Journal of Applied Biological Sciences 3(2): 143-147, 2009
ISSN: 1307-1130, www.nobel.gen.tr

Mortality Ratio and Stock Analysis of Vimba (*Vimba vimba tenella* (Nordmann,1840)) Population ın Karacaoren I Dam Lake (Burdur-Turkey)

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Received: May 15, 2009
Accepted: July 07, 2009

ABSTRACT

In this study, 808 vimba (*Vimba vimba tenella* (Nordmann, 1840)) individuals were captured during October 1996-April 1998 from Karacaören I Dam Lake and mortality ratio and stock size were estimated. Age distribution of *V. v. tenella* varied from 0- VII and 73.51 % of the observed samples were belonging to I- II age group. The fork length was ranged between 11.7- 27.8 cm. The growth parameters of vimba population were found as L∞ = 43.39 cm, K = 0.0863 and to = -4.7615. The mortality rates of vimba, according to constant parameter system were calculated as; Z=0.71 y^{-1}, M = 0.27 y^{-1} and F = 0.44 y^{-1}. The survival rate of the Vimba is determined as 49.16 %, exploitation rate as 62 %. Mean number and mean biomass of fish in population, bigger than 18 cm length, have been estimated as 762328 and 95044 kg respectively. With the simulations of fishing mortality rates belong to each length group, it was determined that maximum sustainable yield (MSY) could be obtained with increase 40 % increase of the present effort.

Key Words: Vimba, mortality ratio, stock analysis, Karacaoren I Dam Lake, Turkey

INTRODUCTION

Vimba *Vimba vimba tenella* is a cyprinid species which has commercial value in Karacaoren I Dam Lake. Although there are studies regarding biogeography and systematic of vimba in our country [1-4], there are limited studies relating its biology. Tanyolac [5] studied the length-weight and age-length relationships of fresh water fish populations in Ankara and its vicinity. Ekmekci and Erkakan [6] studied the growth and breeding characteristics of vimba *Vimba vimba tenella* in Sarıyar Dam Lake.

Herzig and Winkler [7] studied spawning characteristics and embryonic development of this species, Backiel and Bontemps [8] studied calculation of *V. v. tenella* population's stock size in Vistula river system using three different methods. Backiel and Bontemps [9] reported information regarding the outcomes of vimba transfer to a dam and product yield. Bartel [10] studied migration patterns of vimba.

MATERIALS AND METHODS

Study location

Study was performed in Karacaoren I Dam Lake, which is located in limits of the cities Isparta and Burdur. The dam lake which is located on Aksu Stream has 270 m of altitude and maximum depth of 85 m. At normal water elevation, lake area is 45.5 km^2 and lake volume is $1.234*10^6$ m^3. Annual rainfall is 1068 mm, annual evaporation is 1445 mm and basin area is 5582 km^2. In order to irrigate the downstream the total area of 9500 ha, provide protection from flood and generate electricity, dam construction has started in 1977 and came into operation in 1989. Its main water income is Goksu spring and Aksu Stream; snow and rainwater from Koy Stream, Kizılli Stream and Balliktas Streams provide water. Water for irrigation and electricity generation consist the main water expense [11]. Surface water of the lake goes does to 10°C in winter, and increase to 27-28 °C in summer time.

No frost occurs in lake due to moderate climate conditions.

Karacaoren I Dam Lake has mesotrophic characteristic, its fish fauna consists from the fish species that primarily exist in Aksu Stream, Kovada Channel and Candir Stream [12]. In the dam lake there are 9 fish species. The species are *Sander lucioperca* (Lin.,1758), *Cyprinus carpio* (Lin.,1758), *Capoeta capoeta angorae* (Hanko,1924), *Barbus capito pectoralis* (Heckel,1843), *Vimba vimba tenella* (Nordmann,1840), *Carassius carassius* (Lin.,1758), *Carassius auratus* (Lin.,1758), *Anguilla anguilla* (Lin., 1758) and *Pseudorasbora parva* (Schlegel,1842) [13-14].

Determination of mortality rate

This study was performed in order to investigate mortality rate and stock analysis of *V.v. tenella* (Nordmann 1840) in Karacaoren I Dam Lake between October 1996 and April 1998. Fish specimens were collected using trammel nets with 200m of length and 2 m depth and having mesh size net of 20x20 mm and 80x80 mm from Elsazi, Kizilli and Candir coverts in a way that they can represent their population. Age determination of *V. v. tenella* was performed by comparison of various bone structures parameters such as scale, otolith, vertebra, opercular and subopercular.

The fork length (FL) measurements of caught 808 *V.v. tenella* individuals were performed using measuring board with 1mm sensitivity and weighing performed using digital scale with 1g sensitivity. During mathematical growth analysis of von Bertalanffy growth equations, which were adapted to fishery by Beverton and Holt (1957), were used [15-17].

In order to display the fishing effect on the *V.v. tenella* population in Karacaoren I Dam Lake, annual mortality rates were determined. During total mortality determination, $Z= K^* [(L\infty- L) / (L- L^1)]$ equation, which has developed by Beverton and Holt, was used. Z is the total mortality coefficient; K and L∞ are von Bertalanffy growth constants. L stands for average length of fish under fishing pressure and L^1 stands for initial length of fishing. Natural mortality rates in the population were calculated by the following equation [18].

$$\ln M = - 0.0152- 0.279 * \ln L\infty + 0.6543 * \ln K + 0.463* \ln T$$

In the estimation of the total mortality rate, the Length-Based Linearized Catch Curve Method was used. In this method, the length values taken from commercial fisheries were noted, and the age of each length group was estimated using the von Bertalanffy Equation [18]. Fishing mortality coefficient was obtained using F= Z- M equation. The percentage of mortality in the exploited stock was found with the following equations:

$$S=e^{-Z},\ C= (F/Z)*(100-S),\ D= (M/Z)*(100-S)$$

Where:

M: natural mortality rate; K: Brody growth coefficient; T: annual mean water temperature (°C); Z: total mortality rate; S: the percentage of surviving fish in one year; C: the percentage the of catch; and D: the percentage of natural deaths.

These mortality rates include the ones those occur during one fishing period. However, mortality rates for each age and length groups will be different. Therefore, mortality rates of length groups are giving in virtual population analysis section.

Virtual population analysis

The basis of virtual population analysis is to estimate the beginning stock of the season using the number of caught fish from any age group during fishing period and their mortality rates. For this purpose, length based Jones' cohort analyse method that was suggested by Sparre and Venema was followed, the mentioned formulas are giving below [8].

$$t(L_1)= to- (1 / K)* \ln [1- (L_1 / L\infty)]$$

$$\Delta t = t (L_2) -t (L_1) = (1/ K)* \ln [(L\infty- L_1) / (L\infty - L_2)]$$

$$H (L_1,L_2) = e^{((M * \Delta t) / 2)} = [(L\infty - L_1) / (L\infty - L_2)]^{M / 2 K}$$

$$F / Z= C (L_1, L_2) / [N (L_1) - N (L_2)]$$

$$F = M* (F / Z) / (1- (F / Z)$$

$$Z = F+ M$$

$$N(L_1) = [N (L_1) * H (L_1, L_2) + C (L_1, L_2)] * H (L_1, L_2)$$

Where:

$t (L_1)$ = age of L_1 ; K: Brody growth coefficient; Δt = time interval; $H (L_1,L_2)$ = natural mortality factor; and Z, M, F: total, natural, and fishing mortality rates, respectively. F/Z= stock exploitation ratio.

Bioeconomic analysis of the stock

In order to estimate which fishing effort to use to obtain maximum yield, annual fishing amounts and stock biomass of the stock of *Vimba vimba tenella* in Karacaoren I Dam Lake, Thomson -Bell method was used [18]. The basis of the method is to analyse the changes in stock and yield amount and economical values of them by increasing, decreasing the recent fishing effort, in other words fishery mortality rates in population, at certain percentages. Mathematical explanation of this method as follows.

$$\text{Length interval} = i = (L_i, L_{i+1})$$

$$Zi = M+ X * Fi$$

$$N(L_{i+1}) = N (L_i)* [((1 / Hi) - X* (Fi / Zi)) / (Hi- X* (Fi /Zi))]$$

$$Ci =[N(L_i)- N(L_{i+1})]* X* Fi / Zi$$

$$Wi = q* [(L_i + L_{i+1})/ 2]^b$$

$$Yi=Ci * Wi$$

$$Ni * \Delta ti = [N (L_i)- N (L_{i+1})] / Zi$$

$$Bi * \Delta ti =Ni * \Delta t * Wi$$

Where,

Z = Annual mortality rate of two length groups

$N(L_{i+1}) = L_2$ length individuals number in population

Ci = Caught fish number in the commercial fisheries;

Wi = mean fish weight in annual yield;

Yi = Caught yield amount (kg) between two length groups

$Ni * \Delta ti$ = Average individual number in the population that belongs to length groups

$Bi * \Delta ti$ = Average biomass (kg) in the population that belongs to length groups

X = % value of recent fishing effort that has used for simulation

Statistical significance control of the obtained data was performed using χ^2 and t tests, P = 0.05 confidence limits were taken [19-21].

RESULTS

During the study period, 808 *V. v.tenella* individuals were caught in Karacaoren I Dam Lake. Age distribution of these specimens ranged 0 to VII. I. and II. age groups were dominant, and formed major portion (73.51 %.) of the population. Fork lengths of *V. v. tenella* individuals range 11.7 cm to 27.8 cm. 68.07 % of the caught individuals consist of 16-19 cm length group.

Mortality rates in *Vimba vimba tenella* (Nordmann, 1840) population

Natural mortality rate (M) in Karacaoren I Dam Lake *V. v. tenella* population was found as below. Values regarding calculation of annual total mortality coefficient were given in Table 1.

$\ln M = -0.0152 - 0.279 * \ln L\infty + 0.6543 * \ln K + 0.463 * \ln T$

$\ln M = -1.292409$

$M = 0.27$

Annual mortality coefficient was estimated as follows by using average lengths (L) and L^1, K, $L\infty$ values that were giving in Table 1 for fish under fishing pressure.

$Z = K * [(L\infty - L) / (L - L^1)]$

$Z = 0.0863 * [(43.39 - 20.74) / (20.74 - 18)]$

$Z = 0.71$

Fishery caused annual average fishing mortality coefficient was found by subtracting natural mortality coefficient (M) from the determined total mortality coefficient (Z).

$F = 0.71 - 0.27 = 0.44$

Stock exploitation ratio (E) = 0.44 / 0.71 = 0.62

In conclusion, findings regarding mortality rates are in the following;

$Z = 0.71$ $M = 0.27$ $F = 0.44$ $E = 0.62$

Survival periods (%) and annual % mortality rates were given below.

$S = e^{-Zt} * 100$

$S = e^{-0.71} * 100 = 49.16$

$C = (0.44 / 0.71) * (100 - 49.16) = 31.52$

$D = (0.27 / 0.71) * (100 - 49.16) = 19.32$

Total mortality rates (%) = 50.84

During one year, 50.84 % of the exploited vimba population (over 18 cm in length) died, and 49.16 % of the exploited population survived.

Table 1. Estimation of annual total mortality rate in *V. v. tenella* population

$L^1 = 18$ $L\infty = 43.39$ $K = 0.0863$ $T = 19.6$ °C

Length interval point (L_1-L_2)	Mean point $(L_1-L_2)/2$	Sample number C	Sample number *Mean $C * (L_1-L_2)/2$
18-19	18.5	145	2682.5
19-20	19.5	61	1189.5
20-21	20.5	48	984
21-22	21.5	36	774
22-23	22.5	47	1057.5
23-24	23.5	38	893
24-25	24.5	26	637
25-26	25.5	13	331.5
26-27	26.5	6	159
27-∞	27.5	1	27.5
Total		421	
$\Sigma C * (L_1-L_2)/2$			8735.5
$L = [\Sigma C * (L_1-L_2)/2] / N$			20.74

Virtual population analysis

In the assessment of the exploited *V.v.tenella* stock, the length samples were taken from the commercial fisheries in 1997, and frequencies of each length group were proportioned to the caught 50000 kg of yield during study period. The caught fish amount from each length group is shown in Table 2, it was detected that total 50000 kg and 375439 number of *V.v.tenella* has caught. By the help of these values, the estimated stock amount is in Table 3.

Parameters shown in Table 2 were calculated using following equations.

$t(L_1) = -4.7615 - (1 / 0.0863) * \ln(1 - (L_1 / 43.39))$

$\Delta t = t(L_2) - t(L_1) = (1 / 0.0863) * \ln[(43.39 - L_1) / (43.39 - L_2)]$

$H(L_1, L_2) = e^{((M * \Delta t)/2)} = [(43.39 - L_1) / (43.39 - L_2)]^{M/2K}$

$W = 0.0074 * [(L_1 + L_2) / 2]^{3.2164}$

At the last length group, stock exploitation ratio was taken as an estimated 0.500 value.

$N(L_1) = [N(L_2) * H(L_1, L2) + C(L_1, L_2)] * H(L_1, L_2)$

$N(27) = C(27, \infty) / (F/Z) = 892 / 0.500 = 1784$

$N(26) = [1784 * 1.097 + 5354] * 1.097 = 8020$

$N(25) = [8020 * 1.091 + 11602] * 1.091 = 22203$

$N(24) = [22203 * 1.086 + 23204] * 1.086 = 51385$

$N(19) = [293139 * 1.067 + 54440] * 1.067 = 391823$

$N(18) = [391823 * 1.064 + 129408] * 1.064 = 581271$

Average fish number was determined as 762328 and average biomass was determined as 95044 in fishing period of Karacaoren I Dam Lake. Addition of the fished amount with remaining amount will give the exploited stock at beginning. In other words, 50000kg of fished yield and addition of the remaining of this number, which is 95044 kg, is 145044 kg yield represents the exploited stock at the beginning of the period. Graph that shows the stock condition that was calculated virtual population analysis is shown in Figure 1.

Table 2. Distrubition of the length groups of *V.v.tenella* in the annual yield (50000 kg), converted into age intervals and natural mortality factors (H (L_1,L_2))

to = - 4.7615 K = 0.0863 L∞ = 43.39

Length interval L_1-L_2	Age $t(L_1)$	Δt $t(L_2)$ -$t(L_1)$	W (kg)	In Sample N	In yield (50000 kg) N	H (L_1,L_2)
18-19	1.447	0.465	0.08809	145	129341	1.064
19-20	1.913	0.485	1.10435	61	54424	1.067
20-21	2.398	0.506	0.12256	48	42767	1.070
21-22	2.904	0.529	0.14285	36	32083	1.074
22-23	3.434	0.554	0.16534	47	41887	1.077
23-24	3.989	0.582	0.19016	38	33896	1.081
24-25	4.571	0.613	0.21744	26	23199	1.086
25-26	5.185	0.647	0.24730	13	11600	1.091
26-27	5.833	0.686	0.27987	6	5350	1.097
27-∞	6.519	0.729	0.31528	1	892	--

Table 3. Length-based Virtual Population Analysis (Cohort Analysis) of the *V.v.tenella* population in Karacaoren I Dam Lake

Length interval (L_1-L_2)	Catch N C(L_1-L_2)	Survivor N N(L_1)	Explo. ratio F / Z	Fishing mortality F	Total mortality Z	Mean.N*Δt N(L_1-L_2)*Δt	Mean Biomas*Δt kg B*Δt
18-19	129341	581271	0.683	0.581	0.851	222618	19610
19-20	54424	391823	0.552	0.332	0.602	163926	17105
20-21	42767	293139	0.555	0.336	0.606	127285	15600
21-22	32083	216004	0.547	0.326	0.596	98414	14058
22-23	41887	157349	0.691	0.603	0.873	69464	11483
23-24	33896	96707	0.748	0.801	1.071	42317	8047
24-25	23199	51385	0.795	1.047	1.317	22158	4818
25-26	11600	22203	0.818	1.213	1.483	9563	2364
26-27	5350	8020	0.858	1.631	1.901	3280	918
27-∞	892	1784*	0.500*	0.270	0.540	3303	1041
					Total	762328	95044

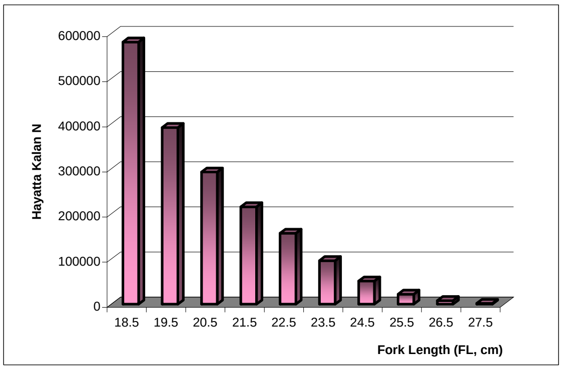

Figure 1. According to the virtual population analysis results, cohort dynamics of V. v. tenella population in Karacaoren I Dam Lake

Bioeconomic analysis of the *V. v. tenella* stock

In order to determine the maximum product yielding fishing effort of *V.v. tenella* stock, fishery mortality rates (F) in population were subject to simulations by certain percentages. As it can be seen on Table 4, when yields correspond to several fishing effort are analysed; it can be noticed that maximum yield can be obtained at 1.4 F-factor, in other words increasing present fishing effort by 40%. In the case of reducing present fishing effort by 20 %, yield would be 49294 kg and insufficient stock utilization would occur. In the case of reducing fishing effort to 0, it has found that the yield would be 0 kg and mean stock biomass would be 426371 kg. Yield-biomass relationships in different F- factors can be seen on Figure 2.

Table 4. Yield and stock biomass for various fishing effort (F)

F- factor	Yield (kg)	Biomass(kg)	F- factor	Yield (kg)	Biomass(kg)
0	0	426371	1.2	50213	82658
0.2	31233	257865	1.4 *	50248 *	73058 *
0.4	42950	179047	1.6	50196	65312
0.6	47498	137270	1.8	50106	58888
0.8	49294	112014	2.0	49997	53456
1	49950	95044			

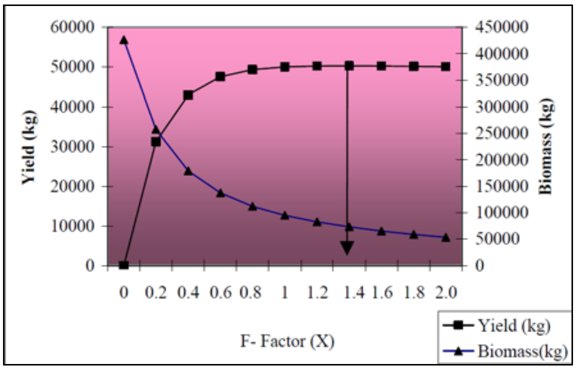

Figure 2. Predicted yield and biomass when the fishing effort increased and decreased (F)

DISCUSSION

V. v. tenella is one of the most exploited species in Karacaoren I Dam Lake following pike-perch and carp species. Age distribution of *V. v. tenella* ranged 0 to VII. The majority of the population formed by individuals belongs to I (33.91%) and II. (39.60%) age groups, representation of individuals belong to other age groups in the population found as 26.49 %. Maximum life span of *V. v. tenella* has reported as 10 years [6].

In this study, according to the constant parameter system, annual total mortality coefficient, natural mortality coefficient (M) and fishing mortality coefficient (F) of *V. v. tenella* population were determined as 0.71 y^{-1}, 0.27 y^{-1} and 0.44 y^{-1}, respectively.

When these values are represented by percentage (%), in *V. v. tenella* population in Karacaoren I Dam Lake, 31.52 % caused by fishing activities and 19.32 % caused by natural reasons, with a total mortality rate of 50.84% during study period. Stock exploitation rate (E) was determined as 62 % and survival rate was determined as 49.16%.

As a result of virtual population analysis, the number and mean biomass of the exploited stock of *V. v. tenella* population in Karacaoren I Dam Lake were calculated as 762328 and 95044 kg, respectively. By the proportion of mean biomass to fish number, average individual weight to exploit in Karacaoren I Dam Lake was determined as 125 g. According to the virtual population analysis of *V. vimba* population that was caught in Vistula River during 1953- 1960, the exploited stock amount was estimated as 950000 and the biomass as 514 tonnes. Average individual weight of exploit stock has reported as 541 g. Stock exploitation ratio has determined as 41 % [8]. In Wlocklawek dam, average biomass of *V. v. tenella* population has estimated as 54210 kg [9].

In conclusion, it has determined that *V. v. tenella* in Karacaoren I Dam Lake show better growth rate than the ones living in other habitats. According to the stock analysis results of *V. v. tenella*, maximum yield can be obtained by 40% increase in present fishing effort. Since there is no special fishing technique for *V.v. tenella*, especially when fish from coverts obtained by trammel nets are considered, fishing effort should be increased.

Acknowledgments

This study was taken from a section of PhD thesis of the first author and supported by Suleyman Demirel University Scientific Research Found, Project no: SDUAF-64

REFERENCES

[1] Kucuk F, Ikiz R. 1993. Aksu çayı ve kollarında (Antalya) bulunan balık türlerinin saptanması. *Turk Zoology Derg* 17, 427-444.

[2] Slastenenko E. 1956. Karadeniz Havzasi baliklari *The Fishes of the Black Sea* basin, İstanbul. (Çeviren H. Altan) EBK Yay. 324-328.

[3] Geldiay R, Balık S. 1996. *Türkiye Tatlisu Baliklari*, E.Ü. Fen Fak. Kitaplar Yay. No. 46. İzmir. 519 s.

[4] Demirsoy A. 1993. *Yaşamin Temel Kurallari,* Omurgalilar/ Anamniyota III, Ankara.

[5] Tanyolac J. 1968. Some Aspect of Local Population of Freshwater Fishes in the Surroundings of Ankara, *Communications* C3, 13, 65-100.

[6] Ekmekci FG, Erkakan F. 1992. Sariyar baraj golünde yaşayan *Vimba vimba tenella* (Nordmann, 1840)'nin bazi buyume ve ureme ozellikleri. *Doğa-Tr. J. of Zoology* 16, 323-341.

[7] Herzig A, Winkler H. 1986. The influence of temperature on the embrionic development of three Cyprinid Fishes *Abramis brama, Chalcalburnus chalcoides mento* and *Vimba vimba. J. Fish Biol* 28, 171-181.

[8] Backiel T, Bontemps S. 1995. Estimation by three methods of *Vimba vimba* population in the vistula river system. *Arch. Ryb. Pol* 3: 2 , 137-158.

[9] Backiel T, Bontemps S. 1996. The recruitment success of *Vimba vimba* transferred over a dam.. *J. of Fish Biol* 48, 992-995.

[10] Bartel R. 1993. Anadromus fishes in Poland. *Bulletin of the Sea Fish*. Inst 1: 128.

[11] Anonymous. 1993. Bazi gollerin ekolojisi, Tarim ve Köyişleri Bakanliği Tarimsal Uretim ve Geliştirme Genel Müd., Turkiye'deki İçsular ve Balik Çiftlikleri İncelemesi 7, 125 s.

[12] Gülle I. 2005. Karacaören I Baraj Gölü (Burdur) planktonunun taksonomik ve ekolojik olarak incelenmesi. Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Isparta, *Doktora Tezi,* 199 s.

[13] Wildekamp RH, Neer van W, Kucuk F, Unlüsayin M. 1997. First record of the Eastern Asiatic gobionid fish *Pseudorasbora parva* from the Asiatic part of *Turkey. J. of Fish Biol*. Brıef Communication 51, 858-861

[14] Becer ZA, Kir I, Cubuk H. 1998. Karacaoren I baraj golü'nde yaşayan *Carassius carassius* L., 1758 populasyonunun bazi ureme özellikleri. *XIV.Ulusal Biyoloji Kong*. 7-10 Eylül , Samsun.

[15] Beverton RJH, Holt SJ. 1957. On dynamics of exploited fish populations. *Fishery Invest*. Lond. Ser. II (XIX). 525 s.

[16] Silliman R. 1969. Comparison between Gompertz and von Bertalanffy curves for expressing growth in weight of fishes. *J. Fish Res. Board Can.* 26, 161-165.

[17] Atay D. 1989. *Populasyon Dinamigi* A.Ü. Zir. Fak. Yay., Ankara. 1154, 324 s.

[18] Sparre P, Venema SC. 1992. Introduction to tropical fish stock assesment. *FAO Fisheries Technical Paper,* 306 / 1, Rev: 1, 376 p. Rome

[19] Elbek AG, Oktay E, Saygi H. 1996. *Su Urunlerinde Temel İstatistik*. E.Ü. Su Urun. Fak.Yay. No. 19. 229 s. Izmir.

[20] Koray T. 1993. Su *Ürünleri Araştirmalarinda Biyometrik Yöntemler*. E.Ü. Su Ür. Fak. Yay. No. 45. I. 166 s. İzmir.

[21] Düzgünes O, Kesici T, Kavuncu O, Gürbüz F. 1987. *Araştirma ve Deneme Metodlari (İstatistik Metodlari II).* A.Ü.Zir. Fak. Yay. No. 1021. 381 s. Ankara.