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DISTRIBUTION AND POPULATION DENSITY OF THE GHOST CRAB, *OCYPODE CURSOR* (LINNEAUS, 1758) IN YUMURTALIK BEACH, TURKEY

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ABSTRACT

The distribution and population density of the ghost crab, *Ocypode cursor* were studied in Yumurtalik Beach,Turkey during summer, 2009. Burrow densities of ghost crab were measured at three beach zones in relation to the Reference Datum (RD) with middle heights of 2, 4, and 9 m, which were located at medi-olittoral, supra-littoral, and sub-terrestrial fringe, respectively.Generally, individuals occurred above 1 m in height in relation to RD and peaked between 2 and 4 m. A range from 0 to 4.2 burrows/m^2 was obtained, and the total number of crabs on this beach (approximately is 2256 km^2) ranging from 18.99 burrows/m^2 to 56.41 burrows/m^2. Significant differences in the mean burrow density were found among three zones. Low densities were recorded in the sub-terrestrial zone in September and peak density in the supralittoral zone in August. In general crabs followed a clumped dispersion on Yumurtalik beach. In total 986 burrow diameters were measured where diameter ranged from 3 to 97.8 mm. The results provided evidence that Yumurtalik Beach can provide suitable habitats for *O. cursor* population. *Ocypode cursor* is not vulnerable to the anthropogenic disturbances and environmental alterations found at Yumurtalık Beach.

Keywords: Ghost crab, *Ocypode cursor*, Yumurtalık Beach, Turkey, Zonation, Burrows, Density

INTRODUCTION

The genus *Ocypode* Weber, 1795 (Decapoda, Ocypodidae), commonly known as ghost crab is distributed in sandy beaches, dunes, mangrove swamps, and estuaries on subtropical and tropical shores (Dahl, 1953; Lucrezi et al., 2009a). All the *Ocypode* crabs are known to produce semipermanent burrows in juvenile to adult stages (Brown and Maclachlan, 1990). The crabs construct deep and complex burrows which provide shelter against climatic extremes and predators, and serve as refuges during molting and maternity (Lucrezi et al., 2009 a). The top of these burrows on the sand surface has a clearly visible hole, and therefore counting burrow entrances is an efficient tool to measure densities of ghost crabs on beaches (Moss and McPhee, 2006). Population of ghost crabs responds predictably to direct physical impacts, and to changes in the form of reduced abundances (Lucrezi et al., 2009a). Also, being abundance and having relatively large size, this species is a key element in the functioning of the shore ecosystem (Valero-Pacheco et al., 2007). Galleries of the crabs whereby aerate, move, and recycle an important amount of the sand beaches. The crabs are at the position of top invertebrate predator on sandy beaches, and are intern prey for a number of higher-order consumers; change in ghost crab population is a good indicator of impacts on whole beach food webs (Chan et al., 2006; Valero-Pacheco et al., 2007; Lucrezi et al., 2009 b).

Many aspects of ecology of *Ocypode* spp. have been investigated (Ewa-Oboho, 1993; Barros, 2001; Quıjon et al., 2001; Turra et al., 2005; Blankensteyn, 2006; Chan et al., 2006; Valero-Pacheco et al., 2007). But comparatively few studies have been carried out on *O. cursor* (Shuchman and Warburg, 1978; Ewa-Oboho, 1993; Strachan et al., 1999). The distribution of *O. cursor* (Linnaeus, 1758) extends from West Africa into the Mediterranean and Atlantic Ocean (d'Udekem d'Acoz, 1999). *Ocypode cursor* is found along the Mediterranean coast (Holthuis, 1961; Enzenross et al., 1997; Kocataş and Katağan, 2003; Özcan et al., 2005) and Aegean Sea (Kocataş and Katağan, 2003; Kocataş et al., 2004) in the Turkish coasts. This species inhabits supra-littoral zone on sandy beaches along the Mediterranean coast of Turkey (Özcan, 2007).

Owing to its global distribution and habit of living in conspicuous burrows along the supra-littoral sandy beaches, crabs of Genus *Ocypode*

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may be valid tool in the rapid identification of environmental impact (Neves and Bemvenuti, 2006). In spite of their ecological importance, few studies have been conducted to estimate their basic population parameters (Türeli et al., 2009) on coasts of Turkey. This study estimated the variation in population density and size of *O. cursor* at three tidal zones of Yumurtalık Beach, Turkey.

MATERIAL AND METHODS

The study was conducted on sandy beach of Yumurtalik Cove, in the coast of Mediterranean, Turkey (36° 46’ N -35° 47’ E). This beach is roughly of 282072 m long and the mean width is 8 m (ArcGIS, 2011). The total area approximately is 2256 km^2 (fig.1). The beach is considered an important recreational site. On Yumurtalik Beach, the air temperatures were recorded between 18 °C and 27.5 °C. The surface sand temperature fluctuated between 18.5 °C and 38 °C. The highest temperatures were found at a depth of 10 cm, where the temperatures ranged from 23 °C to 30.7 °C (Türeli et al., 2009).

Two sites parallel to the shore extending 12 m from the water line to the back of the shore, and 20 m in width were selected for the study. The study sites started within approximately 3 m away from the sea, the point where sea water can reach or cover its utmost during high tide (Reference Datum-RD). Burrow counts were made across nine belts transects. Each belts transect was a continuous 20 m wide strip that extended across the shore from the base of the dunes. The belts was divided into 1 m wide strips comprising three zones in relation to the RD with middle heights of 2, 4, and 9 m, which were located at medio-littoral, supra-littoral, and sub-terrasial fringe, respectively (fig 2). The tide in the beach is semi-diurnal with a maximum range of 0.4-0.6 m (MacPherson et al., 1988). These strips were sampled using contiguous 1 m^2 quadrat and the number and size of burrows of *Ocypode cursor* were recorded. We counted the number of burrows as an estimate of crab density (Shuchman and Warburg, 1978; Warren, 1990; Turra et al., 2005; Neves and Bemvenuti 2006; Rosa and Borzone 2008). Censuses were conducted counting the number of burrows five consecutive days in June-September 2009 (4 months). Once the number of crabs per m^2 was obtained, and density of burrows was calculated for each zone and the value was extrapolated to the 2256 km^2 of sandy beach to estimate the total population of crabs.

A two-way ANOVA was used to test for differences in the number of burrows, and the mean density (burrows/ m^2) among zones and months. The dispersion pattern of *O. cursor* was estimated using a dispersion index (I), equivalent to the ratio between the variance (S^2) and the mean of the number of individuals per quadrat (Elliott,1977). The distribution pattern of the burrows was assessed with the dispersion index (variance/mean), the distribution with values above 1 are clumped, below 1 uniform, and equal to 1 random (Krebs, 1989).

The mean burrow diameter was compared among month and zones by a Kruskal-wallis test.The outcomes of the ANOVAs and Kruskal-wallis tests cited above for the comparison of the mean density and mean diameter of *O. cursor* burrows among zones and month were followed by the Scheffe’s test and the non-parametric Tukey-type test, respectively, for post hoc pair wise comparison (Turra et al., 2005).

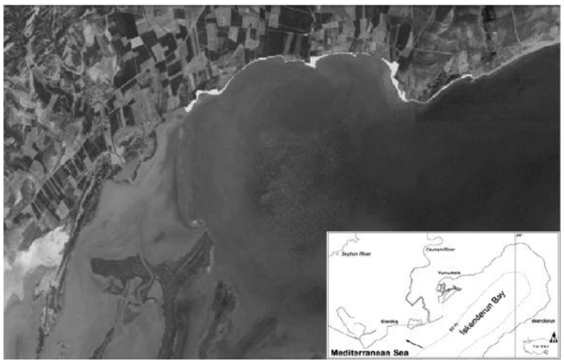

Fig. 1: Map of study area at Yumurtalik Beach, Turkey

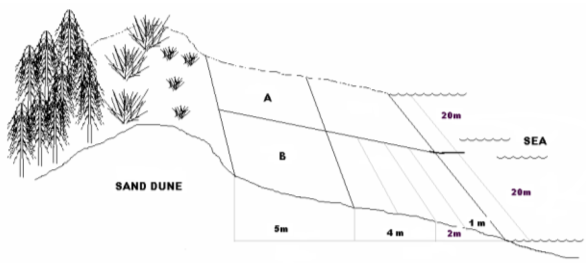

Fig. 2: Schematic diagram of the levels sampled on Yumurtalik Beach

RESULTS

The total number of burrows counted were 456, 1078, and 131 in medio-littoral, supra-littoral, sub-terrasial zones, respectively. No burrows were found in sub-terrasial zone in September, and the highest burrows were counted in supra-littoral zone in August (table 1). The number of burrows found in the supra-littoral zone was significantly different from the number of burrows in other zones (F=15.708, df=2, $p<0.05$) (table 2).

Table 1: Mean density of burrows for *Ocypode cursor* burrows Yumurtalik Beach, Turkey

Date	Zone	Burrows / m^2	Number of burrows	Total number of crabs
June	Mediolittoral	1.73	139	
	Supralittoral	3.82	306	
	subterrasial	1.15	92	
	Total	2.23	537	50.48
July	Mediolittoral	0.30	24	
	Supralittoral	3.41	273	
	subterrasial	0.36	29	
	Total	1.35	326	30.65
August	Mediolittoral	3.17	254	
	Supralittoral	4.20	336	
	subterrasial	0.12	10	
	Total	2.5	600	56.41
September	Mediolittoral	0.48	39	
	Supralittoral	2.03	163	
	subterrasial	0	0	
	Total	1.68	202	18.99

The mean population density estimated from the five censuses showed a variation from 0 to 4.20 burrows/ m^2 in September and August, respectively (table 1). Results show that crab density was dependent on characteristics of zones (table 2). Low densities were recorded in the sub-terrasial zone followed by peak of density in the supra-littoral zone (fig 3).

Table 2: Two-way ANOVA for the mean number of burrows per m^2 of *Ocypode*. *Cursor* month and zones. Differences are significant at $p<0.05$

Source of variation	df	Mean square	F	P
Month	3	1.779	3.3092	0.111
Zone	2	9.037	15.708	0.004
Residual	6	0.575	46.510	

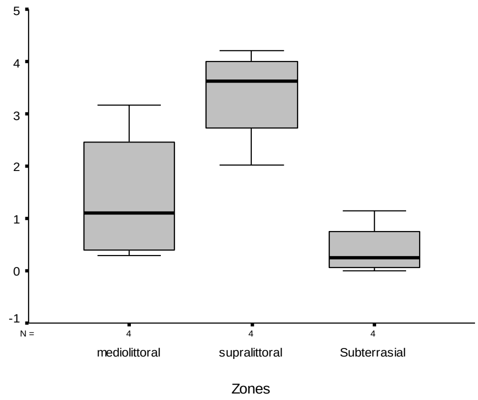

Fig. 3: Comparison of mean number of burrows per m^2 in different zones

In general, crabs (burrows) indicated clumped dispersion, while sub-terrasial zone was a uniform dispersion in September (table 3). We can be said that crab's population dispersion pattern was an aggregation on Yumurtalik Beach.

Table 3: Dispersion pattern of *Ocypode cursor* in relation to month and tidal level based on the relationships between the variance and the number of individuals

Sampling date	zones	Total number of burrows	Dispersion Index	Type of distribution
June	Mediolittoral	136	5.26	
	Supralittoral	306	6.25	clumped
	Subterrasial	92	2.80	
	Mediolittoral	24	4.74	
July	Supralittoral	273	6.45	clumped
	Subterrasial	29	3.66	
	Mediolittoral	254	6.52	
August	Supralittoral	336	3.31	clumped
	Subterrasial	10	3.17	
	Mediolittoral	39	6.29	clumped
September	Supralittoral	163	2.90	
	Subterrasial	0	0	uniform

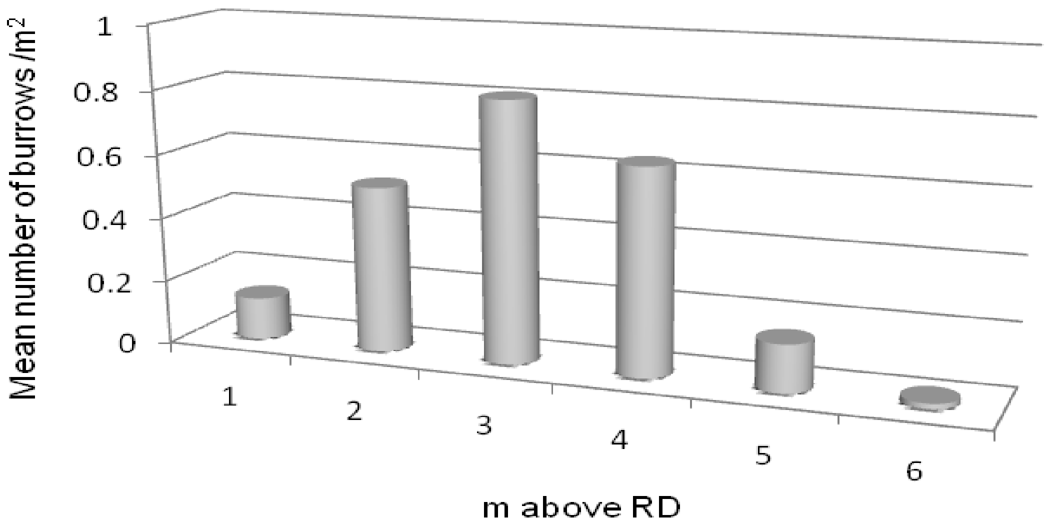

Fig. 4: Zonation of study area at Yumurtalik Beach, Turkey

Ocypode cursor showed zonation, with individuals occurring above 1 m height RD. The peak of density occurred in supra-littoral between 2 and 4 m height above the RD, while fewer individuals were recorded in the sub-terrasial zone (fig 4).

A total of 986 burrow diameters were measured in five censuses during 4 months. Overall, the diameter ranged from 3 mm to 97.82 mm (table 4). High value was obtained in supra-littoral zone in August.

Table 4: Mean burrow diameter ± standard error of *Ocypode cursor* on Yumurtalik Beach, Turkey

		Zone	N	mean±SE (min-Max) mm
Month	June	Mediolittoral	116	14.97±0.78 (4.00-59.50)
		Supralittoral	158	23.53±1.13 (3.00-70.00)
		Subterrasial	47	33.72±1.70 (4.00-54.00)
		Total	321	21.93±0.75 (3.00-70.00)
	July	Mediolittoral	17	27.41±2.96 (11.00-51.00)
		Supralittoral	156	37.69±1.09 (11.00-79.00)
		Subterrasial	25	38.98±2.07 (23.00-63.63)
		Total	198	36.97±0.95 (11.00-79.00)
	August	Mediolittoral	173	30.80±1.59(3.74-78.03)
		Supralittoral	167	48.36±1.80 (4.32-97.87)
		Subterrasial	9	55.45±6.13 (11.01-72.19)
		Total	349	39.84±1.27 (3.74-97.87)
	September	Mediolittoral	25	21.31±3.18 (6.88-73.62)
		Supralittoral	93	30.46±1.64 (5.61-77.37)
		Subterrasial	-	-
		Total	118	28.53±1.49 (5.61-77.37)

Table 5: Comparison of mean burrow diameter among zones and month through Kruskal-illis test (H). Differences are significant at $p<0.05$

Comparison	**H**	**df**	**p**
Among zones	95.061	2	.000
Among month	142.274	3	.000

The mean burrow diameter between month and zones were significantly different (table 5). No difference was found between July and August (Mann-Whitney U, $p>0.05$). Moreover, no significant difference was found in the mean burrow diameter between supra-littoral and sub-terrasial zone on the beach (Mann-Whitney U, $p>0.05$). In the medio-littoral, a large number of small burrows were found in every sampling, showing a constant recruitment of juvenile crabs to the population. While the mean burrow diameter increased away from medio-littoral (table 4).

DISCUSSION

Ghost crabs are important component of sandy beach ecosystems, occupying a pivotal trophic role such as apex invertebrate predators while being prey for vertebrate consumers (Wolcott, 1978). Burrow counts and size has consequences for using ghost crabs are ecological indicators: both counts and opening diameters are only reliable proxies for population densities and size structures if field measurements are taken when pedestrians distribution is less (Lucrezi et al., 2009 b).

Yumurtalik Beach is considered a relatively undisturbed with only occasional presence of visitors. Here, tidal influence is minimal. On the Turkey coasts, *O. cursor* is only ghost crab species present (Özcan, 2007). The size of crab population within the study area on Yumurtalık Beach was found to vary throughout the four month study period. The high numbers and mean population density were found in August (table 1). The similar results have been reported for northern Israel (Shuchman and Warbung 1978), northern Cyprus (Strachan et al., 1999), and northern-eastern Mediterranean Turkey (Türeli et al., 2009). Strachan et al. (1999) suggested that the high numbers in August seemed to be due to recruitment of large number of juveniles.

The number of burrows found in the supra-littoral zone was significantly different from the number of burrows in the other zones ($F=15.757$, $df=2$, $p<0.05$). Moreover, *O. cursor* showed zonation, with individuals occurring above 1 m in height above RD. The peak of density occurred in supra-littoral, between 2 and 4 m height above the RD, while fewer individuals were recorded in the sub-terrasial zone (fig 4). This pattern was different from that shown by Shuchman and Warbung (1978), and Strachan et al. (1999). They claimed that the most densely populated area was between three and twelve meters' from the water's edge. However, Ewa-oboho (1993) claimed that *O. cursor* was abundant only at tidal height of 1 m-1.6 m above chart datum, such as in this study. These data show that cross-shore distribution *O. cursor* is variable among beaches. As has been shown for community and population parameters, beach types explain spatial differences well at local and regional scales (McLachlan and Jaramillo, 1995). In addition distribution of *O. cursor* seemed to be related to ontogenetic development.

Strachan et al. (1999) found burrow densities in the general crab zone varied from $0.04m^{-2}$ to $0.67\ m^{-2}$ along the length of beach. The other study on *O cursor* conducted in Northern Israel showed that it inhabits the non-tidal region (Shuchman and Warbung, 1978). These authors reported that population density of this species during summer was lowest in the seashore belt region of 0 to 40 m (0.07 to $0.19m^{-2}$) and highest in the 40 to 50 m belts (0.37 to $0.98m^{-2}$). As in other studies on Yumurtalık Beach, we found burrow density ranged from 2.18 to 2.72 m^2 in 2001 to 0.50 to 0.52 m^2 in 2002 (Türeli et al., 2009). This study showed the mean population density estimation variated from 0 to 4.20 burrows/ m^2 in September and August, respectively (table 1) on Yumurtalik Beach. Our results showed that burrow densities of *O. cursor* on Yumurtalık Beach of Turkey were higher than those found in crab species at other beaches. Moreover, higher burrow densities were observed during 2009 compared to other sampling year on Yumurtalık Beach.

In the medio-littoral zone, a large number of small burrows were found in each sampling while the mean burrow diameter increased away from medio-littoral (table 4). Similar results have been reported by Shuchman and Warbung (1978) and Strachan et al. (1999). High numbers of juvenile crabs were generally found closer to the sea, with the more adults were located at a greater distance from the sea (Valero-Pacheco et al., 2007). Fisher and Tevesz (1979) commented that the variation in spatial distribution of adults and juveniles is most a function of physiological competence.

All species of Genus *Ocypode* show change in the area they occupy in a dynamic way with conditions of available space, temperature, etc at each geographic region (Valero-Pacheco et al., 2007). Quıjon et al. (2001) recommended that *O. gaudichaudii*'s habitat and related significant differences among sandy beaches. Spatial variability has always been addressed in sandy beach ecology. Therefore, it is recommended that counting number of ghost crabs be included in ecological or morphological sand dunes survey, because dune modification will affect part of the habitat of these animals (Barros, 2001). Neves and Bemvenuti (2006) had suggested that the number of burrows is a rapid tool for impact verification at sandy beach and for use in environmental monitoring programs.

In conclusion, the results of this study suggested that Yumurtalik Beach can provide suitable habitats for *O. cursor* population. *Ocypode cursor* is not vulnerable to anthropogenic disturbances and environmental alteration at Yumurtalık Beach, with the density of burrows higher on beach with temporal density data.

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