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FOOD UTILIZATION OF COD (GADUS MORRHUA L.) AND DAB (LIMANDA LIMANDA L.)

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ABSTRACT: Energy, protein, and lipid measurements were carried out on the stomach contens and different sections of intestines in cod (*Gadus morrhua*) and dab (*Limanda limanda*) taken from their natural biotope and compared with results of fishes kept in aquariums and fed with specific food organisms. Under natural conditions, cod utilized food more effectively than dab as follows: total amount of energy 7,0% protein 12,0%, and lipid 13,0%. The utilization of specific food was, for energy 9,5%, for protein 16,0% and for lipid 8,2% higher in cod than in dab.

RESUMEN: Fueron realizadas mediciones de energía, proteina y lípidos del contenido, tanto estomacal como de diferentes secciones intestinales del bacalao (*Gadus morrhua*) y de la lima (*Limanda limanda*), que fueron capturados en sus biotopos naturales. Dichos resultados fueron comparados con los de peces, que fueron mantenidos y alimentados con organismos específicos. En condiciones naturales el bacalao utiliza más efectivamente el alimento que la lima de la manera siguiente: energía total 7,0%, proteina 12,0% y lípidos 13,0%. La utilización específica del alimento era mayor en el bacalo que en la lima de la manera siguiente: energía 9,5%, proteína 16,0% y para lípidos 8,2%.

INTRODUCTION

The food serves the organisms as an energy source. By determining the energy value of food ingested, food digested, and food eliminated, the energy transfer can be calculated. The utilization of food differs not only according to nutrient content, but also from animal to animal. HALVER and TIEWS (1979) concluded that the nutrient-utilization-ratio (NUR), expressed as a percentage of the built-in energy, for *Cyprinus carpio* lay between 30% and 37%, whereas for *Ictalurus punctatus* it was between 38% and 80%. According to NEUHAUS and HALVER (1979), the NUR for *Myxocephalus scorpius* ranged between 68% and 80%; PANDIAN (1967) noted that for *Megalops cyprinoides* and *Ophiocephalus striatus* the NUR lay between 70% and 80%, respectively.

This paper investigates the NUR as well as the protein and lipid absorption of food contained in the stomach and in various sections of intestine in cod and dab, living in their natural biotope. Furthermore, *in vivo* experiments will be carried out to compare the values for estimating particularly the size of difference

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of food utilization of both fish species.

MATERIALS AND METHODS

Between September 1980 and February 1981, cod and dab were collected monthly from two locations (Bocknis-Eck, Millionenviertel (Western Baltic)) in Kiel Bay in all 90 individuals of each species. The fish were caught by mens of bottom trawl. From each haul, five cod 30 cm in length, and five dab of 20 cm were selected for *in vivo* experiments, and 15 of both species of the same length were dissected directly. The digestive tract was removed and cut it into four parts: stomach, upper mid-gut, lower mid-gut, and rectum. Their contents were stored at -20 C, after 24 hours they were lyophilized, homogenized and, finally, pressed into 5-15 mg pellets to be stored under vacuum in a desiccator. For *in vivo* experiments two aquariums were used. 30 cod and 30 dab were fed with specific food consisting of *Nephthys* sp., *Mytilus edulis*, *Clupea harengus* and *Arenicola* sp., twice a day. As soon as they were observed to have processed their food, they were dissected and the content of their digestive tracts was treated in the same way as described above.

The energy content was measured using Phillipson Oxygen Microbomb Calorimeter (1964), the protein content was determined according to LOWRY *et al.*, (1951) and the lipid content by using the method of ZÖLLNER and KIRSCH (1961). This paper is based on the results of 960 calory, 240 protein, and 240 lipid measurements.

RESULTS

UTILIZATION OF NATURAL FOOD

Cod and dab utilize the nutrients of natural food at a rate of 51% and 47% respectively; specifically, protein 53%/47% and lipid 44%/38% (Fig. 1). The distribution of the respective 90 energy values per fraction of intestinal content was below an average of 20% for both species. The decrease of the nutrient content through progressive digestion was tested by means of a T-test and was found to be significant. Table 1 shows the effectiveness of the uptake of nutrients in three sections of the digestive tract.

UTILIZATION OF SPECIFIC FOOD

The mean values of the nutrients of food in their original values and after feeding are presented for both fishes in Fig. 2. The total amount of energy was determined to be 24 Kj and was taken to be 100%; the initial protein value of food was 60% and that of lipid 18,5%. The utilization of food during the digestion period revealed the following values for cod: energy 56%, protein 72%, and lipid 34%. On the contrary, the results for dab were somewhat lower. Their energy utilization amounted to 50%, protein utilization 60%, and lipid utilization 29%. The standard deviation for both species based on 30 animals lay at an average of 15%. The nutrient values of the stomach contents of the upper-and lower mid-gut as well as those of the rectum of both species were compared in a similar way. The energy value of the food decreases significantly due to

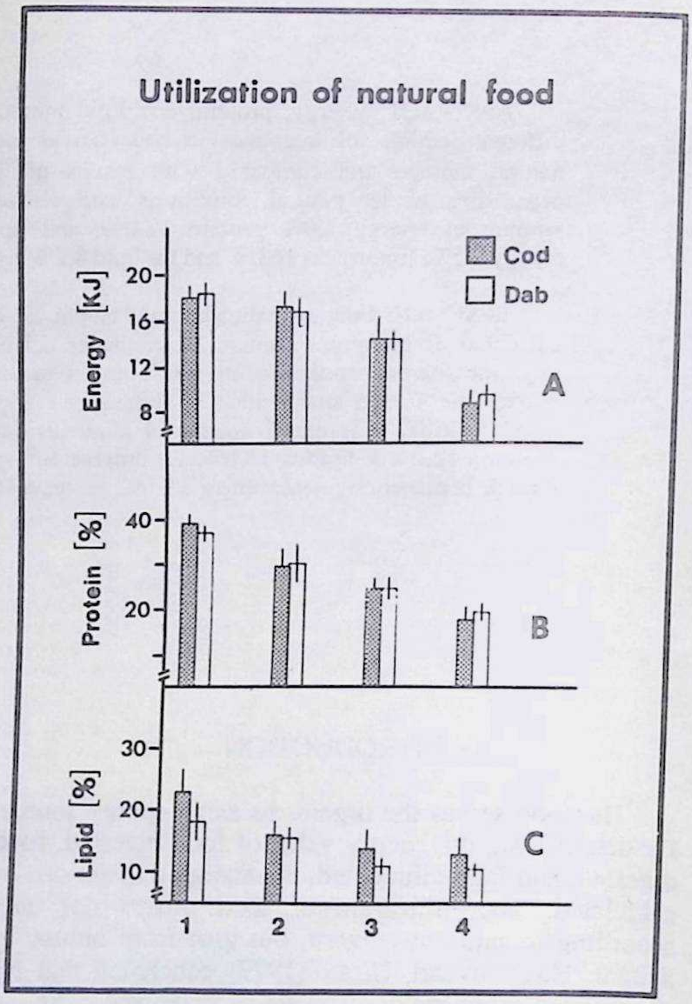

Fig. 1.- Utilization of natural food. Energy (A), protein (B), and lipid content (C) of the nutrients in the stomach (1), upper mid-gut (2), lower mid-gut (3), and rectum (4) of cod and dab are shown. Each bar represents a standard error of ninety replicate samples. For further explanations, see text.

digestion as one advances along the digestive tract.

The utilization effectiveness, of various sections of the intestine is presented in Table 1.

DISCUSSION

By the determination of nutrient content in foods, irregular variations were observed in the natural as well as in the specific food. These variations are based on the heterogenity in the contens of the food.

In contrast to specific food, the original value of the natural food could not be measured. An indirect determination was, however, possible because fish kept in aquariums and fish from a natural biotope utilized the nutrient quite similarly in the stomach and in each section of the digestive tract (Table 1). With this assumption, the energy utilization of natural food stands at 69% ford cod and at 62% for dab.

Figure 2 shows that the energy content of specific food in the stomach is approximately 13% lower for cod and approximately 10% lower for dab than its original value. It is obvious because the predigestion has already begun in the stomach. The metabolic processes depend upon age and weight and are therefore independent variables (KAUSCH, 1972). If a certain body weight is reached, the digestive capacity decreases (PANDIAN, 1967). In this investigation the cod were 30 cm in length weighing 230 g, the dab were 20 cm in length with and average body weight of 103 g. According to the length/age relationship (THUROW, 1970), cod and dab had just reached the first maturity stages.

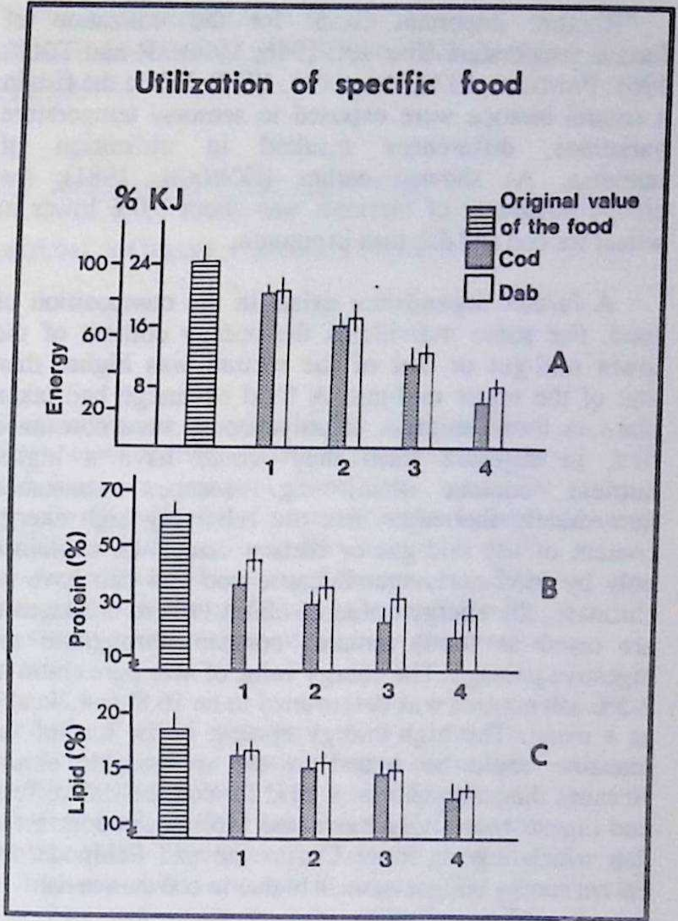

Fig. 2.- Utilization of specific food. Energy (A), protein (B), and lipid content (C) of the nutrients in the stomach (1), upper mid-gut (2), lower mid-gut (3), and rectum (4) of cod and dab are shown. The standard deviations of thirty replicate samples are given. For further explanation, see text.

Tabla 1.- Effectiveness of uptake of nutrients in different sections of the digestive tract in cod and dab are given (values in %).

NUTRIENT UPTAKE IN NATURAL BIOTOPE

	Upper mid-gut		Lower mid-gut		Rectum	
	Cod	Dab	Cod	Dab	Cod	Dab
Energy	10,5 ± 9,4	11,9 ± 16,1	15,6 ± 15,1	13,3 ± 12,0	24,9 ± 13,9	22,0 ± 15,5
Protein	23,6 ± 6,2	19,3 ± 11,0	11,2 ± 7,8	12,3 ± 9,2	18,0 ± 10,4	15,0 ± 11,3
Lipid	28,6 ± 14,5	16,7 ± 7,7	10,6 ± 6,7	20,0 ± 6,6	4,8 ± 7,2	1,7 ± 8,0

NUTRIENT UPTAKE IN IN-VIVO EXPERIMENTS

	Stomach		Upper mid-gut		Lower mid-gut		Rectum	
	Cod	Dab	Cod	Dab	Cod	Dab	Cod	Dab
Energy	11,5 ± 11,2	11,4 ± 8,1	13,3 ± 9,7	11,5 ± 13,2	16,1 ± 12,0	12,4 ± 9,6	14,7 ± 9,7	14,2 ± 24,0
Protein	39,0 ± 6,8	27,4 ± 5,7	15,4 ± 6,9	15,0 ± 6,2	10,4 ± 7,3	9,6 ± 5,2	7,5 ± 10,0	8,0 ± 6,5
Lipid	10,5 ± 4,5	7,5 ± 6,6	14,2 ± 5,0	13,5 ± 5,9	6,6 ± 3,5	8,1 ± 6,3	2,7 ± 7,5	0,9 ± 5,7

Another important factor for the utilization of food is temperature (BROWN, 1946; MOLNAR and TÖLG, 1961; PANDIAN, 1970; ISHIWATA, 1970). While the fish in a natural biotope were exposed to seasonal temperature variations, differences resulted in utilization of nutrients. As showed earlier (GÖRÖGH, 1981), the energy utilization of nutrients was about 5,0% lower in winter for cod and dab than in autumn.

A further dependency exists in the composition of food. For some individuals the energy content of the lower mid-gut or that of the rectum was higher than that of the upper mid-gut. A food exchange had taken place in those animals. If polychaetes were consumed first, in digested form they would have a higher nutrient content than, e.g. seastars consumed immediately thereafter. But the relatively high energy content of the mid-gut or rectum cannot be explained only by food exchange. Because cod and dab have no chitinase, the energy value of chitin (where crustaceans are usted as food) remains constant throughout the digestive passage. The energy value of near pure chitin of 2-5% ash content was determined to be 16,8kJ=4,2kcal/g as a mean. The high energy content in the rear of the intestine could be traced to the indigestible chitin. Because the composition of food for cod and dab differs, cod ingests more Polychaets and Mollusc, in contrast to dab which ingests more Crustaceae and Echinoderms; the net energy budget is much higher in cod than in dab.

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