APPENDIX – Methods to quantify fish diet

1. Introduction

This Supplementary Appendix focuses on the nomenclature standardization of methods employed on studies of fish trophic ecology, showing equations, modification proposals and synonyms used in the scientific literature. Its organization follows the structure adopted in the main text.

2. Stomach evaluation

2.1. *Frequency of stomachs with food*

The *frequency of stomach with food* $\left(\%Sf_j\right)$ expresses the percentage of stomachs with any food that belongs to a given fish species j $\left(Sf_j\right)$ and the total number of stomachs analyzed for this species $\left(S_j\right)$:

$$\%Sf_j = \frac{Sf_j}{S_j} x100$$

Eq1

The $\%Sf_j$ is also referred as *percentage* (Duncan, 1912) or *proportion* (Mironova, 1961; Pearson & Gage, 1984) regarding stomachs with food contents.

2.2. *Frequency of empty stomachs*

The *frequency of empty stomach* $\left(\%Se_j\right)$ expresses the percentage between the number of empty stomachs that belongs to the species j $\left(Se_j\right)$ and the total number of stomachs analyzed for this species $\left(S_j\right)$:

$$\%Se_j = \frac{Se_j}{S_j} x100$$

Eq2

The $\%Se_j$ is also referred as *percentage* (Duncan, 1912) or *proportion* (Longley, 1917) regarding empty stomachs. Synonymies match such terms as *coefficient*, *emptiness*, *factor*, *fullness*, *index*, and *vacuity* (Hureau, 1970; Albertine-Berhaut, 1973; Duhamel & Hureau, 1985; Reyes-Marchant, Cravinho, & Lair, 1992; El-Ganainy, 2010).

2.3. *Degree of stomach fullness*

The *degree of stomach fullness* (DSF_i) categorizes each stomach i (or its content) from empty to full applying arbitrary categories (k) according to the degree of stomach distention (or the weight/volume of its content). These scales are extremely subjective, varying between two (Swynnerton & Worthington, 1940) and eight categories (Rao, 1964). Synonyms to DSF_i match terms such as *gut*, *percent*, *repletion* and *fullness* (Thomerson & Wooldridge, 1970; Hambrick & Hibbs, 1977; Barla, Vera, & O 'Brien, 2003)

2.4. *Stomach repletion degree*

The *stomach repletion degree* (SRD_j) (Santos, 1978) calculates the weighted average among the different DSF_i values attained to the different specimens i belonging to a given species j. For this end, the SRD_j considers the DSF category (k_{DSF}), the total number of stomachs classified into this DSF category (S_k) and the total number of stomachs evaluated for the species (S_j):

$$SRD_j = \frac{[(k1_{DSF} \cdot S_{k1}) + (k2_{DSF} \cdot S_{k2}) + ... + Kn_{DSF} \cdot S_{kn})]}{S_j}$$

Eq3

Thus, $K1_{DSF}$ represents the value assigned to the first fullness category, S_{k1} represents the number of stomachs classified into the first fullness category; $K2_{DSF}$ represents the value assigned to the second fullness category, S_{k2} represents the number of stomachs classified into the second fullness category; Kn_{DSF} represents the value assigned to the last fullness category, S_{kn} represents the number of stomachs that belongs to the last fullness category; and S_j represents the total number of stomachs evaluated for the species j.

The SRD was independently developed by Pelicice & Agostinho (2006) under the synonymy *mean stomach fullness*.

2.5. *Gastro-somatic relationship*

The *gastro-somatic relationship* (GSR_i) (Blegvad, 1917) represents a percentage (as proposed by Hureau, 1970) between the stomach weight (W_S) and the total body weight (W_B) of each specimen i:

$$GSR_i = \frac{W_{S_i}}{W_{B_i}} \cdot 100$$

Eq4

Several modification proposals were developed to estimate the GSR_i. The W_{S_i} also was calculated as either the weight of the stomach content (Hureau, 1970) or the eviscerated body weight (i.e., after removing digestive trait, liver and reproductive organs) (Buckley & Miller, 1994). Alternatively, the W_{B_i} was replaced by measurements in volume relating to either the stomach or its content (Kimball & Helm, 1971). Other proposals replaced the W_{B_i} by the expected maximum stomach weight for a given body size $\left(W_{S_{\exp i}}\right)$. The $W_{S_{\exp i}}$ is obtained from a regression between the maximum stomach weight observed in the species j (or the maximum stomach volume) and the fish body sizes (Wallace, 1976; Knight & Margraf, 1982; Herbold, 1986).

Synonymies include matches among terms such as *coefficient*, *gut*, *fullness*, *index*, *relative*, *repletion* and *stomach* (Hureau, 1970; Albertine-Berhaut, 1973; De Silva, 1973; Claridge & Gardner, 1977; Lobel & Ogden, 1981; Villiers, 1982; Waters *et al*., 2004).

3. Single indices

3.1. *Frequency of occurrence*

The *frequency of occurrence* $\left(\%O_{fj}\right)$ expresses a percentage between the total number of stomachs belonging to the species *j* in which the food category f occurred $\left(Sf_{fj}\right)$ and the total number of stomachs with food assessed in that species $\left(Sf_j\right)$:

$$\%O_{fj} = \left(\frac{Sf_{fj}}{Sf_j}\right) \cdot 100$$

Eq5

Synonyms combine terms regarding to *occurrence* and *frequency* with *composition*, *index*, *method*, *number*, *percent*, *percentage*, *relative* and *total* (Oosten & Deason, 1938; Hynes, 1950; Luther, 1962; Prakash, 1962; Manooch III, 1977).

The replacement of the denominator Sf_j by the sum of the total number of occurrences $\left(\sum Sf_{fj}\right)$ represents the *percentage of occurrence* $\left(\%PO_{fj}\right)$ (Hynes, 1950; Natarajan & Jhingran, 1961; Harris, 1985; Rosecchi & Nouaze, 1987; King, 1988a). Differently from the

$\%O_{fj}$, the sum of every $\%PO_{fj}$ value for a given species results in 100%. Although this feature apparently facilitates comparisons with other single indices (Harris, 1985), it creates an artificial total number of stomachs, which are computed more than one time in the analysis. It inserts bias in the diet analysis and overestimate the occurrence of abundant food categories in detriment of those less abundant.

3.2. *Numerical frequency*

The *numerical frequency* $(\%N_{fj})$ represents a percentage between the amount (i.e. counting data) of prey items belonging to the food category f found in the stomach of a given specimen i (N_{fi}) and the total amount of prey items belonging to all food categories found into the stomach of this same specimen $\left(\sum N_{fi}\right)$. This outcome is weighted by the total number of stomachs with food analyzed for the species j (Sf_j):

$$\%N_{fj} = \frac{1}{Sf_j} \cdot \sum_{j=1}^{Sf} \left(\frac{N_{fi}}{\sum_{i=1}^{f} N_{fi}} \right) \cdot 100$$

Eq6

Synonyms combine terms relating to *number*, *numeric* and *numerical* with *abundance*, *composition*, *frequency importance*, *index*, *mean*, *method*, *percent*, *percentage*, *prey*, *proportion*, *system* and *total* (Hynes, 1950; Thompson, 1959; Doble & Eggers, 1978; Delbeek & Williams, 1987; Cortés & Gruber, 1990; Somerton, 1991; Muñoz & Ojeda, 1998; Mannini et al., 1999; Chipps & Garvey, 2007; Pethybridge, Daley, & Nichols, 2011).

3.3. *Gravimetric frequency*

The *gravimetric frequency* $\left(\%W_{fj}\right)$ represents a percentage between the weight of the food category f consumed by a given specimen i $\left(W_{fi}\right)$ and the total weight of all food categories consumed by this same specimen $\left(\sum W_{fi}\right)$. This outcome is weighted by the total number of analyzed stomachs with food of the species j $\left(Sf_j\right)$:

$$\%W_{fj} = \frac{1}{Sf_j} \cdot \sum_{j=1}^{Sf} \left(\frac{W_{fi}}{\sum_{i=1}^{f} W_{fi}} \right) \cdot 100$$

Eq7

Synonyms combine terms such as *weight* (*dry* or *wet*) and *mass* associated with *abundance*, *composition*, *contribution*, *frequency*, *importance*, *index*, *mean*, *method*, *percent*, *percentage*, *prey*, *proportion*, *relative* and *total* (Hynes, 1950; Doble & Eggers, 1978; Matallanas, 1982; Cortés & Gruber, 1990; Du Buit, 1991; Ojeda & Deaborn, 1991; Somerton, 1991; Muñoz & Ojeda, 1998; Mannini *et al*., 1999; Santos & Borges, 2001; Chipps & Garvey, 2007; Pethybridge, Daley, & Nichols, 2011).

3.4. *Volumetric frequency*

The *volumetric frequency* $\left(\%V_{fj}\right)$ represents a percentage between the volume of the food category f consumed by a given specimen i $\left(V_{fi}\right)$ and the total volume of all food categories consumed by this same specimen $\left(\sum V_{fi}\right)$. This outcome is weighted by the total number of stomachs with food analyzed for the species j $\left(Sf_j\right)$:

$$\%V_{fj} = \frac{1}{Sf_j} \cdot \sum_{j=1}^{Sf} \left(\frac{V_{fi}}{\sum_{i=1}^{f} V_{fi}} \right) \cdot 100$$

Eq8

Synonyms combine terms related to *volume* and *volumetric* with *abundance*, *analysis*, *composition*, *contribution*, *dominance*, *frequency*, *importance*, *index*, *mean*, *method*, *percent*, *percentage*, *proportion*, *relative*, *system* and *total* (Tester, 1932; Oosten & Deason, 1938; Hynes, 1950; Powles, 1958; Thompson, 1959; Prakash, 1962; Palmisano and Helm, 1971; Manooch III, 1977; Moor, Wilkinson, & Herbst, 1986; Delbeek & Williams, 1987; Nwadiaro & Okorie, 1987; Chipps & Garvey, 2007).

3.5. *Frequency of dominance*

The *frequency of dominance* $(\%D_{fj})$ (Southern, 1935) represents a percentage between the total numbers of stomachs of the species j in which the food category f occurred as dominant food $(Sf_{d_{fj}})$ and those in which only one food category dominated $(Sf_{1d_{ij}})$. An important adaptation proposal replaced the $Sf_{1d_{ij}}$ by the total number of stomachs with food analyzed for the species j (Sf_j) (Frost and Went 1940). This modification become this method an assessment of occurrence frequency concerning the preferred food consumed (Hynes, 1950).

$$\%D_{fj} = \left(\frac{S_{d_{fj}}}{Sf_j} \right) \cdot 100$$

Eq9

Nevertheless, the criteria to determine what is dominance is subjective. The dominant food category can be defined as that category that concentrated 50% or higher proportion

(Corbet, 1961) either of the bulk (i.e. volume, Southern (1935)) or weight (Newsome & Gee, 1978; Willoughby & Tweddle, 1978)) or the amount (Blake, 1977) of the total food present in the stomach evaluated. Synonyms to $\%D_{fj}$ include *dominance method* (Hynes, 1950).

3.6. *Points method*

The *points method* $(\%P_{fj})$ (Swynnerton & Worthington, 1940) allocates values (i.e. points) (P_{fi}) for each food category f present in the stomach of the species j. Food categories with both higher abundance and bulk receive highest scores than those less representative and with lower volume. An adaptation proposal (Frost, 1943; Hynes, 1950) represented a milestone for the $\%P_{fj}$. Firstly, each stomach should be pointed according to arbitrary preset values $\left(\sum P_{fi}\right)$ considering their degree of stomach fullness (DSF_i). Afterward, these points should be proportionally distributed among the different food categories f consumed by the specimen i (P_{fi}) considering the proportion and volume occupied by each food category in the stomach. The last step consists in dividing this outcome by the total number of stomachs with food analyzed for the species j (Sf_j):

$$\%P_{fj} = \frac{1}{Sf_j} \cdot \sum_{j=1}^{Sf} \left(\frac{P_{fi}}{\sum_{i=1}^{f} P_{fi}} \right) \cdot 100$$

Eq10

Most of the adaptation proposals to the $\%P_{fj}$ focused on the scale values adopted to pointing either the stomach *per se* or the stomach content bulk. Concerning the stomach *per se*, proposals assigned different score values (usually with different number of categories) considering either the degree of stomach fullness (DSF_i) (Swynnerton & Worthington, 1940;

Rao, 1964) or estimates regarding the maximum potential of stomach repletion, obtained by regression models (Thompson, 1959; Godfriaux, 1969; Allen & Wootton, 1984), or the gastro-somatic relationship (GSR_i) (O'Brien & Fives, 1994). Nonetheless, some proposals assigned a unique score value for all the stomachs, regardless its repletion level (Macer, 1977; Donald, Anderson, & Mayhood, 1980). Regarding the stomach content bulk, proposals assigned score values according either to the total volume of the stomach content (Graham & Jones, 1962; Braga, 1999) or to the specimen body size (Smily, 1955) or the GSR_i (Xie, Cui, & Li, 2001). Other proposals considered either the size (Gysels *et al*. 1997) or the weight (Azuma & Motomura, 1998) of the consumed food items.

Other adaptation proposals focused on the $\%P_{fj}$ calculation. Some proposals build indices that combine the values assigned to the stomachs with those assigned to the food categories (Linfield, 1980; Mitchell, 1984; Brewer & Warburton, 1992) and the specimen body length (Tippets & Moyle, 1978; Harris, 1985). Other proposal replaced the $\sum P_{fi}$ by the Sf_j (Braga, 1999).

Synonyms combine terms regarding to *points* and *volume* with *abundance*, *analysis*, *composition*, *diet*, *fullness*, *index*, *method*, *percentage*, *scheme*, *system* and *total* (Hynes, 1950; Le Roux, 1956; Thompson, 1959; Toor, 1964; Munro, 1967; Sinha & Jones, 1967; Godfriaux, 1969; King, 1988b; Lima-Junior & Gotein, 2001; Shepherd & Clarkson, 2001).

3.7. *Rank method*

The *rank method* $\left(\%R_{fj}\right)$ (Pollard 1973), also named *ranking method* (Cadwallader & Douglas, 1986), ponders the bulk of the food categories f consumed by the species j employing ranking techniques (similar to that used in non-parametric statistical methods). The food categories bulk is measured and organized (i.e. listed) from the bulkiest to the least ones.

The next step consists in allocating values to all food categories corresponding to their ranking positions. Afterwards, each rank position value is subtracted from the total number of food categories consumed by the specimen i. The rank value is expressed as a percentage of the total values allocated. The original proposal (Pollard, 1973) gives more one point to each rank position (Table 1). A modification proposal suppressed this extra point (Jackson, 1976).

Table 1 Methodological steps in the rank method allocation points considering the stomach contents of a given fish specimen

Food items	Volume (ml)	Rank position	k	Rank calculation	Individual rank value (R_{fj})
A	22	1	5	5-1+1 = 5	5 ÷ 15 = 0.33
B	16	2	5	5-2+1 = 4	4 ÷ 15 = 0.27
C	13	3	5	5-3+1 = 3	3 ÷ 15 = 0.20
D	7	4	5	5-4+1 = 2	2 ÷ 15 = 0.13
E	2	5	5	5-5+1 = 1	1 ÷ 15 = 0.07
Total	60		5	15	1,00

To respect the precept of data repetition, $\%R_{fj}$ should be calculated for each fish specimen i and, afterward, weighted by the total number of stomachs with food analyzed for the species j $\left(Sf_j\right)$:

$$\%R_{ij} = \frac{1}{Sf_j} \cdot \sum_{j=1}^{Sf} \left(\frac{R_{fj}}{\sum_{i=1}^{f} R_{fj}} \right) \cdot 100$$

Eq11

3.8. Prey-specific abundance

The *prey-specific abundance* $\left(\%PS_{fj}\right)$ (Amundsen, Gabler, & Staldvik, 1996) could be calculated considering the amount or weight/volume. Assuming a gravimetric (W)

perspective as example, the $\%PS_{W_{fj}}$ represents a percentage between the weight of the food category f consumed by a given specimen i $\left(W_{fi}\right)$ and the total weight of all food categories consumed by this same specimen. While other single indices are weighted by the total number of stomachs with food analyzed for the species j $\left(Sf_j\right)$, the $\%PS_{W_{fj}}$ is weighted only by the number of stomachs of the species j in which only the food category f occurred $\left(Sf_{fj}\right)$:

$$\%PS_{W_{fj}} = \frac{1}{Sf_{fj}} \cdot \sum_{j=1}^{Sf} \left(\frac{W_{fi}}{\sum_{i=1}^{f} W_{fi}} \right) \cdot 100$$

Eq12

4. Composite indices

Several composite indices (previously denominated as *compound indices*, Hyslop, 1980) were developed independently by different researchers for fish trophic assessments. Due to this, some composite indices present the same mathematical expression and distinct names. In the other hand, distinct mathematical expressions received the same name. Moreover, almost all composite indices have been modified from their original formulae. In this section indices' authorship, names and equations were correctly presented and standardized.

4.1. *Index of Preponderance*

The *Index of Preponderance* $\left(IP_{if}\right)$ (Natarajan & Jhingran, 1961) is expressed as percentage by the equation:

$$IP_{fj} = \left(\frac{\%V_{fj} \cdot \%O_{fj}}{\sum(\%V_{fj} \cdot \%O_{fj})} \right) \cdot 100$$

Eq13

Modification proposals replaced the $\%V_{fj}$ either by the $\%P_{fj}$ (Luther 1962) or by the $\%W_{fj}$ (Pitcher 1980) or by the $\%D_{fj}$ (Cardona & Castelló, 1989) or by the $\%N_{fj}$ (Argillier, Barral, & Irz 2012). Other proposals replaced the $\%O_{fj}$ either by the $\%PO_{fj}$ (Natarajan & Jhingran, 1961; Mohan & Sakaran, 1988) or by the caloric value of the food category (Probst *et al*., 1984).

As IP_{fj} has been independently developed several times in different countries (India, Brazil, France, Nigeria and Russia), it received several different names. These names include *feeding index* (Kawakami & Vazzoler, 1980), *modified index of relative importance* (Pitcher, 1980, 1981), *prey importance index* (Probst *et al*., 1984 as a modification proposal derived from the *index of relative importance*, presented below), *index of food dominance* (King, 1990), *index of relative significance* Reshetnikov *et al*., 1993; Popova & Reshetnikov, 2011), *food ponderal index* (King, 1994), *food index* (Hahn, Agostinho, & Goitein, 1997), *alimentary index* (Alvim, Maia-Barbosa, & Alves, 1998), *alimentary importance index* (Salvador-Jr, Salvador, & Santos, 2009) and *dominance index* (Montaña & Winemiller, 2013).

4.2. *Index of Relative Importance*

The *Index of Relative Importance* $\left(IRI_{fj}\right)$ (Pinkas, Oliphant, & Iverson, 1971) is expressed as percentage (according the modification proposal of Simenstad, 1977) by the equation:

$$IRI_{fj} = \left(\frac{\left(\%N_{fj} + \%V_{fj} \right) \cdot \%O_{fj}}{\sum \left(\%N_{fj} + \%V_{fj} \right) \cdot \%O_{fj}} \right) \cdot 100$$

Eq14

Other modification proposals replaced the $\%V_{fj}$ either by the $\%W_{fj}$ (Simenstad & Kinney, 1978) or by the $\%P_{fj}$ (Coetzee, 1986). Alternatively, the $\%O_{fj}$ was replaced by the $\%PO_{fj}$ (Rosecchi & Nouaze, 1987). Drastic proposals eliminated the $\%N_{fj}$ from the equation (Pitcher & Calkins, 1979); other ones included $\%W_{fj}$ in the computation leading to compute energetic assessments twice (Coleman & Mobley, 1984). Other proposal changed the original mathematical functions of sum by multiplication (Muir, Emmett, & McConnell, 1986); it makes IRI_{fj} similar to the *relative importance index* of George & Hadley (1979) (section 4.7). Synonyms include *index of relative abundance* (Pitcher & Calkins, 1979) and *relative importance value* (Coetzee, 1986).

4.3. *Food Quotient*

The *Food Quotient* (*quotient alimentaire*, Hureau 1970) is expressed as percentage (according the modification proposal of Rosecchi & Nouaze, 1987) by the equation:

$$FQ_{fj} = \left(\frac{\%N_{fj} \cdot \%W_{fj}}{\sum \%N_{fj} \cdot \%W_{fj}} \right) \cdot 100$$

Eq15

Modification proposals replaced the $\%W_{fj}$ either by the $\%P_{fj}$ (Lima-Junior & Goitein, 2001) or by the $\%V_{fj}$ (Leclerc *et al*., 2014). Synonyms include *coefficient alimentaire* (Vivien, 1973), *alimentary coefficient* (Harmelin-Vivien & Bouchon, 1976), *main food* (Berg, 1979) *and importance index* (Lima-Junior & Goitein, 2001).

4.4. *Hobson-Chess' Index*

Originally named as *Ranking Index* (Hobson & Chess, 1973), it is expressed as:

$$HC_{fj} = \%V_{fj} \cdot \left(\frac{Sf_{fj}}{S_j} \right)$$

Eq16

Modification proposal replaced the $\%V_{fj}$ by the $\%P_{fj}$ (Christensen, 1978). Synonym include *comparative feeding index* (Christensen, 1978),

4.5. *Food Index*

The *Food Index* (*indice alimentaire*, Lauzanne, 1975) is expressed as:

$$FI_{fj} = \frac{\%V_{fj} \cdot \%O_{fj}}{100}$$

Eq17

Modification proposals replaced the $\%O_{fj}$ by $\%PO_{fj}$ (Rosecchi & Nouaze, 1987). Alternatively, the $\%V_{fj}$ was replaced by the $\%W_{fj}$ (Raymundo-Huizar & Lozano, 2008). Synonyms include *feeding index* (Kraiem, 1996).

4.6. *Kurian' index*

Originally named as *Index of Relative Importance* (Kurian, 1977), it is expressed by the equation:

$$KI_{fj} = \left(\frac{\dfrac{\%V_{fj} \cdot \%O_{fj}}{\%N_{fj}}}{\sum \dfrac{\%V_{fj} \cdot \%O_{fj}}{\%N_{fj}}} \right) \cdot 100$$

Eq18

4.7. *George-Hadley' index*

Originally named as *Relative Importance Index* (George & Hadley, 1979), it is expressed as:

$$GH_{fj} = \left(\frac{\%N_{fj} \cdot \%W_{fj} \cdot \%O_{fj}}{\sum \left(\%N_{fj} \cdot \%W_{fj} \cdot \%O_{fj} \right)} \right) \cdot 100$$

Eq19

Modification proposals replaced the $\%O_{fj}$ by $\%PO_{fj}$ (Rosecchi & Nouaze 1987). Alternatively, the $\%W_{fj}$ was replaced either by the $\%V_{fj}$ (Price, Tonn, & Paszkowski, 1991) or by the $\%P_{fj}$ (Ayoade, Fagade, & Adebisi, 2008). Drastic proposals eliminated some parameters from the original equation, as the $\%W_{fj}$ (Townsend, 1983) or the $\%N_{fj}$ (Price *et al*., 1991) (in the last case, making GH_{fj} similar to IP_{ij} of Natarajan & Jhingran, 1961). Synonym include *index of relative importance* (Williams & Williams, 1980).

4.8. *Granado-García Index*

Originally named as *Index of Food Importance* (Granado-Lorencio & García-Novo, 1986), it is expressed by the equation:

$$GG_{fj} = \frac{\sum \left(\%O_{fj} \cdot k_f \right)}{n_k - 1}$$

Eq20

This index requires the estimate of the $\%O_{fj}$ of the different food categories consumed and the classification of each food category into a scale $\left(k_f \right)$ according to their frequency of occurrence and abundance, where n_k represents the total number of k_f categories established. Originally, Granado-Lorencio & García-Novo (1986) employed a scale with four k_f .

Synonymies include *alimentary importance index* (Vilella, Becker, & Hartz, 2002; Yafe et al., 2002), *index of alimentary importance* (Dufech, Azevedo, & Fialho, 2003) and *feeding importance index* (Nunes & Hartz, 2006).

4.9. *Main Food Item*

The *Main Food Item* (Zander, 1982) is expressed as percentage (according to the modification proposal of Rosecchi & Nouaze, 1987) by the equation:

$$MFI_{fj} = \left(\frac{\sqrt{\%W_{fj} \cdot \left(\frac{\%N_{fj} + \%O_{fj}}{2} \right)}}{\sum \sqrt{\%W_{fj} \cdot \left(\frac{\%N_{fj} + \%O_{fj}}{2} \right)}} \right) \cdot 100$$

Eq21

Modification proposals replaced the $\%O_{fj}$ by the $\%PO_{fj}$ (Rosecchi & Nouaze, 1987). Alternatively, the $\%W_{fj}$ was replaced by the $\%P_{fj}$ (Pasquaud, Girardin, & Élie, 2004).

4.10. *Simple Resultant Index*

The *Simple Resultant Index* (Mohan & Sankaran, 1988) is expressed as:

$$SRI_{fj} = \left(\frac{\sqrt{\%V_{fj}^{\ 2} + \%PO_{fj}^{\ 2}}}{\sum \sqrt{\%V_{fj}^{\ 2} + \%PO_{fj}^{\ 2}}} \right) \cdot 100$$

Eq22

Modification proposals replaced the $\%V_{fj}$ either by the $\%W_{fj}$ (Figueiredo et al., 2005) or by the $\%N_{fj}$ (Ara *et al*., 2009). Alternatively, the $\%PO_{fj}$ was replaced by the $\%O_{fj}$ (Ara *et al*., 2009).

This index can be graphically interpreted against the Cartesian coordinate system. For this end, Mohan & Sankaran (1988) developed the *Weighted Resultant Index* that apply circular statistic principles on the RS_{fj}.

4.11. *King' Index*

Originally named as *Index of Relative Importance* (King, 1988b), it is expressed as:

$$KI_{fj} = \%PO_{fj} + \%P_{fj}$$

Eq23

4.12. *King' Preponderance Index*

Originally named as *Index of Food Preponderance* (King, 1989), it is expressed as:

$$KPI_{fj} = \frac{\%PO_{fj} + \%D_{fj}}{2}$$

Eq24

4.13. *Geometric Index of Importance*

The *Geometric Index of Importance* $\left(GII_{fj}\right)$ (Assis, 1996) represents the arithmetic mean among different single indices used to describe the diet of a given fish species. The $\%DM_{fj}$ represents diet measures (e.g. $\%O_{fj}$, $\%N_{fj}$, $\%W_{fj}$, $\%V_{fj}$) and n_{DM} represents the number of diet measures used in the index

$$GII_{fj} = \frac{\sum\left(DM_{1fj} + DM_{2fj} + ...DM_{nfj}\right)}{n_{DM}}$$

Eq25

4.14. *Modified Food Object Number*

The *Modified Food Object Number* (Udo, 2002b) is expressed as:

$$MFON_{fj} = \%O_{fj} + \%P_{fj} \cdot (\%O_j \cup \%P_j)^{-1}$$

Eq26

4.15. *Prey-Specific Index of Relative Importance*

The *Pre-Specific Index of Relative Importance* $\left(PSIRI_{fj}\right)$ (Brown *et al*., 2012) is expressed by the equation:

$$PSIRI_{fj} = \frac{\%O_{fj} \cdot \left(\%PS_{N_{fj}} + \%PS_{W_{fj}}\right)}{2}$$

Eq27

As in the other indices, the measures of weight can be replaced by volume $\left(\%PS_{V_{fj}}\right)$. When the researcher has neither $\%PS_{N_{fj}}$ nor $\%PS_{W_{fj}}$ nor $\%PS_{V_{fj}}$, the $PSIRI_{fj}$ can be expressed either as $PSIRI_{fj} = \%O_{fj} \cdot \%PS_{W_{fj}}$ or $PSIRI_{ij} = \%O_{fj} \cdot \%PS_{V_{fj}}$ or $PSIRI_{ij} = \%O_{fj} \cdot \%PS_{N_{fj}}$.

5. Modelling of feeding levels, trends and behaviors

5.1. *Quantification of stomach content, filling rate and energy budget*

By considering initially empty stomach $\left(S_0 = 0\right)$, amount of food in a fish stomach at a given time t $\left(S_t\right)$ was predicted by continuous model tending to a steady state under the gradual effect of volume saturation (Elliot & Pearson, 1978), where F is the feeding rate and R is the evacuation (digestion) rate:

$$S_t = \frac{F}{R}\left(1 - e^{-Rt}\right)$$

Eq28

Assuming a constant feeding rate F, the total amount $\left(A_t\right)$ consumed in a time range t can be calculated by (Elliot & Pearson, 1978):

$$A_t = Ft$$

Eq29

The first derivative of this function gives the rate of filling of the stomach that corresponds to the rate of change of hunger:

$$\frac{dS_t}{dt} = Fe^{-Rt}$$

Eq30

By combining (**Eq31**) and (**Eq33**) one obtains:

$$\frac{dS_t}{dt} = F - RS_t$$

Eq31

In other modeling way, this rate was calculated by considering also the body mass $\left(M\right)$ (Esposito *et al.*, 2010), where S_{max} is the maximum capacity of predator' stomach and k_H is the handling rate:

$$\frac{dS_t}{dt} = \min\left[M, \left(S_{\max} - S_t\right)\right]k_H - RS_t$$

Eq32

The S_{max} value can be calculated as an allometric function of the individual body mass (Basset, Fedele, & DeAngelis, 2002), where α is the allometric constant independent of body mass and β is the allometric scaling exponent:

$$F_{\max} = \alpha M^{\beta}$$

Eq33

At the steady state, the amount of food in the stomach reaches equilibrium S_{eq} associated with null rate of filling (Elliot & Pearson, 1978**;** Dill, 1983**)**:

$$\frac{dS_t}{dt} = 0 \Leftrightarrow F = RS_{eq} \Leftrightarrow S_{eq} = \frac{F}{R}$$

Eq34

Analytic expression of S_{eq} can be also obtained directly from (**31**) for $t = +\infty$.

After rearrangement of (**Eq34**) and (**Eq37**), the feeding rate F can be expressed by:

$$F = RS_{eq} = \frac{dS_t}{dt} + RS_t$$

Eq35

More realistic models to estimate feeding rate were developed by considering variable F as a decreasing function of satiation S_t. Decrease of F in relation to S_t can occur by linear, power or exponential way (Dill, 1983), where $F_{\max}$ is the filling rate at maximal fish hunger (i.e. at $S_t = 0$):

$$F = F_{\max} - aS_t \qquad \text{(Linear)} \qquad \textbf{(Eq36)}$$

$$F = F_{\max} - aS_t^{\ b} \qquad \text{(Power)} \qquad \textbf{(Eq37)}$$

$$F = F_{\max} - ae^{S_t b} \qquad \text{(Exponential)} \qquad \textbf{(Eq38)}$$

The linear case is solvable and gives two complex analytic forms of satiation (S_t) and rate of change of hunger (dS_t / dt):

$$S_t = \frac{F_{\max}\left(1 - e^{-Rt}\right)}{R + a\left(1 - e^{-Rt}\right)}$$

(Eq39)

And

$$\frac{dS_t}{dt} = \frac{RF_{\max}}{R + a\left(1 - e^{-Rt}\right)} e^{-Rt} \left[1 - \frac{a\left(1 - e^{-Rt}\right)}{R + a\left(1 - e^{-Rt}\right)}\right]$$

(Eq40)

Identifying decision rules associated with optimal feeding requires evaluation of foraging level and quality. Profitability (PF) concept was initially introduced as the ratio of energy gained (E) per handling time unit (H) (Krebs, 1978), where PF corresponds to energetic efficiency or net energy gain per unit of time:

$$PF = \frac{E}{H}$$

(Eq41)

In a shell capture model, prey (mussel) size-depending PF was formalized taking into account energy content (E), probability of opening (P), handling time for opening (H), time wasted on unopened prey (W), probability of failing to open prey $(1 - P)$ (Meire & Eryvnck, 1986):

$$PF = \frac{E \times P}{H \times P + W\left(1 - P\right)}$$

(Eq42)

5.2. Assessment of food availability

The *total food resources available* (FR) was formalized in individual-based model in relation to both prey abundance and body mass in different observation patches (Esposito *et al*., 2010), where p is the patch index evaluated, n is the total number of patches, A_p is the prey items abundance and M_p is the prey items mass:

$$FR = \sum_{p=1}^{n} A_p M_p$$

Eq43

The heterogeneity of A_p (E_A) and M_p (E_M) associated to inter-patch variation was assessed by *Pielou' evenness index* based on *Shannon diversity index* (Esposito *et al*., 2010), where A is the average prey abundance (mean of all patches), M is the average prey body mass (mean of all patches) and n is the total number of patches:

$$E_A = \frac{-\sum_{p=1}^{n}\left(\frac{A_p}{nA} \cdot \ln \frac{A_p}{nA}\right)}{\ln n}$$

Eq44

And

$$E_M = \frac{-\sum_{p=1}^{n}\left(\frac{M_p}{nM} \cdot \ln \frac{M_p}{nM}\right)}{\ln n}$$

Eq45

5.3. Analysis of feeding modulation factors

Under assumption of abundant food and scarce (limited) time, foragers are more likely energy limited. The total net gain G while foraging for a spent time t_f was expressed in relation to energy expenditure on feeding c and rate of intake b (Ydenberg & Hurd, 1998):

$$G = (b - c)t_f$$

(Eq46)

Higher c and b correspond to higher foraging work and higher return, respectively.

The spent foraging time t_f corresponds to that required to reach the energy limit (E) at rate of intake b, $t_f = E/b$, leading to another analytical expression of total net gain G:

$$G = E\left(1 - \frac{c}{b}\right)$$

(Eq47)

Taking into account resting time t_r (after foraging stops) and metabolic rate r, daily gained energy G_d was formalized by (Houston, 1995):

$$G_d = t_f(b - c) - t_r r$$

(Eq48)

Leading to equivalent expression:

$$G_d = E\left(1 - \frac{c}{b} + \frac{r}{b}\right) - r\left(t_f + t_r\right)$$

(Eq49)

Variation of body mass of predator was modeled by (Esposito *et al*., 2010):

$$\frac{dM}{dt} = \begin{cases} S_t \cdot R \cdot a - C_F & if \quad food \quad is \quad active \\ -C_k & if \quad food \quad is \quad not \quad active \end{cases}$$

(Eq50)

where S_t is the amount of food in the stomach at time t; R is the evacuation (digestion) rate; a is the assimilation efficiency of digested food that becomes available for growth or physiological processes (Begon, Townsend, & Harper, 2008); C_F is the cost of food processing; and C_K is the resting, searching or community energy costs.

Growth rate (g) represents the elementary change in body size (s) per time unit (Houston & McNamara, 1989; Ludwig & Rowe, 1990; McNamara & Houston, 1994): $g = ds / dt$. Growth rate g of bluehead chub (*Nocomis leptocephalus*) was expressed as balance between feeding gains $(k \cdot f)$ and loss $(w \cdot s)$ components (Koojman, 2000; Lika & Nisbet, 2000), where k is the assimilation-conversion efficiency; f is the feeding rate (mass.time^{-1}; mg.d^{-1}); s is the body size (mass); and ω is the mass-specific maintenance rate:

$$g = \frac{ds}{dt} = k.f - \omega.s$$

(Eq51)

These parameters were also used to formalize the difference between current $s(t)$ and initial body size $s(0)$ states:

$$S(t) - S(0) = \left[\frac{k.f}{w} - S(0)\right]\left(1 - e^{-w.t}\right)$$

(Eq52)

General balance of feeding is expressed by the depletion of pellets dR / dt over the course of an experimental trial taking into account that feeding rate is a nonlinear function of foraging effort $(f(\varepsilon))$ and that the fish species consume pellets according to Holling type II functional response (Holling, 1959; Abrams, 1982, 1991; Houston & McNamara, 1989; Werner & Anholt, 1993; Leonardsson & Johansson, 1997; Skalski & Gilliams, 2002):

$$\frac{dR}{dt} = -\left[\frac{a..\varepsilon.R}{1 + a..\varepsilon.R.H}\right]n = -f(\varepsilon)n$$

(Eq53)

where $R(t)$ is the amount of pellets (mg) occurring at time t; ε is the foraging effort $(0 \leq 1)$ (maximum effort is associated to $\varepsilon = 1$); n is the number of individuals fish (population size); H is the handling time (h.mg^{-1}); and a is the capture rate at maximum foraging effort (h^{-1}).

Also, prey mortality was used as negative constraint to predict feeding state of the predator (Abrams, 1982, 1991; Houston & McNamara, 1989; Werner & Anholt, 1993; Leonardsson & Johansson, 1997**;** Skalski & Gilliams, 2002):

$$\frac{dn}{dt} = -\alpha\varepsilon pn = -\mu(\varepsilon)n$$

(Eq54)

where n is the number of prey; p is the number of predators; ε is the foraging effort of the prey; α is the predator capture rate at maximum prey foraging effort ε; and $\mu(\varepsilon)$ is the prey per capita mortality rate supposed to be linear in ε.

5.4. Analysis and optimization of foraging behaviors

Model maximizing rate of energy intake was applied to predict coral fish diet on the basis of ratio between two linear combinations associated to feeding gain and cost (Tricas, 1989):

$$\frac{E}{T} = \frac{\sum_{i=1}^{n} \lambda_i E_i}{1 + \sum_{i=1}^{n} \lambda_i H_i}$$

(Eq55)

where E/T is the rate of energy intake; E is the total energy gain; T is the total foraging time; n is the number of coral species (preys); E_i is the energetic return for coral species i; λ_i is the encounter rate of coral species i; H_i is the handling time of coral species i.

Growth rate maximization model is associated with maximal foraging effort $(\varepsilon = 1)$ regardless of predator presence or absence. It can arise in absence of growth-mortality trade-off. This model can be associated with **Eqs. 47, 51** (Ydenberg & Hurd, 1998). Applied to **Eq. 47**, it consists in determining the most efficient tactic (c) giving maximal gained energy (G).

Mortality risk minimization-based model focuses on the variation of foraging effort under threatening effects of predators or competing intruder species. In bluehead chubs threatened by predation from green sunfish, mortality risk was formalized by **Eq54**. Optimal foraging effort (ε) for mortality risk minimization was determined by (Brown, 1992):

$$\varepsilon = \frac{\varpi \ s}{a(k - \varpi \ sH)R}$$

(**Eq56**)

where ω is the mass-specific maintenance rate (d^{-1}); s is the body size (mg wet mass); k is the assimilation-conversion efficiency; H is the handling time ($h.mg^{-1}$); a is the capture rate at maximum foraging effort (h^{-1}); and R is the amount of pellets.

Apart from filling rate of stomach (dS/dt), (**Eqs 33-35**), food depletion rate (**Eq53**) and mortality rate (**Eq54**), other models were developed taking into account reproductive rate (dV/dt). These models aimed to determine the foraging effort ε maximizing the fitness under the control of age t and/or body size s (Houston & McNamara, 1989, 1999; Ludwig & Rowe, 1990; McNamara & Houston, 1994):

$$\frac{dV^*}{dt} = \max_{\varepsilon}\left(\frac{dV^*}{ds}g(\varepsilon) - \mu(\varepsilon)V^*\right)$$

(Eq57)

where $V*$ is the reproductive value of forager species that behaves optimally over the remaining lifetime (which depends both on body size s and age t, $V*(s,t)$); $g(\varepsilon)$ is the growth rate or change in body size per time; and $\omega(\varepsilon)$ is the mortality rate.

An optimization model was based on linear combination of growth and mortality rates ($g(\varepsilon)$ and $\omega(\varepsilon)$). By dividing the terms of **Eq55** by $V*$, one obtains:

$$\frac{dV^*}{V^* dt} = \max_{\varepsilon}\left(\frac{dV^*}{V^* ds} g(\varepsilon) - \mu(\varepsilon)\right) = \max_{\varepsilon}\left(\theta\ g(\varepsilon) - \mu(\varepsilon)\right)$$

(Eq58)

Where $\theta = \frac{dV^*}{V^* ds}$ is the marginal rate of substitution of mortality rate for growth rate (MRS) (mass^{-1}, e.g. mg^{-1}).

High θ indicates foraging behavior more governed by investment in growth than avoidance in death. Thus, MRS provides a conceptual connection between behavior and life history.

Reproductive rate model (**Eq55**) was separately considered under two enclosed conditions by supposing $(dV*/dt)$ as null (simplified model A) or not (general model B). Model A provided simplification making reproductive value to depend only on body size and not on age or time of year (Werner & Gilliam, 1984). Under this static assumption, the optimal foraging effort ε was conditionally determined as:

$$\varepsilon = \begin{cases} 1 & if \quad R < \sqrt{\dfrac{\omega s}{kH}} \dfrac{1}{a\left(1-\sqrt{\dfrac{\omega s H}{k}}\right)} \\ \sqrt{\dfrac{\omega s}{kH}} \dfrac{1}{a\left(1-\sqrt{\dfrac{\omega s H}{k}}\right)R} & otherwise \end{cases}$$

(Eq59)

where ω is the mass-specific maintenance rate (d^{-1}); s is the body size (mg wet mass); k is the assimilation-conversion efficiency; H is the handling time ($h.mg^{-1}$); a is the capture rate at maximum foraging effort (h^{-1}); and R is the amount of pellets.

Model B provide more generalist assumption that reproductive value depends both on body size- and age, the optimal foraging effort (ε) of bluehead chub in presence of green sunfish (predator) was conditionally determined as (Houston & McNamara, 1989; Ludwig & Rowe, 1990; McNamara & Houston, 1994):

$$\varepsilon = \begin{cases} \dfrac{\omega s}{a(k-\omega s H)R} & if \quad R < \dfrac{\alpha p}{k a \theta} \\ \left(\sqrt{\dfrac{k a \theta R}{\alpha p}} - 1\right)\dfrac{1}{aHR} & if \quad \dfrac{\alpha p}{k a \theta} < R < \dfrac{\alpha p (1 + aHR)^2}{k a \theta} \\ 1 & otherwise \end{cases}$$

(Eq60)

where ω is the mass-specific maintenance rate (d^{-1}); s is the body size (mg wet mass); p is the number of green sunfish predators; ε is the foraging effort of bluehead chub; α is the predator capture rate of green sunfish at maximum bluehead chub foraging effort ε; k is the assimilation-conversion efficiency; H is the handling time ($h.mg^{-1}$); a is the capture rate at maximum foraging effort (h^{-1}); R is the amount of pellets; and θ is the marginal rate of substitution of mortality rate for growth rate (mg^{-1}), (MSR).

6. References

Abrams, P. A. (1982). Functional responses of optimal foragers. *The American Naturalist* **120**, 382–390. https://doi.org/10.1086/283996

Abrams, P. A. (1991). Life history and the relationship between food availability and foraging effort. *Ecology* **72**, 1242–1252.

Albertine-Berhaut, J. (1973). Biologie des stades juveniles de téleostéens mugilidae *Mugil auratus* Risso 1810, *Mugil capito* Cuvier 1829 et *Mugil saliens* Risso 1810. *Aquaculture* **2**, 251–266. https://doi.org/10.1016/0044-8486(73)90158-0

Allen, J. R. M. & Wootton, R. J. (1984). Temporal patterns in diet and rate of food consumption of the three-spined stickleback (*Gasterosteus aculeatus* L.) in Llyn Frongoch, an upland Welsh lake. *Freshwater Biology* **14**, 335–346. https://doi.org/10.1111/j.1365-2427.1984.tb00158.x

Alvim, M. C. C., Maia-Barbosa, P. M. & Alves, C. B. M. (1998). Feeding of *Holoshesthes heterodon* Eigenmann (Teleostei, Cheirodontinae) of the Cajuru Reservoir (Minas Gerais, Brazil), in relation to the vegetal biomass on its depletion zone. *Revista Brasileira de Zoologia* **15**, 995–1002.

Amundsen, P. A., Gabler, H. M. & Staldvik, F. J. (1996). A new approach to graphical analysis of feeding strategy from stomach contents data-modification of the Costello (1990) method. *Journal of Fish Biology* **48**, 607–614. https://doi.org/10.1111/j.1095-8649.1996.tb01455.x

Ara, R., Arshad, A., Amrullah, N., Amin, S. M. N., Daud, S. K., Azwady, A. A. N. & Mazlan, A. G. (2009). Feeding habits and temporal variation of diet composition of fish larvae (Osteichthyes: Sparidae) in the Sungai Pulai seagrass Bed, Johore, Peninsular Malaysia. *Journal of Biological Sciences* **9**, 445–451. https://doi.org/10.3923/jbs.2009.445.451

Argillier, C., Barral, M., & Irz, P. (2012). Growth and diet of the pikeperch *Sander lucioperca* (L.) in two French reservoirs. *Archives of Polish Fisheries* **20**, 191–200. https://doi.org/10.2478/v10086-012-0024-0

Assis, C. A. (1996). A generalised index for stomach contents analysis in fish. *Scientia Marina* **60**, 385–389.

Ayoade, A., Fagade, S. & Adebisi, A. (2008). Diet and dietary habits of the fish *Schilbe mystus* (Siluriformes: Schilbeidae) in two artificial lakes in southwestern Nigeria. *Revista de Biología Tropical* **56**, 1847–1855.

Azuma, M. & Motomura, Y. (1998). Feeding habits of largemouth bass in a non-native environment: the case of a small lake with bluegill in Japan. *Environmental Biology of Fishes* **52**, 379–389. https://doi.org/10.1023/A:100747610

Barla, M. J., Vera, M. S. & O 'Brien, E. D. (2003). Relative abundance and autecology of three piscivorous fishes in lakes of the upper basin of Salado River (Buenos Aires Province, Argentina). *Ecología Austral* **13**, 205–214.

Basset, A., Fedele, M. & DeAngelis, D. L. (2002). Optimal exploitation of spatially distributed trophic resources and population stability. *Ecological Modelling* **151**, 245–260. https://doi.org/10.1016/S0304-3800(01)00490-2

Begon, M., Townsend, C. R. & Harper, J. L. (2008). *Ecology: from individuals to ecosystems*, 4th edn. Blackwell Publishing, Malden.

Berg, J. (1979). Discussion of methods of investigating the food of fishes, with reference to a preliminary study of the prey of *Gobiusculus flavescens* (Gobiidae). *Marine Biology* **50**, 263–273. https://doi.org/10.1007/BF00394208

Blake, B. F. (1977). Food and feeding of the mormyrid fishes of Lake Kainji, Nigeria, with special reference to seasonal variation and interspecific differences. *Journal of Fish Biology* **11**, 315–328. https://doi.org/10.1111/j.1095-8649.1977.tb04125.x

Blegvad, H. (1917). On the food of fish in Danish waters within the Skaw. *Report of the Danish Biological Station* 24, 17-72.

Braga, F. M. D. S. (1999). O grau de preferência alimentar: um método qualitativo e quantitativo para o estudo do conteúdo estomacal de peixes. *Acta Scientiarum. Biological Sciences* 21, 291-295. https://doi.org/10.4025/actascibiolsci.v21i0.4445

Brewer, D. T. & Warburton, K. (1992). Selection of prey from a seagrass/mangrove environment by golden lined whiting, *Sillago analis* (Whitley). *Journal of Fish Biology* 40, 257–271. https://doi.org/10.1111/j.1095-8649.1992.tb02571.x

Brown, J. S. (1992). Patch use under predation risk. I. Models and predictions. *Annales Zoologici Fennici* **29**, 301–309.

Brown, S. C., Bizzarro, J. J., Cailliet, G. M. & Ebert, D. A. (2012). Breaking with tradition: redefining measures for diet description with a case study of the Aleutian skate *Bathyraja aleutica* (Gilbert 1896). *Environmental Biology of Fishes* 95, 3–20. https://doi.org/10.1007/s10641-011-9959-z

Buckley, T. W. & Miller, B. S. (1994). Feeding habits of yellowfin tuna associated with fish aggregation devices in American Samoa. *Bulletin of Marine Science* **55**, 445–459.

Cadwallader, P. L. & Douglas, J. (1986). Changing food habits of Macquarie perch, *Macquaria australasica* Cuvier (Pisces: Percichthyidae), during the initial filling phase of Lake Dartmouth, Victoria. *Australian Journal of Marine and Freshwater Research* **37**, 647–647. https://doi.org/10.1071/MF9860647

Cardona, L. & Castelló, F. (1989). Alimentación de los juveniles de *Liza aurata* (Risso) en la Albufera des Grau (Isla de Menorca, Baleares). *Bolletí de la Societat d'Història Natural de les Balears* **33**, 159–168.

Chipps, S. R. & Garvey, J. E. (2007). Assessment of diets and feeding patterns. In *Analysis and interpretation of freshwater fisheries data* (eds C. S. Guy and M. L. Brown), pp. 473-514. American Fisheries Society, Bethesda.

Christensen, M. S. (1978). Trophic relationships in juveniles of three species of sparid fishes in the South African marine littoral. *Fishery Bulletin* **76**, 389–401.

Claridge, P. N. & Gardner, D. C. (1977). The biology of the northern rockling, *Ciliata septentrionalis*, in the Severn Estuary and Bristol Channel. *Journal of the Marine Biological Association of the United Kingdom* **57**, 839–839. https://doi.org/10.1017/S0025315400025194

Coetzee, P. S. (1986). Diet composition and breeding cycle of blacktail, *Diplodus sargus capensis* (Pisces: Sparidae), caught off St Croix Island, Algoa Bay, South Africa. *South African Journal of Zoology* **21**, 237–243. https://doi.org/10.1080/02541858.1986.11447989

Coleman, N. & Mobley, M. (1984). Diets of commercially exploited fish from Bass Strait and adjacent Victorian Waters, South-eastern Australia. *Marine and Freshwater Research* **35**, 549–549. https://doi.org/10.1071/MF9840549

Corbet, P. S. (1961). The food of non-cichlid fishes in the Lake Victoria Basin, with remarks on their evolution and adaptation to lacustrine conditions. *Proceedings of the Zoological Society of London* **136**, 1–101. https://doi.org/10.1111/j.1469-7998.1961.tb06080.x

Cortés, E. & Gruber, S. H. (1990). Diet, Feeding Habits and Estimates of Daily Ration of Young Lemon Sharks, *Negaprion brevirostris* (Poey). *Copeia* **1990**, 204–218. https://doi.org/10.2307/1445836

De Silva, S. S. (1973). Food and feeding habits of the herring *Clupea harengus* and the sprat *C. sprattus* in inshore waters of the west coast of Scotland. *Marine Biology* **20**, 282–290. https://doi.org/10.1007/BF00354272

Delbeek, J. C. & Williams, D. D. (1987). Food resource partitioning between sympatric populations of brackishwater sticklebacks. *Journal of Animal Ecology* **56**, 949–967. https://doi.org/10.2307/4959

Dill, L. M. (1983). Adaptive flexibility in the foraging behavior of fishes. *Canadian Journal of Fisheries and Aquatic Sciences* **40**, 398–408. https://doi.org/10.1139/f83-058

Doble, B. D. & Eggers, D. M. (1978). Diel feeding chronology, rate of gastric evacuation, daily ration, and prey selectivity in Lake Washington juvenile sockeye salmon (*Oncorhynchus nerka*). *Transactions of the American Fisheries Society* **107**, 36–45. https://doi.org/10.1577/1548-8659(1978)107<36:DFCROG>2.0.CO;2

Donald, D. B., Anderson, R. S. & Mayhood, D. W. (1980). Correlations between brook trout growth and environmental, variables for mountain lakes in Alberta. *Transactions of the American Fisheries Society* **109**, 603–610. https://doi.org/10.1577/1548-8659(1980)109<603:CBBTGA>2.0.CO;2

Du Buit, M. H. (1991). Food and feeding of saithe (*Pollachius virens* L.) off Scotland. *Fisheries Research* **12**, 307–323. https://doi.org/10.1016/0165-7836(91)90015-8

Dufech, A. P. S., Azevedo, M. A. & Fialho, C. B. (2003). Comparative dietary analysis of two populations of *Mimagoniates rheocharis* (Characidae: Glandulocaudinae) from two streams of Southern Brazil. *Neotropical Ichthyology* **1**, 67–74. https://doi.org/10.1590/S1679-62252003000100008

Duhamel, G. & Hureau, J. C. (1985). The role of zooplankton in the diets of certain Sub-Antarctic marine fish. In *Antarctic nutrient cycles and food webs* (eds W. R. Siegfried, P. R. Candy and R. M. Laws), pp. 421-429 Springer-Verlag, Berlin.

Duncan, F. M. (1912). The Marine Biological Association, and some account of the work it has accomplished. *Journal of the Royal Society of Arts* **60**, 486–494.

El-Ganainy, A. A. (2010). Some biological aspects of the filefish *Setphanolepis diaspros* (Family: Monacanthidae) from the Gulf of Suez, Egypt. *Researcher* **2**, 75–78.

Elliott, J. M. & Persson, L. (1978). The estimation of daily rates of food consumption for fish. *Journal of Animal Ecology* **47**, 977–991. https://doi.org/10.2307/3682

Esposito, S., Incerti, G., Giannino, F., Russo, D. & Mazzoleni, S. (2010). Integrated modelling of foraging behaviour, energy budget and memory properties. *Ecological Modelling* **221**, 1283–1291. https://doi.org/10.1016/j.ecolmodel.2010.01.009

Figueiredo, M., Morato, T., Barreiros, J. P., Afonso, P. & Santos, R. S. (2005). Feeding ecology of the white seabream, *Diplodus sargus*, and the ballan wrasse, *Labrus bergylta*, in the Azores. *Fisheries Research* **75**, 107–119. https://doi.org/10.1016/j.fishres.2005.04.013

Frost, W. E. & Went, A. E. J. (1940). River Liffey survey III. The growth and food of young salmon. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical* **46**, 53–80.

Frost, W. E. (1943). The natural history of the minnow, *Phoxinus phoxinus*. *Journal of Animal Ecology* **12**, 139–139. https://doi.org/10.2307/1374

George, E. L. & Hadley, W. F. (1979). Food and habitat partitioning between Rock bass (*Ambloplites rupestris*) and smallmouth bass (*Micropterus dolomieui*) young of the year. *Transactions of the American Fisheries Society* **108**, 253–261. https://doi.org/10.1577/1548-8659(1979)108<253:FAHPBR>2.0.CO;2

Godfriaux, B. L. (1969). Food of predatory demersal fish in Hauraki Gulf. *New Zealand Journal of Marine and Freshwater Research* **3**, 518–544. https://doi.org/10.1080/00288330.1969.9515315

Graham, T. R. & Jones, J. W. (1962). The biology of Llyn Tegid trout 1960. *Proceedings of the Zoological Society of London* **139**, 657–683. https://doi.org/10.1111/j.1469-7998.1962.tb01598.x

Granado-Lorencio, C. & Garcia-Novo, F. (1986). Feeding habits of the fish community in a eutrophic reservoir in spain. *Ekologia Polska* **34**, 95–110.

Gysels, E., Bisthoven, L. J., De Vos, L. & Ollevier, F. (1997). Food and habitat of four *Xenotilapia* species (Teleostei, Cichlidae) in a sandy bay of northern Lake Tanganyika (Burundi). *Journal of Fish Biology* **50**, 254–266. https://doi.org/10.1006/jfbi.1996.0310

Hahn, N.S., Agostinho, A. A. & Goitein, R. (1997). Feeding ecology os curvina *Plagioscion squamosissimus* (Hechel, 1840) (Osteichthyes, Perciformes) in the Itaipu reservoir and Porto Rico Floodplain. *Acta Limnologica Brasiliensia* **9**, 11–22.

Hambrick, P. S. & Hibbs, R. G. (1977). Feeding chronology and food habits of the blacktail shiner, *Notropis venustus* (Cyprinidae), in Bayou Sara, Louisiana. *The Southwestern Naturalist* **22**, 511–511. https://doi.org/10.2307/3670152

Harmelin-Vivien, M. L. & Bouchon, C. (1976). Feeding behavior of some carnivorous fishes (Serranidae and Scorpaenidae) from Tuléar (Madagascar). *Marine Biology* **37**, 329–340. https://doi.org/10.1007/BF00387488

Harris, J. H. (1985). Diet of the Australian bass, *Macquaria novemaculeata* (Perciformes: Percichthyidae), in the Sydney Basin. *Marine and Freshwater Research* **36**, 219–219. https://doi.org/10.1071/MF9850219

Herbold, B. (1986). An alternative to the fullnex index. In *Contemporary studies on fish feeding: the proceedings of GUTSHOP '84* (eds C. A. Simenstad and G. M. Cailliet), pp. 315-320. Springer Sciences+Business Media Dordrecht, Dordrecht.

Hobson, E. S. & Chess, J, R, (1973), Feeding oriented movements of the atherinid fish *Pranesus pinquis* at Majuro Atoll, Marshall Islands. *Fishery Bulletin* **71**, 777–786.

Houstonm A, I, & McNamara, J. M. (1989). The value of food: effects of open and closed economics. *Animal Behavior* **37**, 546–562. https://doi.org/ 10.1016/0003-3472(89)90034-1

Houston, A. I. (1995). Energetic constraints and foraging efficiency. *Behavioral Ecology* **6**, 393–396. https://doi.org/10.1093/beheco/6.4.393

Holling, C. S. (1959). Some characteristics of simple types of predation and parasitism. *Canadian Entomologist* **91**, 385–398. https://doi.org/10.4039/Ent91385-7

Hureau, J. C. (1970). Biologie comparée de quelques Poissons antarctiques (Nototheniidae). *Bulletin de l'Institut océanographique de Monaco* **68**, 244–244.

Hynes, H. B. N. (1950). The food of fresh-water sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*), with a review of methods used in studies of the food of fishes. *Journal of Animal Ecology* **19**, 36–58. https://doi.org/10.2307/1570

Jackson, P. D. (1976). A note on the food of the Australian grayling, *Prototroctes maraena* Gunther (Galaxioidei: Prototroctidae). *Marine and Freshwater Research* **27**, 525–525. https://doi.org/10.1071/MF9760525

Kawakami, E. & Vazzoler, G. (1980). Método gráfico e estimativa de índice alimentar aplicado no estudo da alimentação de peixes. *Boletim do Instituto Oceanográfico de São Paulo* **29**, 205–207.

Kimball, D. C. & Helm, W. T. (1971). A method of estimating fish stomach capacity. *Transactions of the American Fisheries Society* **100**, 572–575. https://doi.org/10.1577/1548-8659(1971)100<572:AMOEFS>2.0.CO;2

King, R. P. (1988a). Observations on *Liza grandisquamis* pisces mugilidae in Bonny River Nigeria. *Revue d'Hydrobiologie Tropicale* **21**, 63–70.

King, R. P. (1988b). New observations on the trophic ecology of *Liza grandisquamis* (Valenciennes, 1836) (Pisces: Mugilidae) in the Bonny River, Niger Delta, Nigeria. *Cybium* **12**, 23–36.

King, R. P. (1989). Distribution abundance size and feeding habits of *Brienomyrus brachyistius* (Gill 1862) (Teleostei: Mormyridae) in a Nigerian rainforest stream. *Cybium* **13**, 25–36.

King, R. P. (1994). Seasonal dynamics in the trophic status of *Papyrocranus afer* (Günther, 1868) (Notopteridae) in a Nigerian rainforest stream. *Revue d'Hydrobiologie Tropicale* **27**, 143–155.

Knight, R. L. & Margraf, F. J. (1982). Estimating stomach fullness in fishes. *North American Journal of Fisheries Management* **2**, 413–414. https://doi.org/10.1577/1548-8659(1982)2<413:ESFIF>2.0.CO;2

Koojman, S. A. L. M. (2000). *Dynamic energy and mass budgets in biological systems*. Cambridge University Press, New York.

Kraiem, M. M. (1996). The Diet of *Barnus callensis* (Cyprinidae) in Northern Tunisia. *Cybium* **20**, 75–85.

Krebs, J. R. (1978). Optimal foraging: decision rules for predators. In *Behavioral ecology: an evolutionary approach* (eds J. R. Krebs and N. B. Davies), pp. 23-63. Blackwell Scientific Publications, Oxford.

Kurian, A. (1977). Index of relative importance - a new method for assessing the food habits of fishes. *Indian Journal of Fisheries* **24**, 217–219.

Lauzanne, L. (1975). Régimes alimentaires d'*Hydrocyon forskalii* (Pisces, Characidae) dans le lac Tchad et ses tributaires. *Cahiers - ORSTOM. Série Hydrobiologie* **9**, 105–121.

Le Roux, P. J. (1956). Feeding habits of the young of four species of Tilapia. *South African Journal of Science* **53**, 33–37.

Leclerc, J.-C., Riera, P., Noël, L. M. L. J., Leroux, C. & Andersen, A. C. (2014). Trophic ecology of *Pomatoschistus microps* within an intertidal bay (Roscoff, France), investigated through gut content and stable isotope analyses. *Marine Ecology* **35**, 261–270. https://doi.org/10.1111/maec.12071

Leonardsson, K. & Johansson, F. (1997). Optimum search speed and activity: a dynamic game in a three-link trophic system. *Journal of Evolutionary Biology* **10**, 703–729. https://doi.org/10.1046/j.1420-9101.1997.10050703.x

Lika, K. & Nisbet, R. M. (2000). A dynamic energy budget model based on partitioning of net production. *Journal of Mathematical Biology* **41**, 361–386. https://doi.org/10.1007/s002850000049

Lima-Junior, S. E. & Goitein, R. (2001). A new method for the analysis of fish stomach contents. *Acta Scientiarum Maringá* **23**, 421–424. https://doi.org/10.4025/actascibiolsci.v23i0.2723

Linfield, R. S. J. (1980). Ecological changes in a lake fishery and their effects on a stunted roach *Rutilus rutilus* population. *Journal of Fish Biology* **16**, 123–144. https://doi.org/10.1111/j.1095-8649.1980.tb03692.x

Lobel, P. S. & Ogden, J. C. (1981). Foraging by the herbivorous parrotfish *Sparisoma radians*. *Marine Biology* **64**, 173–183. https://doi.org/10.1007/BF00397106

Longley, W. (1917). Studies upon the biological significance of animal coloration. I. The colors and color changes of West Indian reef-fishes. *Journal of Experimental Zoology* **23**, 533–601. https://doi.org/10.1002/jez.1400230305.

Luther, G. (1962). The food habits of *Liza macrolepis* (Smith) and *Mugil cephalus* Linnaeus (Mugilidae). *Indian Journal of Fisheries* **9**, 604–626.

Ludwig, D. & Rowe, L. (1990). Life-history strategies for energy gain and predator avoidance under time constraints. *The American Naturalist* **135**, 686–707. https://doi.org/10.1086/285069

Macer, C. T. (1977). Some aspects of the biology of the horse mackerel [*Trachurus trachurus* (L.)] in waters around Britain. *Journal of Fish Biology* **10**, 51–62. https://doi.org/10.1111/j.1095-8649.1977.tb04041.x

Mannini, P., Katonda, I., Kissaka, B. & Verburg, P. (1999). Feeding ecology of *Lates stappersii* in Lake Tanganyika. In *From limnology to fisheries: Lake Tanganyika and other large lakes* (eds O. V. Lindqvist, H. Molsa, K. Salonen and J. Sarvala), pp. 131–139. Springer-Science+Business Media, Dordrecht.

Manooch III, C. S. (1977). Foods of the red porgy, *Pagrus linnaeus* (Pisces: Sparidae), from North Carolina and South Carolina. *Bulletin of Marine Science* **27**, 776–787.

Matallanas, J. (1982). Feeding habits of *Scymnorhinus licha* in Catalan waters. *Journal of Fish Biology* **20**, 155–163. https://doi.org/10.1111/j.1095-8649.1982.tb03916.x

McNamara, J. M. & Houston, A. I. (1994). The effect of a change in foraging options on intake rate and predation rate. *The American Naturalist* **144**, 978–1000. https://doi.org/10.1086/285721

Meire, P. M. & Ervynck, A. (1986). Are oystercatchers (*Haematopus ostralegus*) selecting the most profitable mussels (*Mytilus edulis*)? *Animal Behavior* **34**, 1427–1435. https://doi.org/10.1016/S0003-3472(86)80213-5

Mironova, N. V. (1961). Biology of the Barents Sea saithe, *Pollachius virens* (L.). *Internationale Revue der Gesamten Hydrobiologie und Hydrographie* **46**, 447–459. https://doi.org/10.1002/iroh.19610460311

Mitchell, S. J. (1984). Feeding of ling *Genypterus blacodes* (Bloch & Schneider) from 4 New Zealand offshore fishing grounds. *New Zealand Journal of Marine and Freshwater Research* **18**, 265–274. https://doi.org/10.1080/00288330.1984.9516048

Mohan, M. V. & Sankaran, T. M. (1988). Two new indices for stomach content analysis of fishes. *Journal of Fish Biology* **33**, 289–292. https://doi.org/10.1111/j.1095-8649.1988.tb05471.x

Montaña, C. G. & Winemiller, K. O. (2013). Evolutionary convergence in Neotropical cichlids and Nearctic centrarchids: evidence from morphology, diet, and stable isotope analysis. *Biological Journal of the Linnean Society* **109**, 146–164. https://doi.org/10.1111/bij.12021

Moor, F. C., Wilkinson, R. C. & Herbst, H. M. (1986). Food and feeding habits of *Oreochromis mossambicus* (Peters) in hypertrophic Hartbeespoort Dam, South Africa. *South African Journal of Zoology* **21**, 170–176. https://doi.org/10.1080/02541858.1986.11447976

Muir, W. D., Emmett, R. L. & McConnell, R. J. (1986). *Diet of juvenile and subadult white sturgeon in the lower Columbia River and its estuary*. National Oceanic and Atmospheric Administration pp 1–17. California Fish and Game, Washington.

Muñoz, A. A. & Ojeda, F. P. (1998). Guild structure of carnivorous intertidal fishes of the Chilean coast: implications of ontogenetic dietary shifts. *Oecologia* **114**, 563–573. https://doi.org/10.1007/s004420050481

Munro, J. L. (1967). The food of a community of East African freshwater fishes. *Journal of Zoology London* **151**, 389–415. https://doi.org/10.1111/j.1469-7998.1967.tb02122.x

Natarajan, A. V. & Jhingrand, A. G. (1961). Index of preponderance - a method of grading the food elements in the stomach analysis of fishes. *Indian Journal of Fisheries* **8**, 54–59.

Newsome, G. E. & Gee, J. H. (1978). Preference and selection of prey by creek chub (*Semotilus atromaculatus*) inhabiting the Mink River, Manitoba. *Canadian Journal of Zoology* **56**, 2486–2497. https://doi.org/10.1139/z78-337

Nunes, D. M. & Hartz, S. M. (2006). Feeding dynamics and ecomorphology of *Oligosarcus jenynsii* (Gunther, 1864) and *Oligosarcus robustus* (Menezes, 1969) in the Lagoa Fortaleza, southern Brazil. *Brazilian Journal of Biology* **66**, 121–132. https://doi.org/10.1590/S1519-69842006000100016

Nwadiaro, C. & Okorie, P. (1987). Feeding habit of the African bagrid *Chrysichthys filamentous* in a Niggerian Lake. *Japanese Journal of Ichthyology* **33**, 376–383. https://doi.org/10.1007/BF02904098

O'Brien, K. & Fives, J. M. (1994). The feeding relationships of a small demersal fish community in the western Irish Sea. *Irish Fisheries Investigations. Series B (Marine)* **41**, 1–12.

Ojeda, F. P. & Dearborn, J. H. (1991). Feeding ecology of benthic mobile predators: experimental analyses of their influence in rocky subtidal communities of the Gulf of Maine. *Journal of Experimental Marine Biology and Ecology* **149**, 13–44. https://doi.org/10.1016/0022-0981(91)90114-C

Oosten, J. V. & Deason, H. J. (1938). Remarks on populations of the shad (*Alosa sapidissima*) along the Atlantic coast region. *Transactions of the American Fisheries Society* **67**, 155–177. https://doi.org/10.1577/1548-8659(1937)67[155:TFOTLT]2.0.CO;2

Palmisano, J. J. & Helm, W. T. (1971). Freshwater food habits of "*Salvelinus malma*" (Walbaum) on Amchitka Island, Alaska. *BioScience* **21**, 637–641. https://doi.org/10.2307/1295738

Pasquaud, S., Girardin, M. & Élie, P. (2004). Diet of gobies of the genus *Pomatoschistus* (*P. microps* and *P. minutus*), in the Gironde estuary (France). *Cybium* **28**, 99–106.

Pearson, M. & Gage, J. D. (1984). Diets of some deep-sea brittle stars in the Rockall Trough. *Marine Biology* **82**, 247–258. https://doi.org/10.1007/BF00392406

Pelicice, F. M. & Agostinho, A. A. (2006). Feeding ecology of fishes associated with *Egeria* spp. patches in a tropical reservoir, Brazil. *Ecology of Freshwater Fish* **15**, 10–19. https://doi.org/10.1111/j.1600-0633.2005.00121.x

Pethybridge, H., Daley, R. K. & Nichols, P. D. (2011). Diet of demersal sharks and chimaeras inferred by fatty acid profiles and stomach content analysis. *Journal of Experimental Marine Biology and Ecology* **409**, 290–299. https://doi.org/10.1016/j.jembe.2011.09.009

Pinkas, L., Oliphant, M. S. & Iverson, I. L. K. (1971). Food habits of albacore, bluefin tuna, and bonito in California waters. California Department of Fish and Game. *Fish Bulletin* **152**, 1–105.

Pitcher, K. W. & Calkins, D. G. (1979). *Biology of the Harbor Seal, Phoca vitulina richardsi, in the Gulf of Alaska*. Alaska Department of Fish and Game, Alaska.

Pitcher, K. W. (1980). Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. *Fishery Bulletin* **78**, 544–549.

Pitcher, K. W. (1981). Prey of the Steller sea lion, *Eumetopias jubatus,* in the Gulf of Alaska. *Fishery Bulletin* **9**, 467–472.

Pollard, D. A. (1973). The biology of a landlocked form of the normally catadromous salmoniform fish *Galaxias maculatus* (Jenyns). V. Composition of the diet. *Marine and Freshwater Research* **24**, 281–295. https://doi.org/10.1071/MF9730281

Popova, O. A. & Reshetnikov, Y. S. (2011). On complex indices in investigation of fish feeding. *Journal of Ichthyology* **51**, 686–691. https://doi.org/10.1134/S0032945211050171

Powles, P. M. (1958). Studies of reproduction and feeding of Atlantic cod (*Gadus callarias* L.) in the Southwestern Gulf of St. Lawrence. *Journal of the Fisheries Research Board of Canada* **15**, 1383–1402. https://doi.org/10.1139/f58-076

Prakash, A. (1962). Seasonal changes in feeding of coho and chinook (spring) salmon in Southern British Columbia waters. *Journal of the Fisheries Research Board of Canada* **19**, 851–866. https://doi.org/10.1139/f62-053

Price, C. J., Tonn, W. M. & Paszkowski, C. A. (1991). Intraspecific patterns of resource use by fathead minnows in a small boreal lake. *Canadian Journal of Zoology* **69**, 2109–2115. https://doi.org/10.1139/z91-294

Probst, W. E., Rabeni, C. F., Covington, W. G. & Marteney, R. E. (1984). Resource use by stream-dwelling Rock bass and smallmouth bass. *Transactions of the American Fisheries Society* **113**, 283–294. https://doi.org/10.1577/1548-8659(1984)113<283:RUBSRB>2.0.CO;2

Rao, K. S. (1964). Food and feeding habits of fishes from trawl catches in the Bay of Bengal with observations on diurnal variation in the nature of the feed. *Indian Journal of Fisheries*e **11**, 277–314.

Raymundo-Huizar, A. R. & Lozano, M. S. (2008). Hábitos alimentarios del pez triglido *Prionotus ruscarius* (Gilbert & Starks, 1904) durante 1996, en las costas de Jalisco y Colima, México. *Revista de Biología Marina y Oceanografía* **43**, 7–15. https://doi.org/10.4067/S0718-19572008000100002

Reshetnikov, Y. S., Amencio, L. S., Provorova, G. Y. & Trunov, V. L. (1993). Feeding of fish in the Ucayali Basin. *Ekologiya i kultivirovanie anazonskikh ryb (Ecology and Cultivation of Amazonian Fish)* 66–143.

Reyes-Marchant, P., Cravinho, A. & Lair, N. (1992). Food and feeding behaviour of roach (*Rutilus rutilus*, Linné 1758) juveniles in relation to morphological change. *Journal of Applied Ichthyology* **8**, 77–89. https://doi.org/10.1111/j.1439-0426.1992.tb00670.x

Rosecchi, E. & Nouaze, Y. (1987). Comparaison de cinq indices alimentaires utilisés dans l'analyse des contenus stomacaux. *Revue des Travaux de l'Institut des Pêches Maritimes* **49**, 111–123.

Salvador-Jr, L. F., Salvador, G. N. & Santos, G. B. (2009). Morphology of the digestive tract and feeding habits of *Loricaria lentiginosa* Isbrücker, 1979 in a Brazilian reservoir. *Acta Zoologica (Stockholm)* **90**, 101–109. https://doi.org/10.1111/j.1463-6395.2008.00336.x

Santos, E. P. (1978). *Dinâmica de populações aplicada à pesca e piscicultura*. HUCITEC-EDUSP, São Paulo.

Santos, J. & Borges, T. (2001). Trophic relationships in deep-water fish communities off Algarve, Portugal. *Fisheries Research* **51**, 337–341. https://doi.org/10.1016/S0165-7836(01)00257-0

Simenstad, C. A. (1977). ADF&G-OCS Fish Food Habits Analysis. Environmental Assessment of Alaskan Continental Shelf. *Annual Reports of Principal Investigators* **4**, 411–446.

Simenstad, C. A. & Kinney, W. J. (1978). *Trophic relationships of outmigranting chum salmon in Hood Canal, Washington 1977*. Washington State Department of Fisheries, Washington.

Sinha, V. R. P. & Jones, J. W. (1967). On the food of the freshwater eels and their feeding relationship with the salmonids. *Journal of Zoology London* **153**, 119–137. https://doi.org/10.1111/j.1469-7998.1967.tb05034.x

Shepherd, S. A. & Clarkson, P. S. (2001). Diet, feeding behaviour, activity and predation of the temperate blue-throated wrasse, *Notolabrus tetricus*. *Marine and Freshwater Research* **52**, 311–322. https://doi.org/10.1071/MF99040

Skalski, G. T. & Gilliams, J. F. (2002). Feeding under predation hazard: testing models of adaptive behavior with stream fish. *The American Naturalist* **160**, 158–172. https://doi.org/10.1086/341012

Smyly, W. J. P. (1955). On the biology of the stone-loach *Nemacheilus barbatula* (L.). *Journal of Animal Ecology* **24**, 167–186. https://doi.org/10.2307/1884

Somerton, D. A. (1991). Detecting differences in fish diets. *Fishery Bulletin* **89**, 167–169.

Southern, R. (1935). Reports from the Limnological Laboratory. III. The food and growth of brown trout from Lough Derg and the River Shannon. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical* **42**, 87–172.

Swynnerton, G. H. & Worthington, E. B. (1940). Note on the food of fish in Haweswater (Westmorland). *Journal of Animal Ecology* **9**, 183–187. https://doi.org/10.2307/1454

Tester, A. L. (1932). Food of the small-mouthed black bass (*Micropterus dolomieu*) in some Ontario waters. *Ontario Fisheries Research Laboratory* **46**, 171–203.

Thomerson, J. E. & Wooldridge, D. P. (1970). Food habits of allotopic and syntopic populations of the topminnows *Fundulus olivaceus* and *Fundulus notatus*. *The American Midland Naturalist* **84**, 573–573. https://doi.org/10.2307/2423875

Thompson, R. B. (1959). Food of the squawfish *Ptychocheilus oregonensis* (Richardson) of the Lower Columbia River. *Fishery Bulletin* **158**, 43–58.

Tippets, W. E. & Moyle, P. B. (1978). Epibenthic feeding by rainbow trout (*Salmo gairdneri*) in the McCloud River, California. *Journal of Animal Ecology* **47**, 549–559. https://doi.org/10.2307/3800

Toor, H. S. (1964). Biology and fishery of the pig-face bream, *Lethrinus lentian* Lacepede I. Food and feeding habits. *Indian Journal of Fisheries* **11**, 559–580.

Townsend, D. W. (1983). The relations between larval fishes and zooplankton in two inshore areas of the Gulf of Maine. *Journal of Plankton Research* **5**, 145–173. https://doi.org/10.1093/plankt/5.2.145

Tricas, T. C. (1989). Prey selection by coral-feeding butterfly fishes: strategies to maximize the profit. In *The butterflyfishes: success on the coral reef* (ed P. J. Motta), pp. 171–185. Springer, Dordrecht. https://doi.org/10.1007/978-94-009-2325-6_13

Udo, M. T. (2002). Trophic attributes of the mudskipper, *Periophthalmus barbarus* (Gobiidae: Oxudercinae) in the mangrove swamps of Imo River Estuary, Nigeria. *Journal of Environmental Sciences (China)* **14**, 508–517.

Vilella, F. S., Becker, F. G. & Hartz, S. M. (2002). Diet of *Astyanax* species (Teleostei, Characidae) in an Atlantic Forest River in Southern Brazil. *Brazilian Archives of Biology and Technology* **45**, 223–232. https://doi.org/10.1590/S1516-89132002000200015

Villiers, L. (1982). The feeding of juvenile goby *Deltentosteus quadrimaculatus* (Pisces, Gobiidae). *Sarsia* **67**, 157–162. https://doi.org/10.1080/00364827.1982.10420542

Vivien, M. L. (1973). Régimes et comportements alimentaires de quelques poissons des récifs coralliens de Tuléar (Madagascar). *La Terre et La Vie* **27**, 551–577.

Wallace, D. C. (1976). Feeding behavior and developmental, seasonal and diel changes in the food of the silverjaw minnow, *Ericymba buccata* Cope. *The American Midland Naturalist* **95**, 361–361. https://doi.org/10.2307/2424400

Waters, D. S., Kwak, T. J., Arnott, J. B. & Pine, W. E. (2004). Evaluation of stomach tubes and gastric lavage for sampling diets from blue catfish and flathead catfish. *North American Journal of Fisheries Management* **24**, 258–261. https://doi.org/10.1577/M02-156

Werner, E. E. & Gilliam, J. F. (1984). The ontogenetic niche and species interactions in size-structured populations. *Annual Review of Ecology and Systematics* **15**, 393–425. https://doi.org/10.1146/annurev.es.15.110184.002141

Werner, E. E. & Anholt, B. R. (1993). Ecological consequences of the trade-off between growth and mortality rates mediated by foraging activity. *The American Naturalist* **142**, 242–272. https://doi.org/10.1086/285537

Williams, J. E. & Williams, C. D. (1980). Feeding ecology of *Gila boraxobius* (Osteichthyes: Cyprinidae) endemic to a thermal lake in Southeastern Oregon. *The Great Basin Naturalist* **40**, 101–114.

Willoughby, N. G. & Tweddle, D. (1978). The ecology of the catfish *Clarias gariepinus* and *Clarias ngamensis* in the Shire Valley, Malawi. *Journal of Zoology London* **186**, 507–534. https://doi.org/10.1111/j.1469-7998.1978.tb03936.x

Xie, S., Cui, Y. & Li, Z. (2001). Dietary-morphological relationships of fishes in Liangzi Lake, China. *Journal of Fish Biology* **58**, 1714–1729. https://doi.org/10.1006/jfbi.2001.1580

Yafe, A., Loureiro, M., Scasso, F. & Quintans, F. (2002). Feeding of two Cichlidae species (Perciformes) in an hypertrophic urban lake. *Iheringia. Série Zoologia* **92**, 73–79. https://doi.org/10.1590/S0073-47212002000400009

Ydenberg, R. & Hurd, P. (1998). Simple models of feeding with time and enery contstraints. *Behavioral Ecology* **9**, 49–53. https://doi.org/10.1093/beheco/9.1.49

Zander, C. D. (1982). Feeding ecology of littoral gobiid and blen- nioid fish of the Banyuls area (Mediterranean Sea). I. Main food and trophic dimension of niche and ecotope. *Vie et Milieu* **32**, 1–10.