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Sarconesiopsis magellanica (Diptera: Calliphoridae) life-cycle, reproductive and population parameters using different diets under laboratory conditions

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ABSTRACT

Sarconesiopsis magellanica is a forensically relevant necrophagous blowfly that can aid in determining the post-mortem interval (PMI) as it is the first to colonise decomposing corpses. The blowfly has been reported in several South-American countries including Colombia, in high-altitude regions ranging from 1200 to 3100 m above sea level. The present study reports this blowfly's life cycle and an analysis of its reproductive and population parameters under laboratory conditions for the first time. Six successive generations of flies were produced with an average of 65.38% adults emerging with respect to the total number of puparia. The shortest life cycle from egg to adult emergence was found in individuals fed on a lyophilised liver (LL) diet, while the longest one was found in individuals fed with an egg-powdered milk (E-PM) diet; intermediate values were found when the pig liver (PL) diet was tested. The greatest adult longevity was achieved when the PL diet was used, the LL diet giving the shortest. The population parameters based on the horizontal life table were: net reproductive rate (R_o) = 447.752 ± 9.9, mean generational time (T_c) = 18.18 ± 0.38, natural population increase rate (r_m) = 0.145 and finite population increase rate (λ) = 1.398. This blowfly colony represents a valuable asset for both basic and applied studies. Members of the *S. magellanica* colony so established were used for analysing the life-cycle, reproductive and population parameters, and further medical and forensic application studies are currently underway.

Sarconesiopsis magellanica (Le Guillou 1842) (Diptera: Calliphoridae) is a necrophagous and hemisynanthropic blowfly [1,2]. These flies are important in forensic research because they can aid in determining the post-mortem interval (PMI), being one of the first insects to colonise a decomposing corpse [3]. Furthermore, this species is important in medicine as it is a potential mechanical vector for pathogens, such as virus, bacteria, fungi, protozoa and helminths [4,5].

The fly has been reported in several South-American countries such as Argentina [1], Bolivia, Chile, Ecuador and Peru [6,7]. It has been found in the Antioquia, Boyacá, Cundinamarca and Norte de Santander departments in Colombia, particularly in sites located from 1200 to 3550 m above sea level [7,8].

Analysing such organisms' life-cycle stages and their colonisation under laboratory conditions might provide access to valuable biological material for undertaking basic and applied research in medicine and forensic sciences. Additional studies of colonised insects have been related to systematics, bionomy, genetics, insecticide susceptibility, vector competence, vector capacity, vaccine development and the establishment of cell cultures [9,10].

Life tables have been used to describe the development, survival and fecundity for a cohort of individuals and to provide basic information about a particular population's growth [11,12]. A vertical life table is used for determining survival and mortality whilst a horizontal life table is useful for estimating species' reproductive and population parameters such as net reproductive rate, natural population increase rate, mean generational time and finite population increase rate [13].

Insect feeding is one of the key factors in mass fly breeding under laboratory conditions. Two of the most important diet quality indicators are biomass accumulation and fecundity [14]; organic tissues are amongst the optimal diets for necrophagous insects as they are able to satisfy both requirements. However, artificial diets have also been used (though infrequently) and, when evaluated, have proved optimal for supplying nutrients for flies throughout their life cycle [15]. The first such diets had the disadvantage of producing offensive odour and contamination [16]. It has also been shown that the presence of toxins in

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decomposing tissues from natural diets can alter the development rate and lead to errors in estimating the PMI when necrophagous insects are used for forensic study under laboratory conditions [17]. Artificial diets can be a reliable alternative for breeding and maintaining strains, that is, continuous generations of an insect strain [17–19].

Even though work on the life-cycle, colonisation, reproductive and population parameters of some species from the Calliphoridae family has been carried out in different parts of the world [11,20,21], just one report describing the *S. magellanica* life cycle in samples collected from Perú has been published to date [7]. The present work was thus aimed at determining the biological cycle of *S. magellanica*, as well as analysing the blowfly's reproductive and population parameters for the first time in specimens raised on both a natural and two artificial diets under laboratory conditions. Life tables from this species were also constructed.

1. Materials and methods

1.1. Obtaining and breeding S. magellanica

Adult *S. magellanica* were captured in Bogotá, Colombia, specifically in the upper part of the city's Parque Nacional (4°37′8.90″ N, 74°3′27.73″ W, 2800 m above sea level, 14 °C). About 1.5 kg of decomposing pig's liver was used as bait for attracting the specimens, which were then trapped by using entomological nets. The blowflies were transported (in plastic jars covered with a veil) to the Universidad del Rosario's Medical and Forensic Entomology laboratory, where they were identified taxonomically using previously described keys [8]. Adult forms were kept in 45 cm × 45 cm × 45 cm Gerberg cages under controlled environmental conditions in the laboratory at 24 °C with 70% relative humidity and a12-h photoperiod (light/darkness). The blowflies were initially fed on pig's liver (PL) and a carbohydrate source, sugar solution (30% sucrose), supplemented with vitamin B12 [22].

1.2. Colonisation

Eggs of *S. magellanica* were collected from parental females' first oviposition (two masses each containing around 100 eggs) deposited on the food substrate to start the colonisation. The eggs were then placed on Petri dishes with fresh food substrate (decomposing pig's liver). The larvae which emerged were used for the colony's continuity. The blowflies were placed in Gerberg cages on reaching the adult phase where the biological cycle continued. Six continuous insect generations were analysed. The feeding, physical and environmental conditions necessary for guaranteeing biological cycle continuity throughout different generations were verified. Pertinent safety measures were taken to avoid one strain contaminating another within the insectariums, using veils to cover the Gerberg cages and respectively labelling each cage and plastic jar.

1.3. Life cycle of S. magellanica

The *S. magellanica* life cycle was evaluated using a natural diet (PL) and two artificial diets: lyophilised liver (LL) and egg-powdered milk (E-PM) (Table 1) [21,23]. The LL diet has previously been described [21] as a source having a high protein percentage to provide better adaptation and development of the insects; it also contains phosphate that promotes larval growth; the E-PM diet, despite containing a lower protein proportion when compared to LL, is rich in casein, lactoalbumin and cholesterol that are also essential for developing and maintaining the insect's life cycle [23]. This biological analysis was begun from three ovipositions (each one of around 150 eggs) which were obtained from the previously established colony (i.e., this was the fourth generation) and each oviposition was given its respective diet. Larvae that hatched from the eggs and passed from one instar to another were counted and maintained under the same environmental conditions as the adult organisms. The following aspects were taken into account when analysing each diet's efficacy: developmental stage duration (in days; the I, II and III larval instars, puparia and adult), sex ratio and adult longevity. The size of immature and adult stages was also determined using a stereomicroscope (Nikon, Tokyo, Japan; SMZ1500) linked to a high-resolution digital camera (DS-Ri1-U2) and NIS-Elements software. Immature stages were measured from front to back using a stereoscope (Leica; Solms, Germany) with specialised software (Application Suite) LAS EZ version 2.0.0. The lengths of random samples taken from 15 specimens belonging to each stage and from each pot were averaged. Adult size was inferred by measuring wing length, from the basicosta to the mid-costal vein [24]. A total of 15 adults were randomly taken for each plot.

1.4. Vertical life table and estimating mortality

The vertical life table was constructed from a cohort of 100 virgin female adults which emerged the same day. Following a settling period, the parental females suitable for oviposition were grouped according to each selected diet and placed in separate cages. The eggs oviposited daily on the substrate were collected and counted, as were the different stages of the development cycle up to the adults' deaths for evaluating the effect of the diets. The vertical life table was constructed, its parameters were established and survival curves were drawn following the procedure proposed by Rabinovich [13].

Table 1
The composition of two artificial diets used to rear *Sarconesiopsis magellanica* (Diptera: Calliphoridae) under laboratory conditions.

Ingredients	Lyophilised liver (Rueda et al., 2010) [21]	Egg-powdered milk (modified from Álvarez et al., 2005)
$Na_2HPO_4{\cdot}12H_2O$	0.012 g	–
KH_2PO_4	0.012 g	–
NaCl	1.2 g[a]	–
Powdered liver	6 g	–
Glucose	1.2 g	–
Nutritive agar	4.6 g[a]	2.5 g
Brain heart infusion (BHI)	4.2 g	9 g[a]
Blood	25 mL	–
Whole powdered milk	–	6 g
Powdered egg	–	6 g
Distilled water	200 mL	100 mL

[a] Ingredient modified regarding the amount of grams.

1.5. Horizontal life table and estimating reproductive and population parameters

The horizontal life table was constructed from a cohort of 50 females that had emerged on the same day and taken from the fifth generation; they were left for 12 days with a greater number of males for mating. Females close to ovipositing were then placed in wide-mouth flasks conditioned for maintaining the specimens and their oviposition. The eggs individually laid by the blowflies were counted daily until such flies died. Necropsy was performed on each female to establish the number of eggs retained. The reproductive and population parameters were calculated from this table according to the procedure described by Rabinovich [13]; that is, reproductive value (V_x), net reproductive rate (R_o), mean generational time (T_c), intrinsic rate of population increase (r_m) and finite rate of population increase (λ). The equations used for these calculations were as follows:

1. Age-specific survival rate (l_x) was the mean probability that an adult will survive to age x and was calculated by pooling all individuals from both sexes: $l_x = y_x/y_o$, where y_x = mean number of surviving adult flies at age x and y_o = total number of adult flies used in the experiment;
2. Fecundity (f_x) was the number of eggs laid daily, counted and divided by the number of surviving females, to provide data regarding the number of eggs per female per day:

   Fecundity (F_x) = total number of eggs laid per day x/total number of surviving adult females on day x;
3. The male population was taken into consideration in two sex life table analysis, and the sex ratios (SRs) were thus calculated for each day. Two (male/female) sex life tables were constructed and the sex ratios were calculated every day.

   Sex ratio (SR) = F or $M/M + F$, where, F = number of female flies alive per day and M = number of male flies alive per day;
4. Age-specific fecundity (m_x) is the mean number of eggs laid per female aged x days:

$$m_x = \text{Fecundity}(f_x)) \times \text{sex ratio (SR)};$$

5. Net reproductive rate (R_o) = $\Sigma l_x m_x$;
6. Mean generation time (T_o) = $\Sigma l_x m_x / R_o$;
7. Intrinsic rate of population increase (r_m) = Ln R_o/T_o; and
8. Finite rate of population increase (λ) was estimated from: $\lambda = e^{r_m}$.

1.6. Statistical analysis

Colonisation and life-cycle data were analysed according to descriptive statistical parameters; the data derived from some biological phases and life-table variables were also recorded. The data's significance was examined using the Shapiro–Wilk normality test. An analysis of variance (ANOVA) for multiple factors was used to assess differences in time, size and survival amongst several treatment groups (E-PM, LL and PL diets). The Bonferroni multiple comparison test was used for examining differences amongst treatment groups. Numerical differences for the above-mentioned tests were reported as means with 95% confidence intervals (CIs). All statistical analyses were performed using IBM SPSS Statistics 20 software. Non-parametric tests such as the Kruskal–Wallis and Wilcoxon with 95% CI were also used when required.

2. Results

2.1. Establishing the colony

Six generations were used for establishing the *S. magellanica* colony (Bogotá, Colombia, strain). The number of specimens for the different stages of the blowfly's biological development cycle was determined in each generation (Table 2). The final average number of adults which emerged was 65.38% in relation to the total number of puparia.

2.2. Life cycle

The immature life cycle of *S. magellanica* from the egg stage until adult emergence (total) was shorter with the LL diet, lasting 24.8 ± 0.31 days, and the longest was recorded with the E-PM diet (29.6 ± 0.64 days). There were statistically significant differences amongst the three diets evaluated ($p = 0.001$), being higher between the E-PM diet and the LL diet ($p = 0.001$) (Table 3). The only larval instar that lasted longer when fed on the LL diet was instar II.

Adults emerged between days 24.8 and 29.6 on the three diets evaluated; the greatest longevity was recorded for blowflies fed on PL (32.5 ± 0.32 days) during this period and, on the contrary, the lowest longevity was recorded with the LL diet (18.1 ± 0.81 days). Statistically significant differences were observed ($p = 0.001$) (Table 3).

When analysing the species' size during different developmental stages, statistically significant differences were found amongst I, II and III larval instars, puparia and adults ($p = 0.015$) concerning the three diets evaluated, even though it was observed that the E-PM diet had the greatest values, except at LII (Table 4). Nevertheless, the data showed that II instar larvae had the largest size when fed on the LL diet and adults recorded the greatest size on the E-PM diet. It was also established that females on the three diets had a greater size than their male counterparts, where statistically significant differences were found for E-PM ($p = 0.005$) and PL ($p = 0.008$) diets but not for the LL diet ($p = 0.47$) (Table 4); their ratio was numerically superior to males on LL and E-PM diets (54.3% and 69.11%, respectively); however, males were more numerous on the PL diet (51.22%).

Table 2
Population unit, larval survival, pupa survival and number of adults in each generation of *Sarconesiopsis magellanica* (Diptera: Calliphoridae) reared on diets under laboratory conditions.

Generation	Eggs	Larval stage I	Larval stage II	Larval stage III	Pupa	% Emergence	Adults		SE	VC
							Females	Males		
P							120	92		
F1	610	260	187	175	147	48.30	45	26	1.2	4.47
F2	430	410	390	386	368	50.00	101	83	0.86	3.01
F3	1050	1030	1023	1019	1015	48.97	350	147	1.3	4.73
F4	3480	3420	3410	3405	3225	79.53	1425	1140	1.24	2.70
F5	10,200	10,183	10,175	10,172	10,120	82.81	4690	3690	0.72	1.51
F6	40,663	40,480	40,348	40,390	40,120	82.69	21,580	11,596	1.23	2.57
Average						65.38				

SE: standard error; VC: variation coefficient.

Table 3
Duration of immature lifecycle and longevity of adults from *Sarconesiopsis magellanica* (Diptera: Calliphoridae) reared on diets under laboratory conditions.

Diet	Egg	LI	LII	LIII	Pupa	Total ± SE	VC	Adult longevity			
								Females ± SE	VC	Males ± SE	VC
E-PM	1.1	2.1	1.5	8.5	13.4	29.6 ± 0.64	0.07	22.3 ± 0.40	0.02	20.3 ± 2.85	0.19
LL	1.3	1.5	2.1	7.4	12.5	24.8 ± 0.31	0.03	18.1 ± 0.81	0.07	16.6 ± 2.04	0.22
PL	1.15	2.1	1.1	8.2	14.1	26.65 ± 0.95	0.08	32.5 ± 0.32	0.13	31.3 ± 1.22	0.11

LI: larval stage I, LII: larval stage II, LIII: larval stage III, E-PM: egg-powdered milk diet, LL: lyophilised liver diet, PL: pig liver diet, SE: standard error and VC: variation coefficient.

Table 4
Morphometry of the developmental stages *Sarconesiopsis magellanica* (Diptera: Calliphoridae) reared on diets under laboratory conditions.

Diet	Egg (mm)	LI (mm)	LII (mm)	LIII(mm)	Pupa (mm)	Adult (mm)	
						Female	Male
		Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
PL	1.2	1.3 ± 0.01	4.2 ± 0.10	11.1 ± 0.19	7.7 ± 0.11	14.2 ± 0.30	14.0 ± 0.31
E-PM	1.2	2.1 ± 0.02	5 ± 0.18	11.3 ± 0.21	8.3 ± 0.10	14.7 ± 0.28	14.4 ± 0.31
LL	1.2	1.3 ± 0.02	5.1 ± 0.15	9.5 ± 0.19	7.2 ± 0.06	12.5 ± 0.37	11.9 ± 0.3

LI: larval stage I, LII: larval stage II, LIII: larval stage III, E-PM: egg-powdered milk diet, LL: lyophilised liver diet, PL: pig liver diet, SE: standard error.

Table 5
Vertical life table of *Sarconesiopsis magellanica* (Diptera: Calliphoridae) reared on lyophilised liver (LL), egg-powdered milk (E-PM) and pig liver (PL) diets under laboratory conditions.

X	Diet	a_x	l_x	d_x	q_x	$\log a_x$	$\log l_x$	T_x	e_x
Egg	E-PM	150	1	0.000	0.000	2.176	0.000	5.247	5.247
	LL	150	1	0.000	0.000	2.176	0.000	5.101	5.101
	PL	150	1	0.000	0.000	2.176	0.000	4.902	4.902
LI	E-PM	125	0.833	0.167	0.208	2.097	−0.079	4.247	5.096
	LL	120	0.800	0.200	0.242	2.079	−0.097	4.101	5.126
	PL	124	0.827	0.173	0.223	2.093	−0.083	3.902	4.720
LII	E-PM	97	0.776	0.224	0.256	1.987	−0.110	3.413	4.399
	LL	105	0.875	0.125	0.138	2.021	−0.058	3.301	3.772
	PL	112	0.903	0.097	0.127	2.049	−0.044	3.075	3.405
LIII	E-PM	74	0.763	0.237	0.265	1.869	−0.118	2.637	3.457
	LL	94	0.895	0.105	0.125	1.973	−0.048	2.426	2.710
	PL	94	0.839	0.161	0.172	1.973	−0.076	2.172	2.588
Pupa	E-PM	69	0.932	0.068	0.086	1.839	−0.030	1.874	2.010
	LL	74	0.787	0.213	0.282	1.869	−0.104	1.530	1.944
	PL	71	0.755	0.245	0.260	1.851	−0.122	1.333	1.765
Adult	E-PM	65	0.942	0.058	0.078	1.813	−0.026	0.942	1.000
	LL	55	0.743	0.257	0.445	1.740	−0.129	0.743	1.000
	PL	41	0.577	0.423		1.613	−0.238	0.577	1.000

LI: larval stage I, LII: larval stage II, LIII: larval stage III, E-PM: egg-powdered milk diet, LL: lyophilised liver diet, PL: pig liver diet, X: developmental stage, a_x: number of individuals observed, l_x: the original cohort that survives at the beginning of each stage, d_x: the original cohort that dies in each stage, q_x: mortality rate (average probability of death that an individual has), T_x: number of individuals alive beyond age X, e_x: life expectancy per individual at age X.

Table 6
Horizontal life table based on a laboratory culture fed on pig's liver (PL) diet of *Sarconesiopsis magellanica* (Diptera: Calliphoridae) under laboratory conditions.

X	l_x	m_x	R_o	$X \times l_x \times m_x$	V_x	T_c
1	1	0.0	0.0	0.0	1.40	0
2	1	0.0	0.0	0.0	2.80	0
3	1	0.0	0.0	0.0	4.20	0
4	1	0.0	0.0	0.0	5.60	0
5	1	0.0	0.0	0.0	6.99	0
6	1	0.0	0.0	0.0	9.79	0
7	1	0.0	0.0	0.0	9.79	0
8	1	0.0	0.0	0.0	11.19	0
9	1	0.0	0.0	0.0	12.59	0
10	1	0.0	0.0	0.0	13.99	0
11	1	0.0	0.0	0.0	15.39	0
12	1	23.7	23.7	284.2	16.79	0.63
13	1	44.7	44.7	44.7	18.19	1.30
14	1	18.4	18.4	257.9	19.59	0.58
15	1	71.1	71.1	71.1	20.98	2.38
16	1	18.4	18.4	294.7	22.38	0.66
17	1	34.2	34.2	34.2	23.78	1.30

Table 6 (*Continued*)

X	l_x	m_x	R_o	$X \times l_x \times m_x$	V_x	T_c
18	1	39.5	39.5	710.5	25.18	1.59
19	1	23.7	23.7	23.7	26.58	1.01
20	0.97	47.4	46.1	922.4	28.73	2.06
21	0.92	36.8	33.9	33.9	31.90	1.59
22	0.87	21.1	18.3	402.2	35.44	0.90
23	0.87	21.1	18.3	18.3	37.05	0.94
24	0.82	15.8	12.9	310.0	41.04	0.69
25	0.68	34.2	23.4	23.4	51.11	1.31
26	0.63	21.1	13.3	345.7	57.59	0.77
27	0.50	5.3	2.6	2.6	75.54	0.16
28	0.39	13.2	5.2	145.4	99.23	0.32
29	0.26	0.0	0.0	0.0	154.16	0
30	0.26	0.0	0.0	0.0	159.48	0
31	0.21	0.0	0.0	0.0	205.99	0
32	0.16	0.0	0.0	0.0	283.52	0
33	0.16	0.0	0.0	0.0	292.38	0
34	0.13	0.0	0.0	0.0	361.48	0
35	0.00	0.0	0.0	0.0	0.00	0
		$\sum$	447.75		2181.84	18.18

X: age of female cohort (in days), l_x: survival of the female cohort at age X, m_x: average female fecundity per cohort at age X, R_o: net reproductive rate, V_x: reproductive value of females in the cohort at age X, T_c: mean generational time.

2.3. Vertical life table

The vertical life table (Table 5), beginning with the daily count of individuals observed in the species' different developmental stages (a_x), shows that percentage survival (l_x) was greater during the I instar larvae, puparia and adult forms on the E-PM diet, whilst a greater percentage (d_x) (having an inversely proportional pattern to the previous column) died on LL and PL diets. However, there were no significant differences related to these two parameters ($p = 0.53$). Likewise, the average probability of death (q_x) was similar to the previous results, that is, low on E-PM and slightly higher on LL and PL diets.

2.4. Survival curve

The survival curve for individuals fed on the E-PM and LL diets (Fig. 1), according to Rabinovich's classification [13], had a type IV curve as they represented a population in which mortality affected early stages; however, survival was greater for the III instar larvae on the LL diet. The survival curve on the PL diet was type II, due to a constant number of individuals dying during each developmental stage.

2.5. Horizontal life table

The following reproductive parameter values were obtained: average oviposition per female was 5.10 ± 0.51, average oviposition value was 140.38 ± 21.9 eggs per female (variation interval: 76.16–202.75) and average eggs per female oviposited during their entire life was 656.76 ± 85.43 (variation interval: 457–949).

Population parameters were calculated from the values obtained from Table 6. The following data were determined: net reproductive rate (R_o) = 447.752 ± 9.9 female daughters per female from the cohort, mean generational time (T_c) = 18.18 ± 0.38 days, intrinsic rate of population increase (r_m) = 0.083 females descendent from each female cohort per day and finite rate of population increase (λ) = 1.398 individuals per female per day.

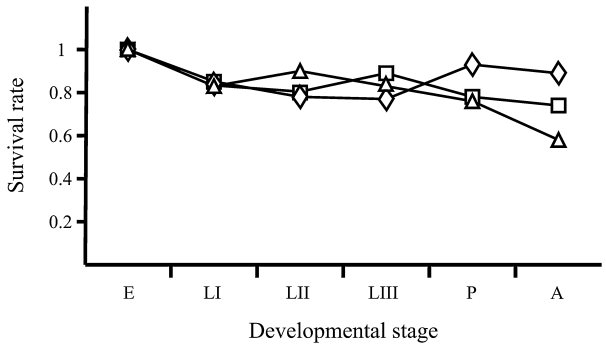

Fig. 1. *S. magellanica* survival curves during different developmental stages. E: eggs. LI: larval stage I. LII: larval stage II. LIII: larval stage III. P: puparia. A: adults. Open rhombus: E-PM diet. Open triangles: PL diet. Open squares: LL diet.

3. Discussion

Even though there was high mortality of immature forms and a relatively low percentage of adult emergence during *S. magellanica* colonisation (particularly during initial generations), this situation changed drastically throughout the course of the other generations and as the species became optimally adapted to the physical, environmental and nutritional conditions established in the insectarium until its evolution to a colonised strain having excellent performance. The strain's high mortality and low production during the initial stages of colonisation (where females had reduced oviposition) was also established in recent work on this topic using *Lucilia sericata* [25]. However, there was more drastic mortality between the egg stage and the first larval stage in the present work, thereby supporting previous findings [26].

The average *S. magellanica* life-cycle duration from egg to adult emergence was shorter for blowflies fed on the LL diet, it was intermediate on the PL diet and E-PM diet-fed instars lasted the longest. A previous work evaluating the stage development of this same species [7], stating that its preference was liver and fish [4], has shown an average duration of 26 days on a natural diet; similar results were registered in the present study. Likewise, the average life-cycle duration from egg to adult emergence in other species, that is, *L. sericata* [21,23] and *Cochliomyia hominivorax* (Coquerel, 1858) [23] was similar to the results in the present study in which those fed on the LL diet demonstrated the shortest biological cycle. By contrast, other reports have shown that *C. vicina* and *L. sericata* displayed shorter life cycles on pig's leg, kidney, heart or brain diets [27,28]. Although the immature stage duration of *S. magellanica* was shorter in the study by Greenberg and Szyska [7] compared with our results, previous studies have recorded shorter life cycles in other species when using natural diets [15,29,30]. It is probable that in addition to the nutritional factors present in the diets, other

variables are also associated with the specimens' adaptive processes in the insectarium, such as the food's physical characteristics, willingness to take it, frequency of food intake, population density and environmental factors. These factors might enable insects to rapidly assimilate one diet (within a determined time period) with respect to other diets under laboratory conditions, thereby reflecting a shortening in their biological cycle, as observed with the LL diet, likely due to its rapid digestion, a larger amount of calories, as well as the protein substances and other readily available nutritious sources [30].

The longevity of adult males and females fed on the PL diet was greater compared to the other diets, this being similar to that recorded in *Chrysomya megacephala* (Fabricius, 1794) [18]. However, the E-PM diet was the substrate on which the greatest longevity was obtained for other studies, as happened in *L. sericata* [18]. On the other hand, adult *S. magellanica* females had greater longevity than males that fed on LL and PL diets, thus agreeing with several authors who have recorded such situation [11,29]. This could be explained by natural selection, bearing in mind that females are better endowed in evolutionary terms for devoting a greater part of their lives to reproduction and thus live longer than males [31].

The I and III larval instars, puparia and adults were of greater size on the E-PM diet in the present work. According to Mendonca et al. [18], this could have resulted from the quality and amount of food ingested having a positive influence on ovary development and adult fecundity; females were thus bigger than males on the three diets evaluated here (an important, possibly genetically-determined, morphological characteristic) due to an evolutionary process endowing bodily advantages through selective pressure on specimens from the same sex [32]. Further, there was a decrease in the male sex ratio in the present report, the same characteristics were observed in other species (*Chrysomya putoria*, *Chrysomya albiceps*, *Compsomyiops* spp., *Hemilucilia semidiaphana*, *Paralucilia eximia*, *S. splendida* and *S. versicolor*) [4].

The vertical life table did not reveal significant differences regarding mortality and survival parameters concerning the diets evaluated here. On the one hand, the study by Zhang et al. [33] showed that the E-PM diet induced higher survival rates, similar to those observed here for the LI instar, puparia and adult stages. On the other hand, during the development of *S. magellanica* under laboratory conditions it was observed that the survival rate varied according to developmental stage, for example, being low in puparia, which could have been related to the morphological and physiological disorganisation produced during metamorphosis [34].

The LL and E-PM diets' survival curves were type IV, indicating that the *S. magellanica* population had similar survival patterns regarding the two artificial diets evaluated, in turn determining that the mortality rates occurred during early life-cycle stages. Such a pattern suggested that late stages were more resistant and confirmed the effectiveness of the diets used; similar results have been reported previously [21]. According to Rabinovich [13], life expectation (ex) was constant on a survival type II curve whilst this parameter increased for the type IV curve.

Using the horizontal life table for analysing their productive parameters revealed that fecundity was an important demographic parameter in the change of dynamic behaviour regarding the different populations of insect species under experimental conditions [35]. The age at which females first mate has an important effect on population growth, defined as being pre-oviposition time from the moment of adult female emergence to the first day of oviposition [11]. *S. magellanica* had a 12-day pre-oviposition period in the present study which was close to other values reported for different species from the Calliphoridae family, such as 13 days in *L. cuprina* [12] and 8–15 days in *Calliphora vomitoria* (Linnaeus, 1758) [36]; these differences in the beginning of adult female oviposition in species belonging to the same taxa could be due to the environmental and nutritional conditions established for breeding insects under laboratory conditions.

However, the net reproductive rate (R_o = 447.752 female daughters per female from the cohort) showed that the *S. magellanica* population was undergoing active growth as this value was >1 [13]. Even though the value for this parameter was high in the present work compared to the data obtained for *L. cuprina* (R_o = 106.1) by Abou Zied et al. [12], an even higher value (R_o = 586.84) was established by Rueda et al. [21] in a study on *L. sericata*. However, in spite of the differences in net reproductive rate regarding the aforementioned values (for three different species from the Calliphoridae family), high reproductive ability can be inferred for each of them. The mean generation time (also associated with the previous parameter) (T_c) of 18.18 days for *S. magellanica* indicated that a new generation was obtained for each period, being very close to other values recorded for *L. cuprina*, T_c = 19.8 [12], *L. sericata*, T_c = 17.81 [21], and *C. albiceps*, T_c = 15.18 [37], suggesting possible abiotic effects acting on this parameter under laboratory conditions for specimens from the same taxa.

As opposed to previous records, the intrinsic rate of population increase was moderate (r_m = 0.145) for *S. magellanica*, meaning that positive instantaneous growth was close to 1.5%, the difference between birth and mortality rates being equal over a determined time; according to Price [38], two conditions should apply for the intrinsic rate of population increase to remain high: the mortality rate should be low and the birth rate should be high. This situation could explain such moderate value, bearing in mind that the cohort of insects analysed in the present work came from a generation from a colony already adapted to laboratory conditions. Higher values have been recorded for other species, such as *L. cuprina*, r_m = 0.23 [12], *C. megacephala*, r_m = 0.21 [11], and *L. sericata*, r_m = 0.6 [21]. Nevertheless, it should be pointed out that there must be identical experimentation conditions to enable comparing this estimator's value under laboratory conditions among specimens of the Calliphoridae family and that such parameter is genetically determined in different species [13]. The finite rate of population increase (λ) was 1.398 for *S. magellanica*, representing the number of individuals added to the population by each female in a single day, suggesting that the colony was increasing in a stable and constant manner throughout the generations analysed under laboratory conditions [21].

The adaptability of *S. magellanica* to breeding under laboratory conditions, the analysed life cycle on different food substrates and the relatively high reproductive capacity and population parameters reflected the optimal biological development of the blowfly cycle under controlled laboratory conditions making possible the maintenance of the population as a stable colony, which will be a valuable asset for both basic and applied studies.

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