ZOOPLANKTON SECONDARY PRODUCTION MODELS IN CULTURES OF *Daphnia magna*: A COMPARISON STUDY

M. Gómez[1] , I. Martínez[1], I. Mayo[1], J.M. Morales[1] & T.T. Packard[1]

[1] Laboratory of Biological Oceanography. Department of Biology. University of Las Palmas de Gran Canaria. Canary Islands, SPAIN

E-mail: mgomez@dbio.ulpgc.es

INTRODUCTION

Secondary production is heterotrophic growth, the rate of biomass increase per time in zooplankton or benthic metazoans. It reflects the net balance between metabolic gains in biomass and the integral of all metabolic losses.

Then, modeling secondary production rates in the zooplankton is essential for population ecology studies, yet assessing these rates is difficult, indirect, and poorly known to the general ecology community. Here we test five secondary production models in cultures of *Daphnia magna* (Huntley and López, 1992; Hirst and Sheader, 1997; Hirst and Lampitt, 1998; Stockwell and Johansson, 1997; Shuter and Ing, 1997).

MATERIAL AND METHODS

Different cultures of *D. magna* were grown on phytoplankton, baker's yeast or corn flour at 18-21ºC. Growth rates were calculated from time course of size (Fig.1) and dry mass (Fig.2).

Mother culture (20L)

- Phytoplankton culture (*Scenedesmus sp, Ankistrodesmus sp.*)
- Yeast culture (*Saccharomyces cerevisiae*)
- Corn flour culture (comercial)

Harvest → Size measurements → Freezer (-20ºC) → Parameters:

- * Dry mass
- * Growth rates
- *Condition factor[CF = (a·W)/L³]

Seawater models

- Huntley and López(1992): $g = 0.0445 \cdot e^{0.111T}$
- Hirst and Sheader(1997): $g=0.0732 \cdot 10^{0.0246T}/Wc^{0.2962}$
- Hirst and Lampitt(1998): $g=0.0723 \cdot 10^{0.0208T}/Wc^{0.3221}$

Freshwater models

- Shuter and Ing(1997): $P=10^{(\alpha+\beta T)} \cdot B$
- Stockwell and Johansson(1997): $P=10^{(a\log10M+b)} \cdot CF \cdot M \cdot N$

RESULTS

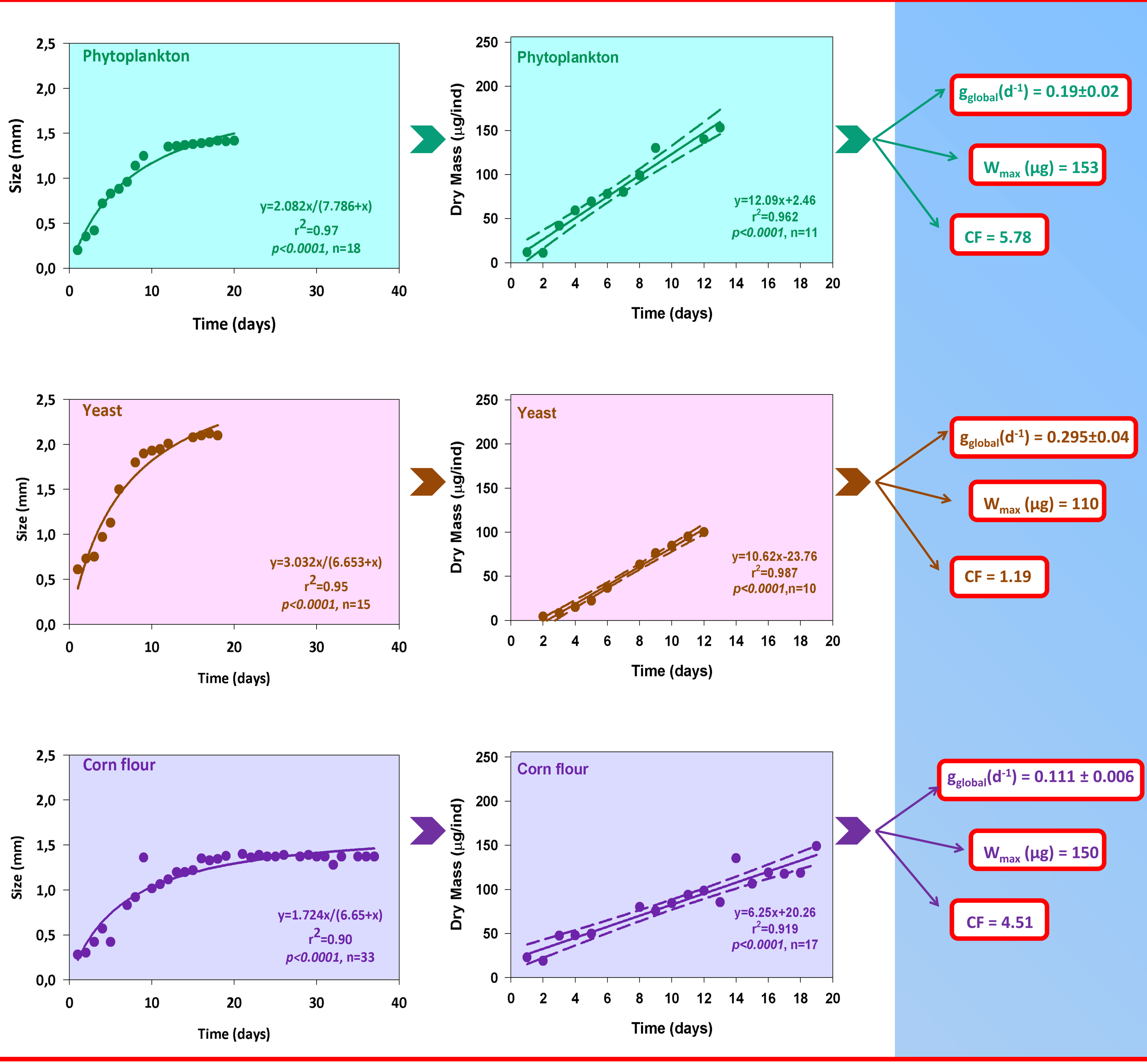

Fig1. *Daphnia magna* growth as function of size and dry mass, fed on three different types of food. Indicating the measured values of global growth rate (g_{global}), maximum weight (W_{max}) and conditions factor (CF) of each type of food.

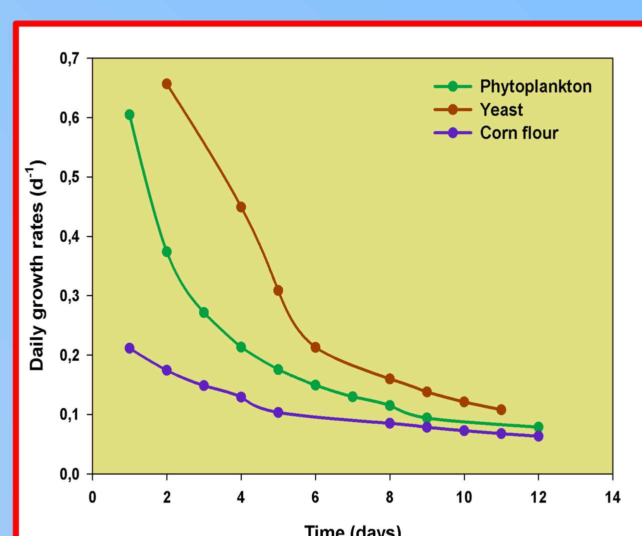

Fig2. Evolution of daily growth rates, g(days⁻¹), for *Daphnia magna* on three different types of food

Both the growth (Fig.2) and the secondary production (Fig.3) displayed a coherent pattern during the first 12 days:

- ➢Daily growth rates decreased continuously with the steepest decline in the yeast (Fig. 2)
- ➢Daily secondary production for the culture fed on phytoplankton and corn flour increased slightly, whereas in the culture fed on yeast the increase in the first 5 days is greater (Fig.3).

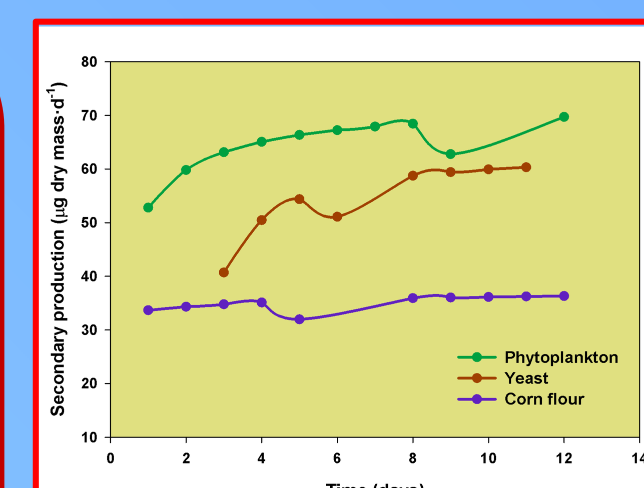

Fig3. Measured daily rates of secondary production in *Daphnia magna* growth on three different types of food

Conclusion 1:

➢Althought the highest global growth rates were obtained with yeast (0.295 d⁻¹), the highest values of the condition factor (5.778) and secondary production (643 µg dry mass· d⁻¹) as well as the maximum weight were found in *Daphnia* fed on phytoplankton (Fig1 and Table 2). A mixture yeast and phytoplankton should be the optimal food for culturing *Daphnia magna.*

Table 2. Secondary production values obtained with several models in µg dry mass·d⁻¹

Kind of food	Measured dates	Huntley and López (1992)	Hirst and Sheader (1997)	Hirst and Lampitt (1998)	Stockwell and Johansson (1997)	Shuter and Ing (1997)
Phytoplankton	643	1979	283	208	719	683
Yeast	452	1000	169	127	502	349
Corn flour	350	1286	224	169	386	454

Conclusion 2:

➢The Huntley and López (1992) model overestimates secondary production, the Hirst and Sheader (1997) and the Hirst and Lampitt (1998) models underestimated them. The best secondary production calculation was found using the Stockwell and Johansson (1997) model (Fig4 and Table 3). This conclusion is also extrapolated to the observed daily growth rates (Table 1).

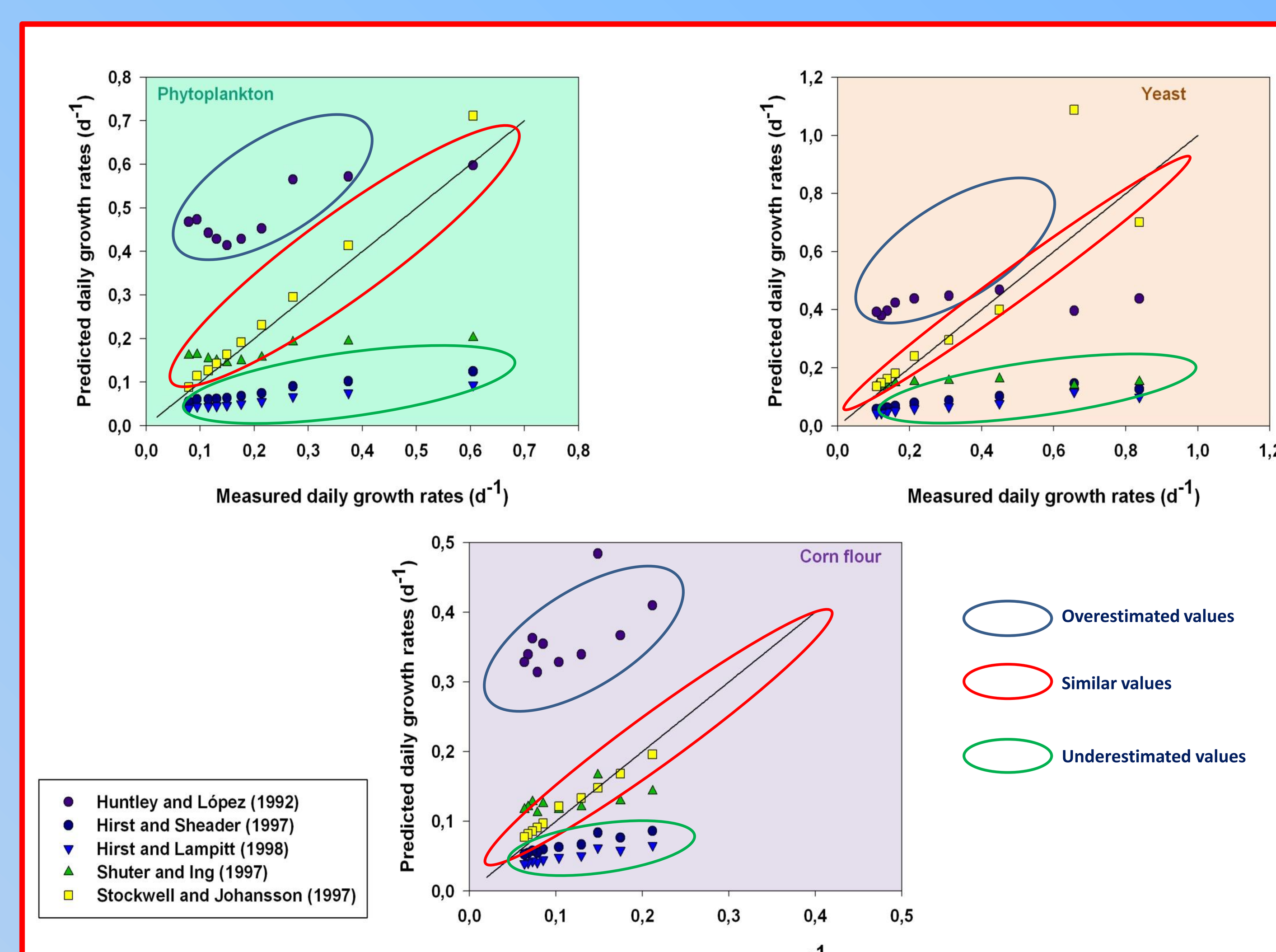

Fig4. Modelled versus measured growth rates in *D. magna* fed three different foods. The line in all three panels represents a one-to-one correspondence. The key identifies the models used.

Conclusion 3:

➢On a utilitarian basis, because size is such a good index of biomass and so easy to measure, we recommend monitoring it, instead of dry-mass, in future growth-rate studies. Montagnes et al. (2010) also recommend size as a proxy for dry-mass in *Oxyrrhis marina*.

Table 1. Daily growth rates (d⁻¹) obtained with several models

Kind of food	Measured dates	Huntley and López (1992)	Hirst and Sheader (1997)	Hirst and Lampitt (1998)	Stockwell and Johansson (1997)	Shuter and Ing (1997)
Phytoplankton	0.221 ± 0.162 (n = 10)	0.484 ± 0.067 (n = 10)	0.076 ± 0.022 (n = 10)	0.056 ± 0.017 (n = 10)	0.248 ± 0.189 (n = 10)	0.166 ± 0.021 (n = 10)
Yeast	0.332 ± 0.262 (n = 9)	0.419 ± 0.030 (n = 9)	0.087 ± 0.031 (n = 9)	0.067 ± 0.026 (n = 9)	0.372 ± 0.322 (n = 9)	0.146 ± 0.009 (n = 9)
Corn flour	0.113 ± 0.051 (n = 10)	0.362 ± 0.050 (n = 10)	0.065 ± 0.012 (n = 10)	0.049 ± 0.009 (n = 10)	0.120 ± 0.041 (n = 10)	0.128 ± 0.016 (n = 10)

Table 3. Relationship between predicted and measured dates of secondary production

Kind of food	Huntley and López (1992)	Hirst and Sheader (1997)	Hirst and Lampitt (1998)	Stockwell and Johansson (1997)	Shuter and Ing (1997)
Phytoplankton	14.99x – 766.73, r^2 = 0.48 (slope = 14.99)	1.72x - 82.51, r^2 = 0.57 (slope = 1.72)	1.24x – 59.26, r^2 = 0.58 (slope =1.24)	0.88x + 14.90, r^2 = 0.76 (slope = 0.88)	5.23x - 268.41, r^2 = 0.48 (slope = 5.23)
Yeast	4.30x – 104.65, r^2 = 0.64 (slope = 4.30)	0.61x – 12.07, r^2 = 0.71 (slope = 0.61)	0.32x + 0.14, r^2 = 0.64 (slope = 0.32)	1.09x + 0.99, r^2 = 0.78 (slope = 1.09)	1.50x – 36.69, r^2 = 0.64 (slope = 1.50)
Corn flour	24.6x – 733.89, r^2 = 0.57 (slope = 24.6)	3.16x – 88.35, r^2 = 0.55 (slope = 3.16)	2.31x – 64.25, r^2 = 0.54 (slope = 2.31)	2.31x – 42.56, r^2 = 0.48 (slope = 2.31)	8.76x – 261.67, r^2 = 0.57 (slope = 8.76)

REFERENCES

▪Hirst, A.G. and M. Sheader, 1997. Are in situ weight-specific growth rates body-size independent in marine planktonic copepods? A re-analysis of the global syntheses and a new empirical model. *Marine Ecology Progress Series* 154:155-165

▪Hirst, A.G. and R.S. Lampitt, 1998. Towards a global model of in situ weight-specific growth in marine planktonic copepods. Marine Biology 132: 247-257

▪Huntley, M.E. and M.D.G López, 1992. Temperature-dependendent production of marine copepods: a global synthesis. *American Naturalist*, 140:201-242

▪Lovegrove, T., 1966. The determination of the dry weight of plankton and the effect of various factors on the values obtained. *In: Some comteporary studies in marine science. (H. Barnes ed.). George Allen and Unwin LTD*. London. pp 429-467.

▪Shuter, B.J. and K.K. Ing, 1997. Factors affecting the production of zooplankton in lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 54: 359-377

▪Stockwell, J.D. and O.E. Johansson, 1997. Temperature-dependent allometric models to estimate zooplankton production in temperate freshwater lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 54:2350-2360

▪Montagnes, D.J.S., C.D. Lowe, L. Martin, P. Watts, N. Downes-Tettmari, Z. Yang, E.C. Roberts & K. Davidson, 2010. *Oxyrrhis marina* growth, sex and reproduction. Journal of Plankton Research, doi: 10.1093/plankt/fbq111