour of the shell.

4.4. Experiment on *O. carneola.*

4.4.1. Experimental conditions. 11 specimens of each size class (see section 2) were utilised. Water flow very low, parallel to the aquarium length. White sand upstream.

4.4.2. Results. The results of these experiments are summarized in Table 3.

a. Here also, the nature of the substrate does not influence the motion of *O. carneola*. For the following tests, this result allows to group the counts for each category of animals, irrespective of the nature of the substrate in which motion originates.

b. Motion does not vary with the size classes of the specimens, contrary to the case of *O. longispira*.

c. All categories of olives, here again, are more mobile during the night than during the day.

5. EXPERIMENTS OF SUBSTRATE CHOICE

5.1. Material and method

The bottom of the test aquarium is divided into two halves, each containing one of the two sediments to be tested. Sediments tested: black and white sand (see section 2). The sediments are contiguous, not separated by any physical obstacle, in order to allow the olives to effect their choice in a situation where they are in actual contact with both types of sediment. Half the *Oliva* sample is deposited in each type of sediment at the start of the experiment. Counts of presences (not motion !) in each sediment are effected every morning and evening. A specimen found on the borderline between sediments is counted as a 0.5 presence in each of the sediments.

5.2. Experiments on *O. carneola*

5.2.1. Experimental conditions. Aquarium: 50 cm x 34.5 cm. Water height: 25 cm. Thickness of sediment : 1.5 cm (enough to cover the specimens).16 specimens of each size class (see section 2) were utilised. Water flow perpendicular to border between sediments. The experiment is repeated after inverting the relative position of the two substrates, in order to account for a possible rheotaxis already evidenced in *Oliva vidua* (TURSCH, 1991).

5.2.2. Results. The results of these experiments are summarized in Table 4 (white sand upstream) and 5 (white sand downstream). There were no highly significant differences in the observed behaviour of the size classes (see VAN OSSELAER, 1992 for details). The χ^2 test being very sensitive to the size of the samples, only global figures are reported in the tables.

Two cases are observed: either *O. carneola* chooses the white substrate or its choice is not significant. Even when significant, the overall choices (58.2% and 53.4%) are only marginal.

5.3. Experiment on *O. coerulea*

5.3.1. Experimental conditions. Aquarium: 60 cm x 24 cm. Water height: 35 cm. Thickness of both sediments: 2.5 cm (enough to cover specimens). 10 specimens were utilised. Water flow parallel to border between sediments. Inversion of sediments is thus not necessary.

5.3.2. Results. The results of these experiments are summarized in Table 6. *O. coerulea* has a highly significant preference for white sand but this choice is marginal (57.6 %).

5.4. Experiments on *O. longispira*

5.4.1. Experimental conditions. Aquarium: 50 cm x 34.5 cm. Water height: 25 cm. Thickness of both sediments: 0.5 cm (not enough to completely cover specimens). 5 specimens (large size class, see section 2) of each colour (black and white) were utilised. Very low water flow not parallel to border between sediments. Repetition of the experiment with inversion of sediments was deemed necessary.

5.4.2. Results. The results of these two experiments being not significantly different (see VAN OSSELAER, 1992); the pooled results are presented in Table 7. The choice of black olives is always non significant. White olives have a highly significant overall choice for the black substrate (in which they are not concealed and which is not their substrate of origin !). Here again, the choice is only marginal (64%). On the total, the difference between the behaviour of black and white olives is confirmed by a highly significant χ^2 (2x2) test.

6. CONCLUSIONS AND DISCUSSION

Burrowing. The present results indicate that examination of the first 5-6 cm of

substrate is sufficient for a reliable quantitative sampling of *Oliva*. This is in agreement with a large number of field observations and has a direct bearing on the planning of quadrat studies and in the design and utilisation of dredges.

As reported above, most species bury deeper in white, coarse sand but the difference does not exceed 1.6 cm.

Motion. The motions observed in these experiments are minimal estimates. Our figures do not account for the specimens possibly returning to the initial compartment after a motion, nor for their motion inside a given compartment. In addition, if the border effect previously demonstrated for *Oliva vidua* (TURSCH, 1991) is effective here, it would restrict the passage of borders. These considerations equally affect every single experiment but do not modify the validity of the conclusions: at this stage our purpose is not to quantify actual mobility but to compare mobility under various parameters (size, colour of the shell, nature of substrate, day and night).

In the cases examined, motion was higher during the night than during the day and did not seem to vary with the nature of the substrate. For the colour polymorphic *O. longispira*, it did not vary with the colour of the shell. At least in some cases (for example *O. longispira* during the day) activity can vary with the size of the shell.

Choice of substrate. Substrate preferences (when they can be evidenced at all) can be highly significant but never overwhelming (a marginal majority of 61.1% of the specimens, at best). Many species of *Oliva* are restricted to a given type of substrate and the reasons for that specificity are still entirely unknown. The present results indicate it is unlikely that this restriction of habitat is caused by a choice of substrate by adult specimens. The possibility that sediment specificity could be explained by the occurence of a specific food in a given substrate is also unconvincing. *Oliva* are catholic carnivores and although they will occasionally specialize in a readily available food (FOTHERINGHAM, 1976) they are not fussy eaters. *Oliva* of several species have been easily maintained for years in our laboratory and did produce larvae on a variety of diets that are unusual for them.

It is to be noted that when white specimens of *O. longispira* exhibited a (weak) preference for a black substrate, the choice was made at night. It is thus improbable that the choice of sediment was made on the basis of colour. Surface features and/or granulometry are more likely to intervene in the choice.

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Table 1. Burrowing depth.

Species	Shell Max. Diameter (mm)	n	Burrowing depth Min (cm)	Max (cm)	Mean (cm)	Reaction to lowering water level
O. carneola	9.7	33	1	3	1.6	move to surface (no emergence)
O. coerulea	14.1	15	1.5	4	2.2	move to surface (no emergence)
O. longispira (< 22.8 mm)	6.7	23	0.5	2	1.3	move to surface (no emergence)
O. longispira (> 31.3 mm)	13.1	28	1	4	2.7	move to surface (no emergence)
O. reticulata	15.9	17	1.5	4	3.2	no reaction
O. sericea	25	16	2.5	5.5	3.4	emergence of all specimens

n: number of observations.

Table 2. Motion of *Oliva longispira*.

	***Oliva* categories**	Small white	Small white	Small black	Small black	Large white	Large white	Large black	Large black
	Departure sediment	black	white	black	white	black	white	black	white
DAY	Σ observations	34	30	40	29	16	14	13	17
	Σ motions	9	8	6	4	0	0	0	0
	Σ no motion	25	22	34	25	16	14	13	17
	% motion	26.5	26.7	15.0	13.8	0.0	0.0	0.0	0.0
	$H_0$1: χ^2 (2x2)	NS		NS		NS		NS	
	$H_0$4: χ^2 (2x2)	NS				NS			
	$H_0$2: χ^2 (2x2)	**				**			
NIGHT	Σ observations	29	22	33	26	13	12	12	13
	Σ motions	16	14	23	10	10	9	7	5
	Σ no motion	13	8	10	16	3	3	5	8
	% motion	55.2	63.6	69.7	38.5	76.9	75.0	58.3	38.5
	$H_0$1: χ^2 (2x2)	NS		*		NS		NS	
	$H_0$4: χ^2 (2x2)	NS				*			
	$H_0$2: χ^2 (2x2)	NS				NS			
$H_0$3 χ^2 (2x2)		**		**		**		**	

NS: non significant; *: significant (at the 0.05 level); **: highly significant (at the 0.01 level).

Table 3. Motion of *O. carneola*.

	DAY				NIGHT			
***Oliva* categories**	Small	Small	Large	Large	Small	Small	Large	Large
Departure sediment	black	white	black	white	black	white	black	white
Σ observations	29	28	35	28	35	38	43	37
Σ motions	6	7	4	3	17	20	28	23
Σ no motion	23	21	31	25	18	18	15	14
% motion	20.1	25.0	11.4	10.7	48.6	52.6	65.1	62.2
$H_0$1: χ^2 (2x2)	NS		NS		NS		NS	
$H_0$2: χ^2 (2x2)	NS				NS			
$H_0$3: χ^2 (2x2)			**					
					**			

NS: non significant; *: significant (at the 0.05 level); **: highly significant (at the 0.01 level).

Table 4. Substrate choice by *O. carneola* (white sand uptream).

	Black Substrate	White Substrate	χ^2
Day	63.5 (40.7%)	98.5 (59.3%)	**
Night	81.5 (44.0%)	103.5 (56.0%)	NS
Day & Night	145 (41.8%)	202 (58.2%)	**

NS: non significant; **: highly significant (at the 0.01 level).

Table 5. Substrate choice by *O. carneola* (white sand downstream).

	Black Substrate	White Substrate	χ^2
Day	97.5 (55.7%)	77.5 (44.3%)	NS
Night	80.5 (38.9%)	126.5 (61.1%)	**
Day & Night	178 (46.6%)	204 (53.4%)	NS

NS: non significant; **: highly significant (at the 0.01 level).

Table 6. Substrate choice by *O. coerulea*.

	Black substrate	White substrate	χ^2
Day	57 (43.9%)	73 (56.1%)	NS
Night	65.5 (41.0%)	94.5 (59.0%)	*
Day & Night	122.5 (42.4%).	167.5 (57.6%)	**

NS: non significant; *: significant (at the 0.05 level); **: highly significant (at the 0.01 level).

Table 7. Substrate choice by *O. longispira*.

	Black substrate	**White substrate**	χ^2	χ^2 **(2x2)**
white / Day	43 (61.4%)	27 (38.6%)	NS	
white / Night	53 (66.2%)	27 (33.8%)	**	
black / Day	32 (45.7%)	38 (54.3%)	NS	
black / Night	37 (46.2%)	43 (53.7%)	NS	
white / Day & Night	96 (64.0%)	54 (36.0%)	**	**
black / Day & Night	69 (46.0%)	81 (54.0%)	NS	

NS: non significant; **: highly significant (at the 0.01 level).