ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 63 (1), 2011: 97-103

Growth, Mortality and Spatial Distribution of Brushtooth Lizardfish, *Saurida undosquamis* (Richardson, 1848), Inhabiting the Karataş Coasts (Iskenderun Bay, Northeastern Mediterranean)

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Abstract: This study was carried out from September 2002 to April 2003 in Karataş Coasts (Iskenderun Bay). A total of 279 specimens were trawled by monthly sampling in 2002-2003 fishing season. The age of *Saurida undosquamis* was estimated by examining sagittal otoliths and it was found out that the age composition varied from I to VI age classes. The mean total length and total weight values were calculated as 14.22±3.42 cm and 20.73±15.42 g respectively and the calculated length-weight relationship was $W=0.0083*L^{2.879}$. The von Bertalanffy growth parameters were L_∞: 38.05 cm, K: 0.124 year^{-1} and t_o: -1.680 year. The instantaneous rate of total mortality (Z) was 1.77, the natural mortality (M) was 0.35 and the fishing mortality (F) was estimated to be 1.42. The exploitation rate (E) was calculated as 0.80 using value of M and F. Therefore, the population of *S. undosquamis* from the coast of Karataş, Iskenderun Bay was exploited over the optimum level because of overfishing pressure.

Key words: *Saurida undosquamis*, Iskenderun Bay, Length-weight relationship, mortality, exploitation rate.

Introduction

The greatest change in Levantine marine environment took place after the opening of the Suez Canal. The creation of a direct link between Mediterranean and Indo-Pacific basins resulted in the introduction of unintentional and intentional species into Levantine aquatic systems (Goren, Galil 2005). To date, over 65 fish species of Indo-Pacific origin (lessepsian) have entered Levantine Basin through the Suez Canal and established flourishing populations (Goren, Galil 2005, Golani *et al.* 2002, Cicek, Bilecenoglu 2009).

The brushtooth lizardfish, *Saurida undosquamis* is distributed in the Eastern Indian Ocean, Malay Peninsula, southern Philippines, northern Java, Arafura Sea, Louisiade Archipelago, and northern half and southwestern Australia. The fish is a benthic species, found on the sublittoral zone above 100 m over sand or mud bottoms of coastal waters. It feeds mainly on fish, crustaceans, and other invertebrates (Froese, Pauly 2009).

The brushtooth lizardfish, was first recorded in 1953 along the Mediterranean coast of Israel and was found to be much rarer than the native Mediterranean lizardfish *Synodus saurus* (Goren, Galil 2005, Ben Tuvia 1953). However, by 1955 *S. undosquama* had became an important part of the trawl catch, with commercial catches increasing steadily to a total of

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266.5 tons in 1956, 20% of the total annual trawl catch (Goren, Galil 2005, Oren 1957a, b). In some years *S. undosquamis* represented up to 53% of the total catch in the northeastern Mediterranean coasts (Goren, Galil 2005, Gorgy 1966, Gucu, Bingel 1994).

S. undosquamis is of major commercial importance to the bottom trawl fisheries in the northeastern Mediterranean. The landings of this species were reported 348 t for the Mediterranean coasts of Turkey and 1575 t for the whole Mediterranean in 2007-2008 fishing season (Anonymous 2010).

Distribution, age, growth, maturity, mortality and bottom trawl selectivity parameters (Ben Yami, Glaser 1974, Bingel 1988 a, b, Bingel, Avsar 1988 a, b, Gucu, Bingel 1994, Gucu *et al.* 1994, Mater, Torcu 1996, Tureli, Erdem 1997, Celik, Torcu 2000, Ismen 2003, Özyurt 2003) were determined for *S. undosquamis* in the Mediterranean previously. This study aims to determine the age, growth, mortality and exploitation of *S. undosquamis* off the Karataş coast of Iskenderun Bay.

Material and Method

This study was carried out between September 2002 and April 2003 off the Karataş Coasts of Iskenderun Bay during the 2002-2003 fishing season. The materials were obtained by monthly sampling using commercial bottom trawl vessel (Coskun Reis, 22 m length and 285HP) in depths from 0 to 100 m from the stations represented in Fig. 1. Trawl operations were done during the day time with 1 h haul duration using Mediterranean Type Bottom Trawl 22 mm mesh size (knot-to-knot).

All of the catches were transferred from field to the laboratory in ice and stored at -18 °C in the refrigerator. Then the samples were defrosted and sorted by species and weighed for the determination of Catch Per Unit Effort (CPUE) in the laboratory for each depth range. In order to determine population parameters, the sub sampling procedure was applied as recommended by Holden and Raitt (1974). The total length and the total weight were measured and weighed to the nearest 1 mm and 0.01 g respectively. The sagittal otoliths were examined under the stereo binocular microscope for the age determination.

The length-weight relationships were determined according to the allometric equation given by Sparre and Venema (1998) where $W=a*L^b$. In this equation, W is total weight, a and b are regression constants and L is total length. Growth in length and weight were expressed in terms of von Bertalanffy equation $L_t=L_\infty[1-e^{-K(t-to)}]$. The growth parameters K, L_∞ and t_o were estimated using the Least Squares Method as recommended by Sparre and Venema (1998).

Correspondence between empirical data and an expected distribution was tested by Khi^2 test. The b value was tested by t-test to verify that it was significantly different from the isometric growth (b: 3).

Total mortality rate (Z) was estimated based on the length at first capture methods evaluated by Beverton and Holt (1957). $Z=K*(L_\infty-L_m)/(L_m-L_c)$. L_m is the average total length of the entire catch, while L_c is the length at which 50% of the fish entering the gear are retained (Sparre, Venema 1998). Instantaneous natural mortality rates (M) were estimated using the equation derived by Ursin (1967) based on the mean total length, where $M=W^{-(1/b)}$ (W: mean total length; b: constant of length-

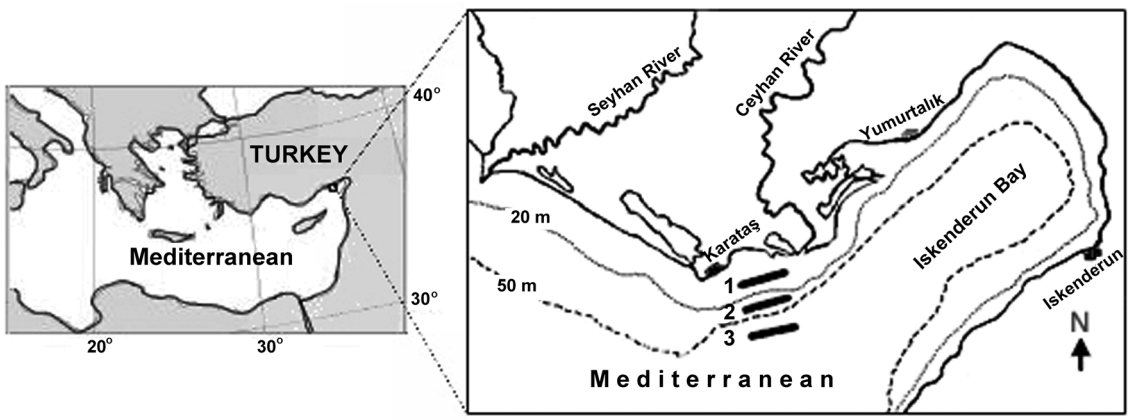

Fig. 1. Study area and sampling stations.

weight relationship). Fishing mortality rates (F) were calculated as the difference between *Z* and *M* (Z=F+M). The value of the average annual exploitation rate (*E*) was obtained by E=F/Z (Sparre and Venema 1998).

Results

Monthly Time Series of Trawl Catch

Monthly distribution of CPUE value of *S. undosquamis* for each depth range and whole study period is given in Fig. 2. As it can be seen, the highest CPUE was obtained in September as 4.1 kg h^{-1} and the lowest one was observed 1.6 kg h^{-1} in January with the mean value of 2.5±0.8 kg h^{-1}.

Taking into consideration CPUE distribution in each depth range, over half of the catch (55.78%) was obtained in depths of 0-20 m, and 38.69% was obtained in depths of 20-50 m, and 5.53% was obtained in depths of 50-100 m. To take CPUE distribution in each depth range into consideration, *S. undosquamis* spreads to a wide depth range, it prefers depths below 50 m and the value of CPUE decreases from coastal area to deeper waters.

During the study period, *S. undosquamis* represented 12.69% of the total catch in the depth of 0-20 m and 8.67% in the depth of 20-50 m with the mean value of 9.46%.

Age and Growth Parameters

A total of 279 individuals were sampled, ranging in size from 4.70 to 24.40 cm TL and in weight from 1.68 g to 98.02 g. Overall mean total length and weight were calculated as 14.22±3.42 cm and 20.73±15.42 g respectively. Length-frequency distribution of *S. undosquamis* was given in Fig. 3. As can be seen in the figure, the dominant length classes were 12-15 cm.

Length-frequency distribution, minimum, maximum and mean length and weight values of *S. undosquamis* for each age class are listed in Table 1. As it can be seen, the age of *S. undosquamis* ranged from I to VI age classes and the most dominant age class was II with a value of 44.1% and age class I ranks second with a value of 31.9%.

The relationship between *TW* and *TL* is presented in Fig. 4. Length-weight relationship was expressed $W=0.0048L^{3.079}$. The growth parameters calculated by von Bertalanffy were L_∞: 38.05 cm, K: 0.124 $year^{-1}$ and t_o: -1.680 year.

The back-calculated lengths were determined by using von Bertalanffy growth parameters and both the observed and calculated growths in total length are listed in Table 2. The growth curves were not significantly different between the observed and calculated length ($p>0.05$). The von Bertalanffy growth curve was fitted to lengths-at-age for *S. undosquamis* (Fig. 5). Growth is fast until the II age classes and with growth in length is slightly reduced beyond the age class II.

Mortality and Exploitation

The annual instantaneous rate of natural mortality (*M*) was estimated at 0.35 yr^{-1} and instantaneous total mortality rate was estimated at 1.77. Using the

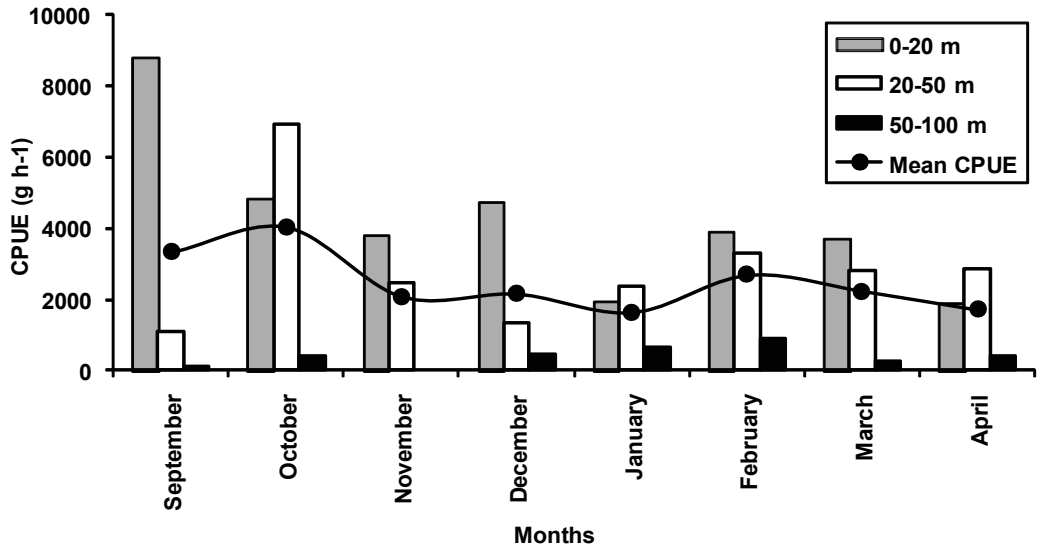

Fig. 2. Monthly distribution of CPUE value for *Saurida undosquamis* off Karataş coast.

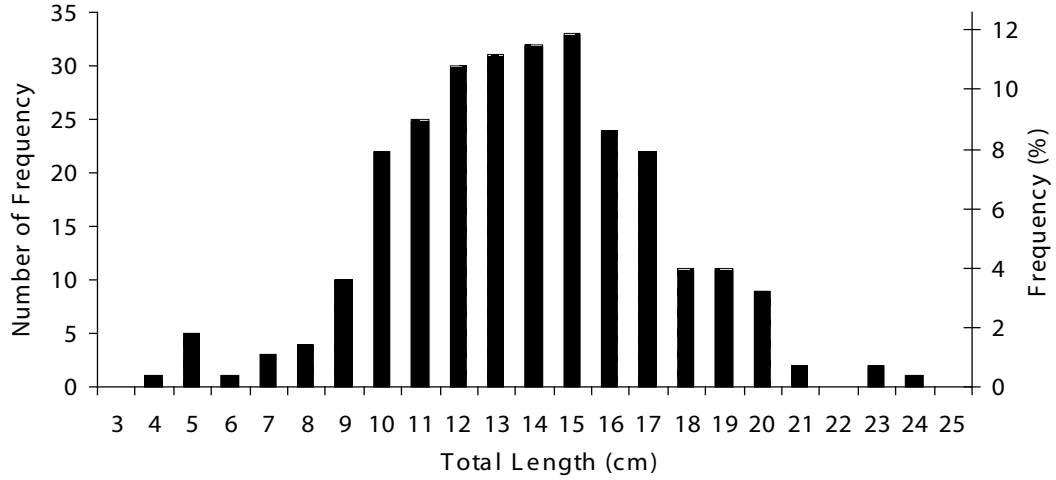

Fig. 3. Length-frequency distribution for *Saurida undosquamis* off Karataş coast (10 mm length classes).

Table 1. Length-frequency distribution, minimum, maximum and mean length and weight values for each age class for *Saurida undosquamis* off Karataş coast.

Age	n (frequency)	Total Length (cm)		Total Weight (g)	
		Min-Max	Mean	Min-Max	Mean
I	89 (% 31.9)	4.70-12.60	10.47±2.00	1.68-13.51	7.23±3.00
II	123 (% 44.1)	11.80-16.50	14.53±1.08	10.87-29.74	18.48±5.01
III	16 (%5.7)	15.50-17.20	16.90±0.22	24.80-36.50	31.00±3.41
IV	42 (% 15.1)	16.40-21.30	18.61±0.93	30.11-62.08	41.76±7.93
V	6 (% 2.2)	20.60-21.30	20.80±0.29	53.54-64.80	59.35±3.83
VI	3 (% 1.1)	23.40-24.40	23.80±0.53	78.93-98.02	86.95±9.91
Total	279	4.70-24.40	14.22±3.42	1.68-98.02	20.73±15.42

estimate of *Z* from the mean total length and the estimate of *M* obtained based on the length at first capture methods, an estimate of fishing mortality was obtained at 1.42 The exploitation rate was estimated at 0.80 using the value of *Z* and the estimated *F*.

Discussion

To take CPUE distribution in each depth range into consideration, *S. undosquamis* is distributed over a wide field and the relative index of CPUE and the population abundance decreased with depth. It is reported that the lessepsian fish species are generally distributed on the shallow areas (Ben-Yami, Glaser 1974). Indeed, their biomass proportion of the total catch accounted for 51.9% and 67.6% in October of 1983 and 1984, respectively at depths of 14-59 m (Gucu, Bingel, 1994). In this case, distribution pattern of *S. undosquamis* shows similarity with other lessepsian fish species.

A dramatic decrease from the opening of the fishing season to the end of the season was observed for the most of trawlable species during the study period. Different from the other trawlable species, monthly distribution of CPUE of *S. undosquamis* did not show dramatic changing during the fishing season (Cicek 2006). Indeed while the coefficient of variation of CPUE was 175.4% for *M. barbatus* and the value was calculated 33.28% for *S. undosquamis*.

During the study period, *S. undosquamis* represented 12.69% of the total catch off the Karataş coast. Whereas, *S. undosquamis* represented over 50% of the total catch in the northeastern Mediterranean coasts in some years (According to Goren, Galil 2005, Gorgy 1966, Gucu, Bingel 1994).

The mean CPUE was calculated as 2.5 kg h^{-1} this study. In the previous study, the values were reported as 12.0 kg h^{-1} in 1983, 9.9 kg h^{-1} in 1984 and 0.5 kg h^{-1} in 1989 in Iskenderun Bay (Gucu *et al.* 1994). According to this the CPUE decreased from 1983

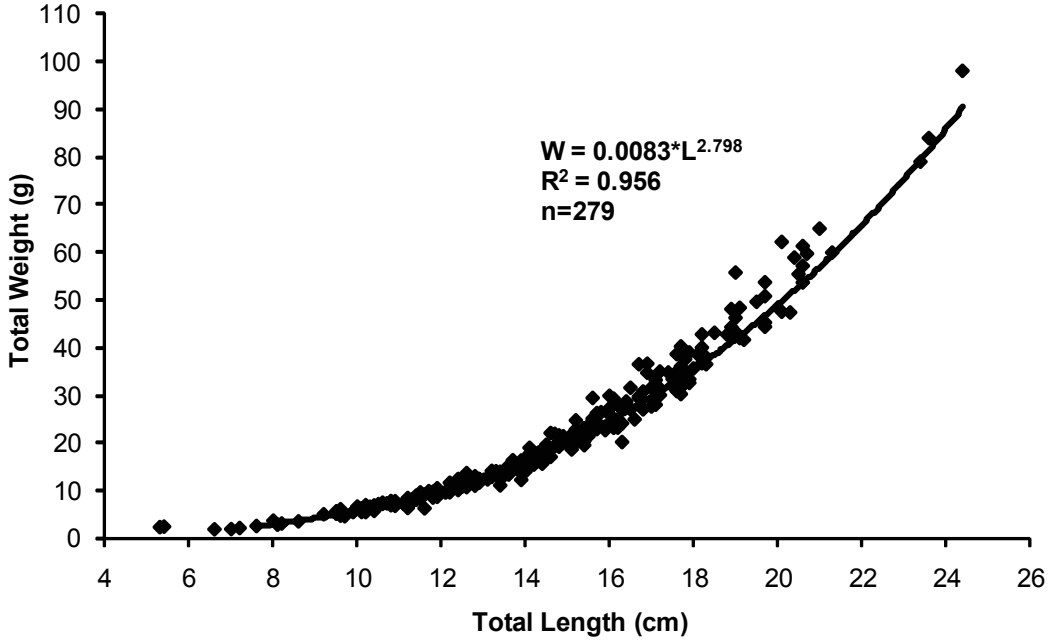

Fig. 4. Length-weight relationship for *Saurida undosquamis* off th Karataş coast.

Table 2. Observed and calculated total length of *Saurida undosquamis* using von Bertalanffy growth equations off Karataş coast.

Age	Total Length (cm)		Total Weight (g)	
	Observed	Calculated	Observed	Calculated
I	10.47	10.72	7.23	7.13
II	14.53	13.90	18.48	15.85
III	16.90	16.70	31.00	27.92
IV	18.61	19.18	41.76	42.77
V	20.80	21.38	59.35	59.67
VI	23.80	23.31	86.95	77.94

to 1989, than the value has increased respectively. Similarly, fluctuations of the biomass were reported in the coasts of Israel as well (Goren, Galil 2005).

LW relationships parameters and the von Bertalanffy growth parameters are listed in Table 3 for the previous studies in Turkey. As can be seen on the table, *b* value ranged from 2.6165 to 3.2957 in these studies. All these results indicate that type of growth showed isometric or positive allometric growth in the previous studies, except for Can *et al.* (2002) and Mater and Torcu (2000). The growth type was founded as negative allometric growth in this study (*b*: 2.789, SE: 0.036; 95% confidence intervals of *b*: 2.808-2.950). According to Froese and Pauly (2009) *b* value was reported between 2.933 and 3.320 with the median value 3.031 for different regions of Mediterranean. The *K* observed in this study which is lower than previous 0.3 imply growth of *S. undosquamis* population inhabiting off Karataş coasts was slow (Froese , Pauly 2009). Therefore, estimated low *b* value and negative allometric growth are not surprising in this study.

The value of L_{∞} was reported as 22.43 cm by Tureli and Erdem (1997) in Iskenderun Bay and 41.27 cm by Avsar *et al.* (2000) in Mersin Bay. The value L_{∞} reported by Tureli and Erdem (1997) is probably not the correct estimation because individual catches bigger than 22.43 cm are not rare in the catch of bottom trawl fisheries in Iskenderun and Mersin bays. Indeed maximum observed length was 24.40 cm in this study and the value was given 33.0 cm by Cicek *et al.* (2006) in Mersin Bay. The

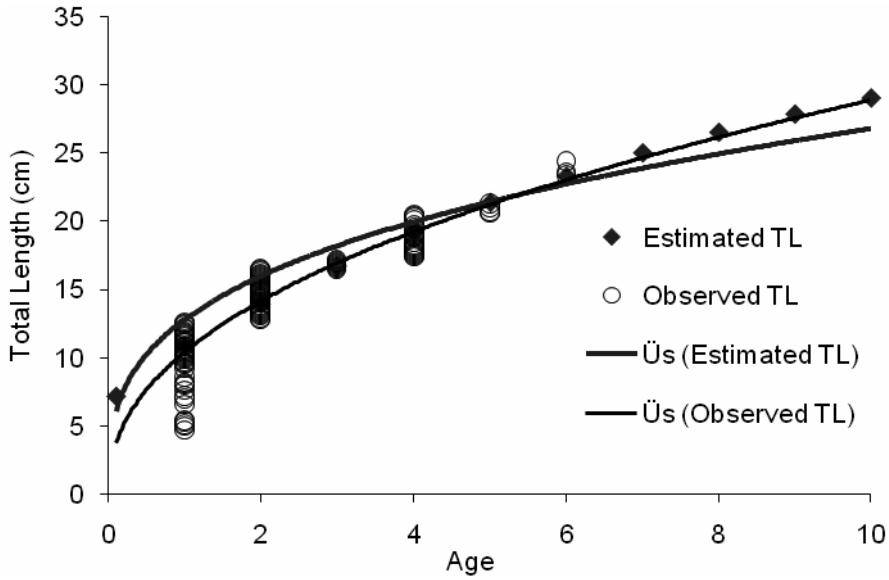

Fig. 5. von Bertalanffy length-at-age growth curve for *Saurida undosquamis* off Karataş coast.

Table 3. Length-weight relationship and von Bertalanffy growth parameters of *Saurida undosquamis* from Turkish coasts.

n	a	b	R^2	L_∞ (cm)	K (yıl^{-1})	t_0 (yıl)	Author/s
430	0.3830	2.617	0.81	-	-	-	Mater, Torcu 1996
100	0,0117	2,797	0.90	-	-	-	Can *et al.* 2002
333	0.1270	3.022	-	22.43	0.597	-1.365	Tureli, Erdem 1997
2757	0.0047	3.086	0.98	41.27	0.118	-1.895	Cicek *et al.* 2006
137	0.0000052	3.092	0.98	-	-	-	Anonymous 1993
66	0.0000045	3.105	0.98	-	-	-	Anonymous 1993
100	0.2650	3.296	0.91	-	-	-	Mater, Torcu 1996
275	0.0083	2.789	0.96	38.05	0.124	-1.680	This study

value of $L_¥$ ranges from 29.8 to 68.5 cm with the median value of 37.0 cm in 31 studies from different parts of the world (Froese, Pauly 2009). There are close similarities for the estimated $L_¥$ values between this study and median value reported by Froese and Pauly (2009). However, the estimated parameters may vary as a function of a variety of factors such as region, sampling methods, year, methodology etc. (Gonçalves *et al*. 2003).

The length at first sexual maturity determined in the previous studies ranged from 12.5 cm to 16.0 cm (Tureli, Erdem 1997, Ozyurt 2003, Ismen 2003). When the length at first maturity of these species 12.5 cm was taken into consideration (Tureli, Erdem 1997, Ozyurt 2003) 70.2% of the total catch consisted of immature individuals off Karataş coasts. Otherwise when the length at first maturity, 16.0 cm, was taken into consideration (Ismen 2003) 70.0% of the total catch consisted of mature individuals off Karataş coasts. On the other hand, when the age at first maturity of these species II-III years old were taken into consideration (Tureli, Erdem 1997, Ozyurt 2003, Ismen 2003) at least 76.0% of the total catch consisted of immature or just matured individuals.

The estimated fishing mortality rates and exploitation rates were very high in the study area. These results indicated that this species was under extensive fishing pressure on the fish populations in the studied area.

Acknowledgement: This study is a part of PhD Thesis and supported by Cukurova University Scientific Research Found. Project No: FBE.2002.D.138

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Received: 12.05.2010
Accepted: 13.01.2011