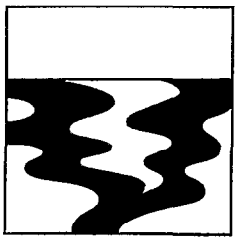

Comments about ivlev's electivity index

Roger GRAS (1) and Lucien SAINT-JEAN (2)

SUMMARY

The authors show that the absolute value of the Ivlev's electivity index and its sign do not represent accurately the degree of prey selection, as the index is markedly influenced by the abundance of prey in the natural environment.

They propose a new index which allows, under certain conditions, the calculation of the proportion of zooplankton biomass which can readily be used by a predator, according to its prey selection characteristics.

KEY WORDS : Africa — Lake Chad — Zooplankton eaters fishes — Prey selection.

RÉSUMÉ

REMARQUES SUR L'INDICE DE SÉLECTIVITÉ D'IVLEV

Les auteurs montrent à l'aide d'un exemple théorique relatif à un poisson zooplanctophage collectant ses proies par filtration passive du milieu, que la valeur absolue et le signe de l'indice de sélection d'Ivlev n'ont pas de signification propre, dépendant en particulier de l'abondance, dans le milieu, des proies les plus inégalement sélectionnées par l'animal.

Ils proposent un nouvel indice de sélection qui permet, sous certaines conditions, d'estimer la fraction du zooplancton effectivement utilisable par un zooplanctophage, compte tenu de la sélection des proies qu'il effectue.

MOTS-CLÉS : Afrique — Lac Tchad — Poissons zooplanctophages — Sélection des proies.

Ivlev's electivity index has frequently been used in the study of prey selection by fish predators, with particular reference to planktivores (HUTCHINSON, 1971; O'BRIEN and VINYARD, 1974; GUISANI, 1974, IM, 1977; MORIARTY *et al.*, 1973; LAUZANNE and ILTIS, 1975). The index is determined by the equation: $E_i = \frac{r_i - p_i}{r_i + p_i}$ where r_i is the percentage of prey "i" in the stomach contents of the predator (number of "i" individuals/total number of prey individuals in the stomach $\times 100$) and p_i is the percentage of the prey in the natural environ-

(1) *Hydrobiologiste O.R.S.T.O.M., 24, rue Bayard, 75008 Paris.*
(2) *Hydrobiologiste O.R.S.T.O.M., C.R.O. B. P. V 18, Abidjan (R.C.I.).*

ment, which is calculated only from the prey eaten by the predator.

E_i ranges from —1 to +1 using this index. A positive index close to +1 should indicate that the prey is either actively hunted or at least well retained by the gillrakers and other filtration mechanisms of the predator.

In fact, further research has shown that the absolute value of the index and its sign do not represent accurately the degree of prey selection as the index is markedly influenced by the abundance of prey in the natural environment. This trend is particularly evident for prey which is strongly selected or rejected. A theoretical example is used here to illustrate this trend, which has already been noted by JACOBS (1974). In this example the predator is planktivorous and retains a given percentage of the prey present in the environment by filtering water through its gillrakers (Table I).

These percentages represent the *collecting efficiency* which should be constant irrespective of the absolute or relative abundance of the prey. It is assumed that the collecting efficiency of the most selected prey is close to 100 %, although this theoretical maximum value is never actually obtained in the wild. Two cases have been considered in which the number of prey only has been varied. In each case, the number (N'_i) of consumed prey was determined by multiplying the number of prey i contained in a unit volume of the filtered environment by its

TABLE I

Example of the variation in Ivlev's index (E_i) and the index r_i/p_i in relation to the number of prey in the environment (see text for full explanation)

PREY	A	B	C	D	E
Collecting efficiency.	5 %	20 %	40 %	40 %	100 %
case 1					
N_i	10 000	500	200	50	100
$N'_i = N_i \times$ collecting efficiency	500	100	80	20	100
p_i (%)	92,2	4,6	1,8	0,5	0,9
r_i	62,5	12,5	10,0	2,5	12,5
r_i / p_i	0,68	2,72	5,43	5,43	13,59
E_i	—0,19	+0,46	+0,69	+0,69	+0,86
case 2					
N_i	100	50	200	500	10 000
N'_i	5	10	80	200	10 000
p_i	0,9	0,5	1,8	4,6	92,2
r_i	0,05	0,1	0,8	1,9	97,1
r_i / p_i	0,05	0,22	0,42	0,42	1,05
E_i	—0,90	—0,64	—0,41	—0,41	+0,03

TABLE II

Variation of Ivlev's index in the different types of prey consumed by *Brachysynodontis batensoda* (Pisces, Mochocidae) from the eastern archipelago of Lake Chad : Nauplii and Rotifera included in the calculation in line 1, not included in line 2. **1** data collected at Tchongolerom on 9 April 1973; **2** and **3**, data collected at Lafia on 1 and 2 May 1973; T.n. = *Thermocyclops neglectus;* M.l. = *Mesocyclops leuckarti* (1); M = males; F = females

	Rotifera	Nauplii	Copepodid stages of Cyclopides				Adults of T.n.		Ad. M.l.	*Thermo-diaplomus galebi*		*Moina micrura*	*Diapha-nosoma excisum*
			C_1	C_2	C_3	C_{4-5}	M	F	M+F	C_{1-5}	M+F		
1	—0,18	+0,58	+0,80	+0,71	+0,40	+0,12	+0,04	—0,31	—0,27	—1	—1	+0,84	+0,72
			+0,58	+0,42	—0,02	—0,31	—0,39	—0,64	—0,61	—1	—1	+0,65	+0,44
2	—0,11	+0,09	+0,74	+0,51	+0,55	+0,42	+0,31	—0,34	—1	+0,22	—1	+0,86	+0,79
			+0,21	—0,18	—0,13	—0,29	—0,42	—0,80	—1	—0,47	—1	+0,48	+0,30
3	—0,09	+0,06	+0,59	+0,47	+0,38	—0,32	—0,21	—0,60	+0,24	+0,60	—1	+0,76	+0,58
			+0,19	+0,03	—0,09	—0,68	—0,61	—0,83	—0,24	+0,19	—1	+0,46	+0,16

(1) Selon des données récentes (B. DUSSART, communication personnelle), cette espèce serait à rapporter à *Mesocyclops salinus* ONABAMIRO.

TABLE III

Example of the calculation of the index S_i and the values found in the three series of data from Table II. The numbers are gross values except for the number N_i of Nauplii and Rotifera, in which cases the gross numbers are respectively equal to 886 and 8900 individuals (2‰ of the sample). (See table II for T.n., M.l., T.g., D.e., M.m.)

	Rotifera	Nauplii	Copepodid stages of Cyclopides				Adults of T.n.		Ad. M.l.	T. g.		M. m. (®)	D. e.	
			C_1	C_2	C_3	C_{4-5}	M	F	M+F	C_{1-5}	M+F			
N_i.....	178 000	17 720	429	253	231	764	847	1069	42	39	129	58	83	1
N'_i.....	5 007	2 724	160	61	22	40	37	23	1	0	0	27	21	
$S_i = \frac{N'_i}{N_i} \cdot \frac{N_R}{N'_R}$	0,06	0,33	0,80	0,52	0,20	0,11	0,09	0,05	0,05	0	0	1	0,54	
S_i.....	0,06	0,09	0,53	0,24	0,27	0,19	0,15	0,04	0	0,12	0	1	0,65	2
S_i.....	0,07	0,16	0,55	0,39	0,31	0,08	0,09	0,04	0,21	0,50	0	1	0,52	3
$\overline{S_i}$.....	0,06	0,23	0,67	0,42	0,25	0,12	0,11	0,05	0,08	0,15	0	1	0,56	

collecting efficiency. Two selection indices were then calculated: Ivlev's index and another index introduced here, r_i/p_i.

It is obvious from table I that the indices obtained at the same collecting efficiency are different in the two examples. The absolute value and sometimes the sign (B, C, D prey) of Ivlev's index fluctuated according to the abundance of the most irregularly selected prey (A and E). Accordingly the sign of E has no particular meaning since Ivlev's index, like r_i/p_i, has only a relative value. The changes in value and/or sign of the two above-mentioned indices makes it difficult to interpret any variation in prey selection in comparative studies. It is necessary for the composition of the prey populations used to be more or less similar so that a comparison is demonstrative. Of the two indices, only r_i/p_i traduce readily the different collecting efficiency which exist between two given species: the C prey whose collection efficiency is twice as high as that of the B prey has a r_i/p_i index which is proportionately higher. This result is not given by Ivlev's index.

Ivlev's index calculated from prey consumed by a planktivorous Mochocid from Lake Chad *(Brachysynodontis batensoda)* also vary markedly in value and/or sign according to whether or not Nauplii and Rotifera are included in the calculation (Table II). The index $L = r_i - p_i$ (where L = the selectivity index as defined by STRAUSS (1979)) has the same disadvantages as the indices used above.

A new index is proposed here in which the value is given to a reference prey R. It is preferable for the reference prey R to be one which is frequently consumed, easily identified and abundant in the natural environment, so that the values of r_i and p_i can be calculated with the greatest possible accuracy

The index is obtained by dividing the r_i/p_i of the different prey by the r_i/p_i of the reference prey, for instance the E prey. A value for the collection efficiency expressed in relation to the value 1 given to the E prey is then obtained. The collection efficiency can also be obtained directly using the equation: $S_i = \frac{N'_i \times N_R}{N_i \times N'_R}$ where N_i and N_R are the number of any i prey and the number of the reference prey in the natural environment respectively and N'_i and N'_R are the number of the same prey in the stomach contents.

Table III gives an example of this calculation. In this example, the selected reference prey is the cladoceran *Moina micrura* which is frequently taken by the predator in question, due to its abundance, its spherical shape, its large size and low vagility, which facilitate its easy collection through passive filtering.

This index does not have the disadvantages of Ivlev's and Strauss's indices, and its calculation is quick and simple. Furthermore, it allows for the calculation under certain conditions, of the useful biomass of prey i.e. the proportion of zoo-

TABLE IV

Example of the calculation of the useful biomass of prey (Bu in mg of dry weight per m³) according to data provided by the station of Tchongolerom (earstern archipelago of Lake Chad) in March-April 1973. Rotifera are not taken into consideration. S_i : average selection index from Table III ; B_i : biomass of the different prey in the natural environment ; B_T = total biomass ; T.g. = *Thermodiaptomus galebi*

	Nauplii	Copepodid stages of Cyclopides				Adults of T.n.		Ad. M.l.	T. g.		*Moina*	*Diaphanosoma*	TOTAL
		C_1	C_2	C_3	C_{4-5}	M	F	M+F	C_{1-5}	M+F			
B_i.....	23,9	3,2	2,8	4,1	24,9	29,3	86,8	4,7	5,8	47,2	6,7	3,1	$B_T = 242,6$
$\overline{S_i}$.....	0,23	0,67	0,42	0,25	0,12	0,11	0,05	0,08	0,15	0	1	0,56	
$\overline{S_i} \times B_i$....	5,5	2,2	1,2	1,0	3,0	3,2	4,3	0,4	0,9	0	6,7	1,7	$B_u = 30,1$

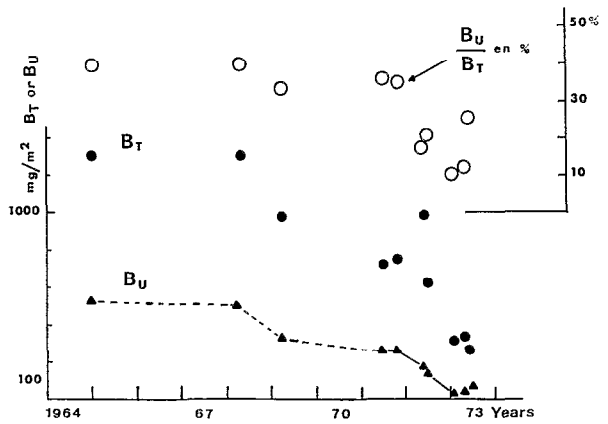

FIG. 1. — Variation in the total biomass (B_T) of the zooplankton (mg dry weight/m²), in the « useful biomass » (B_u) and in the ratio B_u/B_T in the eastern archipelago of lake Chad from 1964 to 1973. An annual average for five stations is given in 1964-65 ; the other values correspond to shorter periods

plankton biomass which can readily be used by a predator. The useful biomass is obtained by multiplying the biomass of the différent prey in the natural environment by their selection index (Table IV). The resulting value represents the *available* stock for a given predator at a given moment and in a given environment. Moreover, the *used* part of this stock can be calculated using values for the daily ration and the abundance of the predator. The calculation of the useful biomass is most accurate when the collection efficiency of the reference prey is near 100 %.

When these calculations are applied to the populations of plankton and *B. balensoda* in Lake Chad it is possible to state that the deceleration in growth rate and/or the decrease in the stock of planktivores which was observed in 1972-1973 as a result of the lowering of the water level (BENECH, 1975) may be accounted for by a group of factors such as a decrease in the useful fraction (B_u/B_T, where B_u = useful biomass and B_T = total biomass) of this stock (fig. 1). Further information on these trends is given by GRAS *et al. (in press)* and BENECH (1975).

The argument and example on which this brief critical analysis of the indices E and r_i/p_i is based can, at first sight, be transferred to types of food collection other than passive filtration. The value of the S_i index still has to be shown in practice, but it does allow the estimation of the useful fraction of a given stock of prey to the predator. Further refinement of these and other methods of quantifying the predator prey relationship are urgently required.

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