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THE FEEDING OF EUROPEAN EEL, *ANGUILLA ANGUILLA* L. IN THE RIVER ASI, TURKEY

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Abstract: The feeding behaviour of European eel in the eastern limit of the distribution attained in the river Asi was investigated. Fish were dominant food organisms of eels especially if they are larger than 40 cm in total length. Trichoptera and Odonata larvae were also consumed by eels in the River Asi. It was observed that summer and also spring days are important feeding period for eels in the River Asi. Fish were consumed mostly in rainy seasons when river discharge is remarkably high. However, aquatic invertebrates were consumed mostly in summer days.

Key words: Asi River, European eel, diet, stomach contents, Turkey

Introduction

European eel, *Anguilla anguilla* L. is a widely spread diadrom species, which is found for feeding activity in freshwaters flowing into Atlantic Ocean and Mediterranean Sea The Asi River is one of the rivers located in the eastern tip of the distribution of European eel. Climate in the catchment of Asi differs from that in Europe in considerably higher temperatures, and precipitation largely restricted to the winter months (Hatay Directorate of Agriculture 2003). It is not surely known how the arid season affects the food contents of the eel and what the roles of river temperature as well as the discharge have on the feeding of eel in the River Asi. Since the study area has different climate from other distributional areas, the diet investigation of eel is important for understanding the growth and directly contribution Asi population into total eel stock.

Bearing in mind its economic value, there are many of studies about eel biology in natural and artificial reservoirs, ponds etc. Many studies about stomach contents of the eel (Rasmussen & Therkildsen 1979; Hussein 1981; Mann & Blackburn 1991; Barak & Mason 1992), which have focused on the European part of the distribution area, show that eels are piscivore and also feed on benthic invertebrates. However, there seems to be no studies tailored on the stomach contents as well as other biological properties of eels in the River Asi. The results of this study are the first document about some biological properties of European Eel from Turkey and also from Middle East except Golani et al., (1988).

Present study not only constitutes a database that provides preliminary information on the stomach contents of European eel in the River Asi, but also serves to find of the ecologic effects on the food contents of eel especially under temperature and discharge limitations in the hot and arid climate.

Materials and Methods

Study area

The River Asi (Orontes) that originates from Lebanon after passing Syria empties its waters into the Mediterranean Sea in Turkey. The River Asi plays an important role in the south-western Asia including Turkey, Syria and Lebanon as a water source for irrigation in this semiarid region. The length of the river is approximately 380 km, 94 km of which is in

Turkey. The annual rainfall is noted to be approximately 400-800 mm in this region, but the rainy periods are concentrated only in winter, spring and autumn particularly while the summer months are mostly arid. The mean precipitation is less than 9 mm /m^2per year with the high water temperature, above 27 ^oC, at least two months in a year, July and August (Hatay Directorate of Agriculture 2003). In this arid season the water level declines practically to zero in some localities.

Data collection

A total of 146 specimens, collected between January 1997 and February 1998 and also in April 2003, were analysed for stomach contents. These samples were collected from six localities along the River Asi (Figure 1). Two catching devices were used: drift net at Demirköprü and fyke nets at the other sampling stations. The drift net is a trap equipped with rectangular frames with a bag net starting from 40x40 mm-mesh size and ending in 10x10 mm-mesh size. This trap is hanged on passageways across the river. The trap was engaged in catching fish 12 hours between 7 p.m. and 7 a.m.

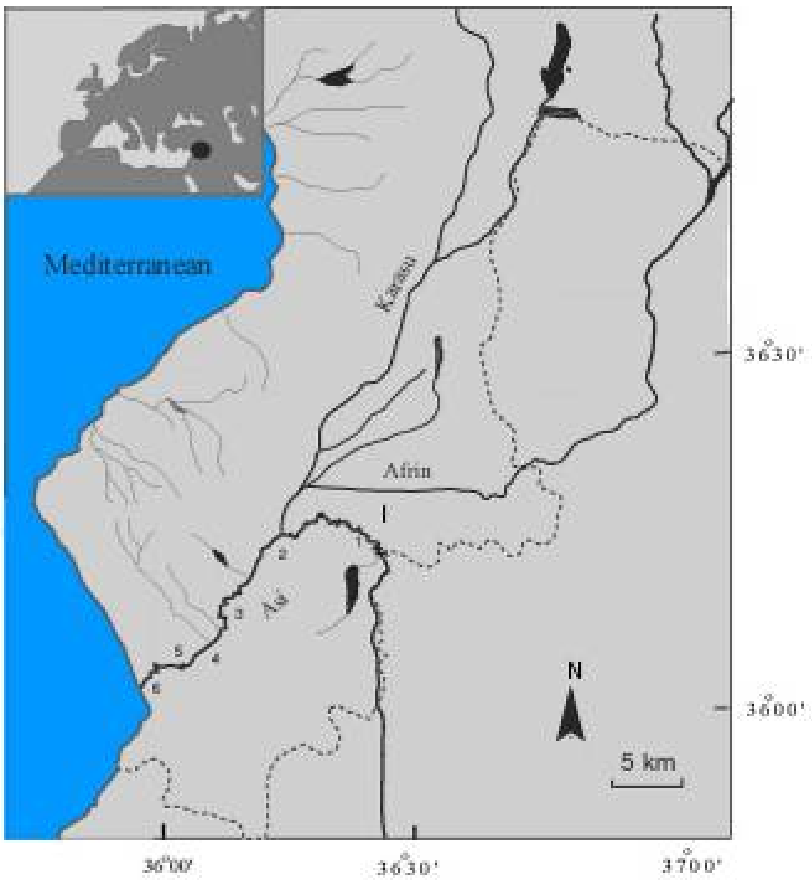

Figure 1. The map shows the area from where the specimens were collected.
1. Demirköprü 2. Güzelburç 3. Aşağıokçular 4. Şeyhhasan 5. Tavlaköyü 6. Samandağ.

The total length and weight of each individual was measured to the nearest cm and g respectively. The body cavity of each fish was opened and the stomach was removed and preserved in 4% formalin. Afterwards, the contents of removed stomachs were identified to the lowest taxonomic level possible, counted and weighed. The following references were used to identify of food items: Pennak (1953), Geldiay & Balık (1996), Demirsoy (1992, 1998), Kuru (1980). Sexes were determined in only 124 individuals (females = 90, males = 34) based on method given by Sinha and Jones (1966).

The specimens were considered in three length classes, namely <40, from 41 to 60, and >61 cm total length. Since the proportion of prey included in the diet of a fish can change seasonally the prey in the diet of eels were presented also for seasons (Bagenal 1978). The percentage of filled stomachs were calculated from the formula of $\%Full = 100 \times N_F / N$ where N_F is the number of samples which have at least one diet item in their stomachs and N is the total number of examined samples. The stomach contents were scored by three different methods, which are the frequency of occurrence (F %), and the percentage of abundance (N %) and percentage of weights (W %). Besides the percentage of IRI (the index of relative importance) of each categorized food organisms was calculated for each diet of eel from the formula (Pinkas et al. 1971)

$$IRI = (N\% + W\%) \times F\% \text{ and } \% IRI$$
$$(\text{as}\%IRI_i = 100 \times IRI_i / \sum IRI_i)$$

were calculated for each prey category and used in diet comparisons.

Condition factor of specimens were calculated from the equation, $C = 100 \times W/L^3$ where W is weight in g and L is total length in cm (Bagenal 1978).

Pearson correlation (using SPSS 8.0 program) at 95 % confidence interval was used to compare all correlations explained in the text such as temperature, discharge and percentage of full stomach, condition and also IRI %values of food consumed by the eels examined. The student t test was used for comparison of the male and female conditions at 95% confidence interval.

Results

The length distribution of the samples varies between 23.5 and 88.4 cm in total length and 18.2 and 1780 g in weight. Percentage of females increased with fish size, being 40% for specimens with less than 40 cm, and about 96% for specimens with more than 60 cm. The larger eel the higher percentage of filled stomachs was observed (Figure 2). Therefore, females have better chances for feeding than males since it was found that the full percentage was about 36% in females while it was only about 8% in males. The percentage of filled stomachs for all specimens including both sexes and immature individuals was found about 27%.

The percentage of full stomachs positively correlated with temperature ($r = 0.82$, $p<0.05$). However there was not any significant correlation between percentage of full stomach and discharge ($p>0.05$). While the feeding of eels in the River Asi had a high ratio in hot summer months, the discharge was the lowest at this time (Figure 3).

The food organisms were mainly fish and insect larvae were mostly Trichoptera and Odonata as shown in Table 1. Main fish consumed by eels were cyprinids, mainly *Carasobarbus chantrei.* It was observed that the kind of food consumed by eels particularly the consumption of benthic invertebrates was to a great extent related with temperature. While fish were consumed during rainy season, when discharge was high, invertebrates were consumed mostly in hot dry season (Table 2).

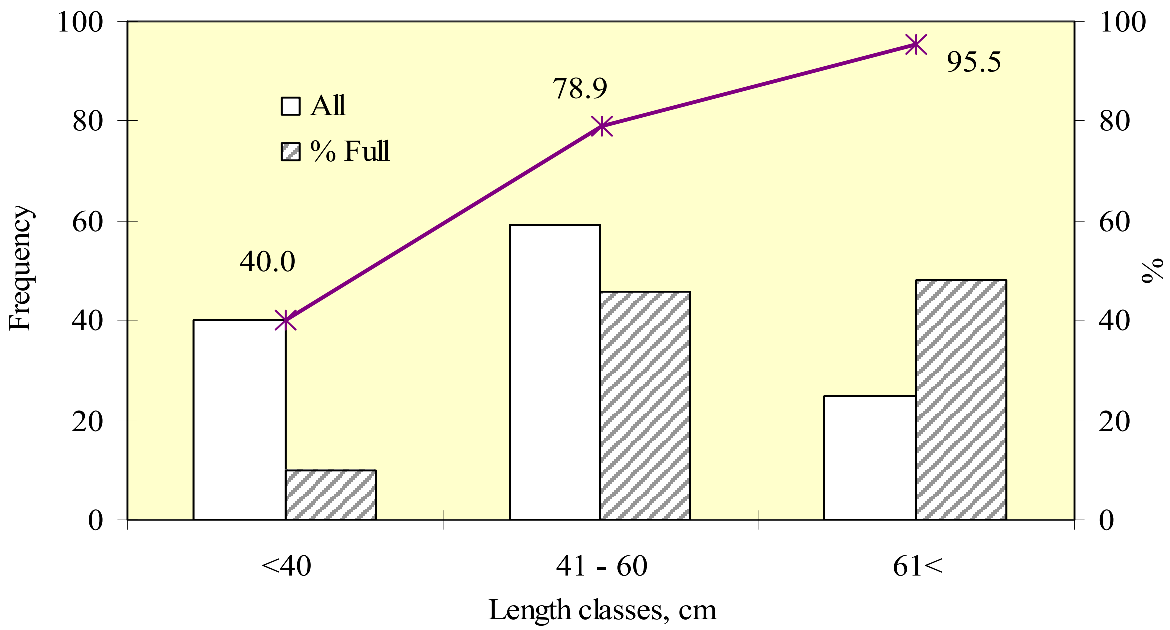

Figure 2. The histogram of all examined specimens and percentages of full stomachs in three total length classes. The line represents percentages of females in three length classes.

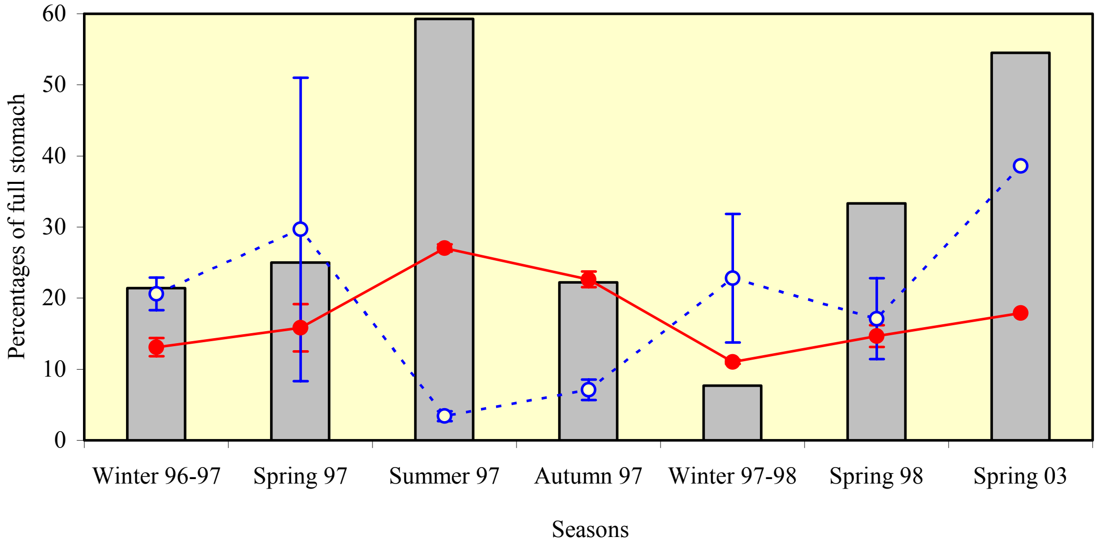

Figure 3. The percentage of full stomachs in eels with temperature and discharge (discharge was got from EİE, 1997). The red and blue lines with standard deviations represent temperature (^{o}C) and discharge (m^3s^{-1}), respectively.

Table 1. Percentage contribution of food organisms in eel diet.

Food organisms	%N	%W	%F	%IRI
Fish (cyprinids)	20.63	70.53	51.52	91.75
Isopoda	2.38	0.25	9.09	0.47
Diptera	0.79	0.01	3.03	0.05
Crustacea	1.59	0.07	6.06	0.20
Mollusca	3.17	0.12	6.06	0.39
Odonata	5.56	6.65	12.12	2.89
Trichoptera	63.49	4.18	3.03	4.01
Ephemeroptera	0.79	0.01	3.03	0.05
Plecoptera	0.79	1.73	3.03	0.15
Terrestrial insects	0.79	0.06	3.03	0.05
digested (unidentified)		16.38	39.39	

Table 2. Seasonal variation of eels diet based on the %IRI values of the two main prey groups (*the food organisms were unidentified).

	Seasons						
% IRI of food organisms	winter 96-97	spring 97	summer 97	autumn 97	winter 97-98	spring 98	spring 03
all food organisms	0.34	3.18	41.94	0.06	0.78	-*	53.70
fish	0.68	8.17	1.61	0.34	2.25	-*	86.94
other invertebrates	0.09	0.00	90.37	0.00	0.00	-*	9.53
temperature, °C	13.11	15.84	27.04	22.64	11.04	14.67	17.90
discharge, m^3s^{-1}	20.60	29.67	3.40	7.10	22.81	17.11	38.60

The condition of females (0.22 ± 0.15) was found to be higher than that of males (0.20 ± 0.04). However, there was no significant difference between males and females according to paired t test ($p>0.05$). The conditions values of only females were considered monthly and a negative correlation ($r = -0.82$, $p<0.05$) was found between condition and temperature (Figure 4).

In addition, European eels were infested by swim bladder parasites, nematodes and Platyhelminthes by the percentage of 22.6%, 12.1% and 6.5% in all examined samples respectively. While the eel was infested by swim bladder parasites during almost the entire seasons, the FO% of nematod and taenia concentrate in relatively cold seasons (Figure 5).

The carcasses of 212 eels were measured and the carcass value of each eel was rationed into their weight. The carcass to weight ratio was calculated as 0.83 in females, and 0.82 in males. There were no statistical differences in this ratio of eels between males and females.

Discussion

Several studies in the Western Europe (Rasmussen & Therkildsen 1979; Barak & Mason 1992; Mann & Blackburn 1991) and also Lake Kinneret (Golani et al. 1988) reported that generally large eels are piscivor. Fish, especially cyprinids were dominant food organisms of eel in this study. The mean length of the eels in the river Asi were recorded as 48.6 cm ± 13.4. Therefore, the high fish ratio as a prey in eel stomach might be explained that the eels in the River Asi were larger than 40 cm.

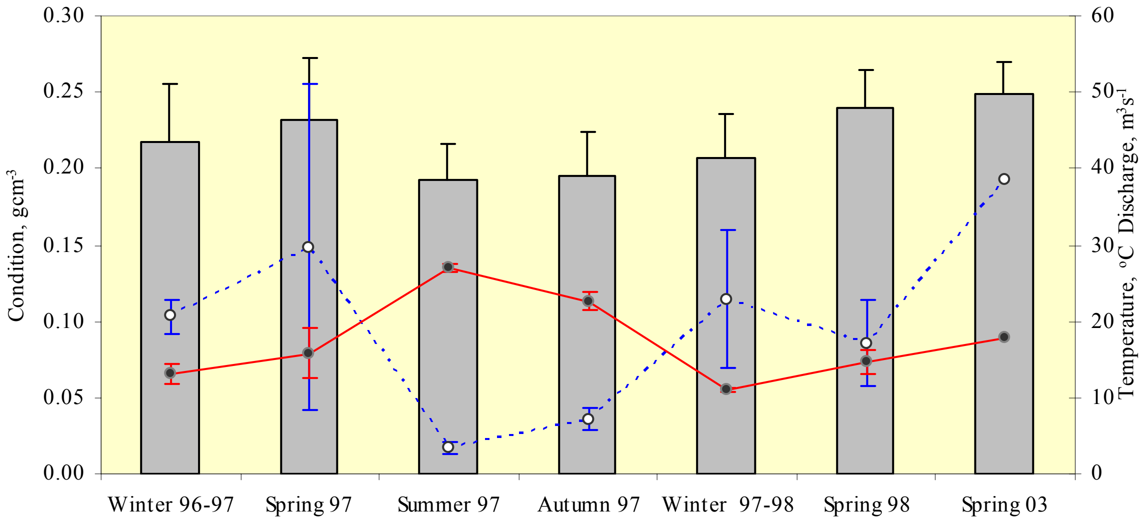

Figure 4. The condition values with standard deviations of European eel in the River Asi and water temperature with respect to months examined (The red and blue lines with standard deviations represent temperature and discharge, respectively).

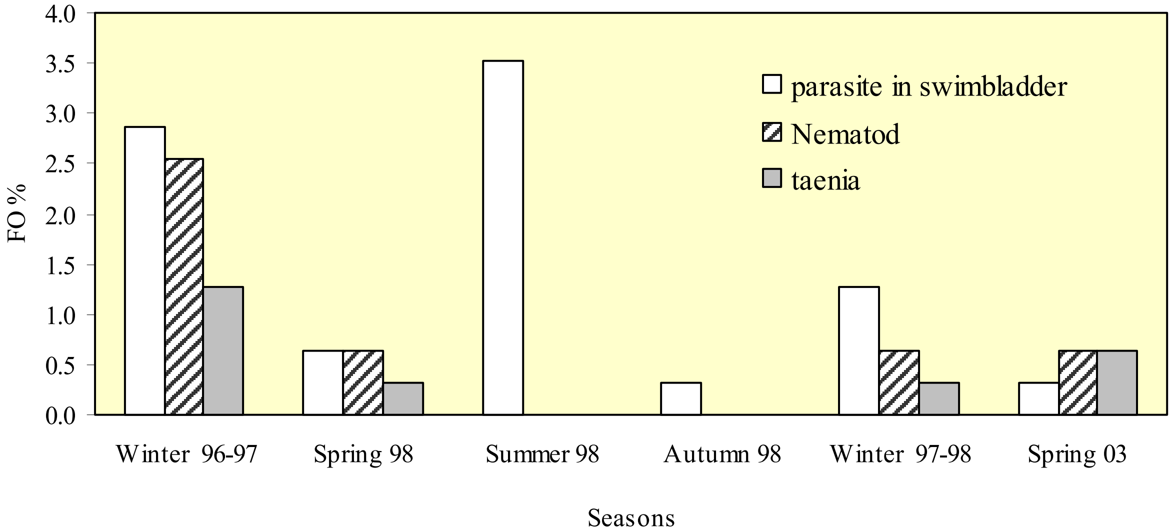

Figure 5. The seasonal variations of parasites of European eel (FO= Frequency of Occurrence).

African catfish, *Clarias gariepinus* was one of the most dominant omnivorous species, which feeds on also fish (Yalçın et al., 2002). But the frequency of occurrence fish in the eel diet (51.5%) was more than that in the catfish diet (6.4%) (Yalçın et al. 2002). Therefore, it seems that contrary to general opinion the competition between eel and catfish was low in the River Asi.

When seasonal percentages of filled stomachs were taken into account, the highest percentages were found to occur in summer months when river water temperature was, as high as 25 to 28 ^{o}C as it is illustrated in Figure 3. This temperature range was in agreement with the optimal environmental temperature (26-27^{o}C) that is reported for eels by Seymour (1984). As it had been found by other researchers (Rasmussen & Therkildsen 1979; Hussein 1981; Neveu 1981; Barak and Mason 1992), there was a positive correlation between feeding activity and temperature in this study. However, lack of data prevented to calculate the coefficient; Table 2 shows that this correlation was based on mostly aquatic invertebrates. However, there is no study about the abundance of aquatic invertebrates in the feeding environment of eel specimens, the eels might be consumed this kind of food just because they could find the aquatic invertebrates easily in this shallow water. These aquatic invertebrates might be in the first place responsible for the growth rate of eels in the river. Conversely, fish were consumed by the eel especially in spring and the discharge was high in this season. One could think that the eels, at least larger ones, could find better chance to feed and as a result of this better grow, if the water level were higher in hot season. Amik Lake, which is eradicated, might have been a suitable feeding place for large eel. Posterior to the eradication of the Amik Lake, which was a part of the River Asi until 1970's, the overuse of water for irrigation, caused the water level to decrease especially in arid seasons. Since the water depth limits the collection of large fishes as huge energy containing food quantitavely, the condition was restricted in hot summer months merely to aquatic invertebrates. Tesch (1977) stated that lake eels had more food in their stomachs compared to river eels. It is, however, unclear what the food content of the eel would have consisted of, if the water level is increased in Asi River. Many scientists indicate that the European eel population has been in the declining trend throughout its distributional areas since 1980 and the cause of this decline is explained by migration obstructions, fisheries, habitat loss, parasite infestation, pollutants (Moriarty & Dekker 1997; Feunteun 2002). Presently, the dams constructed on the river and overusing of water for irrigation both in Syria and in Turkey limit the amount of water in the River Asi. Particularly limited water, untreated urban and/or industrial sewage, overfishing activities, and contaminated runoff that contain fertilizers and pesticides from agricultural areas (Özdilek 2003) along with various dams that hinder migration of this species to upstream reaches in the river would most probably remarkably impact the natural food quantity and composition of eels in the River Asi. However, it can be said that the feeding activity of eel population is not in seriously bad condition in the River Asi. On the other hand, it is still unclear that if these unfavourable circumstances at least water depth could be eliminated how the feeding activity of eels would change or the feeding activity of eel increases. Hence, further studies need to be performed on the effects of environmental threats on the eel in the River Asi.

Pedersen (2000) calculated the condition of wild eels as 0.12 ± 0.02 in the eutrophic Sonderso Lake, Denmark. This value seems lower than that detected in the Asi population. Thus, it is safe to say that this hot and dry area well suits to eels compared with the other distribution areas of eel. The reason of good condition could be explained by food richness and high temperatures as explained above. As seen in Figure 5, the condition values are notably low in degree in dry and hot seasons. While the lengths of eels increase at these seasons, even though full stomachs, the weight of the eel does not increase as much as their length because of high metabolism. Unlike summer months, eels deposit fats on their bodies, which cause weight increments and also high condition values, in the cold season. In fact, it is known that eels need low amount of food to run their essential metabolic activities and mainly depend on their fats (Barak & Mason 1992) to continue their lives.

Richkus & Whalen (2000), noting the study of Secor et al. (1998), reported that in the Chesapeake Bay and Hudson River American eels were infested by the swim bladder parasite, *Anguillicola crassus*, with the high rates (20 – 40%). The parasites were found approximately in one quarter (22.6%) of the Asi River eel's swim bladder. Moreover, 12.1% and 6.5% of the Asi River eels were found to be contaminated with nematodes and Platyhelminthes, in stomachs respectively. The unfavourable effect of swim bladder parasite on the growth and migration activity is known (Rolbiecki 2002; Haenen & Banning 1991; Gollock et al. 2004). In this area, the effects of these parasites on the growth of eels should be investigated.

The eel has an economic value throughout the world. This study tries to explain the feeding status of the eel in highly polluted Asi River. Other biological characteristics of eels such as migration; recruitment, threats such as river contamination, over fishing, and diseases should also be investigated in future studies for the Asi population is part of the whole eel population distributed in Western Europe.

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