RESISTANCE TO DESICCATION AND OXYGEN DEBT IN WEDGE CLAMS

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ABSTRACT

The wedge clams, *Donax cuneatus* Linnaeus and *Donax faba* Gmelin acclimated to about 30° C. and exposed to air, indicated that at room temperature (average 30° C) *Donax faba* have a longer survival time (94 hours) than *D. cuneatus* (69 hours) as suggested by their 50% survival time. Survival of *D. cuneatus* exposed to air was studied at two lower temperatures (17 and 12° C) as well. While the survival of *D. cuneatus* at 17° C does not appear to be markedly different from that at room temperature, at 12° C the 50% survival time of *D. cuneatus* was considerably reduced (29 hours).

The amount of mantle cavity fluid in both *D. cuneatus* and *D. faba* exposed to air declined gradually with increase in the duration of exposure. The relative amount of the mantle cavity fluid was considerably higher in *D. faba* than in *D. cuneatus*.

Oxygen debt estimated from measurements of oxygen consumption of animals exposed to air upto 48 hours, indicated that in *D. cuneatus* and *D. faba* the post-exposure oxygen consumption increased 3·3 and 1·7 times their pre-exposure levels respectively. It is possible that *D. faba* has better anaerobic abilities with more capacity to withstand desiccation which may explain the longer survival time of *D. faba* than that of *D. cuneatus* when exposed to air under the conditions described.

INTRODUCTION

THE capacity of certain intertidal molluscs to withstand extreme conditions such as prolonged exposure and extremes of temperature has been investigated by many workers (*see* Newell, 1964). However, systematic studies on such aspects on molluscs occurring along the Indian coasts are few. *Donax cuneatus* Linnaeus and *Donax faba* Gmelin are the most common among wedge clams occurring in the sandy intertidal zone in the Gulf of Mannar Coast of Mandapam area. These clams are economically important for their meat, which is of food value and is also used as fish bait, and the shells which are used for making lime locally, and hence the present study may be of interest. But for some work on their taxonomy and some studies on their biology by Nayar (1955), Alargar swami (1967) and Krishnamurty *et al.* (1967) these animals have not received much attention. In the present study certain physiological aspects of survival of these two clams, such as the influence of exposure to air and conequent desiccation and oxygen debt, have been investigated.

MATERIAL AND METHODS

The experimental animals were collected from the sandy intertidal area at Vedalai, near Mandapam, and immediately brought to the laboratory in a bucket ¾-full of sea-water. Within an hour after the collection they were transferred to a wooden aquarium tank (60 cm. × 38 cm. × 23 cm.) containing sand (7 cm. depth), which served as the acclimation tank. The tank was supplied with running sea-water at a salinity of 33 ± 1‰, a temperature of 30 ± 1° C and at dissolved oxygen concentration near air saturation.

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Experimental Procedure

For experiments on survival the animals were removed from the acclimation tank, after they had remained in the tank for two to forty-eight hours, and were transferred to aerated sea-water (4 cm. depth) in a large enamel tray. All the animals which showed activity by extending the foot or the siphon were taken out and wiped with a piece of cloth and filter-paper for removing the traces of water on the shell of the animals, and they were kept exposed to air inside the laboratory in lots of five or six animals in dry petri dishes (3–4" diameter). At intervals of six hours or, as indicated, single groups were removed, and each animal in the lot was kept separately in a beaker containing aerated sea-water. The animals were watched at close intervals and if they again showed any activity such as extending either the foot or the siphon (*cf.* Morton *et al.*, 1957) within six hours after their transfer to the beaker, they were taken as living on counter-checking that the animals still retained the ability to withdraw the extended part.

As an index of desiccation the change in the amount of water trapped inside the closed shells was measured. This trapped water for all purposes can be assumed to be the mantle cavity fluid, as indicated by Dugal (1939), and is referred to as such in this paper. Dugal points out that though the mantle cavity fluid is not a true body fluid it becomes definitely altered when enclosed in the clam (*Venus mercenaria*) and that the total carbon dioxide contents were about the same in the mantle cavity fluid and in the fluid drawn from the pericardial cavity of both freshly collected and exposed clams. For this reason, it is felt that it is better to use the term 'mantle cavity fluid' for the water trapped inside the clam. Animals were wiped to remove traces of water as indicated earlier, and their total weights were taken. Then the weight of shells without meat was taken. The animal, removed from the shells by cutting only the adductor muscles, was put on a filter-paper and the fluid inside the mantle cavity absorbed out by gently pressing and rolling the meat on the filter-paper. Subsequently, the wet weight of meat was taken. From the above data the weight of the mantle cavity fluid was calculated for unexposed animals and also for those exposed to air upto 72–96 hours, at intervals of 12–24 hours. Data so obtained are included in Appendices I and II.

In experiments on post-exposure oxygen consumption the animals were exposed to air in separate lots in petri dishes, as in the case of the survival tests, upto 48 hours. At intervals of 12 hours single lots were removed and reimmersed in sea-water, and their metabolic rates were measured as explained below. The apparatus described by Kutty (1966) was used. The animals were kept one each in 300 ml. conical flasks. These flasks or respirometers remained submerged under sea-water inside a 'metabolism chamber' (Job, 1955, 1959). The water flowed through the respirometers without any apparent disturbance to the animals, and the flow was continuous except during the period of the actual determination of the metabolic rate, when the vessels were closed off. The respirometers were closed within 5–10 minutes after the animals were transferred to sea-water and remained closed for the next four hours. From water samples, taken before and after the period of closure, the rate of oxygen consumption was calculated.

The experiments on exposed animals were done at room temperature (average: 30° C; range: 26–33° C) except for a few performed at low temperatures of 12° C and 17° C. The latter experiments were done in a cold room where air temperture could be controlled with fair accuracy ($\pm$ 1° C), the maximum period of the experiments being 3 days. During the experiments on exposure the relative humidity ranged between 75 and 100%, except for the experiment at 17° C. The experiments for determining the oxygen debt were done in sea-water at a temperature of 30 $\pm$ 1° C

Results

Results of experiments on the survival of clams exposed to air are presented in Fig. 1, A-E. Time to 50% survival indicated by cross-marks on the curves drawn in Fig. 1, referred to hereafter only as 'survival time', is taken here as an index of the resistance of the clams to air exposure. The survival time of *D. cuneatus* (average length 1-3 cm.) exposed to air at room temperature

(30° C), was found to be 69 hours (Fig. 1 A). Smaller sized *D. cuneatus* (average length–2 cm.), also exposed to air at room temperature were found to have a shorter survival period. The survival time of the arger *D. cuneatus*, exposed to air at 17° C, was 69 hours (Fig. 1, C) and of those exposed to air at still lower temperature of 12° C was 29 hours (Fig. 1, D). While survival in these

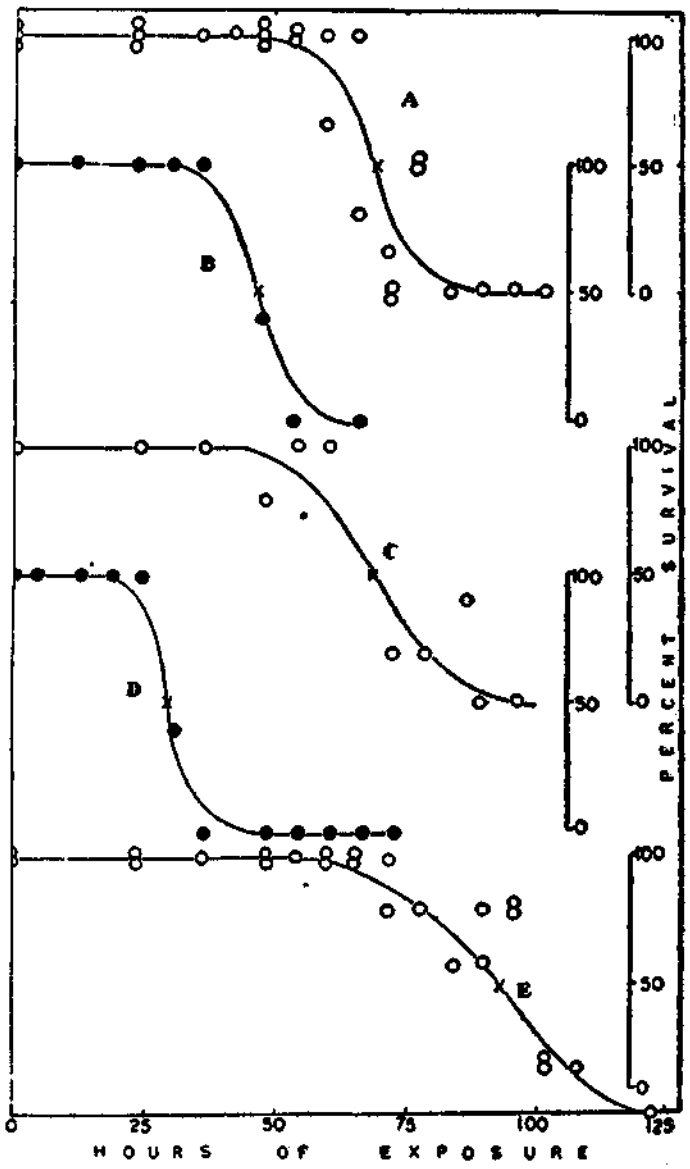

FIG. 1. (A–E). Survival of *Donax cuneatus* and *Donax faba* exposed to air. (A) *Donax cuneatus*—large size (avera length—3 cm.) exposed to air at room temperature (average 30° C; range 26–33° C); relative humidity 85–100%. (B) *Donax cuneatus*—small size (average length—2 cm.) exposed to air at room temperature (average 30° C: Range—26–32° C); relative humidity 75–90%. (C) *Donax cuneatus* (size same as for A) exposed to air at 17 ± 1° C; relative humidity 27–65%. (D) *Donax cuneatus* (size: same as for A) exposed to air at 12 ± 1° C; relative humidity 76–89%. (E) *Donax faba* (average length—2·5 cm.) exposed to air at room temperature (average 30° C; range 24–32° C); relative humidity 80–100%. All curves in the figure are fitted by the eye.

clams at 17° C does not appear to be different from that at room temperature, at 12° C temperature appears to be a prime factor in causing death as evident from the shift in the survival time.

In *D. faba* (average length—2·5 cm.) exposed to air at room temperature the survival time was 94 hours (Fig. 1, E). It is, however, to be noted that even though the time to 50% survival was longer for *D. faba* than *D. cuneatus* the survival curve of the latter appears much steeper (*see* curves A and E in Fig. 1). which may be due to the basic difference in the nature of mortification in the two species under the conditions of the tests.

Results of experiments on desiccation on exposure to air, as indicated by the change in the amount of mantle cavity fluid in *D. cuneatus* and *D. faba*, are given in Tables I A and I B and Fig. 2. In *D. cuneatus* exposed to room temperature the mantle cavity fluid (*see* methods) declined more or less gradually from an initial value (unexposed animals) of 0·41 to 0·34 g./g. of anima weight[1] after 48 hours of exposure (Table I A and Fig. 2, open circles). Determinations made after 72 hours indicated a value of 0·29 g./g. animal weight, but this value may have included some individuals which might have been dead (*see* survival curve A in Fig. 1) and hence cannot be strictly compared. It is also noted that there is no significant difference between the values of the mantle cavity fluid in unexposed animals and those exposed to 24 hours, the mean value being slightly higher in latter case. It is possible that this is because the animals did not lose any water in the first day of exposure, or due to some experimental error, but this cannot be verified further with the available information.

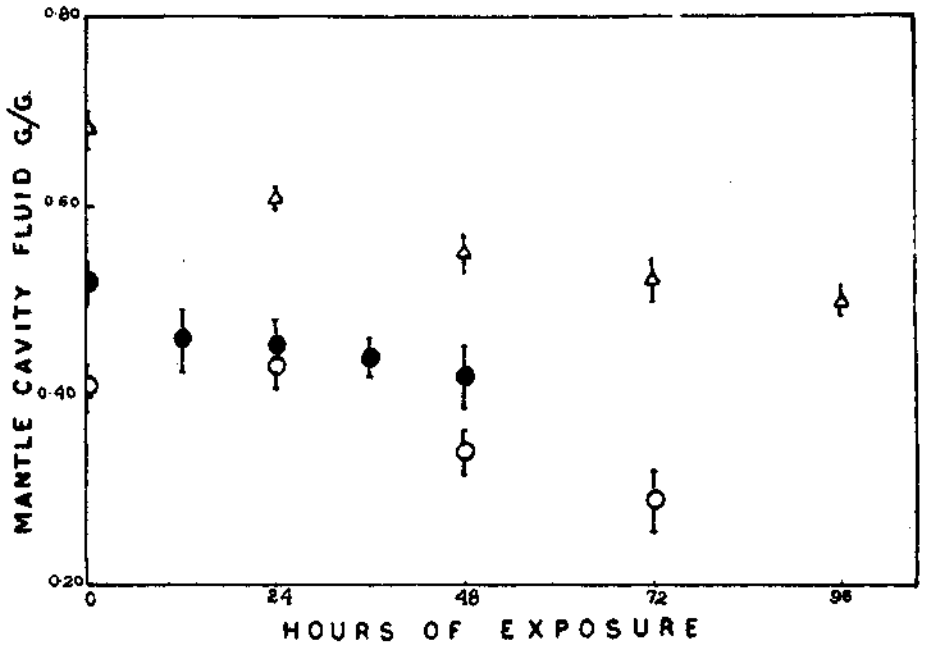

FIG. 2. Decline in the amount of mantle cavity fluid in relation to duration of exposure to air in *Donax cuneatus* and *Donax faba*. The open circles denote values obtained from *Donax cuneatus* exposed to air at room temperature. The closed circles denote values obtained from *Donax cuneatus* exposed to air at 17° C and the triangles represent *Donax faba* exposed to air at room temperature. The values plotted are taken from Tables I A and I B. The vertical lines indicated in the figure denote one standard error from the mean values.

[1] 'Weight of animals' indicates the total weight of the animal excluding the shell weight (*see* Appendices I & II).

TABLE I A

Decline in the amount of mantle cavity fluid (g./g. animal weight) in relation to duration of exposure in Donax cuneatus *exposed to air at room temperature (average : 30° C; range: 28–34° C) and relative humidity of 90–95%; lower column shows values of* Donax cuneatus *exposed to air at 17 ± 1° C and relative humidity of 27–69%. Each value is a mean of 4–6 separate determinations. The figures given after the sign ± indicate standard error. Gram animal weight indicated includes that af mantle cavity fluid*

Experimental temperature	Hours of exposure					
	0	12	24	36	48	72
30° C	0·41 ±0·024	..	0·43 ±0·027	..	0·34 ±0·025	0·29 ±0·032
17° C	0·52 ±0·025	0·46 ±0·033	0·45 ±0·020	0·44 ±0·020	0·42 ±0·031	..

TABLE I B

Decline in the amount of mantle cavity fluid (g/g animal weight) in relation to duration of exposure in Donax faba *exposed to air at room temperature (average: 30° C; range 26–32° C) and a relative humidity of 75–85%. Each value is a mean of 4–6 separate determinations. The figures after the sign ± indicate standard error. Gram animal weight indicated includes that of mantle cavity fluid*

Experimental temperature	Hours of exposure				
	0	24	48	72	96
30° C	0·68 ±0·021	0·61 ±0·012	0·55 ±0·020	0·52 ±0·022	0·49 ±0·016

In *D. cuneatus* exposed to 17° C the mantle cavity fluid declined from an initial value of 0·52 to 0·42 g./g. of animal weight after an exposure of 48 hours (Table I A and Fig. 2, closed circles). While the mean values from clams exposed to 17° C are higher than those exposed to 30° C at all levels of exposures, the difference appears to be insignificant at most levels. It is noted that in animals exposed to 30° C all or most of the water was lost between 24 and 48 hours, whereas in those exposed to 17° C most of the loss was between 0 and 24 hours (*see* Table II). It may be pointed out that *D. cuneatus* kept exposed to air at room temperature appeared to have remained tightly closed especially during the first half of the experimental period, while those exposed to 17° C kept their shells open from the beginning of the experiment and almost throughout the period of exposure. Difference in the experimental conditions other than temperature (relative humidity was markedly low at 17° C *see* legend for Fig. 1) might have influenced the results, but the extent of this influence cannot be known.

In *D. faba* exposed to room temperature the mantle cavity fluid declined gradually from an initial value of 0·68 to 0·55 g./g. of animal weight in animals exposed for 48 hours (Table I B and Fig. 2, triangles). Values of mantle cavity fluid have been determined in animals exposed to 72 and 96 hours as well, which also show a gradual decline with the duration of exposure to air even though loss of water appears to be much less towards the later part (48 to 96 hours). Here again the last two values may have included determinations made on groups in which some animals might have been dead, since mortality in *D. faba*, though to a lesser extent, begins at about the 60th hour of exposure (Fig. 1, E). It appears that in *D. faba* desiccation was at about the same rate in the first two days of exposure (Table II). It is interesting to note that in the three groups of animals tested desiccation, as indicated by the loss of mantle cavity fluid, at the end of the second day of exposure appears to be about the same magnitude (17 to 19%—*see* Table II).

Table I and Fig. 2 show clearly that the relative amount of mantle cavity fluid is more in *D. faba* (about 70% for unexposed animals) than in *D. cuneatus* (both test groups at 30° and 17° C) (40–50% for unexposed animals at all levels of exposure). *D. faba* used are smaller than *D. cuneatus* and there is the possibility that the difference in the relative amount of mantle cavity fluid in the two groups is due to the size difference, but it is felt that size difference will not fully account for the difference in the relative amount of fluid.

TABLE II

Percentage deviation in the amount of mantle cavity fluid from the initial values (unexposed animals) in Donax cuneatus *and* Donax faba *(values calculated from data presented in Tables I A and I B)*

Species	Experimental temperature	Period of exposure in hours		
		0–24	24–48	0–48
Donax cuneatus ..	30° C	+4·9?	−22·0	−17·1
	17° C	−13·4	− 5·8	−19·2
Donax faba ..	30° C	−10·3	− 8·8	−19·1

Results of experiments on the oxygen consumption of *D. cuneatus* and *D. faba* subsequent to specific periods, up to 48 hours, of exposure to air are given in Tables III A and III B and are graphically shown in Fig. 3. In view of the observations of earlier authors (*cf.* van Dam, 1935) that the oxygen debt accumulated during the period of exposure in other bivalves is paid back in the first few hours of reimmersal in water, the present estimate of oxygen debt is made from values obtained during the first four hours of reimmersal in sea-water. The tendency to increase oxygen consumption with an increase in duration of exposure appears to be similar in both species (Fig. 3).

TABLE III A

Oxygen consumption in Donax cuneatus *on reimmersal in sea-water (30° C) subsequent to different periods of exposure to air at room temperature (average: 30° C). Values of the mean ± one standard error are indicated. Each mean is calculated from 4 separate determinations. Metabolic rate shown is per gram wet weight of meat*

	Hours of exposure				
	0	12	24	36	48
Oxygen consumption mg./ g. hour	0·071 ±0·003	0·162 ±0·024	0·170 ±0·015	0·239 ±0·141	0·234 ±0·123

TABLE III B

Oxygen consumption in Donax faba *on reimmersal in sea-water (30° C) subsequent to different periods of exposure to air at room temperature (average 30° C). Values of the mean ± one standard error are indicated. Each mean is calculated from 4 separate determinations, except for the value at 24 hours (n = 3). Metabolic rate shown is per gram wet weight of meat*

	Hours of exposure				
	0	12	24	36	48
Oxygen consumption mg./g./hour	0·413 ±0·107	0·517 ±0·050	0·455 ±0·060	0·623 ±0·079	0·607 ±0·075

The 48 hour-exposed (the longest period tested in this series) groups in both species accumulate maximum oxygen debt as can be known from the enhanced oxygen consumption. Values given in Table III indicate that the oxygen consumption of *D. cuneatus* and *D. faba* increased 3·3 and 1·7 times, respectively, the level of oxygen consumption of unexposed animals. It appears that the higher metabolic rate of *D. faba* than that of *D. cuneatus*, as shown in Fig. 3, is due to the smaller size of *D. faba* tested (Zeuthen, 1953). If one assumes a '*b*' value of unity, which is rather high for molluscs (Zeuthen, 1953) in the weight-length relation of the molluscs investigated for a weight correction, most of the corrected values so obtained from *D. cuneatus* do not appear to be significantly different from those of *D. faba*. Increased oxygen consumption in molluscs consequent to exposure to air has been observed by several authors (Mitchell, 1912; van Dam, 1935; Nagabhushanam, 1966 and others) and has been taken as due to the oxygen debt accumulated during the period of exposure and subsequently rapid on reimmersal to water. It has also been observed that certain molluscs do not accumulate an oxygen debt (Morton *et al.*, 1957). As evident both species included in the present study accumulate an oxygen debt.

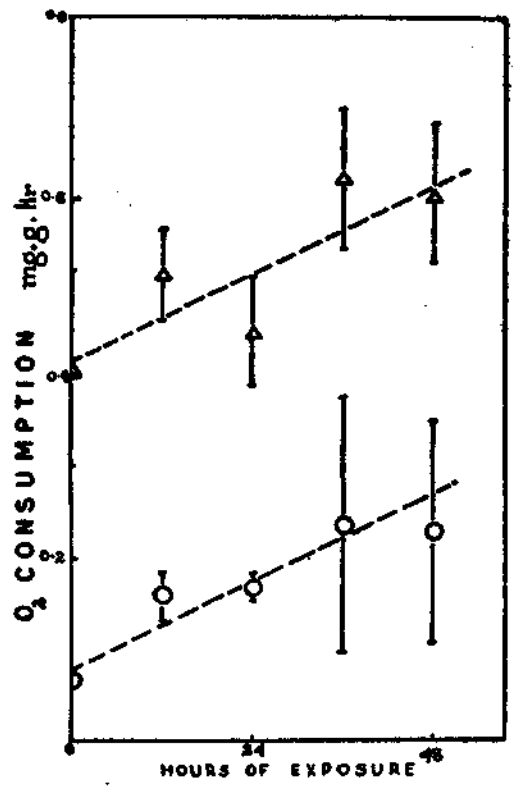

FIG. 3. Oxygen consumption in *Donax cuneatus* (circles) and *Donax faba* (triangles) on reimmersal in sea-water (30° C) subsequent to different periods of exposure to air at room temperature (30° C). The broken lines indicate the trend in increase in oxygen consumption with the increase in the duration of exposure. The vertical lines indicated in the figure denote one standard error from the mean values. The metabolic rates indicated are per gram wet weight of meat.

DISCUSSION

From comparisons of the survival times it would appear, as already pointed out, that at 12° C, temperature does act as one of the major factors causing death in *D. cuneatus* exposed to air as

indicated by the shift of survival curve to the left (compare curves A and D in Fig. 1). The survival time of *D. cuneatus* exposed to air at 17° C appears to be same as that at 30° C. Whether temperature was of more or less consequence in causing mortality at 17° C than at 30° C cannot be clearly known, because of the difference especially in the humidity conditions of the two sets of experiments. The trend in water loss at these two temperatures as indicated by the loss of the mantle cavity fluid does not seem to be markedly different. In both groups (17 and 30° C) animals began dying after about the 2nd day of exposure, when the amount of mantle cavity fluid had declined by about 20% from the initial value.

Low temperature deaths in molluscs have been studied by various authors (Newell, 1964). Kanwisher (1955) has observed that certain molluscs (*Crassostrea virginica, Mytilus edulis, Modiolus modiolus, Littorina littorea,* and *L. rudis*) can withstand even freezing temperatures for long periods. *Mytilus edulis* has been known to revive after 6 to 8 months at −20° C or below in solid ice at Labrador (Kanwisher, 1959). Kanwisher is of the opinion that resistance to freezing runs parallel with ability to withstand desiccation. Within the limited scope of the present experiments such aspects of temperature death cannot be further discussed.

Death at higher temperature has not been included in the present study. *Ostera cucullata* from the tropics of the Indo-Pacific region have been known to tolerate temperatures as high as 45° C (Stephenson, 1924). Such studies will indeed be of much interest as there are only a few observations on the temperature death of molluscs in the tropics.

It may be pertinent to point out that in the present studies ability to survive and withstand exposure have been investigated only at a single level of temperature acclimation in both species. It is needless to stress that a full picture of the adaptational abilities of these animals with regard to temperature can only be known by further studies on animals acclimated to different levels of temperature.

Some field observations made on the clams studied presently indicate that both the species have more or less overlapping distribution in the vertical gradient, but there are possibly demarcations of zones along the intertidal area where only one species (*D. faba*) occurs, which may be taken to suggest that *D. faba* have a wider range of tolerance of the various ecological factors than *D. cuneatus*. This aspect needs further study to arrive at firm conclusions.

Ability to withstand desiccation has been closely correlated with the order of occurrence of certain molluscs in the intertidal areas (Broekhuysen, 1940; Newell, 1964). Morton *et al.* (1967) studied water loss in the lamellibranch *Lasaea rubra* by following the change in weight of animals exposed for 12 hours and found that low neap *Lasaea* lost much more water than the high tidal forms. There does not appear to be much difference in the pattern of water loss between the two species tested presently, but it does appear as already pointed out that *D. faba* has a relatively larger amount of mantle cavity fluid than *D. cuneatus* and this can possibly enable it to withstand desiccation to a better extent and may explain at least partly the longer survival time of *D. faba* exposed to air (Fig. 1). Size difference cannot be the reason for the longer period of survival of *D. faba* as it would appear from the results of tests on the influence of size on survival in *D. cuneatus* exposed to air. If *D. faba* tested were as large as *D. cuneatus*, one may expect the survival period of the former to be longer than that indicated by the presently observed value, thereby suggesting a wider disparity between the two species of clams than is apparently noted.

It also appears that *D. faba* accumulates relatively much less oxygen debt than *D. cuneatus* (Fig. 3). While it is recognized that relative inactivity to a great extent allows the animals to stay exposed for considerable time without accumulating a large oxygen debt, it is possible that the anaerobic abilities of the two clams are different (Cole, 1921; Dugal, 1939; von Brand, 1946, 1951) and that *D. faba* is able to function better anaerobically than *D. cuneatus* possibly by obtaining energy through more unconventional methods (Blazka, 1957; Saz and Weil, 1960). From the present study it can only be concluded that *D. faba* is better adapted than *D. cuneatus* to survive when exposed to air, being subject to less desiccation and probably having better anaerobic abilities.

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APPENDIX I A

Basic data on Donax cuneatus *used in experiments at room temperature (average: 30° C; range: 26–33° C)*
(The experimental details are briefly indicated in the remarks column)

Serial No.	Shell length in cm.	Total weight in g.	Shell weight in g.	Meat weight including mantle cavity fluid in g.	Meat weight excluding mantle cavity fluid in g.	Weight of mantle cavity fluid in g.	Percentage weight of mantle cavity fluid in values given in Column 5	Remarks
1	2	3	4	5	6	7	8	9
1	3·2	5·2025	3·4518	1·7507	1·0361	0·7146	40·81	Unexposed animals
2	3·2	5·0062	3·1428	1·8634	1·2229	0·6405	34·37	,,
3	3·1	4·5601	2·8274	1·7327	1·0721	0·6606	38·12	,,
4	3·1	4·5032	2·8500	1·6532	0·8884	0·7648	46·26	,,
5	3·0	3·8247	2·3980	1·4267	0·7445	0·6822	47·81	,,
6	3·2	5·3203	3·6804	1·6399	0·8613	0·7786	47·47	24 hours exposed
7	3·2	4·9709	3·1951	1·7758	1·0505	0·7253	40·84	,,
8	3·0	3·9291	2·5963	1·3328	0·7112	0·6216	46·63	,,
9	3·1	4·5775	3·0807	1·4968	0·8187	0·6781	45·30	,,
10	3·1	4·4074	2·9560	1·4514	1·0093	0·4421	30·46	,,
11	3·3	4·9914	3·4756	1·5158	0·8437	0·6921	45·65	,,
12	3·1	4·2223	3·0073	1·2150	0·8101	0·4049	33·32	48 hours exposed
13	3·1	4·2312	3·2924	0·9388	0·7049	0·2339	24·91	,,
14	3·2	2·5083	3·0702	1·4381	0·8684	0·5697	39·61	,,
15	3·2	4·3155	2·9782	1·3373	0·9040	0·4333	32·40	,,
16	2·9	3·4915	2·4126	1·0789	0·6670	0·4119	38·17	,,
17	2·8	2·7935	2·1307	0·6628	0·4899	0·1729	26·08	72 hours exposed
18	3·0	3·5249	2·5711	0·9538	0·5918	0·3620	37·95	,,
19	2·9	3·2740	2·3258	0·9482	0·6667	0·2815	29·68	,,
20	3·0	3·4242	2·6106	0·8226	0·6496	0·1730	21·03	,,
21	3·0	3·6048	2·5496	1·0552	0·6385	0·4167	39·49	,,
22	2·9	2·8665	2·1923	0·6742	0·5110	0·1632	24·20	,,

APPENDIX I B

Basic data on Donax cuneatus *used in experiments at 17° C*
(The experimental details are briefly indicated in the remarks column)

Serial No.	Shell length in cm.	Total weight in g.	Shell weight in g.	Meat weight including mantle cavity fluid in g.	Meat weight excluding mantle cavity fluid in g.	Weight of mantle cavity fluid in g.	Percentage weight of mantle cavity fluid in values given in Column 5	Remarks
1	2	3	4	5	6	7	8	9
1	3·3	5·7052	3·8093	1·8959	0·7652	1·1307	59·64	Unexposed animals
2	3·1	4·8850	3·0892	1·7958	0·9376	0·8582	47·79	"
3	2·9	4·4458	2·7519	1·6939	0·7446	0·9493	56·04	"
4	3·1	5·0488	2·9757	2·0731	1·1081	0·9650	46·55	"
5	3·2	5·2954	3·3030	1·9924	0·9820	1·0104	50·71	"
6	3·3	5·4146	3·5333	1·8813	0·9591	0·9222	49·02	12 hours exposed
7	3·2	4·9108	3·2035	1·7073	0·7493	0·9580	56·11	"
8	3·1	4·5035	2·9238	1·5797	0·9661	0·6136	38·84	"
9	3·2	4·3270	2·6651	1·6619	0·8514	0·8105	48·77	"
10	3·2	4·8570	3·0526	1·8044	1·0907	0·7137	39·55	"
11	3·1	4·8432	3·1381	1·7051	0·8916	0·8135	47·71	24 hours expose
12	3·3	5·4070	3·7189	1·6881	1·0080	0·6801	40·29	"
13	3·1	4·5162	2·9410	1·5752	0·6969	0·8783	55·76	"
14	3·0	4·1372	2·8180	1·3192	0·8019	0·5173	39·21	"
15	3·0	3·7903	2·4518	1·3385	0·7444	0·5941	44·39	36 hours expo
16	3·0	4·4111	2·9372	1·4739	0·8180	0·6559	44·50	"
17	3·1	4·0331	2·6855	1·3476	0·8420	0·5056	37·52	"
18	3·0	4·0853	2·6560	1·4298	0·7808	0·6490	45·39	"
19	3·0	4·0534	2·7922	1·2612	0·7049	0·5563	44·11	"
20	3·2	4·6945	3·3190	1·3755	0·6845	0·6910	50·24	"
21	3·2	5·0478	3·6594	1·3884	0·8880	0·5004	36·04	48 hours exposed
22	3·2	4·2814	3·1050	1·1764	0·6532	0·5232	44·47	"
23	3·0	3·7830	2·6060	1·1770	0·5900	0·5870	49·87	"
24	2·9	3·3350	2·3402	0·9948	0·6678	0·3270	32·87	"
25	2·9	3·6228	2·5631	1·0597	0·5892	0·4705	44·40	"

APPENDIX II

Basic data on Donax faba *used in experiments at room temperature* (*average* = 30° *C*; *range*: 26-33° *C*)
(The experimental details are briefly indicated in the remarks column)

Serial No.	Shell length in cm.	Total weight in g.	Shell weight in g.	Meat weight including mantle cavity fluid in g.	Meat weight excluding mantle cavity fluid in g.	Weight of mantle cavity fluid in g.	Percentage weight of mantle cavity fluid in values given in Column 5	Remarks
1	2	3	4	5	6	7	8	9
1	2·7	3·4099	2·3829	1·0270	0·2766	0·7504	73·07	Unexposed animals
2	2·7	3·7539	2·4967	1·2572	0·3179	0·9393	74·71	,,
3	2·4	2·7673	1·8522	0·9151	0·3213	0·5938	64·89	,,
4	2·5	2·7048	1·8869	0·8179	0·2981	0·5198	63·55	,,
5	2·6	2·8287	1·9489	0·8798	0·3032	0·5766	65·54	,,
6	2·5	2·4054	1·7595	0·6459	0·2608	0·3851	59·52	24 hours exposed
7	2·6	2·6920	2·0437	0·6483	0·2607	0·3876	59·79	,,
8	2·5	2·5821	1·9540	0·6281	0·2397	0·3884	61·84	,,
9	2·5	2·4820	1·8884	0·5936	0·2377	0·3559	59·96	,,
10	2·7	3·2965	2·3850	0·9115	0·3110	0·6005	65·88	,,
11	2·7	2·9858	2·3674	0·6184	0·2757	0·3427	55·42	48 hours exposed)
12	2·7	3·3740	2·6574	0·7166	0·3038	0·4128	57·61	,,
13	2·7	3·0722	2·4815	0·5907	0·3084	0·2823	47·79	,,
14	2·5	3·0010	2·2678	0·7332	0·2916	0·4416	60·23	,,
15	2·4	2·4088	1·8661	0·5427	0·2540	0·2887	53·20	,,
16	2·5	2·7300	2·1617	0·5683	0·2987	0·2696	47·44	72 hours exposed)
17	2·8	2·7530	2·2390	0·5140	0·2286	0·2854	55·53	,,
18	2·7	3·2470	2·6336	0·6134	0·2722	0·3412	55·62	,,
19	2·5	2·5218	2·0560	0·4658	0·2068	0·2590	55·60	,,
20	2·6	2·5288	2·0788	0·4500	0·2469	0·2031	45·13	,,
21	2·6	2·7704	2·3450	0·4254	0·2166	0·2088	49·08	96 hours exposed
22	2·5	2·7900	2·3535	0·4365	0·2390	0·1975	45·25	,,
23	2·7	2·7500	2·2266	0·5234	0·2436	0·2798	53·46	,,
24	2·7	2·4817	1·9815	0·5002	0·2413	0·2589	51·76	,,
25	2·4	2·1610	1·7425	0·4185	0·2287	0·1898	45·35	,,