Supplement 1.

Text S1. Data mean-correction methodology

Fictional length and $\delta^{15}N$ values of 30 individuals i of a species j sampled in 3 stations k are presented on the figure S1a, with mean length and $\delta^{15}N$ values differing between stations. Pooling the samples from the 3 stations to assess the relationship between the length and $\delta^{15}N$ values results in a non-significant correlation (r = 0.142, P = 0.454, slope = 0.514) despite the correlations being significant within each station (r = 0.725, P = 0.018, slope = 2.846 for station 1, r = 0.714, P = 0.020, slope = 2.218 for station 2, r = 0.642, P = 0.045, slope = 1.187 for station 3). Therefore, to assess the relationship between the length and $\delta^{15}N$ values in this species at the scale of the whole study zone (i.e. by pooling the stations), it is necessary to account for inter-station differences (i.e. differences in mean length and stable isotope values of each station). In addition, the variability of stable isotope values within each station should be preserved. This can be done by a correction of mean values without changing the variability of data within each station.

The principle is, knowing the general mean of all values and the means of each station, to remove the relevant “station” effect to each individual isotope value. The searched result is that all the stations have the same mean without removing the differences of values between individuals within each station. The figure S1b shows that the means of the 3 stations are all at the same point after mean-correction. Furthermore, the correlation between the length and $\delta^{15}N$ values became significant and closer to the ones within each station (r = 0.646, P < 0.001, slope = 1.663).

If we have a variable X (e.g. length or $\delta^{15}N$ values in figure S1) for an individual i of the species j belonging to the station k, the value of X for this individual (X_{ijk}) is the sum of the mean of X ($\overline{X}_j$), the coefficient of the factor K (coefK) and the residual (e_{ijk}):

$$X_{ijk} = \overline{X}_j + \mathrm{coefK} + e_{ijk} \quad (1)$$

coefK is the difference between the mean of X in the factor level k ($\overline{X}_{jk}$) and $\overline{X}_j$:

$$\mathrm{coefK} = (\overline{X}_{jk} - \overline{X}_j) \quad (2)$$

e_{ijk} is the difference between X_{ijk} and $\overline{X}_{jk}$:

$$e_{ijk} = X_{ijk} - \overline{X}_{jk} \quad (3)$$

Consequently, the equation (1) can then be written as:

$$X_{ijk} = \overline{X}_j + (\overline{X}_{jk} - \overline{X}_j) + (X_{ijk} - \overline{X}_{jk}) \quad (4)$$

The potential effect of K on X is corrected by removing coefK from the equation (4). Consequently, the equation for the factor-corrected X value in the individual i from the factor level k ($\mathrm{cor}X_{ijk}$) is:

$$\mathrm{cor}X_{ijk} = \overline{X}_j + (X_{ijk} - \overline{X}_{jk}) \quad (5)$$

or more simply:

$$\mathrm{cor}X_{ijk} = X_{ijk} - (\overline{X}_{jk} - \overline{X}_j) \quad (6)$$

With this method, data from the different factor levels of K have the same mean for the variable X while the variability of X each factor level is preserved. Thus, the variability of X for pooled factor levels is thus no more the result of differences of X between these factor levels (Fig. S1b).

For example, let us consider the length and $\delta^{15}N$ values of the individual 1 belonging to the station 1 in the figure S1 and in the table S1. The mean of all length values is 1.1, the mean of length values values in the station 1 is 0.6 and the length value of the individual 1 is 0.2 cm. Then, the corrected value is 0.2 – (0.6 – 1.1) = 0.7. Similarly, the mean of all $\delta^{15}N$ values is 12.6, the mean of $\delta^{15}N$ values in the station 1 is 12.3 and the $\delta^{15}N$ value of the individual 1 is 10.0. Then, the corrected value is 10.0 – (12.3 – 12.6) = 10.3.

In this paper, mean-corrections were used to pool stations and then assess the global relationship between length and stable isotope values. However, pooling stations with mean-corrected stable isotope data may also be useful to assess the isotopic niche metrics (Layman et al., 2007; Jackson et al., 2011; Cucherousset & Villéger, 2015) without overestimating them if stable isotope values differ between stations (Le Bourg, 2020, p. 43-47).

References

Cucherousset, J., & Villéger, S. (2015). Quantifying the multiple facets of isotopic diversity: New metrics for stable isotope ecology. *Ecological Indicators, 56,* 152-160. https://doi.org/10.1016/j.ecolind.2015.03.032

Jackson, A.L., Inger, R., Parnell, A.C., & Bearhop, S. (2011). Comparing isotopic niche widths among and within communities: SIBER - Stable Isotope Bayesian Ellipses in R. *Journal of Animal Ecology, 80,* 595-602. https://doi.org/10.1111/j.1365-2656.2011.01806.x

Layman, C.A., Arrington, D.A., Montaña, C.G., & Post, D.M. (2007). Can stable isotope ratios provide for community-wide measures of trophic structure? *Ecology, 88,* 42-28. https://doi.org/10.1890/0012-9658(2007)88%5B42:CSIRPF%5D2.0.CO;2

Le Bourg, B. (2020). Trophic ecology of Southern Ocean sea stars: Influence of environmental drivers on trophic diversity. PhD dissertation, Univesity of Liège. https://orbi.uliege.be/handle/2268/248221

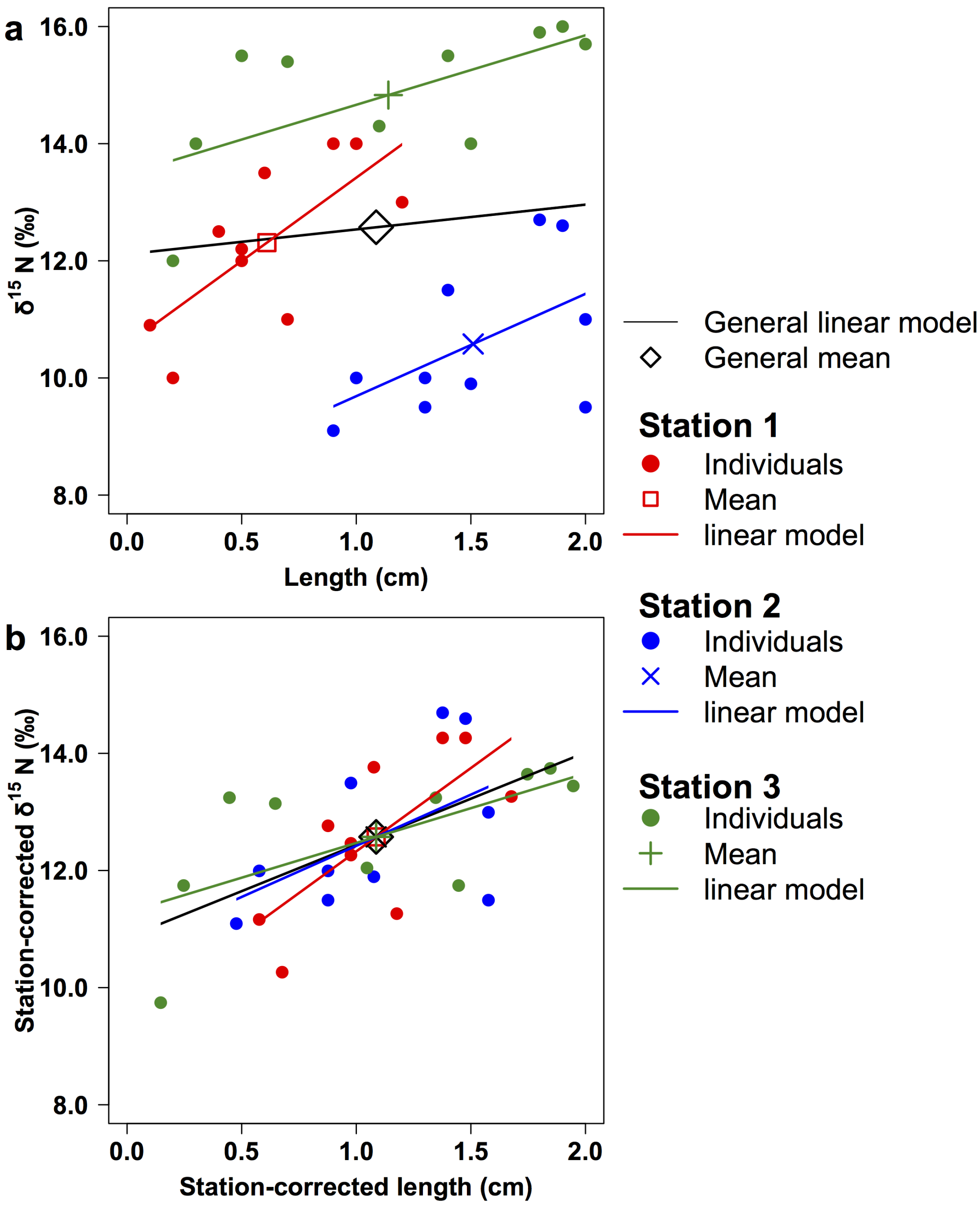

Fig. S1. Theoretical example of mean-correction of length and $\delta^{15}N$ values for organisms of a same species sampled in 3 stations with individual and mean values and the resulting relationship in each station. By looking at the raw data (a), it appears that there are significant relationships between the length and $\delta^{15}N$ values in each station but not at the scale of the whole dataset. After mean-correction by the station (b), length and $\delta^{15}N$ values appeared to be correlated at the scale of the whole dataset while the correlations for each station are preserved. Computation of station-corrected length and $\delta^{15}N$ values are provided in Table S1.

Table S1. Mean-correction of the data in Fig. S1 with individual length and $\delta^{15}N$ values, mean length and $\delta^{15}N$ values in each station and mean length and $\delta^{15}N$ values for all samples.

		Mean-correction of length values								Mean-correction of $\delta^{15}N$ values							
Individual i	Station k	$Length_{ijk}$	– (	Mean $Length_{jk}$	–	Total mean $Length_j$	)	=	$corLength_{ijk}$	$\delta^{15}N_{ijk}$	– (	Mean $\delta^{15}N_{jk}$	–	Total mean $\delta^{15}N_j$	)	=	$cor\delta^{15}N_{ijk}$
Individual 1	Station 1	0.2	– (	0.6	–	1.1	)	=	0.7	10.0	– (	12.3	–	12.6	)	=	10.3
Individual 2	Station 1	1.0	– (	0.6	–	1.1	)	=	1.5	14.0	– (	12.3	–	12.6	)	=	14.3
Individual 3	Station 1	0.9	– (	0.6	–	1.1	)	=	1.4	14.0	– (	12.3	–	12.6	)	=	14.3
Individual 4	Station 1	1.2	– (	0.6	–	1.1	)	=	1.7	13.0	– (	12.3	–	12.6	)	=	13.3
Individual 5	Station 1	0.7	– (	0.6	–	1.1	)	=	1.2	11.0	– (	12.3	–	12.6	)	=	11.3
Individual 6	Station 1	0.5	– (	0.6	–	1.1	)	=	1.0	12.0	– (	12.3	–	12.6	)	=	12.3
Individual 7	Station 1	0.4	– (	0.6	–	1.1	)	=	0.9	12.5	– (	12.3	–	12.6	)	=	12.8
Individual 8	Station 1	0.6	– (	0.6	–	1.1	)	=	1.1	13.5	– (	12.3	–	12.6	)	=	13.8
Individual 9	Station 1	0.1	– (	0.6	–	1.1	)	=	0.6	10.9	– (	12.3	–	12.6	)	=	11.2
Individual 10	Station 1	0.5	– (	0.6	–	1.1	)	=	1.0	12.2	– (	12.3	–	12.6	)	=	12.5
Individual 11	Station 2	1.8	– (	1.5	–	1.1	)	=	1.4	12.0	– (	10.6	–	12.6	)	=	14.0
Individual 12	Station 2	1.7	– (	1.5	–	1.1	)	=	1.3	10.0	– (	10.6	–	12.6	)	=	12.0
Individual 13	Station 2	1.0	– (	1.5	–	1.1	)	=	0.6	10.0	– (	10.6	–	12.6	)	=	12.0
Individual 14	Station 2	1.3	– (	1.5	–	1.1	)	=	0.9	9.5	– (	10.6	–	12.6	)	=	11.5
Individual 15	Station 2	1.9	– (	1.5	–	1.1	)	=	1.5	12.6	– (	10.6	–	12.6	)	=	14.6
Individual 16	Station 2	1.3	– (	1.5	–	1.1	)	=	0.9	10.0	– (	10.6	–	12.6	)	=	12.0
Individual 17	Station 2	1.5	– (	1.5	–	1.1	)	=	1.1	9.9	– (	10.6	–	12.6	)	=	11.9
Individual 18	Station 2	0.9	– (	1.5	–	1.1	)	=	0.5	9.1	– (	10.6	–	12.6	)	=	11.1
Individual 19	Station 2	1.4	– (	1.5	–	1.1	)	=	1.0	11.5	– (	10.6	–	12.6	)	=	13.5
Individual 20	Station 2	2.0	– (	1.5	–	1.1	)	=	1.6	11.0	– (	10.6	–	12.6	)	=	13.0
Individual 21	Station 3	1.9	– (	1.1	–	1.1	)	=	1.8	16.0	– (	14.8	–	12.6	)	=	13.7
Individual 22	Station 3	1.1	– (	1.1	–	1.1	)	=	1.0	14.3	– (	14.8	–	12.6	)	=	12.0
Individual 23	Station 3	0.2	– (	1.1	–	1.1	)	=	0.1	12.0	– (	14.8	–	12.6	)	=	9.7
Individual 24	Station 3	1.4	– (	1.1	–	1.1	)	=	1.3	15.5	– (	14.8	–	12.6	)	=	13.2
Individual 25	Station 3	1.5	– (	1.1	–	1.1	)	=	1.4	14.0	– (	14.8	–	12.6	)	=	11.7
Individual 26	Station 3	2.0	– (	1.1	–	1.1	)	=	1.9	15.7	– (	14.8	–	12.6	)	=	13.4
Individual 27	Station 3	1.8	– (	1.1	–	1.1	)	=	1.7	15.9	– (	14.8	–	12.6	)	=	13.6
Individual 28	Station 3	0.5	– (	1.1	–	1.1	)	=	0.4	15.5	– (	14.8	–	12.6	)	=	13.2
Individual 29	Station 3	0.3	– (	1.1	–	1.1	)	=	0.2	14.0	– (	14.8	–	12.6	)	=	11.7
Individual 30	Station 3	0.7	– (	1.1	–	1.1	)	=	0.6	15.4	– (	14.8	–	12.6	)	=	13.1