CICIMAR OCEÁNIDES
ISSN 2448-9123
https://cicimaroceanides.mx
Centro Interdisciplinario de Ciencias Marinas
https://doi.org/10.37543/oceanides.v38i1.283

Vol.38 No. 1
Enero - Junio
2023

CONVERSION FACTORS FOR DRY WEIGHT FOR THE LION PAW SCALLOP (*Nodipecten subnodosus* SOWERBY, 1835)

Carreño-León, D.P.[1], Vázquez-Sánchez, R.I.[1], Ramírez-Arce, J.L.[1], Monge-Quevedo, A.[1], Lluch-Cota, S.E.[2]*

[1]Programa de Acuicultura, Centro de Investigaciones Biológicas del Noroeste, S.C. [2]Programa de Ecología Pesquera, Centro de Investigaciones Biológicas del Noroeste, S.C. *Corresponding author: slluch@cibnor.mx

ABSTRACT. Biomass of marine species typically needs to be expressed as dry weight. However, direct measurement can be problematic in some operational situations. When fine-grained comparisons between individuals are not required, a widely used solution is the use of conversion factors. These must be specific and generated using the best available information. Based on morphometric measurements of five independent groups of organisms with varying sizes and origins, this study suggests weight conversion factors for the lion paw scallop (*Nodipecten subnodosus*). In all cases, the measurements and sample processing techniques were the same. As predictors of dry weight, conversion factors based on the wet weight of soft tissue, the total weight of animals (including the shell), and the shell length are proposed. In all situations, the correlation coefficients for the models tested are significant. Given the short sample size, especially for the larger animals, it is suggested that the factors be estimated in the future using a larger number of cases.

Keywords: biometry, bivalves, aquaculture, fisheries management, ecophysiology.

Factores de conversión para peso seco en la almeja mano de león (*Nodipecten subnodosus* Sowerby, 1835)

RESUMEN. Típicamente, la biomasa de organismos marinos debe expresarse en términos de peso seco. Sin embargo, su medición directa puede resultar problemática en algunas situaciones operativas. Cuando no se requieren comparaciones detalladas entre individuos, una solución ampliamente utilizada es el uso de factores de conversión, pero éstos deben ser específicos y generarse utilizando la mejor información disponible. Basado en medidas morfométricas de cinco grupos independientes de organismos con diferentes tamaños y orígenes, este estudio sugiere factores de conversión a peso seco para la almeja mano de león (*Nodipecten subnodosus*). En todos los casos, la metodología de medición y el procesamiento de las muestras fueron los mismos. Como predictores del peso seco se proponen el peso húmedo de tejidos blandos, el peso total de los animales (incluyendo la concha) y el ancho de la concha. Todos los coeficientes de correlación de los modelos probados son significativos. Dado el pequeño tamaño de la muestra, especialmente para las tallas mayores, se sugiere que a futuro se reestimen utilizando un mayor número de casos.

Palabras clave: biometría, bivalvos, acuacultura, manejos de pesquerías, ecofisiología.

Carreño-León, D.P., Vázquez-Sánchez, R.I., Ramírez-Arce, J.L., Monge-Quevedo, A. & Lluch-Cota, S.E. (2023). Conversion factors for dry weight for the lion paw scallop (*Nodipecten subnodosus* Sowerby, 1835). CICIMAR Oceánides, 38(1), 1-7.

INTRODUCTION

Many fields of ecology and ecophysiology rely on the ability to estimate individual biomass, such as transient energy fluxes within ecosystems or individuals. Following that, these estimates are becoming increasingly important in informing modeling initiatives to investigate the global distribution of biomass (Bar-On *et al.*, 2018) and the global ocean effects of climate change (Lotze *et al.*, 2019; Pontavice *et al.*, 2019).

Biomass is typically represented in terms of dry weight, which is the weight of tissue after the water content has been removed because it is regarded to be a less variable and more precise measurement than wet weight. This standardized biomass metric is used in many comparative studies and integrative analyses; nevertheless, determining it can be difficult in many circumstances (Pouil *et al.*, 2021; Barría *et al.*, 2021). For example, working with large numbers of organisms can be difficult and time-consuming (Eklöf *et al.*, 2017), often requires the destruction of samples that may be needed for in-depth analyses (Ricciardi & Bourget, 1998), and relies on infrastructure and equipment that is not always readily available.

When the direct measurement is impractical, common procedures include the use of mathematical conversion factors defined from a subsample of the larger sample of the population under study or approximated by other authors (Trevallion *et al.*, 1970; Eleftheriou & Basford, 1989). Because conversion factors can be used as proxies of growth and physiological condition of the individuals, it has long been recognized that a specific weight-to-weight conversion factor is required to ensure that approximations are not abused (Widbom, 1984; Rumohr *et al.*, 1987), for example by using conversion factors estimated for different taxonomic groups or in very different environments (Ricciardi & Bourget, 1998).

This paper investigates and proposes specific conversion factors for the lion's paw scallop (*Nodipecten subnodosus*). The lion's paw scallop has been one of the principal targets in several small-scale fisheries throughout the Baja California Peninsula, where options for fishermen are extremely restricted (Ponce-Díaz *et al.*, 2011). However, its exploitation has been erratic and highly uncertain, owing primarily to sudden, fishing-independent mass mortalities (Ruíz-Verdugo *et al.*, 2016; Salgado-García *et al.*, 2020).

Fecha de recepción: 03 de mayo de 2023

Fecha de aceptación: 22 de junio de 2023

The explanations underlying these acute biomass variations range from direct environmental variable impacts (such as temperature or oxygen) to indirect ecological events (parasite-driven sickness and food availability; González-Ortiz *et al*., 2017; Salgado-García *et al*., 2020).

In Mexico, there is a growing interest in developing commercial aquaculture for the lion's paw scallop (Ruíz-Verdugo *et al*., 2016; Purce *et al*., 2020), but unlike what happens with other scallops in several regions of the world, aquaculture for this species remains a pipe dream, at least in part due to a lack of organized and publicly available technical and scientific knowledge. Fortunately, research is underway to improve our understanding of the species, the organization of its populations, their genetic and phenotypic responses to environmental changes, and our capacity for ecological modeling. This contribution, which proposes shell size and weight to dry weight conversion factors for this regionally important marine bivalve to support the various current and future needs of ecological, physiological, and fisheries research, is part of this growing understanding.

METHODS

This report analyzed morphometric data from five batches of lion's paw scallops in order to determine conversion factors. Three of these batches were collected for different ecophysiological studies, where reproductive age was deliberately avoided, and the fourth and fifth were used to produce larvae and became available for this study after breeding. The first batch, dubbed GRO in this report, consists of 110 individuals obtained in September 2002 from a commercial suspended culture in Guerrero Negro Lagoon (Figure 1) as part of a doctoral dissertation research project (Sicard, 2006). These individuals were selected to be as young and homogeneous as possible. The second and third batches are made up of 18 and 20 randomly selected wild subadults from Bahía de Los Ángeles (BLA) and Laguna Ojo de Liebre (LOL), respectively (Figure 1). BLA was sampled in July 2021, while LOL was sampled in August 2021. The fourth and fifth batches contain a small number of reproductive adults collected from the same sites and sampling dates (6 for RBLA and 5 for RLOL) and processed in the laboratory for post-hatch morphometric weight estimations.

All samples were processed alike, using the same equipment and methods. After cleaning for epibionts, a 0-150 mm analog vernier was used to measure shell height (the distance from the hinge to the furthest shell edge) and length (the distance from edge to edge, perpendicular to the height; Figure 2). Total weight (entire organisms, including the shell) and wet weight (soft tissue after dissection) were recorded using an analytical balance (Precisa XT220A). All soft tissue samples were lyophilized using a Telstar Cryodos-50 at 0.07 mBar and -50°C, and the dry weight was measured with the analytical balance.

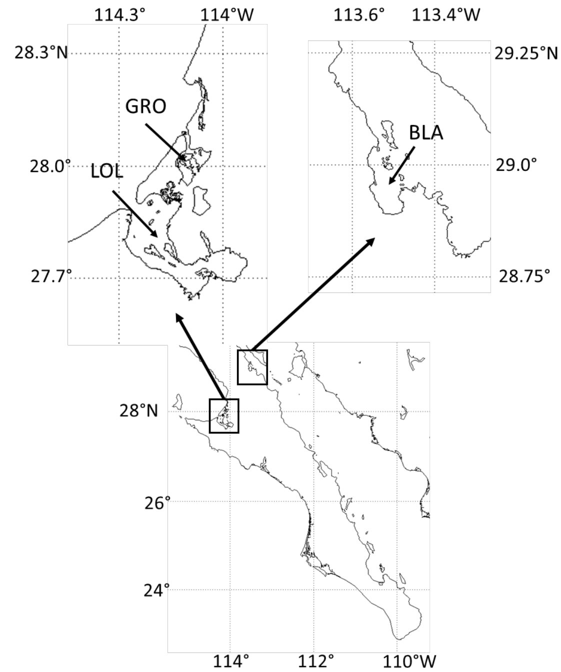

Figure 1. Sampling sites of the lion's paw scallop batches were used in this study.

As a result, the database includes shell height and length, total weight (Tw), wet weight (Ww), and soft tissue dry weight (Dw). A Shapiro-Wilks test (p 0.05) was used to confirm the normality of each variable before any correlation or statistical analysis.

A one-way ANOVA was performed to ascertain whether there were statistically significant differences between the samples in terms of animal size (shell length) and weight (total weight). A post-hoc Tukey test was used to compare all pairs of means.

The relationship between shell height and length was determined using a correlation analysis. An ANOVA and a post hoc Tukey test was used to determine whether different samples might produce different means for the length/height ratios.

Finally, conversion factors for wet weight, total weight, and shell length as predictors of dry weight were obtained after fitting models to the paired data separately. In the first case, two models were utilized: a linear model (intercept set to 0) and a potential model; for the rest, simple linear models offered the best match. All analyses were performed using R Statistical Software (v4.3.0 R Core Team 2023).

RESULTS

The sizes of the specimens used in this investigation range from juveniles to adults (57 to 137 mm). There are three statistically distinct groups: the one from Guerrero Negro, sampled in 2002, with animals ranging from 36 to 112 g in total weight (with shell) and 57 to 74 mm in shell length; the experimental juveniles from LOL and BLA, with between 60 and 214

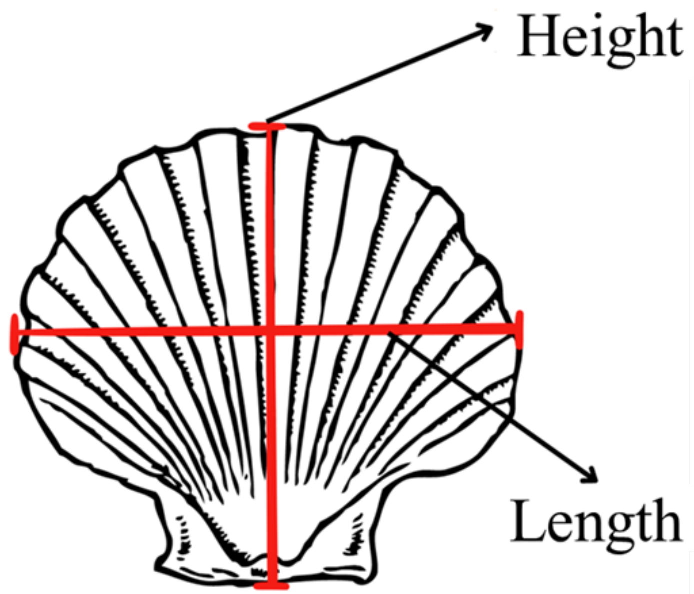

Figure 2. Schematic representation of the shell measurements of *Nodipecten subnodosus* used for this study.

g in total weight and 62 to 99 mm in shell length and verified sexual immaturity; and the adults used for reproduction in laboratory conditions, also from LOL and BLA, with animals ranging from 271 to 495 g and 104.6 to 137.2 mm (Figure 3). Morphometric measurement of lion's paw scallop shells showed high correlation (R2 = 0.9983) between the height and length of the shells, with a ratio close to one (1:0.977) for all samples except Guerrero Negro (Figure 4).

We examined wet weight (soft tissue), total weight (including the shell), and shell length as predictors of dry weight. All the model associations (Figure 5) are statistically significant (Table 1).

DISCUSSION

Conversion factors can be helpful in many situations, particularly in ecology, ecological modeling, and fisheries management. However, they cannot replace actual dry weight estimates in some research areas, such as bioenergetics and individual-scale physiological studies, where the variation between individuals often contains the response being sought. In addition, when comparing the relative weights of tissues and organs, a gross indirect estimation of the total soft tissue dry weight cannot replace direct measurements.

We present four models to choose from based on the available information and the user's particular requirements. The first one offers the possibility of converting wet to dry weights. In this case, two models with good correlation coefficients are proposed: a simple proportion model and a potential model, where the first is simpler and more practical and the second has slightly higher explanatory power and is better suited to larger animals. In the second, with total weight as the predictor of dry weight, the correla-

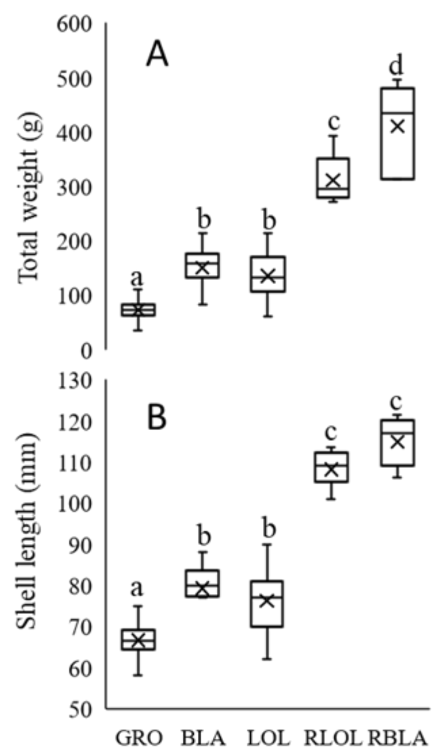

Figure 3. Samples comparison for total weight (A) and shell length (B). Guerrero Negro juveniles sampled in 2002 (GRO), Bahía de Los Ángeles (BLA) and Laguna Ojo de Liebre (LOL) juveniles sampled in 2021, and adults from Bahía de Los Ángeles (RBLA) and Laguna Ojo de Liebre (RLOL). For each group, the x mark indicates the mean, the horizontal line inside the box represents the median, the box indicates the interquartile range, and the whiskers the maximum and minimum values. Letters indicate significant differences between distributions at p 0.05.

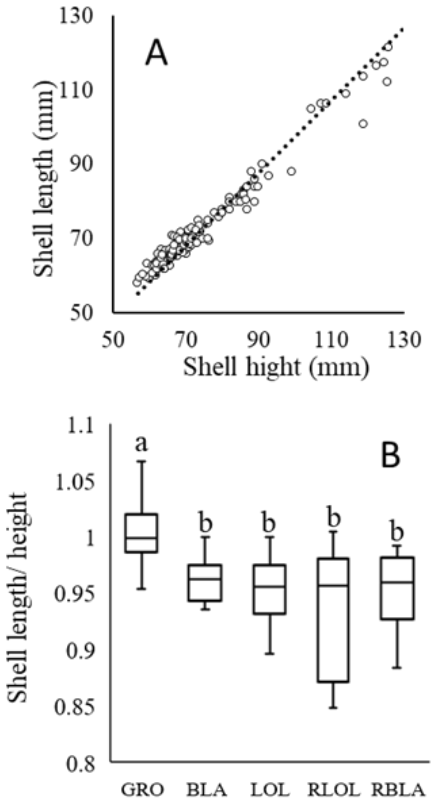

Figure 4. A) Correlation between shells height and length (R^2 = 0.9983) and B) comparison of the height/length ratio between samples: Guerrero Negro subadults sampled in 2002 (GRO), Bahía de Los Ángeles (BLA) and Laguna Ojo de Liebre (LOL) subadults sampled in 2021, and adults from Bahía de Los Ángeles (RBLA) and Laguna Ojo de Liebre (RLOL). For each group, the horizontal line inside the box represents the median, the box indicates the interquartile range, and the whiskers the maximum and minimum values. Letters indicate Differences are significant differences between distributions at p 0.05.

tion coefficient is also relatively high, and a simple linear regression provided the best fit. It should be noted that, while weighting the entire animal (with the shell) seems to be more convenient, it increases the risk of measurement error since many factors can alter the determinations (elimination or not of the excess water outside the shell, draining the individual before it hermetically closes the valves retaining excess water or remove epibionts from the shell surface, among others).

The third conversion factor is thought to be used when dealing with large number of individuals, such as after harvesting in aquaculture or capturing in fisheries, when measuring individual weights is logistically difficult and the information is used as aggregates or averages with no interest in comparing between individuals. Using shell length as a proxy for dry weight provides a reasonable approximation, is the quickest and simplest measurement, and requires no special equipment.

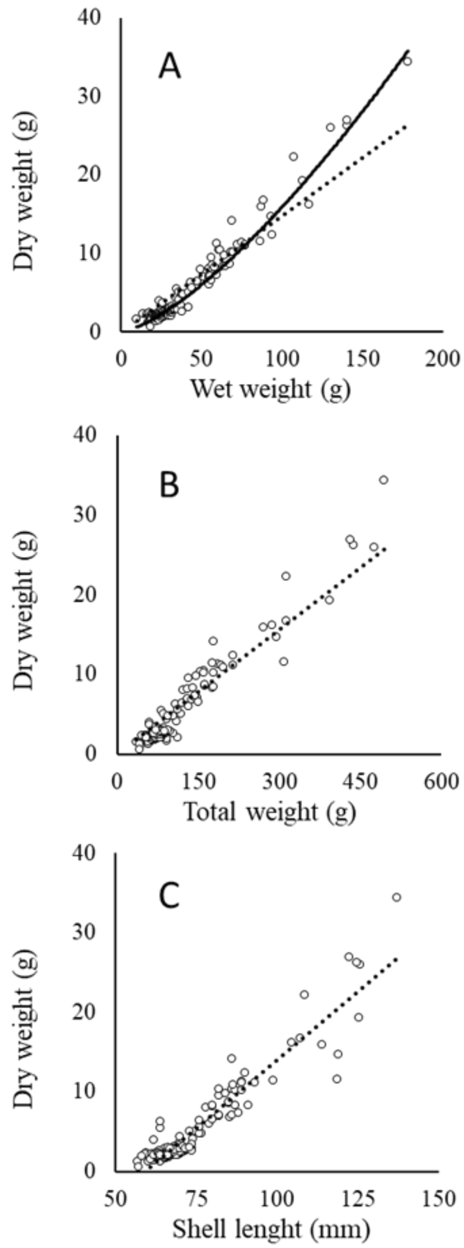

Figure 5. Correlation analyses for the conversion factor models using wet weight (A), total weight (B), and shell length (C) as predictors of dry weight. Model equations and correlation coefficients are reported in Table 1.

We are conscious of the limitations of our research. The most significant is that the number of cases in some of the samples, particularly for the largest sizes (5 and 6 cases for RBLA and RLOL, respectively), leads to a poor representation of larger animals. Moreover, since these few large individuals were weighed after reproduction, we may be underestimating their total mass. The model's capabilities and confidence could be improved in the future as more information about these sizes and different reproductive stages is gathered and incorporated.

Table 1. Models for the conversion factors from wet weight (Ww), total weight (Tw) and shell length (Length) to dry weight for the lion's paw scallop *Nodipecten subnodosus*

Predictor of dry weight	Model	Correlation coef.	Confidence intervals	2.5%	97.5%
Wet weight	0.148 * Ww	0.9285	Coeficcient	0.142	0.154
	-3.7* Ww^1.404	0.9637	Coeficcient	1.335	1.474
			Intercept	-3.948	-3.453
Total weight	0.0521 * Tw	0.9389	Coeficcient	0.050	0.054
Shell length	0.3424 * Length- 20.271	0.8911	Coeficcient	0.324	0.361
			Intercept	-21.684	-18.858

ACKNOWLEDGMENTS

This contribution is a product of the project CONACYT Ciencia de Frontera 78911 "Impactos biológicos de la variabilidad térmica y clima extremo en ectotermos marinos bentónicos: aptitud biológica, potencial de adaptación y plasticidad fenotípica". Gilberto González-Soriano and Carlos Pacheco Ayub provided technical support.

REFERENCES

Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(25), 6506–6511. https://doi.org/10.1073/pnas.1711842115

Barría, C., Abarca, A., Colivoro, D., Célis, A., Couve, P., Cárcamo, D., Durán, L. R., & Oliva, D. (2021). Broodstock conditioning, spawning, embryonic and early larval development of a novel baby clam species for aquaculture in the southeast Pacific: *Tawera elliptica* (Lamarck, 1818). *Aquaculture Research*, *52*(6), 2759–2771. https://doi.org/10.1111/are.15128

du Pontavice, H., Gascuel, D., Reygondeau, G., Maureaud, A., & Cheung, W. W. L. (2020). Climate change undermines the global functioning of marine food webs. *Global Change Biology*, *26*(3), 1306–1318. https://doi.org/10.1111/gcb.14944

Eklöf, J., Austin, Å., Bergström, U., Donadi, S., Eriksson, B. D. H. K., Hansen, J., & Sundblad, G. (2017). Size matters: relationships between body size and body mass of common coastal, aquatic invertebrates in the Baltic Sea. *PeerJ*, *5*(e2906), e2906. https://doi.org/10.7717/peerj.2906

Eleftheriou, A., & Basford, D. J. (1989). The macrobenthic infauna of the offshore northern North Sea. *Journal of the Marine Biological Association of the United Kingdom. Marine Biological Association of the United Kingdom*, *69*(1), 123–143. https://doi.org/10.1017/s0025315400049158

González-Ortiz, L., Hernández-Alcántara, P., Vázquez-Juárez, R., Quiroz-Guzmán, E., García-Garza, M. E., & de León-González, J. Á. (2017). Variación espacial y temporal de la infestación de la concha por *Polydora* sp. (Spionidae: Polychaeta) sobre la almeja mano de león (*Nodipecten subnodosus*) en la laguna Ojo de Liebre, Baja California Sur. *Revista Mexicana de Biodiversidad*, *88*(4), 845–852. https://doi.org/10.1016/j.rmb.2017.10.017

Heye Rumohr, Thomas Brey and Sven Ahkar. (s/f). Vliz.be. Consulted 20-VI-2023, https://www.vliz.be/imisdocs/publications/231721.pdf

Lotze, H. K., Tittensor, D. P., Bryndum-Buchholz, A., Eddy, T. D., Cheung, W. W. L., Galbraith, E. D., Barange, M., Barrier, N., Bianchi, D., Blanchard, J. L., Bopp, L., Büchner, M., Bulman, C. M., Carozza, D. A., Christensen, V., Coll, M., Dunne, J. P., Fulton, E. A., Jennings, S., … Worm, B. (2019). Global ensemble projections reveal trophic amplification of ocean biomass declines with climate change. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(26), 12907–12912. https://doi.org/10.1073/pnas.1900194116

Ponce- Díaz, G., Massó-Rojas, A., Félix-Pico, E.F., Morales-Zárate, M.V., García, N., Lodeiros, C. & Lluch- Cota, S. (2011). *Nodipecten* spp como recurso pesquero. En: *Biología y cultivo de los moluscos pectínidos del género Nodipecten* (pp. 11–26). Limusa.

Pouil, S., Hills, A., Stevenson, L., & Mathews, T. J. (2021). Allometric relationships in the filtration rates of the Asian clam *Corbicula fluminea* fed two phytoplankton species. *Aquatic Ecology*, *55*(3), 915–923. https://doi.org/10.1007/s10452-021-09871-4

Purce, D. N. S., Donovan, D. A., Maeda-Martínez, A. N., & Koch, V. (2020). Scope for growth of cultivated Pacific and Gulf of California populations of lion's paw scallop *Nodipecten subnodosus*, and their reciprocal transplants. *Latin American Journal of Aquatic Research*, *48*(4), 538–551. https://doi.org/10.3856/vol48-issue4-fulltext-2468

Ricciardi, A., & Bourget, E. (1998). Weight-to-weight conversion factors for marine benthic macroinvertebrates. *Marine Ecology Progress Series*, *163*, 245–251. https://doi.org/10.3354/meps163245

Ruiz-Verdugo, C. A., Koch, V., Félix-Pico, E., Beltran-Lugo, A. I., Cáceres-Martínez, C., Mazon-Suastegui, J. M., Robles-Mungaray, M., & Caceres-Martínez, J. (2016). Scallop fisheries and aquaculture in Mexico. En *Scallops - Biology, Ecology, Aquaculture, and Fisheries* (pp. 1111–1125). Elsevier.

Salgado-García, R. L., Kraffe, E., Maytorena-Verdugo, C. I., Rivera-Camacho, A. R., Sicard, M. T., Arellano-Martínez, M., & Racotta, I. S. (2020). Metabolic responses of adult lion's paw scallops *Nodipecten subnodosus* exposed to acute hyperthermia in relation to seasonal reproductive effort. *Scientific Reports*, *10*(1), 2449. https://doi.org/10.1038/s41598-020-59242-6

Sicard, M. T. (2006). *Efecto de la oscilación térmica en la fisiología de la mano de león (Nodipecten subnodosus Sowerby, 1835)*. Tesis de Doctorado. Universidad Autónoma de Nuevo León.

Trevallion, A., Ansell, A. D., Sivadas, P., & Narayanan, B. (1970). A preliminary account of two sandy beaches in South West India. *Marine Biology*, *6*(3), 268–279. https://doi.org/10.1007/bf00347236

Widbom, B. (1984). Determination of average individual dry weights and ash-free dry weights in different sieve fractions of marine meiofauna. *Marine Biology*, *84*(1), 101–108. https://doi.org/10.1007/bf00394532