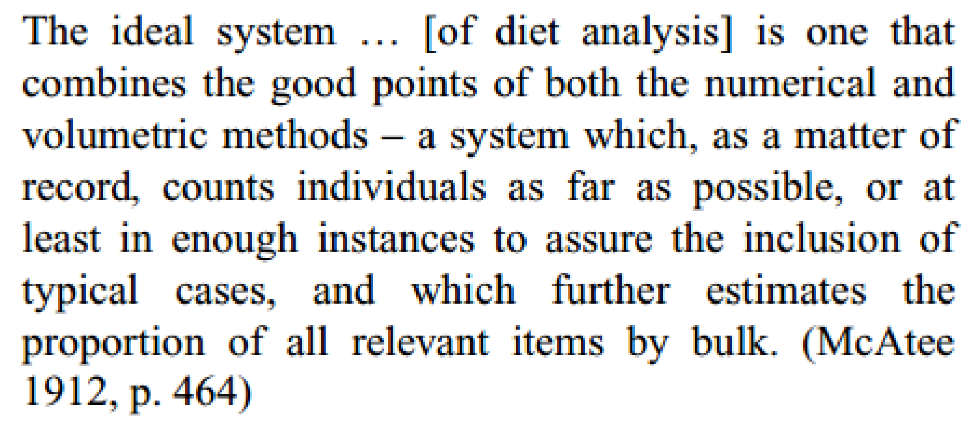
Seabird Diet Analysis - Limitations

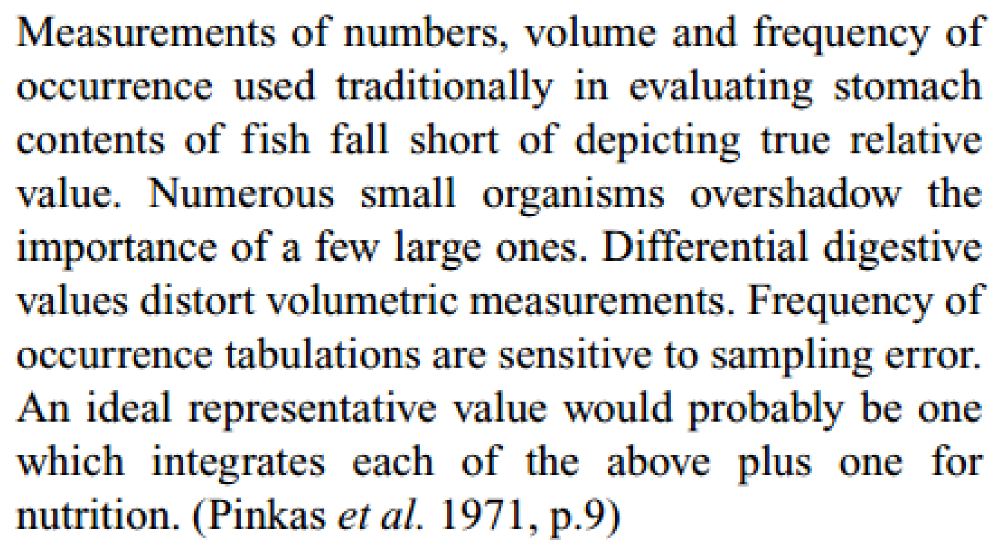
- Difficult to combine mass / volume and number data



The ideal system … [of diet analysis] is one that combines the good points of both the numerical and volumetric methods – a system which, as a matter of record, counts individuals as far as possible, or at least in enough instances to assure the inclusion of typical cases, and which further estimates the proportion of all relevant items by bulk. (McAtee 1912, p. 464)

Need to count individuals

(McAtee 1912)



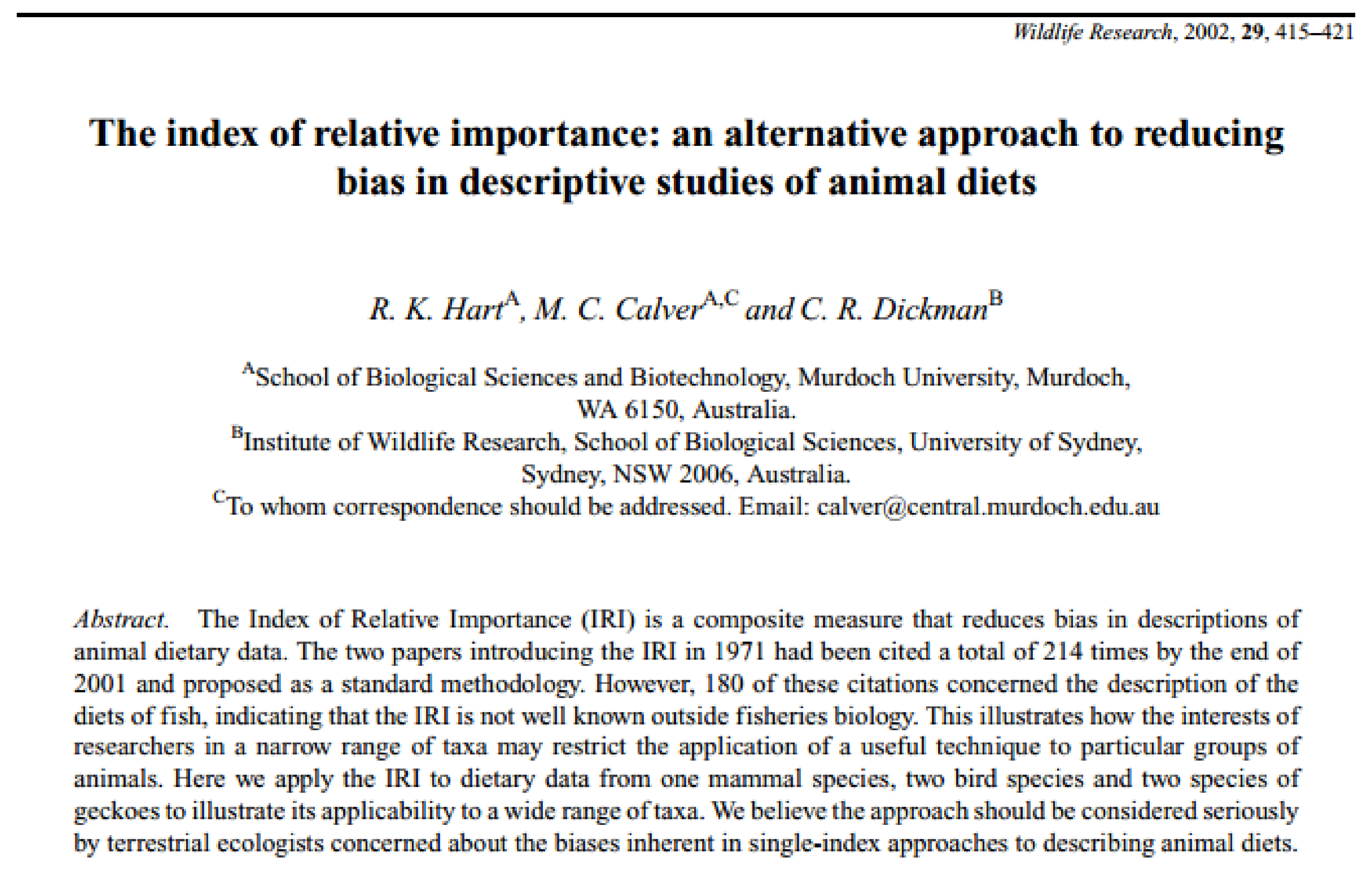
Measurements of numbers, volume and frequency of occurrence used traditionally in evaluating stomach contents of fish fall short of depicting true relative value. Numerous small organisms overshadow the importance of a few large ones. Differential digestive values distort volumetric measurements. Frequency of occurrence tabulations are sensitive to sampling error. An ideal representative value would probably be one which integrates each of the above plus one for nutrition. (Pinkas *et al.* 1971, p.9)

Need to integrate different components into a single metric

(Pinkas et al. 1971)

Seabird Diet Analysis - Metrics

- How can we combine mass / number information ? IRI



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The index of relative importance: an alternative approach to reducing bias in descriptive studies of animal diets

R. K. Hart[A], *M. C. Calver*[A,C] *and C. R. Dickman*[B]

[A]School of Biological Sciences and Biotechnology, Murdoch University, Murdoch,
WA 6150, Australia.
[B]Institute of Wildlife Research, School of Biological Sciences, University of Sydney,
Sydney, NSW 2006, Australia.
[C]To whom correspondence should be addressed. Email: calver@central.murdoch.edu.au

Abstract. The Index of Relative Importance (IRI) is a composite measure that reduces bias in descriptions of animal dietary data. The two papers introducing the IRI in 1971 had been cited a total of 214 times by the end of 2001 and proposed as a standard methodology. However, 180 of these citations concerned the description of the diets of fish, indicating that the IRI is not well known outside fisheries biology. This illustrates how the interests of researchers in a narrow range of taxa may restrict the application of a useful technique to particular groups of animals. Here we apply the IRI to dietary data from one mammal species, two bird species and two species of geckoes to illustrate its applicability to a wide range of taxa. We believe the approach should be considered seriously by terrestrial ecologists concerned about the biases inherent in single-index approaches to describing animal diets.

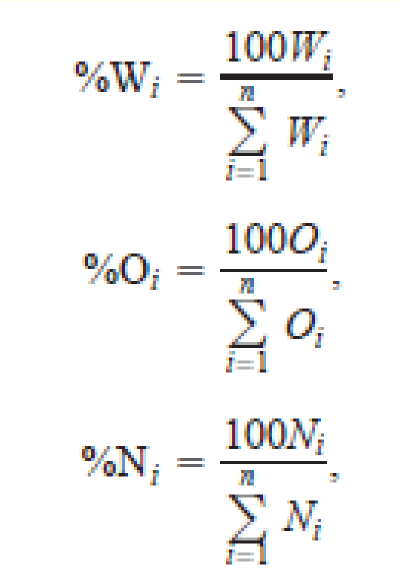
Seabird Diet Analysis - Metrics

- Different metrics biased

  (presence / mass / number)

- Multiple metrics are thus preferable

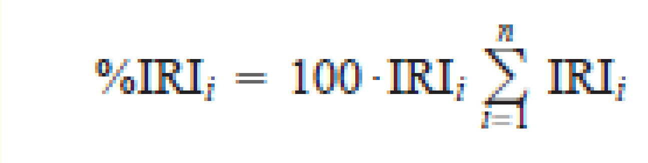
- Good to compare various metrics with correlation



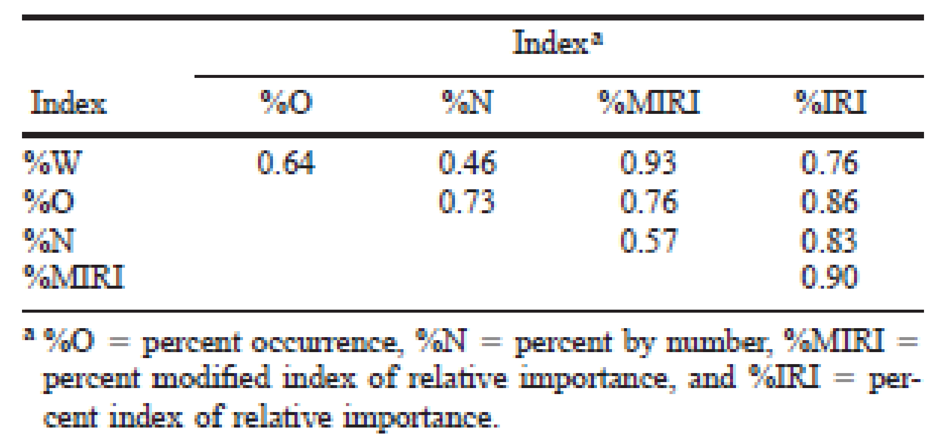
$$\%\mathrm{W}_i = \frac{100W_i}{\sum_{i=1}^{n} W_i},$$

$$\%\mathrm{O}_i = \frac{100O_i}{\sum_{i=1}^{n} O_i},$$

$$\%\mathrm{N}_i = \frac{100N_i}{\sum_{i=1}^{n} N_i},$$



$$\%\mathrm{IRI}_i = 100 \cdot \mathrm{IRI}_i \sum_{i=1}^{n} \mathrm{IRI}_i$$



	Index[a]			
Index	%O	%N	%MIRI	%IRI
%W	0.64	0.46	0.93	0.76
%O		0.73	0.76	0.86
%N			0.57	0.83
%MIRI				0.90

[a] %O = percent occurrence, %N = percent by number, %MIRI = percent modified index of relative importance, and %IRI = percent index of relative importance.

(Liao et al. 2001)

Seabird Diet Analysis - Metrics

Approach I: Use a single component index such as %W, %N, or %O, chosen on basis of specific purposes.

- % Occurrence

$$\%\mathrm{O}_i = \frac{100O_i}{\sum_{i=1}^{n} O_i},$$

- % Number

$$\%\mathrm{N}_i = \frac{100N_i}{\sum_{i=1}^{n} N_i},$$

- % Mass

$$\%\mathrm{W}_i = \frac{100W_i}{\sum_{i=1}^{n} W_i},$$

Seabird Diet Analysis - Metrics

Approach II: Use a compound indices such as IRI, based on the idea that a combination of different component measures provides a more balanced view.

Index of relative importance (IRI) developed to evaluate overall the importance of each prey taxon in the diet:

$$\mathrm{IRI} = (N + V)F,$$

where N is percent number,
V is percent volume (or Mass)
F is percent frequency of occurrence of each prey taxon

(Pinkas et al ., 1971)

Seabird Diet Analysis - Metrics

Approach III: Use the modified relative IRI (%IRI) to:

- Provide bounded metric (from 0 to 100%) for each prey

- Provide standardized total (100%) across all prey

Owing to difficulties experienced when comparing IRI values among prey types, the IRI values for each specific prey taxa (IRI) are converted to % IRI as follows:

$$\%\mathrm{IRI}_i = 100 \cdot \mathrm{IRI}_i \sum_{i=1}^{n} \mathrm{IRI}_i$$

(Pinkas et al ., 1971)

Seabird Diet Analysis - Metrics

Approach IV: Use Relative Prey-Specific IRI (PSIRI) to:

- Account for lack of independence (FO and PA)
- Provide bounded metric (from 0 to 100%) for each prey

$$\%PSIRI_i = \frac{\%FO_i \times (\%PN_i + \%PW_i)}{2}$$

where %FO is percent frequency of occurrence, %PN is percent number and %PW is percent weight of each prey taxon

(Brown et al ., 2012)

Seabird Diet Analysis - Metrics

There is a problem with the IRI:

The determined value of %FO represents an upper limit to %N and %W values because discrete absences are averaged into all measures.

This creates a mathematical dependence between diet measures, whose strength increases with the increasing frequency of zero values in a diet data matrix.

Amundsen et al. (1996), fully realizing this graphical limitation of diet measures in constructing feeding strategy diagrams, proposed a new measure termed the prey-specific abundance.

(Brown et al ., 2012)

Seabird Diet Analysis - Metrics

What does Prey-Specific IRI (PSIRI) do ?

Prey specific abundance is defined as percent numerical abundance of a prey item averaged over the stomach samples in which it occurs (i.e. excluding zero values).

Like %FO, the value of the prey specific abundance for a prey item may take any value (> 0% to 100%) independent of values for all other prey items.

Diet Data Matrix

By Number or Mass

$$\begin{array}{cc} & \textit{prey category } (i) \\ \textit{stomach sample } (j) & \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0.25 & 0.5 & 0.25 \\ 0 & 0 & 0.5 & 0.5 \\ 0 & 0.75 & 0 & 0.25 \end{bmatrix} \end{array}$$

	p1	p2	p3	p4
% FO	25	50	50	75
% PSA	100	50	50	33.3

(Brown et al ., 2012)

Seabird Diet Analysis - Metrics

How Does PSIRI work ?

N and W	p1	p2	p3	p4
s1	1	0	0	0
s2	0	0.25	0.5	0.25
s3	0	0	0.5	0.5
s4	0	0.75	0	0.25

	p1	p2	p3	p4
FO	0.25	0.5	0.5	0.75
PN	100	50	50	33.33
PW	100	50	50	33.33
	p1	p2	p3	p4
PSIRI	25	25	25	25

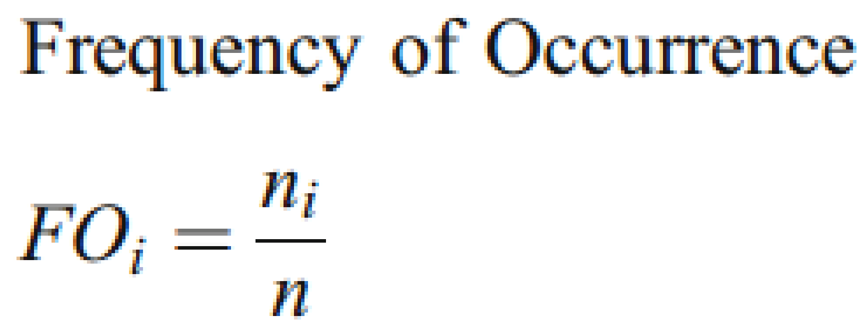
Seabird Diet Analysis - PSIRI

- Prey-specific Index of Relative Importance

(Brown et al. 2012):

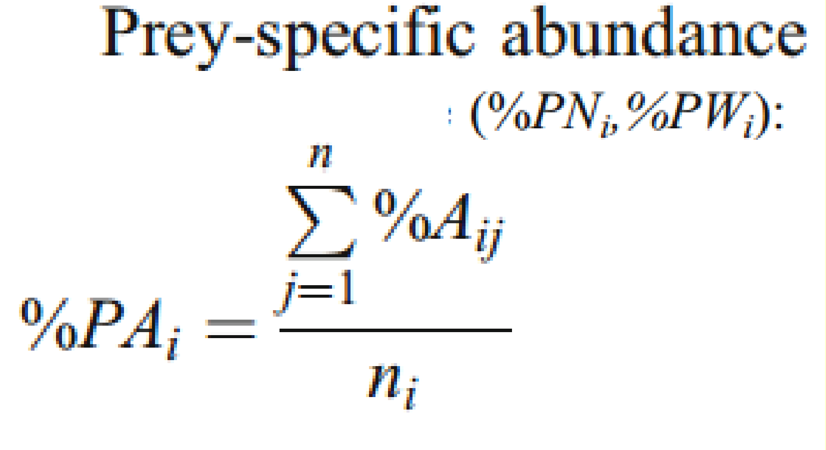
%PSIRI = [(%PN + %PV) * %FO] / 2

PN = numerical percentage
PV = volumetric percentage (or mass)
F = frequency of occurrence



Frequency of Occurrence

$$FO_i = \frac{n_i}{n}$$



Prey-specific abundance

($\%PN_i$,$\%PW_i$):

$$\%PA_i = \frac{\sum_{j=1}^{n} \%A_{ij}}{n_i}$$

Seabird Diet Analysis - PSIRI

- Prey-specific Index of Relative Importance: **PRO**

squid_#	plastic_#	squid_mass_g	plastic_mass_g
100	0	100	0
100	0	100	0
95.24	4.76	50	50
0	100	100	0
0	100	100	0
0	0	70	30
0	0	0	100
0	0	0	0
0	0	0	0
0	0	0	0

MEAN = 98.41	MEAN = 68.25	MEAN = 86.67	MEAN = 60.00

Seabird Diet Analysis - PSIRI

- Prey-specific Index of Relative Importance: **PRO**

$$\%PSIRI = [(\%PN + \%PV) * \%FO] / 2$$

PN = numerical percent, PV = volumetric percent (or mass)
FO = frequency of occurrence

PRO	Squid #	Fish #	Plastic #	Squid mass_g	Fish mass_g	Plastic mass_g
%PA	98.41	-	68.25	86.67	-	60.00

$$\%PSIRI\_squid = [(\%PN + \%PV) * \%FO] / 2$$
$$\%PSIRI\_squid = [(98.41 + 86.67) * 0.6] / 2$$
$$\%PSIRI\_squid = [185.08] / 2 = 55.52\%$$

$$\%PSIRI\_plastic = [(\%PN + \%PV) * \%FO] / 2$$
$$\%PSIRI\_plastic = [(68.25 + 60.00) * 0.3] / 2$$
$$\%PSIRI\_plastic = [128.25] / 2 = 19.24\%$$

Seabird Diet Analysis - PSIRI

- Prey-specific Index of Relative Importance: **GIZ**

GIZ	Squid #	Fish #	Plastic #	Squid mass_g	Fish mass_g	Plastic mass_g
%PA	91.73	100.00	35.52	78.57	100.00	87.50

%PSIRI_squid = [(%PN + %PV) * %FO] / 2
%PSIRI_squid = [(91.83 + 78.57) * 0.7] / 2
%PSIRI_squid = [170.30 * 0.7] / 2 = 59.60%

%PSIRI_plastic = [(%PN + %PV) * %FO] / 2
%PSIRI_plastic = [(35.52 + 87.50) * 0.4] / 2
%PSIRI_plastic = [123.02 * 0.4] / 2 = 24.60%

%PSIRI_fish = [(%PN + %PV) * %FO] / 2
%PSIRI_fish = [(100 + 100) * 0.1] / 2
%PSIRI_fish = [200 * 0.1] / 2 = 10%

Seabird Diet Analysis – Analysis

- Analyze 12 Albatross Boluses:

LAAL

Plastic items:

Fragments

Foam

Line

Sheet

Seabird Diet Analysis – Analysis

- Analyze Albatross Boluses: Relative Composition (by mass)

	Natural_food_g	Natural_NonFood_g	Non-Natural_g
mean	51.05	17.73	31.22
std	18.93	11.39	15.76
median	51.77	18.50	26.34
min	10.89	0.07	14.56
max	84.18	34.69	63.25

Quantifying variability: *CV = SD * 100 / Mean*

	Natural_food_g	Natural_NonFood_g	Non-Natural_g
CV	37.08 %	50.48 %	64.26 %

Seabird Diet Analysis – Analysis

- Analyze Albatross Boluses: Predicting total mass as a function of mass of the three components

Bolus Component	R squared	p value
Natural_food	0.009	0.785
Natural_NonFood	0.619	0.004
Non-Natural	0.568	0.007