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Spatial Distribution and Activity Pattern of the Ghost Crab, *Ocypode cursor* (L., 1758) in Yumurtalik Bay, North-Eastern Mediterranean-Turkey

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Abstract: Spatial distribution and activity pattern of *Ocypode cursor* (L., 1758) were studied for 2 years (2000-2001) in 40×15 m sand beach of Yumurtalik Bay in Turkey. Analysis of frequency distributions of the ghost crab population was based on indirect census, with burrow diameter measurement. Burrow diameter was a good estimator of crab size. Burrow diameter/carapace length and length/width relationships were estimated from samples obtained by excavating burrows and individual capture by trap. These relationship were adjusted by the following equations, respectively: BD = 0.25+1.13 CL; CW = 2.44+1.13 CL (BD is burrow diameter; CL is carapace length; CW is carapace width). Spatial distribution analysis was performed based on distance and altitude to water line. Most small burrows were found close to the sea, while larger burrows were mostly found in places higher up the beach. *O. cursor* was absent from the dry portion of the beach next to the dunes. The activity pattern showed that crabs are more activity during night than day-time. Burrow shape also was analysed. These burrows were in L-or j-shapes.

Key words: Ghost crab, *Ocypode cursor*, burrows, distribution, Yumurtalik Bay, Turkey

INTRODUCTION

Ghost crabs, *Ocypode* sp., are common on sub-tropical to tropical sandy shores. *Ocypode* are nocturnal hiding in burrows during the daytime (Weinstern, 1995; Chan *et al*., 2006). The burrows are essential and serve several purposes. They allow the crabs to breathe air and to escape from predators. They protect the crabs from severe hydro-meteorological forcing due to tidal cycle, ranging from heat irradiation and winds during the period of exposure at low tides, to winds during the period of submergence at high tides. Furthermore the burrows function as a base for various kinds of basic living activities, such as feeding, breeding and territorial behaviour. The burrowing performance of individual species may be affected by body size, sediment grain size, temperature and intertidal morph dynamics (Sassa and Watabe, 2008). The burrow's shape, its length and diameter of its opening are both species-specific and related to dispersal pattern. Burrow shape is also determined by anatomy and of the crab and its sex (Shuchman and Warburg, 1978).

Several physical variables of beaches such as width, slope,granulometry, tidal regime and degree of urbanization, have been used to explain the presence and abundance of the ghost crab (Alberto and Fontoura, 1999; Barros, 2001; Valero-Pacheco *et al*., 2007). Due to its abundance and relatively large size, this species is a key element in the functioning of the shore ecosystem. Ghost crabs can reach 48 mm in carapace width, they can dig galleries of up to 630 mm in length and 590 mm depth, with surface diameters of 50 mm (Strachan *et al*., 1999; Valero-Pacheco *et al*., 2007). Through the maintenance of the galleries the crabs aerate, move and recycle an important amount of nutrients in the sandy shores. They feed on particulate organic matter found among the sand grains, dead fish and other dead marine animals present on the beach, as well as live prey, including hatching turtles, lizard, land crabs, small crab and insects (Wolcott, 1978; Valero-Pacheco *et al*., 2007).

Many ecological aspects of *Ocypode* species have been investigated (Trevallion *et al*., 1970; Schober and Christy, 1993; Alberto and Fontoura, 1999; Barros, 2001; Quijon *et al*., 2001; Fransozo *et al*., 2002; Clayton, 2005; Turra *et al*., 2005). Ecological aspects of this species in the Mediterranean have also been carried out (Shuchman and Warburg, 1978; Ewa-Oboho, 1993; Strachan *et al*., 1999).

Ocypode cursor (Linnaeus, 1758) (Ocypodidae) occur in high densities in marine estuaries. This species burrows into the sand, but unlike other species (Shuchman and Warburg, 1978). They can be found within high-tide limits,

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sometimes this area extends beyond the shore into terrestrial habitats (Ewa-Oboho, 1993). Within the Mediterranean, *O. cursor* is found on east and central Mediterranean beaches (Stevcic and Galil, 1994). This species inhabits sandy beaches along the Mediterranean coast of Turkey.

The aim of this study was to address the spatial distribution and activity pattern of *O. cursor* in beach of Yumurtalik at different tidal zone. The environmental variables (beach slope, temperature and sediment grain size) were compared among zones and related to crab abundance and size.

MATERIALS AND METHODS

Ocypode cursor ranges from the northeastern Mediterranean to Aegean Sea along the Turkish coasts (Kocatas *et al*., 2004).

The study was carried out at one site, Yumurtalik beach (Fig. 1). Which supports a large population of ghost crabs. The beach is considered to be relatively undisturbed, with only occasional presence of visitor.

An area extending 15 m from the water line to the back of the shore and 40 m in width was selected for the study. The study area started within approximately 3 m away from the sea, at the high tide line (Reference Datum-RD) and extended a further 15 m up the RD. The study site was then divided into 4 zones for descriptive purposes. Zone 1 extended to a height of 7.5 m above RD, zone 2 was a horizontal platform, zone 3 extended to a height 15 m above RD and zone 4 was virtually horizontal (Fig. 2). To determine the population size of *O. cursor* in Yumurtalik, it was assumed that the number of burrows present on the beach was as same as the number of crabs. The total numbers and size distributions of burrows were examined in 2001 (August, September and October) and 2002 (June, July and August). During each month, the number of the burrows in all of 4 zones was determined during a period of 5 continuous days. The diameter of each burrow opening in the search area was measured using callipers and was assigned to one of 7 categories (<1, 1-1.9, 2-2.9, 3-3.9, 4-4.9, 5-5.9 and >6 cm). Some burrows were cast by pouring a gypsum slurry into them. When the gypsum had set, the casts were carefully excavated by hand and their shape and dimensions were noted. On several occasions, the burrow occupant was trapped inside the cast, which enabled us to determine the crab's size and sex and to relate these to the burrow size.

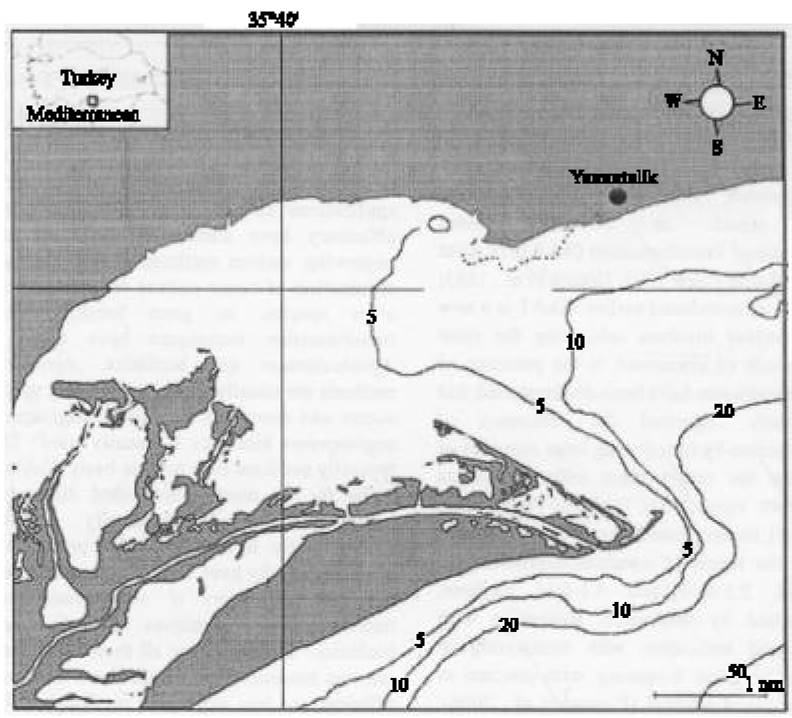

Fig. 1: Yumurtalik Bay, Nouth-Eastern Mediterranean-Turkey

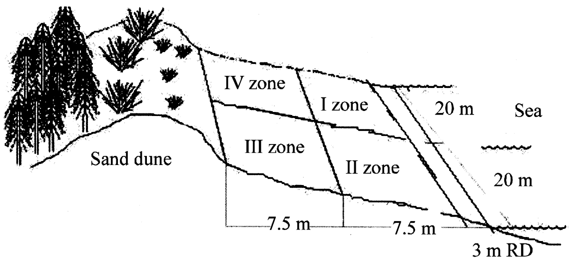

Fig. 2: Schematic diagram of the levels sampled on Yumurtalik Beach

For the study of sand granulometry, 100 g sand samples were taken from a depth of 30 cm in all of 4 zones and sieved using graded Endecott sieves. Grain size analysis was followed (Davis, 1978) relationships.

In the summer of 2002, crabs were occasionally and randomly hand-caught at night when they had emerged from their burrows. No particular selection criteria were applied. Carapace length and width were measured cm and these data were used to investigate morph metric

The activity pattern was obtained through observation made every four periods for 24 h in August and October 2001. Environmental temperatures (air, sand surface, sediment column) were recorded at 6 hourly intervals during 24 h.

RESULTS

The total number of burrows in the Yumurtalik study area changed significantly (ANOVA, F = 13.401, $p<0.01$) during the months of 2001 and 2002 (ANOVA, F = 2.397, $p<0.05$) (Table 1).

The peak count was recorded in August 2001 and July 2002 (Table 1). In 2001 the burrow count for summer was significantly greater than that for autumn (t-test, $p<0.05$). A decrease in the total number of burrows was seen throughout October. In 2002, the numbers of burrows in July was significantly greater than those in June and August (t-test, $p<0.05$) (Table 1). As may be seen in Table 1, the counts of burrow openings during the study period revealed that highest number of burrows occurred summer, dropping towards the end of the summer.

O. cursor was showed in four zonation. The peak of density occurred between 3 and 7.5 m height above the water line, while fewer individuals were recorded in the subterrestrial fringe (between 7.5-15 m) (Table 2). The density varied markedly among the zones for 2001 (ANOVA; F = 7.95, df = 3, $p<0.05$) and 2002 (ANOVA; F = 46.72, df = 3, $p<0.05$). Burrow density ranged from 2.18-2.72 ind/m^2 in 2001 to 0.50-0.52 ind/m^2 in 2002.

Table 1: The number of *O. cursor* burrows recorded in 2001 (August, September, October) and 2002 (June, July, August) of a 40 m wide stretch of Yumurtalik Beach

Year (month)	Mean±SE (min-max)
2001	
August	48.50±8.17 (2-106)
September	33.05±2.32 (15-66)
October	11.00±2.71 (0-33)
2002	
June	14.40±3.42 (0-44)
July	19.90±4.67 (0-50)
August	9.15±1.61 (0-20)

Table 2: The number of *O. cursor* burrows recorded in the four different zones of a 40 m width stretch of Yumurtalik beach

Year (month)	Zone (Height of 7.5 m above RD) I	II	Total	(Height of 15 m above RD) III	IV	Total
2001						
August	390	409		31	140	
September	168	178		163	152	
October	101	119	1365	0	0	486
2002						
June	132	150		0	6	
July	210	188		0	0	
August	76	78	834	12	17	35

Small sized burrows predominated in all zones in 2001 (Table 3). As further from the sea, burrows were larger, but less frequent. In 2002, within Zones 1 and 2, the dominant size categories were 1-1.9 and 2-2.9. In Zones 3 and 4, the burrows were mostly within 2-2.9 and 3-3.9 size categories (Table 3). Each burrow excavated contained only one opening and one occupant.

The burrow diameter was demonstrated to be a good estimator of crab size in the present study. The relationship between burrow diameter and carapace length was investigated in 2001. These relationship were adjusted by the following equations, respectively: BD = 0.25+1.13 CL r^2 = 0.956 (Fig. 3); CW = 2.44+1.13 CL r^2 = 0.974 (Fig. 4) (BD is burrow diameter; CL is carapace length; CW is carapace width).

Surveys carried out in August and in October 2001 demonstrated that crabs showed more activity during the night than during the day. During August, very little crab activity was observed during the day (Fig. 5). The main activities observed were feeding and burrow excavation.

Measurements made during August showed that the mean air temperature (n = 4) above the sand surface ranged from 18°C at 06: 00 h to 27.5°C at 18: 00 h. The temperatures taken from various depths within the sand column were seen to remain relatively constant, varying by <4°C over a 24 h period (Table 4).

Table 3: The percentage of *O. cursor* burrows belonging to each of the seven sizes categories recorded in the four zones of the 40 m wide band where burrows were present on Yumurtalik beach in August

	Zones							
	2001				2002			
Burrow size class (cm)	1	2	3	4	1	2	3	4
<1	33.3	32.8	21.7	28.1	16.1	17.1	-	-
1-1.9	34.2	36.7	23.7	37.8	25.1	22.1	-	13.0
2-2.9	12.1	10.4	19.3	12.2	29.1	29.5	41.6	35.0
3-3.9	10.7	10.3	19.3	15.4	16.8	17.6	33.5	34.7
4-4.9	6.0	4.9	10.6	7.1	8.7	9.1	24.9	13.0
5-5.9	2.4	2.1	3.0	2.4	2.3	1.8	-	4.3
6>	5.0	3.8	1.0	1.2	0.2	0.6	-	-

Table 4: The mean temperatures taken at 6 h intervals through a 24 h period in August 2001. Temperature readings were taken from depths of 10, 20, 30 and 40 cm within the sand column. Recordings of the sand surface temperature (S.S.) and the air temperature at 20 cm above the sand (A.T.) were also taken

	Mean temperatures (°C)					
Time	A.T.	S.S.	10 cm	20 cm	30 cm	40 cm
06: 00	18.0	18.5	23	25.3	26.1	26.2
12: 00	25.0	38.0	30.7	26.8	26.5	26.1
18: 00	27.5	26.6	30.1	28.2	26.5	25.8
00: 00	20.0	22.8	24.7	26.3	26.6	26.6

Table 5: Granulometry data (dry sieving method) relating to the sand samples collected from the four zones on Yumurtalik beach

Zone	Coarse grain (%)	Median grain (%)	Small grain (%)
1	6	78	16
2	6	76	18
3	9	73	18
4	2	78	20

Table 6: Description of the burrow casts obtained from Yumurtalik beach. All have the general L/J shape

Burrow No	Opening diam. (cm)	Distance from sea (m)	Borrow depth (cm)	Length of near-vertical component (cm)	Length of near-horizontal component (cm)
1	2.2	3.00	11.4	16.50	2.5
2	4.3	2.50	46.0	76.00	19.0
3	4.7	6.62	60.0	66.70	5.0
4	5.5	2.80	46.5	48.50	6.0
5	4.3	1.66	27.0	39.00	17.0
6	5.3	3.10	31.0	34.00	3.0
7	4.4	3.10	32.0	3.15	11.5
8	2.5	2.10	26.0	30.00	6.0
9	2.2	1.05	19.5	23.50	2.0
10	2.5	1.90	30.0	36.00	5.0
11	4.4	2.20	32.0	39.00	8.0
12	2.5	3.00	32.0	35.00	3.0
13	3.3	1.80	18.0	25.00	12.0
14	5.5	3.60	36.0	40.00	6.0
15	2.8	1.90	10.0	12.50	4.5
16	3.2	4.60	13.5	16.50	6.5

The beach consisted of medium grade sand. Granulametric characteristics of the sand are given in Table 5. Burrows were found primarily in medium grade sand.

Details of the burrows derived via the cast analyses are given in Table 6. All burrows had a single surface opening, orientated seawards. The burrow then descended obliquely before levelling out. And were L-shaped or J-shaped (Table 6).

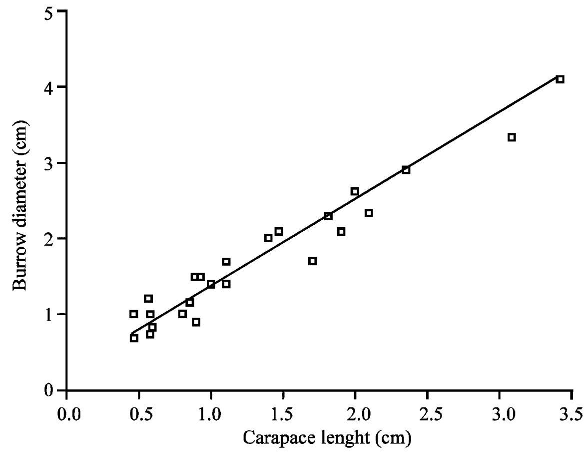

Fig. 3: The relationship between Burrow diameter and carapace length of *O. cursor* from The Nouthern Turkey

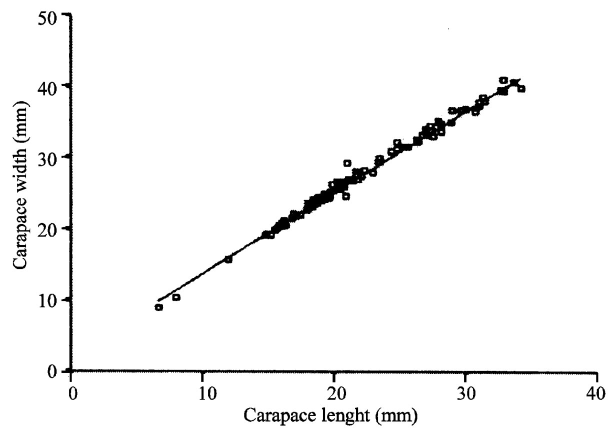

Fig. 4: The relationship between carapace width and carapace lenght of *O. cursor* from The Nouthern Turkey

DISCUSSION

Ocypoda cursor (L., 1758) occurs nearer to the sea in the supralittoral and upper eulittoral zones

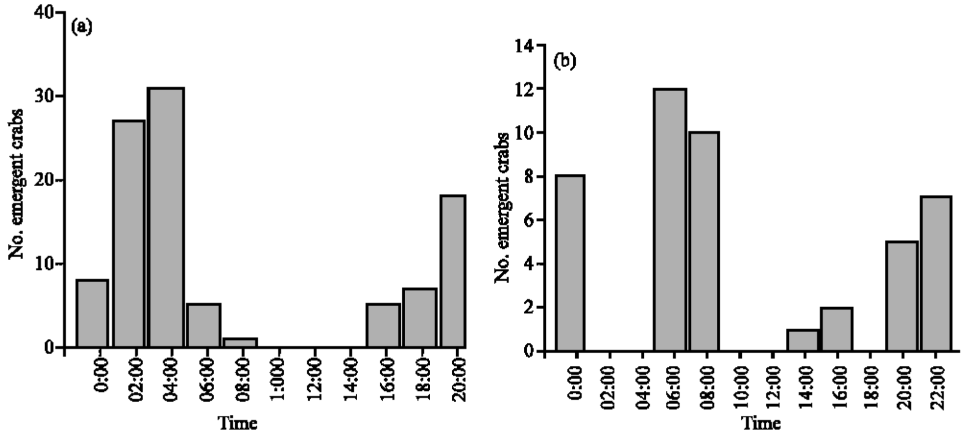

Fig. 5: Numbers of *O. cursor* that had emerged from their burrows on Yumurtalik beach, Recorded throughout two 24 h periods in (A) August- 2001 and (B) October-2001

(Strachan *et al*., 1999). All intertidal crabs exposed to large tidal fluctuations during the lunar cycle, but the differences between neap cycle and spring tides are rather small and insignificant on the eastern Mediterranean (Shuchman and Warburg, 1978). In this study, *O. cursor* showed all zonation in the site. Individuals built their burrows in the adjacent to the high tide line, along a 15 m wide band. Seasonal differences appear to be much more significant for *O. cursor* in our study. As may be seen in Table 1, the counts of burrow openings during the study period revealed that highest number of burrow occurred summer, dropping towards the end of the summer. During the warmer conditions of summer, with air temperatures reaching 27.5 and the surface sand temperature fluctuated between 18.5 and 38°C. The greatest temperatures were found at a depth of 10 cm, where the temperatures range from 23-30.7°C (Table 4). Similar results have been reported by Shuchman and Warburg (1978), who noted during autumn, more crabs were found at a distance of 15-25 m from the sea where sand moisture was about 14%. At the beginning of winter, crabs dispersed and reappeared in spring. From the beginning of summer onwards, more crabs appeared and mostly concentrated in an area closer to the sea (5-10 m). Strachan *et al*. (1999) recorded that the highest number was observed in August, due to the recruitment of large numbers of juvenile.

Within the study area at Yumurtalik beach, the distribution of the crabs was observed be abundant on the beach and density decrease with distance from the sea (Table 2). The present study indicates that density and size of crab are related to distance from the sea. Juvenile crabs were generally found closer to the sea, with larger adults were located further from the sea. At the landward margins of the crab zone, burrows smaller than one diameter were rarely found (Fisher and Tevesz, 1979) suggested that the difference in spatial distributions of adult and juveniles is most likely a fuctions of physiological competence. A similar relationship between the size of the crab and its position on the beach was found for the *O. cursor* population of northern Cyprus (Strachan *et al*., 1999). Their study showed that the species mostly settled 3-12 m from the water's edge. The number of the crabs within the study area on Alagadi beach varied throughout the 3 month study period. Alberto and Fontoura (1999) also recorded that spatial distribution and population structure of *Ocypode quadrata* (Fabricius, 1787) were studied at Pinhal beach, Rio Grande do Sul, from November 1991 to December 1993. They attributed that spatial distribution analysis was performed based on distance and height to water line. These crabs dug burrows preferentially in the central large range of the beach. The spatial distribution of the ghost crab *Ocypode quadrata* was described in five low-energy tide-dominated sandy beaches in Sao Sebastiao Channel (Grande, Zimbro, Pitangueiras, Cabelo Gordo and Segredo) by Turra *et al*. (2005). They found that individuals generally occurred above 1 m of height and peaked in the heights between 1.5 and 2.0 m. The smallest individuals occurred mainly in the medium intertidal, but were also recorded in the sub terrestrial border, which was occupied mainly by large-sized individuals. The individuals were concentrated in the upper intertidal zone on all the sandy beaches. In contrast, A study of distribution, abundance and habitat structure of *Ocypode gaudichaudii*, Milne and Lucas (1843) in sandy beaches of Northern Chile by Quijon *et al*. (2001) reported that the burrow zone extended primarily across the dry and retention zones.

The burrow diameter was demonstrated to be a good estimator of crab size in the present study. The relationship between carapace length and burrow width was investigated in 2001. These relationship were adjusted by the following equations, respectively: BD = 0.25+1.13 CL r^2 = 0.956 (Fig. 3); CW = 2.44+1.13 CL r^2 = 0.974 (Fig. 4) (BD is burrow diameter; CL is carapace length; CW is carapace width). Alberto and Fontoura (1999) were estimated these relationship for *Ocypode quadrata* the following equations, respectively: BD = 0.6648+1.0013. CW; CL = 0.77. $CW^{1.02}$.

Our surveys carried out in August and in October 2001 demonstrated that crabs showed more activity during the night than during the day. During August, very little crab activity was observed during the day (Fig. 5). They were, on several occasions during the night, observed to be close to the water's edge. A similar activity pattern has been reported by Strachan *et al.* (1999) for *O. cursor* in northern Cyprus. It is possible that at these times they were feeding upon the littoral infauna.

In that study, burrows were found primarily in medium grade sand (Table 5). Ewa-Oboho (1993) showed that substratum preference was the most important factor influencing distribution, but lack of tolerance to low salinities (<6%) was also important and prevented *O. cursor* from occurring close to freshwater. *Ocypoda cursor* (L., 1758) was concentrated in well-drained sandy sediment above mid-tide level. *O. cursor* was abundant at tidal height of 1-1.6 m above datum.

Details of the burrows derived via the cast analyses are given in Table 6. All burrows had a single surface opening, orientated seawards. The burrow then descended obliquely before levelling out. And were L-shaped or J-shaped (Table 6). Chan *et al.* (2006) suggested that *Ocypode ceratophthalma* creates burrow of variety shapes at different ages. Juveniles produces shallow J-shaped burrows. Larger crabs have Y-shaped and spiral burrows. Shuchman and Warburg (1978) were found U and Y shaped burrows closer to sea and were inhabited by small to medium size crabs. Sassa and Watabe (2008) addressed that most of the intertidal crabs of family Ocypodidae live in burrows as deep as 200 mm below the sediment surface. In contrast, we found that burrows were deeper than 200 mm (Table 6). There was substantial variation in the observed range of burrow depths.

In northern Israel, Shuchman and Warburg (1978) indicated that the population structure was analyzed directly by measuring the crab's dimensions and indirectly by counting burrows and measuring the diameter of their openings. Direct analysis revealed two distinct size age groups: smaller crabs 0.5-3 cm long and larger ones over 4 cm long. Three main types of burrow shapes were described. In northern Cyprus, Strachan *et al.* (1999) found that all of the *O. cursor* burrows have only one opening. Seven burrows were successfully cast at Alagadi. Six of these were L-or J-shaped. The other one had a longer, sinusoidal horizontal component than the others, but was similar in the other aspects. Strachan *et al.* (1999) suggested that further research is necessary to investigate the variation in burrow form seen in this species and to determine if there are differences which can be related to site, season and sex.

Burrow depth increased with distance from the sea, reflecting the increasing depth of the water table. Shuchman and Warburg (1978) suggested that the distribution of *O. cursor* on the beach could be explained to a certain extent by the gradient of the moisture content of the sand. Laboratory experiments have shown that *O. Cursor* could discriminate between sand samples in which the water content differed by only 1% (Strachan *et al.*, 1999).

In summary, all species of *Ocypode* show that the area of beach they occupy changes in a dynamic way with the various conditions of slope, available space and temperature, grain size. In additions, as size and density of some species of this genus have been demostrated to vary seasonally as a functions of crab recruitment and growth and crab activity (Turra *et al.*, 2005).

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