Growth expansion modeling: kinetic energy tool to measure efficacy, efficiency, economicity and effectiveness

RESUME

This work, in partnership with Dr. Ermias Kebreab (University of Davis), was carried out with the objective of expanding (new models) and perfecting (new applications) the PPFM (Practical Program of Forces Modeling) by promoting the analysis of energy efficiency in growth curves, seeking:

1- Practicality - The PPFM for incorporating the solver supplement (Excel optimizer), will provide the attendance of the adjustments of different curves, in an accurate and free access;

2- Originality - The originality is that the PPFM program allows to evaluate growth (expansion), with multiple objectives, and can be applied in research, teaching (undergraduate and postgraduate) and extension in several areas;

3- Relevance - If we confirm our hypotheses, the modeling concept will be more appropriate when evaluating kinetic energy as a precision tool to measure efficacy, efficiency, economicity and effectiveness.

Therefore, we believe that the project is rich in several merit criteria, for enabling a current and practical modeling concept (force modeling and kinetic evaluation) and that can now be applied with the use of the PPFM spreadsheet, which is open and accessible (use of Excel software from Microsoft) allow for adjustments, with accuracy and precision, in the mathematical models adopted as decision support.

1. INTRODUCTION AND JUSTIFICATION

1.1- The Beauty of Similarities

"The great book of the Universe is written in mathematical language!" (Galileo Galilei / 1564-1642).

The dynamics of growth in biological (or not) structures, although complex, follow basic physical laws, allowing the approximation of Mathematics and Biology (Penna & Oliveira, 2008) (Figure 1).

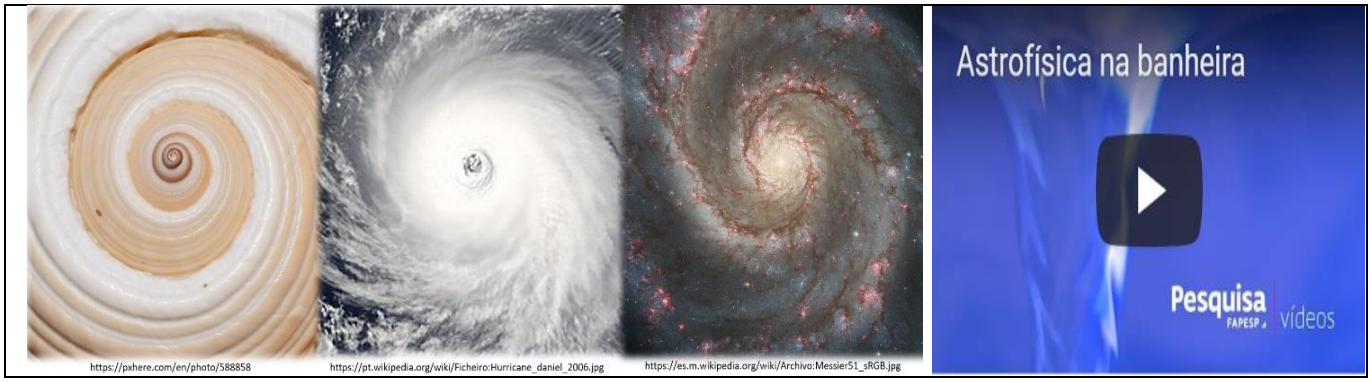


Figure 1. The beauty of the similarity in the Fibonacci sequence (Golden Ratio) in nature and in the universe**.** Astrophysics in the bathtub: Experiment reproduces phenomena that may occur near black holes (https://youtu.be/QI4TR_D8VrI).

Beautiful are the images with similarities in their logarithmic spiral form, called *Spira mirabilis* (wonderful spiral) by Jacob Bernoulli (https://en.wikipedia.org/wiki/Jacob_Bernoulli).

Similarities that even allow "Astrophysics in the bath".

1.2-The "bravery" of the Sigmoid

Another beautiful similarity also emerges for the sigmoid asymptotic growth functions in biological processes, which are almost in their majority, non-linear (MISCHAN & PINHO, 2014).

It is clear that at the beginning and for a certain period the growth, represented by the sigmoid curve, "struggle" to maintain a "J" shape (Figure 2). At this first moment of the sigmoid curve the initial mass is favorable, as well as other resources (nutritional, space, body volume, etc.). This voltage is ruptured exactly at point F1. From this point on, it presents itself as a linear form and preserves its bravery in order to remain so, since there are opposing forces in order to, once again, de-characterize this format. The said resistance is overcome at point F2, whose shape passes a decreasing exponential.

Definitely the sigmoid curve succumbs to external pressures to stabilize at its asymptotic plateau, that is, "pressures" that flatten more and more its curvature.

In this last phase (exponential descending) the own mass acquired militates against. In other words, the nutritional requirements (maintenance) make the synthesis of new biomass unfeasible. Thus, all features are carried to "keep" the accumulated mass around the sigmoid path (Banavar et al., 2002; WEST et al., 2002; CASSIANO et al 2018).

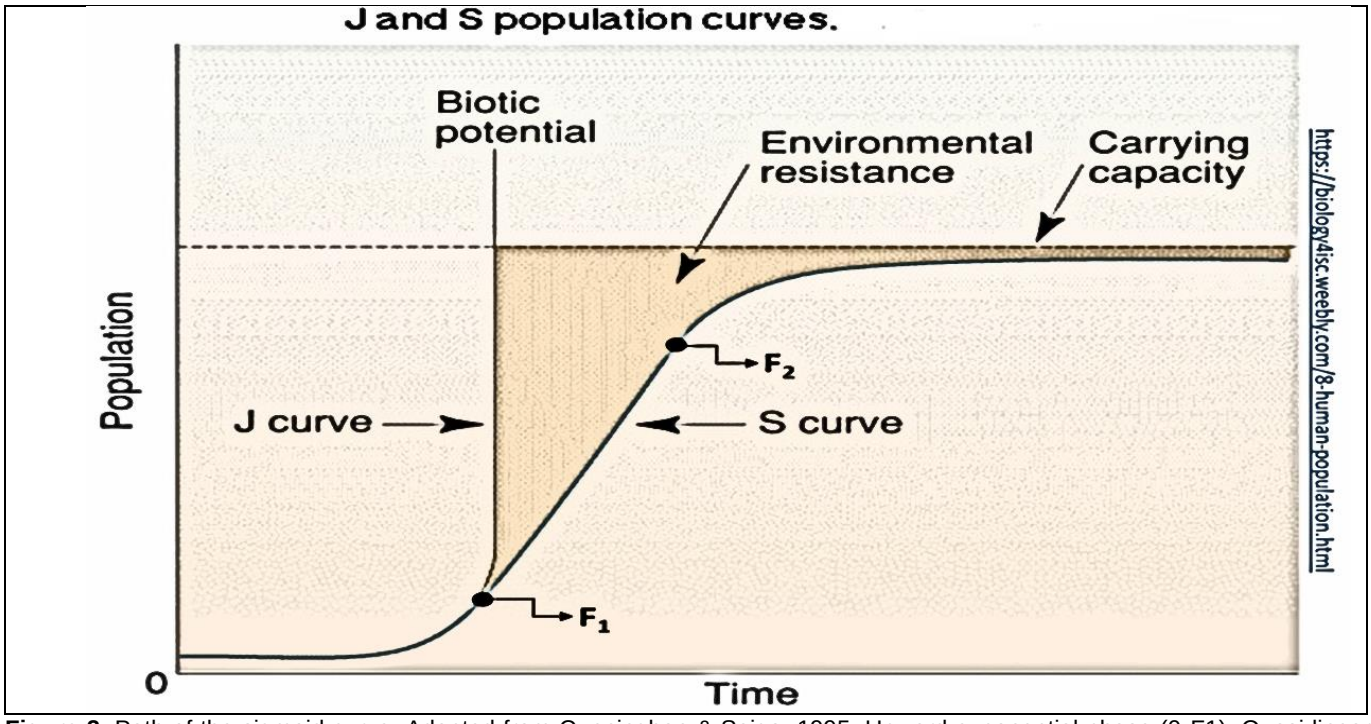


Figure 2. Path of the sigmoid curve. Adapted from Cunninghan & Saigo, 1995. Upward exponential phase (0-F1); Quasi-linear phase (F1-F2); Falling exponential phase (F2-∞).

This path (growth) involves interactions with the environment (favorable or not), preventing the growth path from being kept identical for the same species. This implies that one should be dynamic to adjust to the new realities in each case, including the choice of the most suitable model for each new scenario, with comparisons between different models according to the criteria of information Bayesian (BIC) and corrected Akaike (AICc), which allow the selection of a more adjusted model, by evaluating which one best explains the phenomenon studied (MOTULSKY & CRISTOPOLOS, 2004).

Thus, it is clear and definite that there is to choose models with free inflection point for assessing the metabolic and catabolic more biological accuracy, not allowing "mathematical symmetries" (logistic and Gompertz curves) (Marinakis, 2012; TjØRVE & TJØRVE, 2017).

In this project the "Richards Model" is presented as an "example". Other applicants will be models of modified Gompertz (4 parameters), Weibull, Richards - 5 parameters and a double sigmoid for more complex situations (SEBER & WILD, 2003; Lipovetsky, 2010; TjØRVE & TJØRVE, 2017).

1.3. Mathematical models vs. inflection point

The study of mathematical models of growth curves is already well used in biology, explaining well the growth dynamics (MAKARIEVA et al, 2004).

Many are the proposed sigmoid models to evaluate growth. However, the main difference is that some have the fixed inflection point (KNÍŽETOVÁ et al., 1995).

1.3.1 Logistics Curve

It is considered to be the most used for curve fitting. However, although it is very popular, it has the drawback of having its inflection point fixed at exactly half of the asymptotic maximum value. Consequently, the speed will always be maximal at 50% of the curve (Figure 3). This indicates that the acceleration is always maximum and minimum in positions also symmetrical in the curve (GREGORCZYK, 1991). These accuracies (symmetry) are not biologically coherent (SEBER & WILD, 2003).

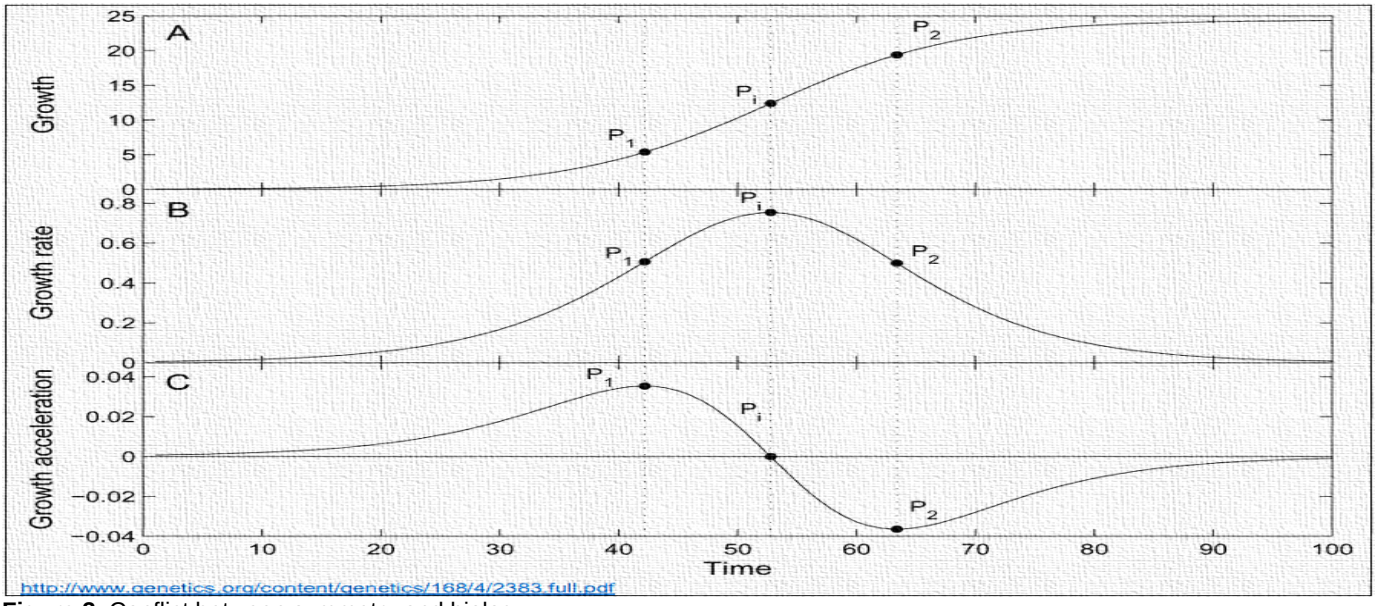


Figure 3. Conflict between symmetry and biology.

This is cruel and severe mathematics for biological events, for forcing the responses to mold into symmetric events that would rarely occur, let alone never.

1.3.2 Traditional Gompertz curve (three parameters)

If the logistic curve is held in "halves", the Gompertz curve is predetermined to define the curve flexion (concave to convex) always at 36.79% of the asymptote value. Such inflexible behavior implies a faster "growth" in the beginning and, later, in a slower approximation to reach the maximum value predicted

for the asymptote. Therefore, it is a great limitation to have the fixed inflection point in its initial third (KOYA & GOSHU, 2013).

1.3.3 Richards curve, New Gompertz, Weibul and Logistics dubla

They present the inflection point free, which allows flexibility to the curve. As we have the proposal to evaluate energy efficiency, the models with free inflection points are the nominees of the proposal (ZUIDHOF, 2005; TJØRVE & TJØRVE, 2017).

The virtues here advocated not only to define a curve, but to dissect important information inherent in its trajectory (speed and acceleration) may be the way to unravel outstanding mysteries not yet discussed (SHIMOJO et al, 2006, 2010).

1.4. Modeling of forces in the kinetics of growth

Approaching "Energy" is almost philosophizing about one of the concepts with multiple applications in nature (SHIMOJO, 2017).

Defining the concept of energy is still a challenge for physics, which in a very simple way would be: energy, ability to perform work.

Thus outlined, energy is neither created nor destroyed, it only transforms from one form to another. In this way, its total quantity remains constant (https://pt.wikipedia.org/wiki/Lei_de_about_energy).

The energy that relates to the movement of bodies is kinetics, that is, in biological areas, would be the ability to induce some kind of change (growth, expansion).

By analogy, one might think that the evaluation of the efficiency and economy of an engine is in transforming the greater amount of thermal energy (fuel burning) into kinetic energy (movement) (https://blogdoenem.com.br/energia-cinetica/).

Similarly, when we think of efficiency in animal production, several are the energy resources offered (Figure 4).

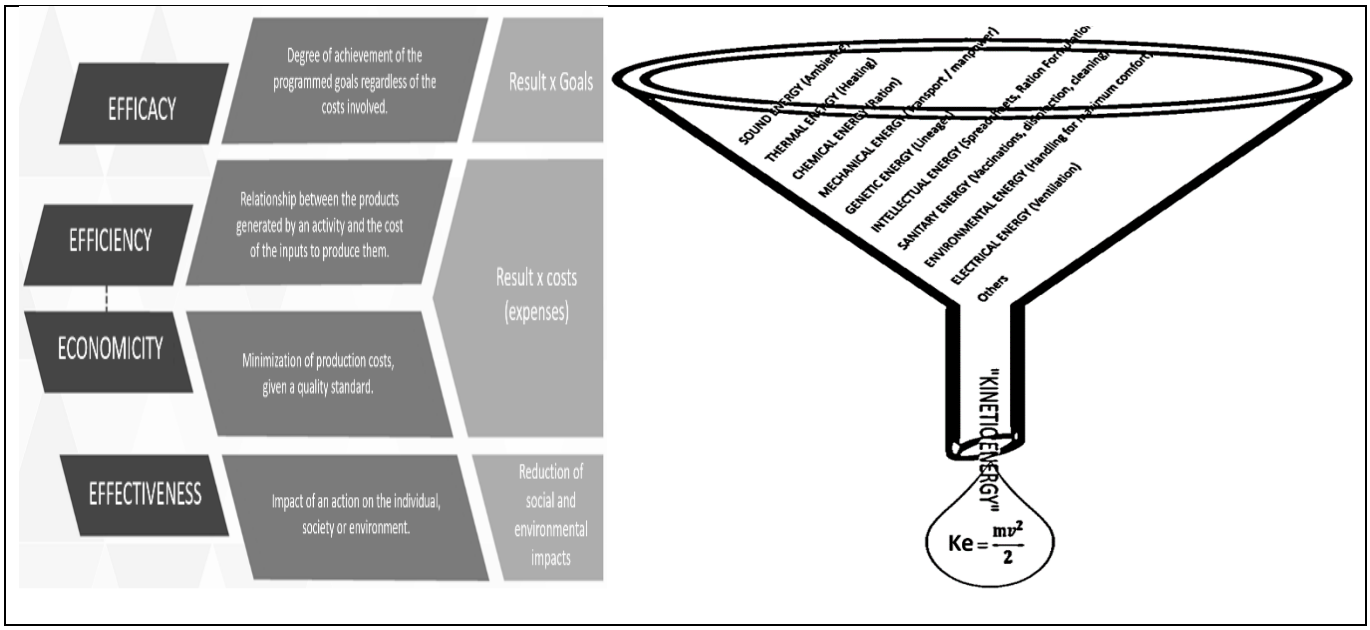


Figure 4. Transformation of energy resources into kinetic energy. Efficacy, efficiency, economicity and effectiveness. Adapted from https://www1.tce.pr.gov.br/multimidia/2016/12/png/00307980.png

Like a motor, an animal destined for production will be more economical and efficient in proportion to the transformation of all the "energy resources" it receives into "Kinetic Energy", measured by mass and velocity at each moment of the growth curve.

Probably kinetic energy is a strong candidate as a "universal currency" in the appreciation of efficacy, efficiency, economicity, and effectiveness as a diagnostic tool in dynamic processes (Figure 6).

In this context, it is reasonable to predict that in the evaluation of the growth dynamics of any biological structure, it will approximate physics to biology, since laws of physics are already well defined (PENNA & OLIVEIRA, 2008).

For example, kinetic energy has quadratic dependence (v^2) in its formula. This implies that by doubling the "growth rate ≈ velocity" of an organism, kinetic energy will quadruple. This allows even for bodies with the same mass, one of them presents higher energy due to the quadratic speed attribute (Table 1).

Table 1. Relationship between mass, velocity and kinetic energy.

mass	velocity	kinetic energy
1	1	0,5
2	1	1
3	1	1,5
4	1	2
1	2	2
2	2	4
3	2	6
4	2	8
1	3	4,5
2	3	9
3	3	13,5
4	3	18
1	4	8
2	4	16
3	4	24
4	4	32

In this way, the mass of the body is proportional to the kinetic force. In addition, bodies having identical velocities (growth rates), the heavier will have the highest kinetic energy value.

Traditionally, we analyzed animal performance by weight gain (mass). However, by the Kinetic Energy equation, the "greatest merit" lies in the speed at which this mass is enlarged (mass expansion).

1.5. Details and qualities of the Sigmoid Curve in the dynamics of growth

Aiming to reconcile new options of models, especially with free inflection point, in order to facilitate dynamic interpretation of growth and the understanding of mass and velocity relationships in the growth dynamics of biological structures, we are proposing a joint work between UNESP (Araçatuba) and the University of California (Davis).

To do so, a new spreadsheet called PPFM (Practical Program for Forces Modeling) (Figure 5) was proposed.

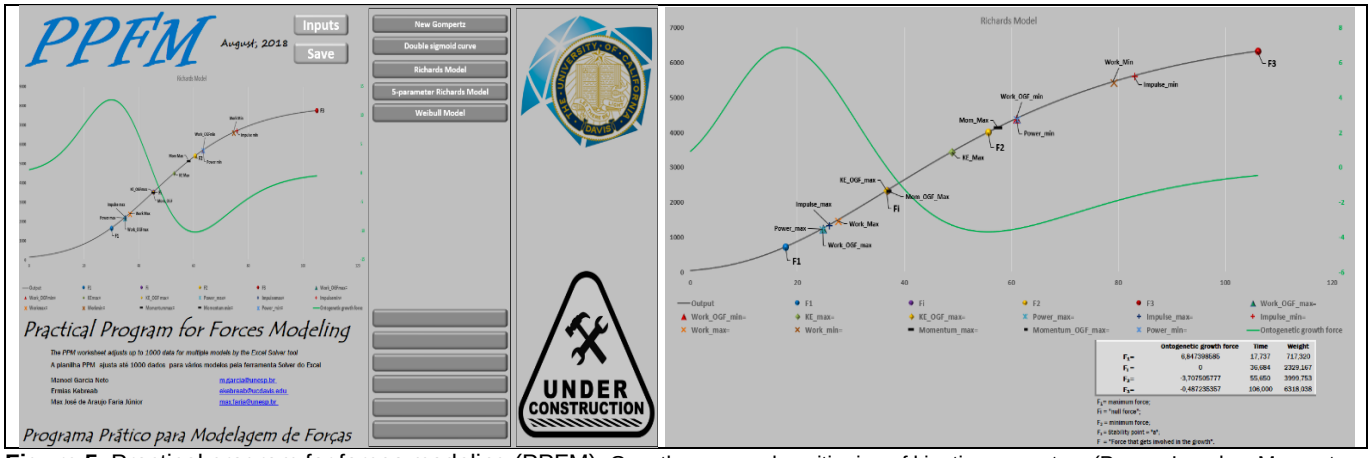


Figure 5. Practical program for forces modeling (PPFM). Growth curve and positioning of kinetic parameters (Power, Impulse, Momentum, Work and Kinetic Energy) and points of curvature (F1, Fi, F2 and F3)

It is necessary to point out that the PPFM spreadsheet has great flexibility because it allows the use of different units to measure the expansion of the mass / output (e.g. kg, grams, individuals, meter, µm3, etc.) of a body, and also to characterize the time / input (e.g. hours, minutes, seconds, days, etc.).

Although the studied body is subject to several forces (nutritional, environmental, genetic, etc.), favorable or not, we will have, in the end, only the effect of a single resulting force (F), that is, the "vector sum" of all forces acting on the structure under study, resulting in kinetic energy.

As the assessed physical structure will normally have its increasing weight (mass) until reaching its asymptote, it will not necessarily be proportional to the acceleration with respect to the resulting force applied to the object, as would be expected for a constant weight mass. Therefore, the larger the mass, the greater the resistance of the body to the change of its speed.

The PPFM spreadsheet allows you to accommodate various formulas of dynamics, such as:

Newton's 2nd Law	F = m.a
Work (W)	W = F.Δd
Mechanical power (P)	P = F.v
Kinetic energy (Ke)	$Ke = \frac{mv^2}{2}$
Quantity of Movement (Q)	Q = m.v
Impulse (I)	I = F.Δt

m = mass; a = acceleration; Δd = displacement; v = velocity.

Thus, for a year the "PPFM" Spreadsheet, whose "embryo" is already very promising with the Richards Model, should be finalized, signaling that there is a lot of useful information hidden in the sigmoid curve.

Going into this new approach, using our model still in the embryonic stage, but already very promising, we can gauge:

a- The need to use models with free inflection point;

b- The importance of asymmetry for both velocity curves and acceleration;

c- The possibility of characterizing, mathematically, the curve in three distinct events (ascending exponential phase, linear phase, descending exponential phase), which houses the following novelties in these intervals (Figure 5).

1.5.1. Exponential Ascending Phase (0↔F1)

Maximum work (W_{max})	$W_{max} = F.\Delta d$
Maximum Mechanical Power (P_{max})	$P_{max} = F.v$
Maximum impulse (I_{max})	$I_{max} = F.\Delta t$

It is evident that these previous formulas (W_{max}, P_{max} and I_{max}) present in common the acceleration (F = m.a) as the primordial factor to define their positioning between F1 and Fi. Thus, growth seeking "acceleration" can be evaluated by these equations.

1.5.2. Inflection point "Fi"

At this point, the kinetic force of ontogenic growth and the moment of ontogenic force are superimposed. A new approach to this important point of the curve may be the action at the "peak" of the new biomass, in defining this passage from the concave to the convex curve.

1.5.3. Fi ↔ F2

Here, it is the action of speed, not acceleration, that reigns. In defining these new placements. That is, Ke_{max} and Mom_{max}.

Kinetic Energy (Ke)	$Ke = \frac{mv^2}{2}$
Movement Quantity (Q_{max})	$Q_{max} = m.v$

1.5.4. F2 ↔ Asymptote

Appears in this interval as W_{min}, P_{min}, W_{min}, I_{min}.

Minimum work (W_{min})	$W_{min} = F.\Delta d$
Minimum Mechanical Power (P_{min})	$P_{min} = F.v$
Minimum impulse (I_{min})	$I_{min} = F.\Delta t$

1.5.5. Point F3

All events succumb to pressures, and neither acceleration nor velocity can sustain "growth".

1.6. Adjusting curves to evaluate forces through the PPFM spreadsheet

To exemplify the scope of this new and inedited approach to energy efficiency analysis in growth curves, three examples will be used:

Example 1: Description of cancerous tumor growth (Marusic, 1994; Liu et al., 2013). (Figure 6)

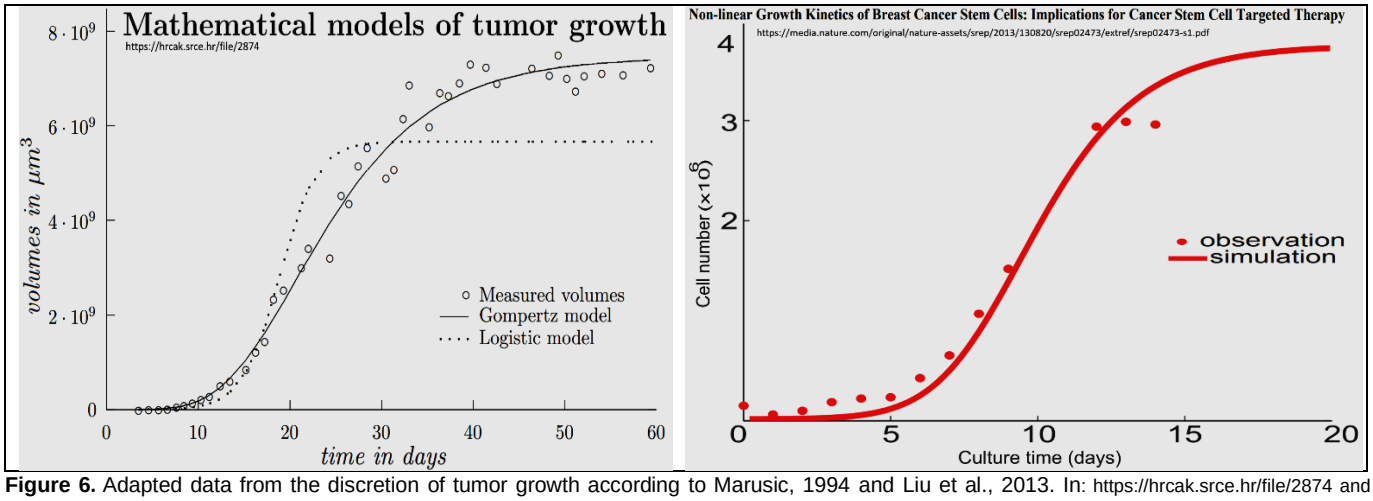


Figure 6. Adapted data from the discretion of tumor growth according to Marusic, 1994 and Liu et al., 2013. In: https://hrcak.srce.hr/file/2874 and https://www.nature.com/articles/srep02473.pdf https: //media.nature.com/original/nature-assets/srep/2013/130820/srep02473/extref/srep02473-s1.pdf

The data were obtained using the Free WebPlotDigitizer Program by Ankit Rahatgi (https://apps.automeris.io/wpd/) (Figure 7).

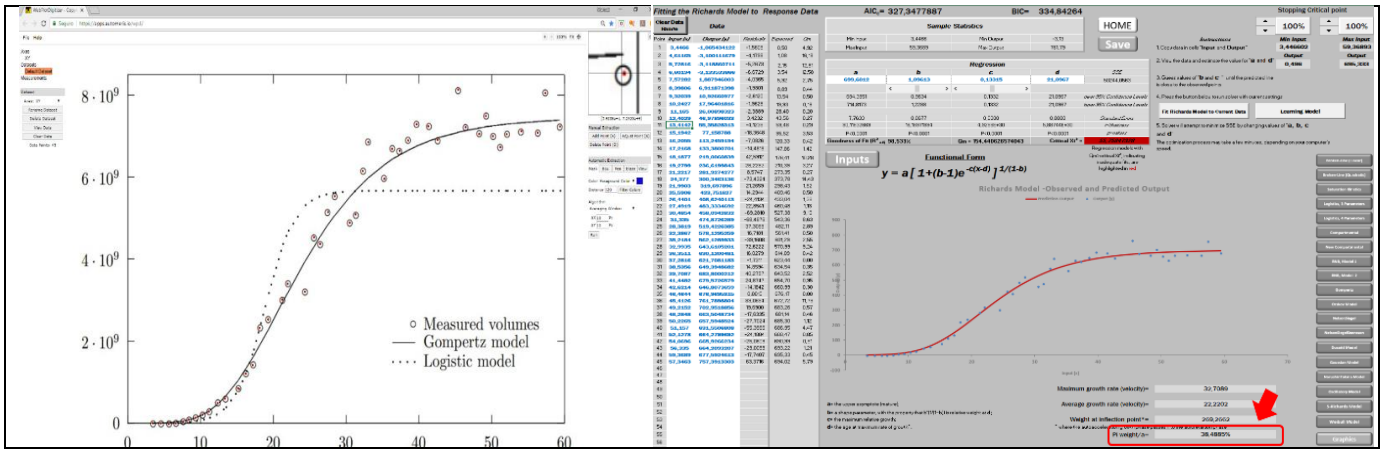


Figure 7. Data determination according to the WebPlotDigitizer User Survey spreadsheet (Published: April 2018) https://apps.automeris.io/wpd/. Growth curve adjusted by the PPM spreadsheet, according to the Richards model, conformed to those provided by Marusic (1994).

Because it is well documented that many growth curves are adequately adjusted by the Gompertz model, obtained from live and in vitro data (Brunner et al., 1985, Norton et al., 1976, Norton 1988), there is a "That this is a general rule". Coincidence is the case studied by Marusic (1994), who presented in our adjustment by the PPFM spreadsheet, the inflection point in 38.49% of the asymptote value, that is, Gompertz because it is very close to the initial third of the curve.

However, in accordance with to data obtained by the PPFM spreadsheet, according to those provided by Liu et al. (2013), the inflection point was 69.98% of the asymptote (Figure 8), that is, the opposite of that observed by Marusic (1994). In this way, this is a case where the growth curve should not

be Gomperized. This is because the unsafe information from it is extended to its later derivatives (speed and acceleration), with serious possible prejudices to the conclusions.

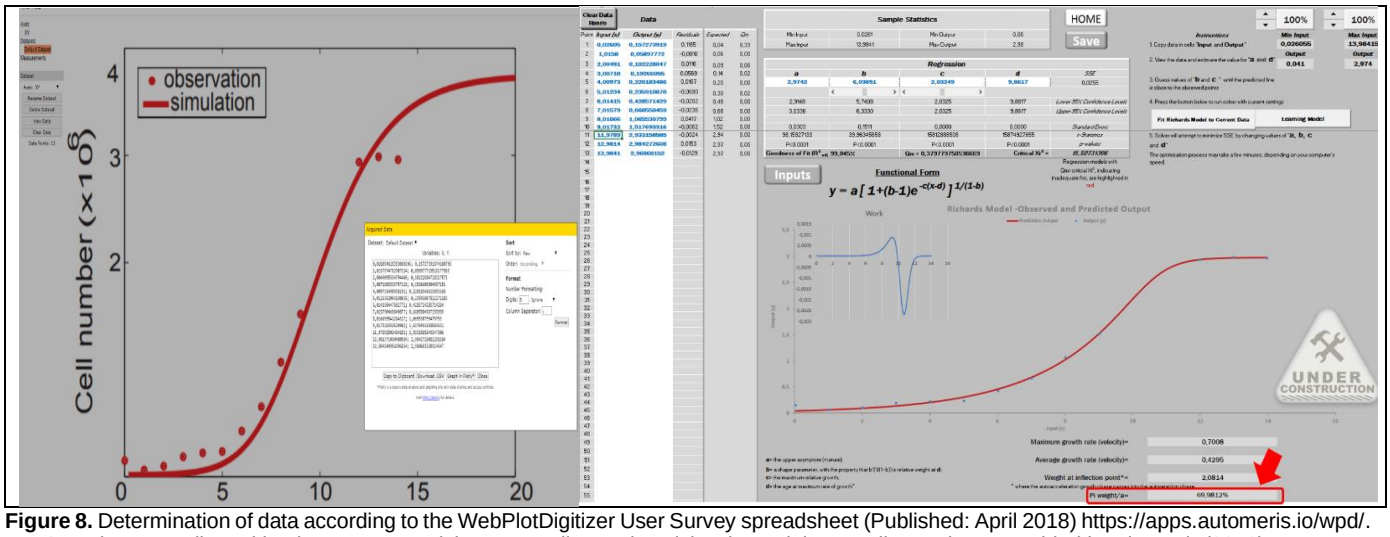


Figure 8. Determination of data according to the WebPlotDigitizer User Survey spreadsheet (Published: April 2018) https://apps.automeris.io/wpd/. Growth curve adjusted by the PPM spreadsheet according to the Richards model, according to those provided by Liu et al. (2013).

In order to show the need for biological and mathematical fit, Wu et al. (2004) emphasizes the great importance of describing the three stages of cancer: the initial exponential growth, the linear intermediate phase, and finally, the decline of tumor growth. By knowing this trajectory, it would be possible to define with more precision the onset of clinical symptoms and the moment of the manifestation of the most serious problems and the chemotherapeutic interventions.

Marusic (1994) concludes his study saying that it is not enough just to describe the growth curve well, but warns about the need for another criterion for selecting the most appropriate model. This is exactly what we propose, to offer a free program to estimate parameters by the non-linear method of least squares, of free inflection models, that allows the interpretation and the understanding of the growth from the point of view of "energy efficiency" throughout its course.

Example 2: description of E. coli growth (Figure 9).

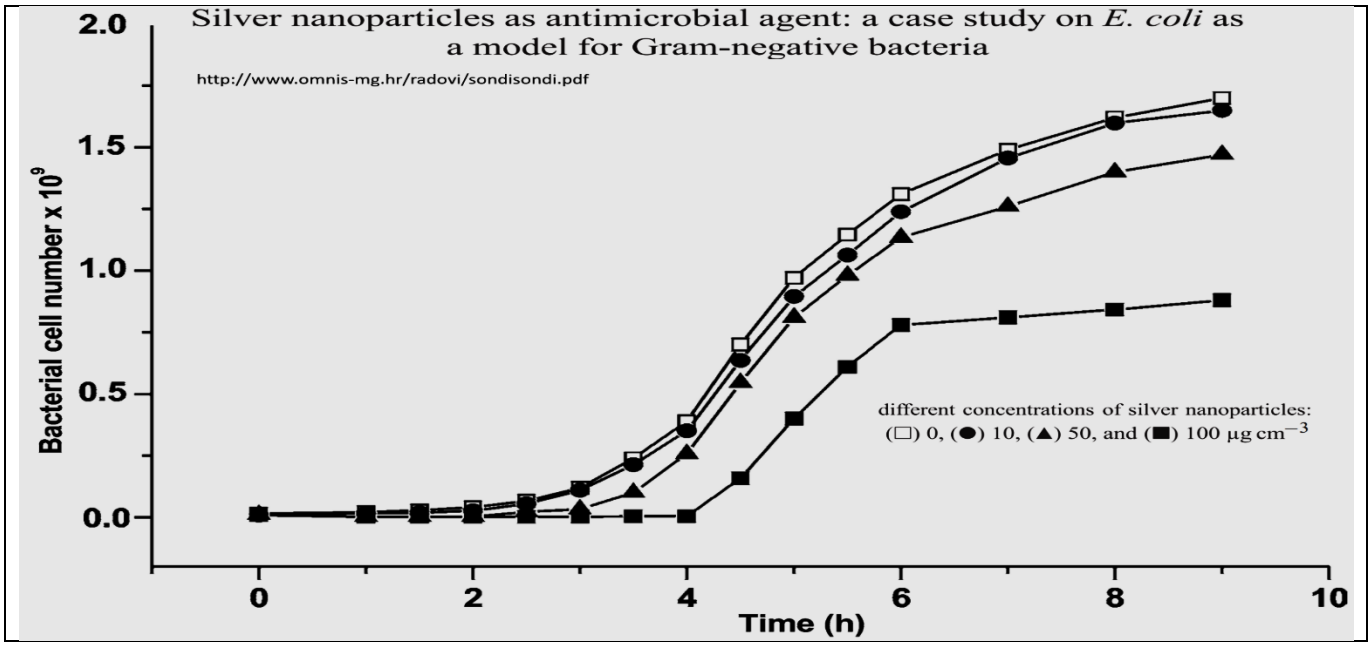
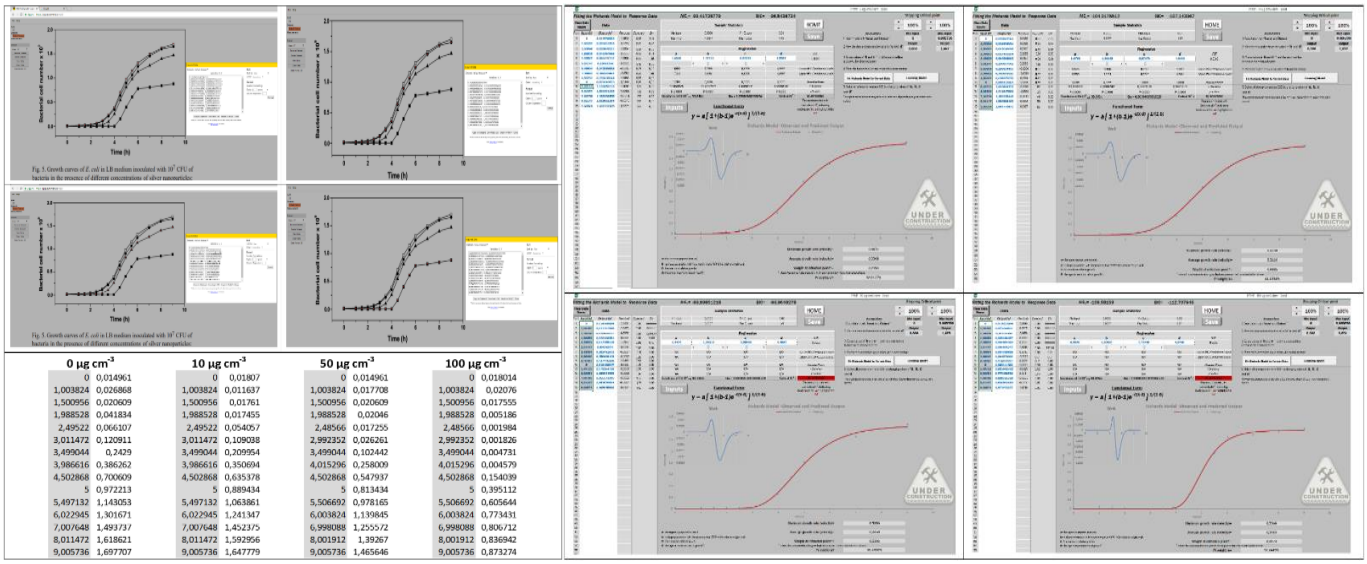


Figure 9. Adapted data from the secretion of E. coli growth, according to Sondi & Salopek-Sondi, 2004. In: http://www.omnis-mg.hr/radovi/sondisondi.pdf

Using the same procedure as in the first example, the data characterizing the four curves were obtained using the free WebPlotDigitizer User Survey (Published: April 2018 / https://apps.automeris.io/wpd/) (Figure 10).



0 μg cm^{-3}		10 μg cm^{-3}		50 μg cm^{-3}		100 μg cm^{-3}	
0	0,014961	0	0,01807	0	0,014961	0	0,018014
1,003824	0,026868	1,003824	0,011637	1,003824	0,017708	1,003824	0,02076
1,500956	0,020609	1,500956	0,01761	1,500956	0,020609	1,500956	0,017555
1,988528	0,041834	1,988528	0,017455	1,988528	0,02046	1,988528	0,005186
2,49522	0,066107	2,49522	0,054057	2,48566	0,017255	2,48566	0,001984
3,011472	0,120911	3,011472	0,109038	2,992352	0,026261	2,992352	0,001826
3,499044	0,2429	3,499044	0,209954	3,499044	0,102442	3,499044	0,004731
3,986616	0,386262	3,986616	0,350694	4,015296	0,258009	4,015296	0,004579
4,502868	0,700609	4,502868	0,635378	4,502868	0,547937	4,502868	0,154039
5	0,972213	5	0,889434	5	0,813434	5	0,395112
5,497132	1,143053	5,497132	1,063861	5,506692	0,978165	5,506692	0,605644
6,022945	1,301671	6,022945	1,241347	6,003824	1,139845	6,003824	0,773431
7,007648	1,493737	7,007648	1,452375	6,998088	1,25557	6,998088	0,806712
8,011472	1,618621	8,011472	1,592956	8,001912	1,39267	8,001912	0,836942
9,005736	1,697707	9,005736	1,647779	9,005736	1,465646	9,005736	0,873274

Figure 10. From the free spreadsheet WebPlotDigitizer User Survey (Published: April 2018) https://apps.automeris.io/wpd/ from the discretion of E. coli growth, according to Sondi & Salopek-Sondi, 2004. In: http://www.omnis-mg.hr/radovi/sondisondi.pdf. Growth curves of E. coli, adjusted according to the PPFM spreadsheet.

Subsequently, the values were rotated in the PPFM spreadsheet, according to the evaluated levels of silver nanoparticles (0, 10, 50 and 100 μg cm-3) (Figure 11).

Among the several outputs of the PPFM spreadsheet, we highlight the sum of the kinetic energy of the studied period. For this, a great facilitator is that the Excel spreadsheet allows the overlap of curves.

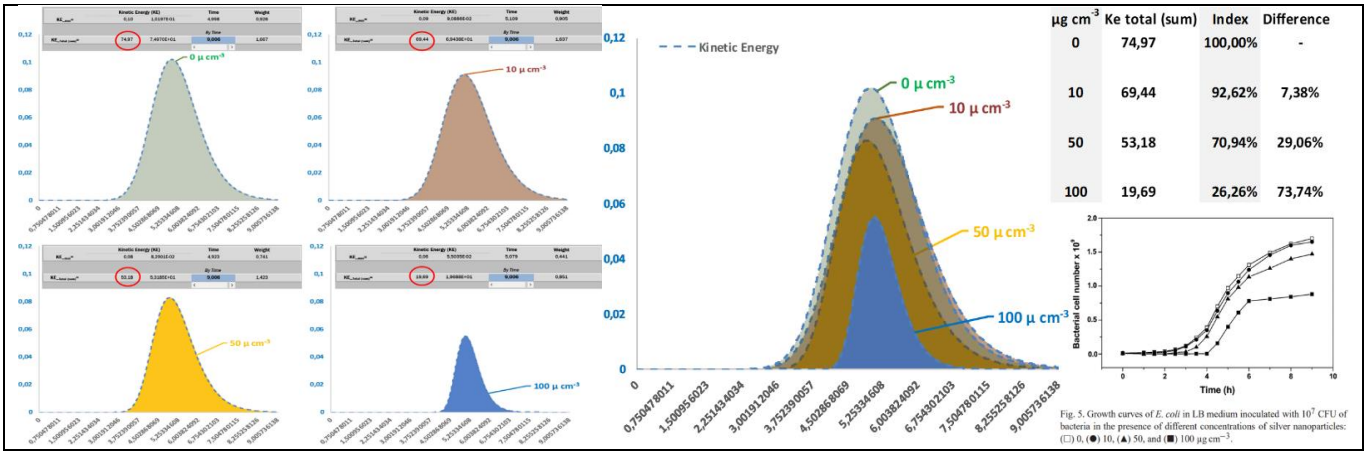


Figure 11. Sum of the kinetic energy of all studied period, according to the PPFM spreadsheet. Original data according to the discretion of E. coli growth, according to Sondi & Salopek-Sondi, (2004). In: http://www.omnis-mg.hr/radovi/sondisondi.pdf. Overlap of curves Sum of the kinetic energy of all studied period.

Through this procedure, after the necessary scale adjustments of the graphs, a reduction of 7.38%, 29.06% and 73.74%, respectively, for the 10, 50 and 100 µg cm^{-3} doses is perfectly visualized. This fact is very promising and encouraging, because much more information, which until the present moment, was hidden in the sigmoid curves.

Example 3: description of the growth of broilers.

The next example of curve fitting indicates the economicity and efficiency in the growth path of broiler chickens, according to sex and lineage (Figure 12), adjusted by the PPFM spreadsheet (Figure 5).

GROWTH MODELING, BODY AND FEATHER COMPOSITION IN BROILER CHICKENS

https://repositorio.unesp.br/bitstream/handle/11449/151288/goncalves_ca_dr_jabo_int.pdf?sequence=6&isAllowed=y

Average body weight (g) of broilers at different ages according to strains

Age[1]		Strain/sex					
		Cobb		Hubbard		Ross	
Male	Female	Male	Female	Male	Female	Male	Female
0	0	42.0	45.2	41.0	38.0	44.0	42.0
7	8	182.2	212.0	139.6	159.4	155.0	193.2
14	15	495.4	544.2	400.8	434.2	436.3	484.2
21	22	1000.8	1027.5	844.6	869.2	908.3	922.1
28	29	1687.1	1625.8	1468.3	1428.8	1561.3	1470.0
35	36	2477.1	2282.9	2172.5	2022.9	2290.8	2081.3
42	43	3237.3	2888.0	2897.9	2587.6	3029.6	2681.5
49	50	3924.0	3537.9	3722.5	3225.3	3922.5	3301.7
56	63*	4824.2	4546.3	4619.6	4191.8	4803.2	4386.3
70	71	6187.7	5021.3	6251.8	4816.3	6245.6	4872.1
84	85	7035.5	5716.7	7486.4	5830.0	7415.7	5557.9
105	106	7659.3	6309.2	8111.9	6375.5	7608.8	6429.2

[1] Values correspond to the average of 12 individual measurements per sex and strain.
* Females corresponded with the body weight measured at 63d.

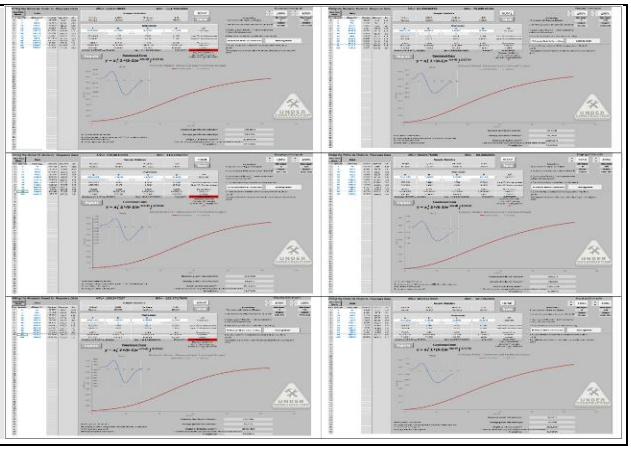


Figure 12. Adapted data from description of broiler growth. In: https://repositorio.unesp.br/bitstream/handle/11449/151288/goncalves_ca_dr_jabo_int.pdf?sequence=6&isAllowed=y. Data adjusted by the PPFM spreadsheet for the growth of broilers, by sex and lineage.

The maximum kinetic energy represents the instant at which the performance efficiency is at its apex. On the other hand, the total kinetic energy (sum) corresponds to the sum of what has been converted, day by day, into kinetic energy (Figure 13). In this way, kinetic energy, as an indicator of efficiency and economy, is much more sensitive in assessing the performance of the animal in relation to its growth path (curve).

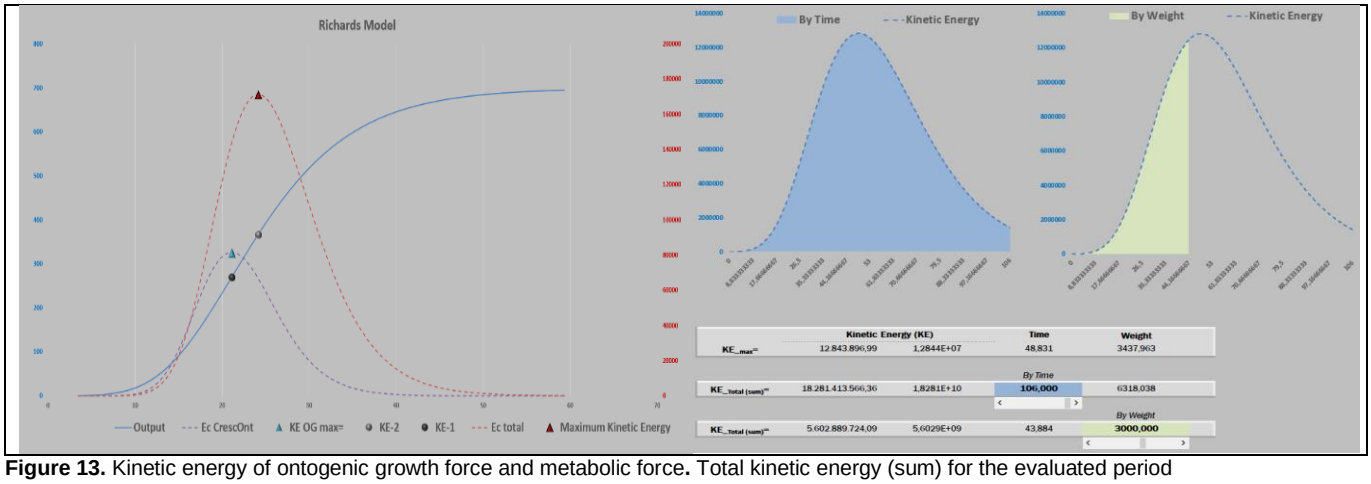


Figure 13. Kinetic energy of ontogenic growth force and metabolic force**.** Total kinetic energy (sum) for the evaluated period

That is, when the maximum amplitude was evaluated, the weight (mass) presented a percentage variation of 2% (females) and 6% (males), at 105 days of age. However, when considered in cumulative kinetic energy (sum), the percentage values for the maximum amplitude are 5.7% (females) and 20.1% (males) for the accumulated energy (sum) (Figure 14).

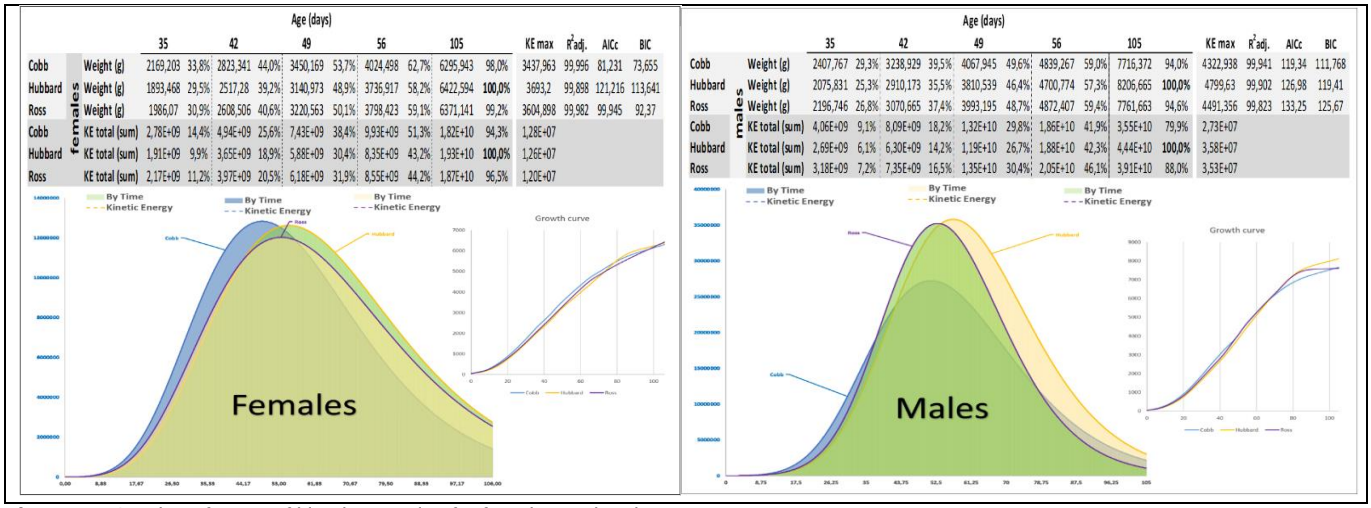


Figure 14. Overlap of sums of kinetic energies for females and males.

Therefore, this difference in measurement (mass vs. kinetic energy), with great clarity, shows that there is much more sensitivity in determining growth (curve) using the sum of the kinetic energy of the studied period as indicated, than simply the accumulated mass in the period.

As a practical application of the study of curves and their unfolding in forces, one can compare the genetic progression of lineages (genetic houses), improvements in nutrition, environmental improvements, handling and benefits of good health or several possible combinations above.

Finally, the efficiency of the system (goal achievement independent of costs) must be analyzed together with efficiency and cost-effectiveness (kinetic energy) and also with an assessment of effectiveness (impact on the environment). For this, it is proposed in this project to offer a new tool (PPFM spreadsheet) that allows to evaluate the performance in its fullness (efficacy, efficiency, economicity and effectiveness).

Example 4: description of the growth of turkey hens.

The next and last example of curve fitting indicates the efficiency in the growth path of turkey hens, according to year (Figure 15 and 16), adjusted by the PPFM spreadsheet.

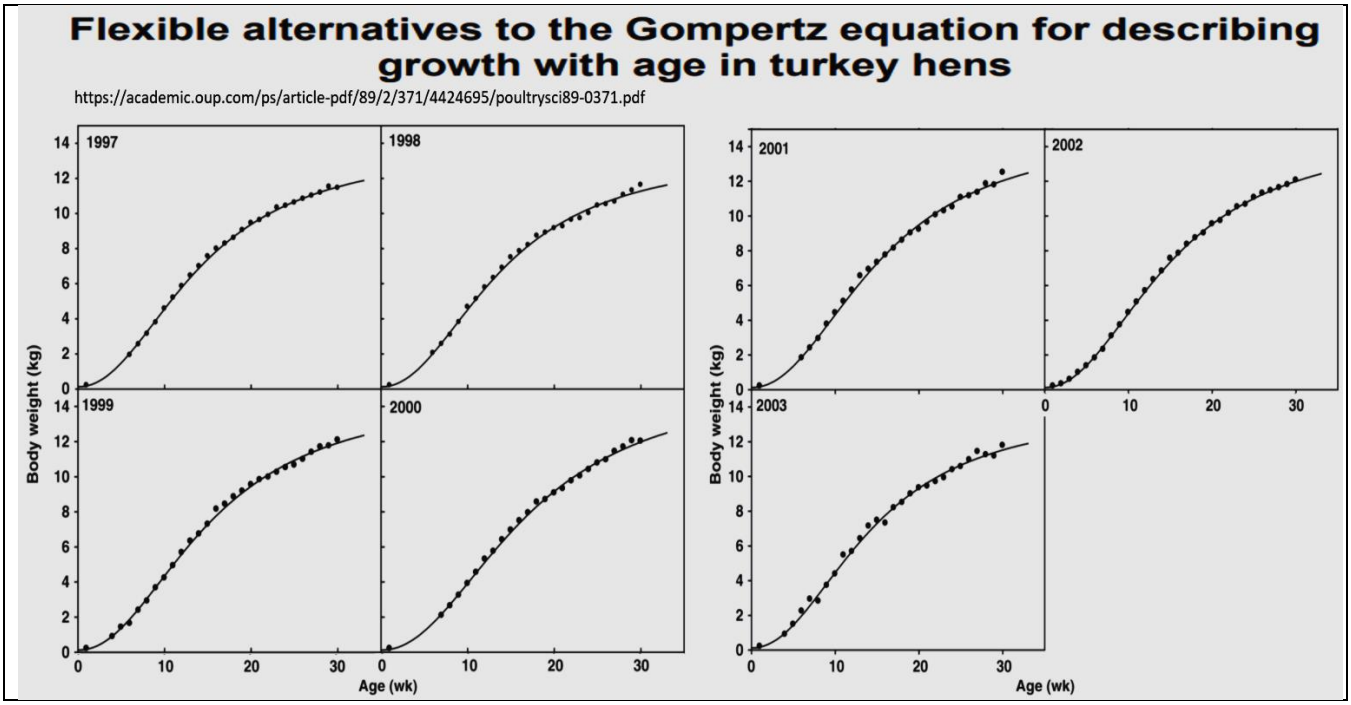
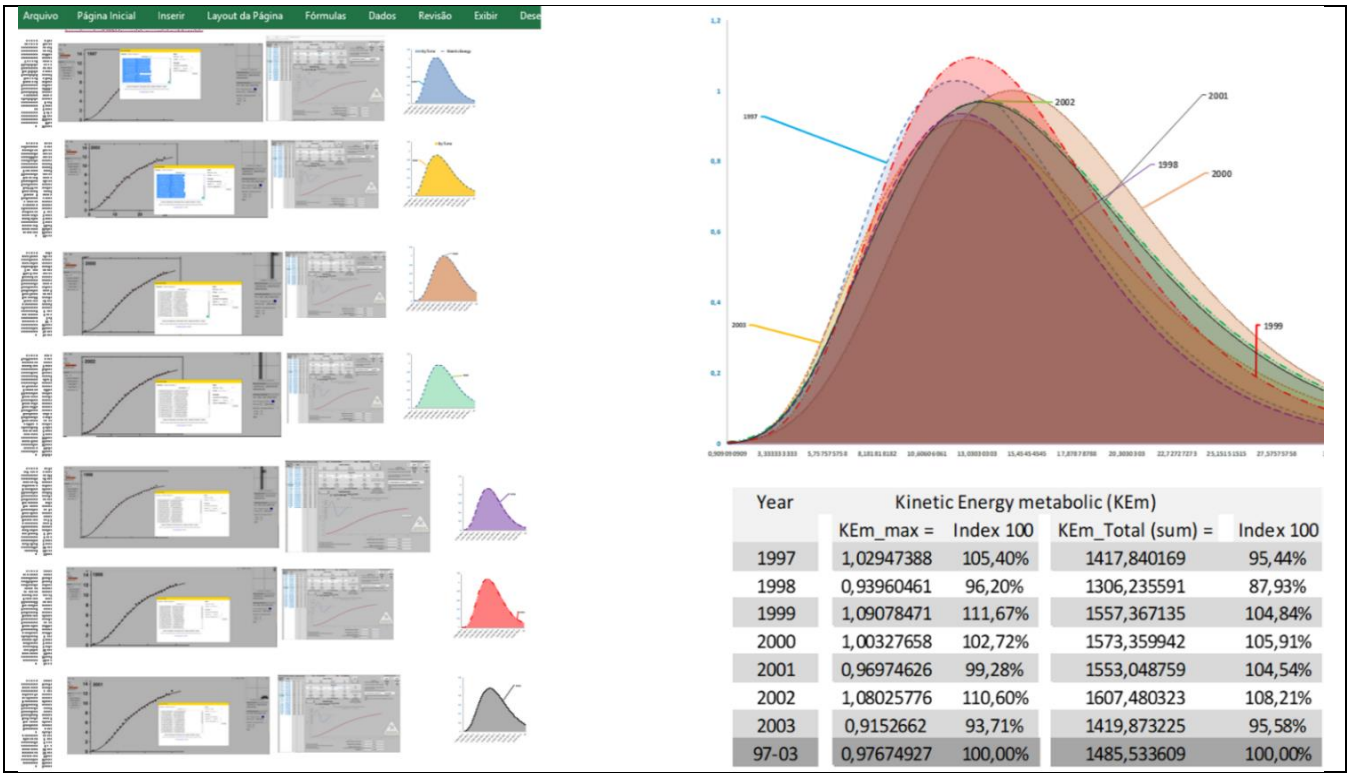


Figure 15. Adapted data from description of turkey hens. In:https://academic.oup.com/ps/article-pdf/89/2/371/4424695/poultrysci89-0371.pdf.



Year	Kinetic Energy metabolic (KEm)			
	KEm_max =	Index 100	KEm_Total (sum) =	Index 100
1997	1,02947388	105,40%	1417,840169	95,44%
1998	0,93960461	96,20%	1306,235591	87,93%
1999	1,09078471	111,67%	1557,367135	104,84%
2000	1,00327658	102,72%	1573,359942	105,91%
2001	0,96974626	99,28%	1553,048759	104,54%
2002	1,08025776	110,60%	1607,480323	108,21%
2003	0,9152662	93,71%	1419,873225	95,58%
97-03	0,97674927	100,00%	1485,533609	100,00%

Figure 16. Data adjusted by the PPFM spreadsheet for the growth path of turkey hens, according to year. Overlap of sums of kinetic energies for turkey hens.

Thus, through the above example it is possible to highlight the greater relevance and innovation of the PPFM Spreadsheet when estimating the sum of the kinetic energy of each year studied. Among these, we will only focus on the performance of the worst and the best year, from the point of view of energy efficiency. Therefore, it is evident at what point in 1998 performance was altered unfavorably (sanitary, nutritional or management problem?) (Figure 17). In the same way, in 2002 the most favorable and persistent response was observed in the best performance of the batch of turkey females (Figure 18). However, by the traditional procedure of evaluations of curve fittings, such facts would never come to the fore, becoming covert.

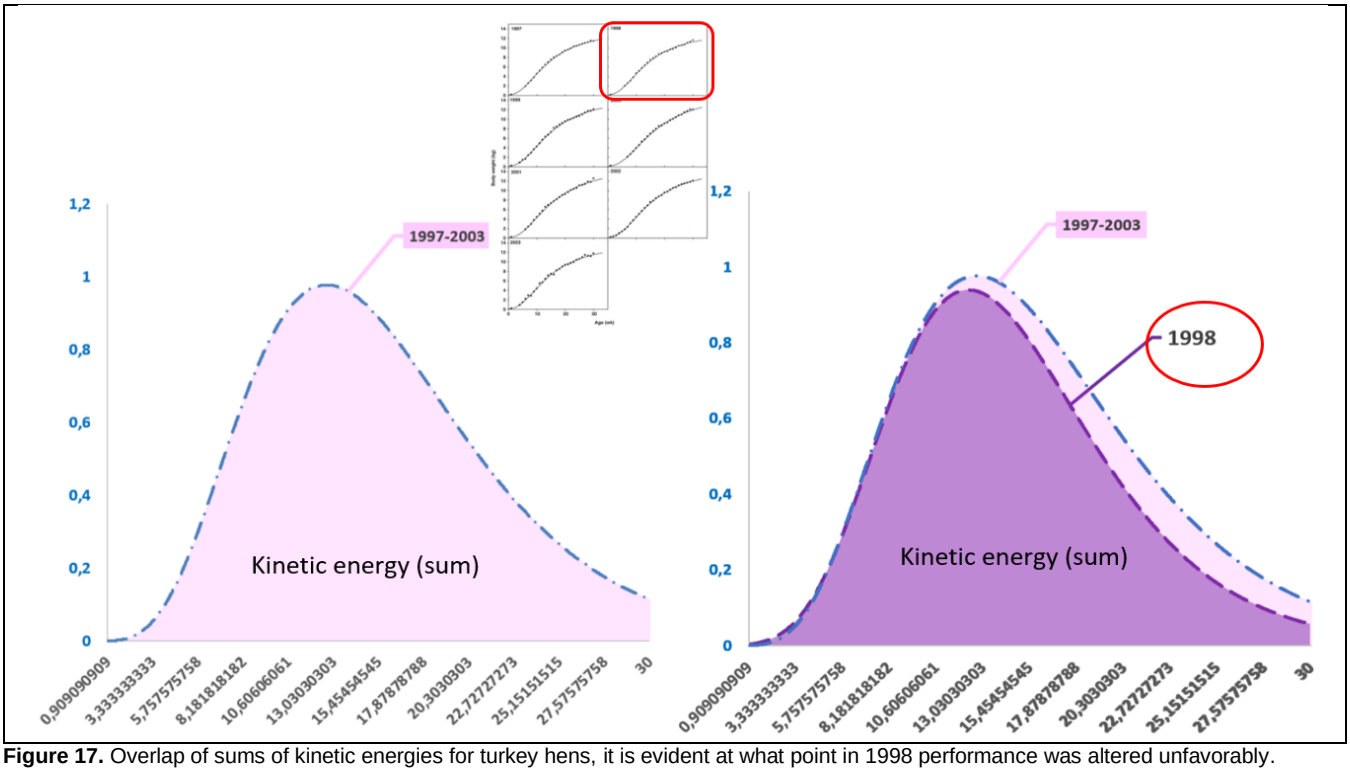


Figure 17. Overlap of sums of kinetic energies for turkey hens, it is evident at what point in 1998 performance was altered unfavorably.

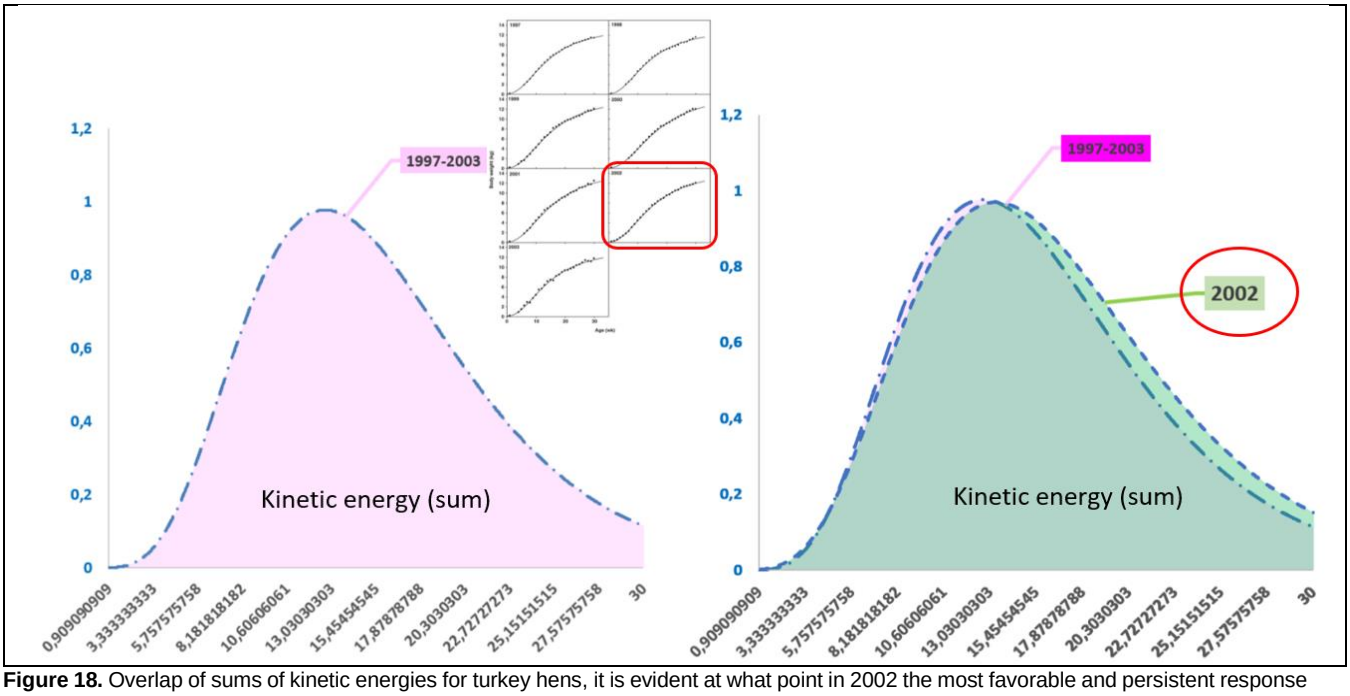


Figure 18. Overlap of sums of kinetic energies for turkey hens, it is evident at what point in 2002 the most favorable and persistent response was observed in the best performance of the batch of turkey females

From the foregoing, the greatest scientific benefit is the unprecedented application of the laws of physics (Newton's laws) directly in the growth curves. Thus, as argued by Shimojo (2006), the relevance and impact of this procedure lies in defining and incorporating kinetic energy (resulting force work) as the best and most efficient methodology to measure growth expansion in biological events or not.

2. PURPOSE

From the above, the purpose of this project is to use the commonly known Excel spreadsheet with the objective of offering a new spreadsheet for free access (PPFM), giving new optimization options (forces and energy) in different growth curves to the modified Gompertz models (4 parameters), Weibull, Richards (5 parameters) and Logistic dual sigmoid.

3.OBJECTIVES

3.1. Validate kinetic energy as the most efficient and appropriate way of measuring growth or expansion of biological structures, using host group databases, personal databases or published works;

3.2. To present the relevance and impact, through publications of the evaluations made by the PPFM spreadsheet, based on simulations of different databases (birds, pigs, fungi, bacteria, cancer, etc.) as a new modeling tool growth;

3.3. Provide a free and accessible modeling spreadsheet with five possibilities for adjusting growth curves to gauge forces.

4. HYPOTHESES

5.1- Curve modeling calculations can be improved by associating kinetic energy in growth dynamics (efficacy);

5.2 - Kinetic Energy is an excellent candidate to measure efficiency and economy in energy processes evaluated in a curve;

5.3 - Nutrition, management and genetic improvement should direct their assessments and efforts also for the speed and acceleration of events and not only for traditional mass;

5.4- This new approach collaborates with social, economic and environmental sustainability (effectiveness);

5.5- The energetic study of the forces allows to explore and obtain more understanding of the models allowing to define efficacy, efficiency, economicity and effectiveness.

5. MATERIAL AND METHODS

5.1- Application of the solver in modeling of regression curves by PPFM

The nonlinear models summarize in a few parameters, usually in three or four, mathematical functions that allow biological interpretations, defining curves that predict orientations, such as:

management, genetic and nutritional performance capacity of the animals (Freitas and Costa, 1983; France and Kebreab, 2008; Tholon and Queiroz, 2009).

So, the purposes to be described (growth curves, yield, degradability, rates, etc.) are very different, requiring that the parametric function adopted be robust to describe, with biological coherence, the proposed prediction with statistical adjustment quality (Morris, 1983). Thus, when adjusting a curve for weight, from birth to maturity, with four parameters, it is possible to have as characteristic: the upper asymptotic weight or the animal's weight limit, the inflection rate (moment that the curvature changes signal, that is, represents the moment of maturity of the animal), the lower asymptotic weight (indication of birth weight), and finally, the slope of the curve or growth rate. However, some models present parameters without biological interpretation, but are important to favor the best accommodation of the most challenging sigmoid curvatures in the estimation of function (Diebold and Li, 2006).

Therefore, when choosing a model, it is fundamental to know the practical interpretation of each parameter, with a clear evaluation of all its components (level, slope and curvature) (Morris, 1983), and that it is parsimonious and balanced (Araújo et al. al., 2013), without allowing the introduction of terms with innocuous benefit. In this way, curves should be represented with a minimum number of parameters, without loss of quality, with adequate flexibility to accommodate challenging curves with abrupt behavior changes.

However, depending on the challenge for the necessary adjustments, to accommodate and gain flexibility in these more demanding and complicated curves, the model may require more parameters (Svensson, 1994).

It is common, when estimating the parameters of the functions, to start in different values, to confirm the optimal point. This precaution is also required in the PPFM (Practical program for forces modeling) spreadsheet, and it is possible to observe the attempts and the final quality of the adjustments made by the iterations, when triggering the Excel solver tool. The iterations finalize successfully in the estimation when they present stable parameters and robust results, which is visually demonstrated by the consistency of the curve to accommodate the original data, with a high adjusted coefficient of determination (R^2adj) and with low residual errors. This spreadsheet currently only offers the Richards model, already shows a lot of versatility and quality of adjustments. Traditionally, the SAS NLIN procedure is used to make the aforementioned arrangement for nonlinear models (SAS 2009), with the use of generalized minimum squares (Freitas, 2005).

The most correct improvement procedure for biological interpretation is by regression (Omer and Abdellah, 2014). In this way, the PPFM procedure is appropriate for continuous variables (quantitative factors), in which the most appropriate statistical procedure is regression analysis (Chew, 1976; Morris, 1983), using the inverse of the diagonal elements of the matrix of variance of the dependent variable, that is, the observations with greater variability receive a lower weight in determining their estimates (Freitas, 2005).

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