LIFE TABLE PARAMETERS AND CONSUMPTION RATE OF *Cydnodromus picanus* Ragusa, *Amblyseius graminis* Chant, AND *Galendromus occidentalis* (Nesbitt) ON AVOCADO RED MITE *Oligonychus yothersi* (McGregor) (ACARI: PHYTOSEIIDAE, TETRANYCHIDAE)

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**ABSTRACT**

The avocado red mite *Oligonychus yothersi* (McGregor) is the major leaf pest in Chile’s avocado orchards. It affects leaf physiology and makes it necessary to seek new natural enemies to interact with low population densities of *O. yothersi*. The potentiality of three predator mites: *Cydnodromus picanus* Ragusa, *Amblyseius graminis* Chant, and *Galendromus occidentalis* (Nesbitt) was evaluated under laboratory conditions (27 ± 1.93°C, 87 ± 3.61% H.R. and 16:8 (L:D) photoperiod) on avocado leaf disks *Persea americana* Mill. var. Hass (Ø = 5 cm) by separately feeding eggs, immature, and adult females of *O. yothersi*, and registering postembryonic development, consumption, as well as life table parameters. The postembryonic development of *C. picanus* was significantly lower (5.46 days) compared to both *A. graminis* (7.33 days) and *G. occidentalis* (8.69 days) which were fed with immature *O. yothersi*. The life table parameters of *C. picanus* were net reproductive rate $R_0 = 25.41$, finite rate of increase $\lambda = 1.29$, and mean generation time $T = 12.46$. The net intrinsic rate of increase ($r_m$) was significantly higher for *C. picanus* ($r_m = 0.25$) in contrast with *G. occidentalis* ($r_m = 0.19$), while *A. graminis* showed $r_m = -0.06$ indicating that its population didn’t have descendants. Under laboratory conditions, $r_m$ registered by *C. picanus* is an indicator of its predatory potential to control *O. yothersi*. It can be assumed that the pest population reduction pattern could be maintained under field conditions.

**Key words**: postembryonic development, predation, pollen, biological control.

**INTRODUCTION**

The avocado, *Persea americana* Mill. (Lauraceae), is the second most cultivated fruit tree in Chile after vineyards, and covers an area of 39 302.59 ha of which 56% is concentrated in the Valparaíso Region (INE, 2007). Furthermore, Chile is the second world exporter of avocados, mainly the Hass variety, with approximately 165 000 t exported during the 2006-2007 season (Comité de Paltas, 2007).

Nevertheless, there is an economic loss associated with exports because of the presence of pests such as *Pseudococcus longispinus* (Targioni & Tozzetti) (Hemiptera: Pseudococcidae), *P. calceolariae* (Maskell) (Hemiptera: Pseudococcidae), *Hemiberlesia lataniae* (Signoret) (Hemiptera: Diaspididae), and *Heliothrips haemorrhoidalis* (Bouché) (Thysanoptera: Thripidae) (SAG, 2007). The most important economic avocado pest at a foliar level is *Oligonychus yothersi* (McGregor) (Acari: Tetranychidae) (Altieri and Rojas, 1999), commonly known as the avocado red mite, and var. Hass is the most susceptible to be attacked by this tetranychid. *Oligonychus yothersi* provokes a decrease in photosynthetic rate, stomatal conductance, and transpiration, negatively affecting the physiology of the avocado leaves (Schaffer et al., 1986). This has a direct consequence on the quality of the fruit and crop yield (Palevsky et al., 2007a), the same as for *O. perseae* Turtle, Baker and Abatiello (Acari: Tetranychidae) found in California, USA (Kerguelen and Hoddle, 2000; Takano-Lee and Hoddle, 2002).

The natural enemies associated with *O. yothersi* in avocado orchards in the Province of Quillota are *Stethorus histrio* Chazeau (Coleoptera: Coccinellidae) and *Oligota pygmaea* Solier (Coleoptera: Staphylinidae), density-dependent generalist predators. Both coleoptera present natural colonization in the orchard only when the pest population increases (Obrycki and Kring, 1998; Kishimoto,
without exerting the necessary regulation to avoid damage produced by the red mite at the leaf physiological level. This makes it necessary to incorporate new predators to the system to interact with low *O. yothersi* population densities in the Chilean avocado orchards managed with biological control agents.

The most important predators of phytophagous mites in the world belong to the Phytoseiidae (Shrewsbury and Hardin, 2003) family which are easily adaptable to perturbed habitats and intensely managed as is the case of fruit orchards (Croft and Luh, 2004). The generalist species do not require large mite pest population densities to be established in an orchard, and migrate to other places through aerial dispersion if they lack prey (Colfer et al., 2003; Tixier et al., 2006). In the absence of phytophagous mites, the generalists have the capacity to use food alternatives such as pollen grains, fungi spores, insects in the immature stages, plant nectar, and exudates (Croft et al., 2004; Nomikou et al., 2005; Bouras and Papadoulis, 2005).

To include new natural enemies in a biological control system, it is fundamental to know their biological and ecological characteristics. The potential of the predators on their prey (De Vis et al., 2006b) can be estimated through population models and the construction of life tables, thus obtaining data about survival, longevity, reproduction, and descendants of the predatory species since these are susceptible to low humidity in the egg stage (De Vis et al., 2006a). The life table and consumption assays were carried out in the laboratories of Instituto de Investigaciones Agropecuarias (INIA) La Cruz, Valparaíso Region, between January and September 2007. Using a data logger, the Petri dish micro-climatic conditions were registered inside the laboratory, thereby obtaining a temperature of 27 ± 1.93 °C, relative humidity of 87 ± 3.61%, and a 16:8 (L:D) photoperiod for all the assays. These micro-climatic conditions were used to register the maximum biological potential of the predatory species since these are susceptible to low humidity in the egg stage (De Vis et al., 2006a). The experimental observations were carried out every 24 h with a 40X stereoscopic magnifying glass (Zeiss, Stemi, Göttingen, Germany). An adhesive (Point sticken blue, Point Chile S.A.) was used to avoid the mites from escaping.

**Breeding of the avocado red mite.** *Oligonychus yothersi* were bred massively on avocado leaves var. Hass, with a modified methodology (Oliveira et al., 2001) using plastic containers (29 x 7 x 39.5 cm) at a temperature of 27 ± 2 °C, relative humidity of 50 ± 10%, and a 16:8 (L:D) photoperiod. The micro-climatic conditions were registered with a digital thermo-hygrometer.

**Phytoseid breeding.** The three predatory species selected were obtained in the phytoseid breeding room located in the INIA La Cruz facilities. Subsequently, gravid females of this species were moved to the assay laboratory where they were bred on avocado leaf disks var. Hass infested with *O. yothersi* inside plastic containers (57 x 42 x 19 cm) opened at the top and covered with muslin to avoid contamination of the predatory mite populations. The assays were carried out with eggs laid by the first-generation females.

**Postembryonic development.** Egg-adult development was determined for each species of phytoseiid. Thirty gravid females were taken from each species and each female was placed inside an avocado leaf disk var.
Hass (Ø = 5 cm) confined with adhesive (sticken). They were eliminated after 5 h, leaving 1 egg per disk (1 egg = 1 replicate), and registering the duration of each developmental stage of the phytoseiid through the exuvium. Longevity of unmated individuals was obtained by making available, on a daily basis, ten 24-h-old eggs, 10 mobile immature individuals (protonymphs and deutonymphs), and five *O. yothersi* adult females. Daily consumption was registered for each phytoseiid.

Avocado (*Persea americana* Mill.) (Lauraceae) var. Hass and hairy brassica (*Hirschfeldia incana* (L.) Lagr.-Foss.) (Brassicaceae) pollen was evaluated as alternative food to verify the survival of the species when facing a scarcity of prey. Daily, avocado var. Hass and *H. incana* pollen was provided separately by means of a fine brush, along with registering postembryonic development and predator longevity. Water was provided by cotton threads through a hole in the leaf for assays with pollen, as well as for those without food supply.

**Fertility and longevity.** Thirty females of known age were placed in avocado var. Hass leaf disks (1 female = 1 replicate), integrating a male for 24 h every 7 days. Each female was given 15 mobile immature *O. yothersi* (protonymphs and deutonymphs). The phytoseiid eggs were counted and eliminated, recording longevity, fecundity, and consumption of the gravid females. To obtain descendants and the proportion of sexes, 10 females were randomly selected from the previous 30. Thus, the eggs of each female were counted and deposited on 10 infested Petri dishes with all the *O. yothersi* stage, respectively, thus recording data about fertility and proportion of sexes for the females of each species.

**Statistical analysis.** A completely random design was applied with 30 replicates per experiment. Postembryonic development, longevity, and consumption data were transformed by $\sqrt{x} + 0.5$ (Steel and Torrie, 1985). Subsequently, ANOVA and Tukey test ($p<0.05$) were applied to evaluate the influence of food on postembryonic development and phytoseiid consumption.

The following were the calculated life table parameters (SAS Institute, 2007): (1) Net reproductive rate, $R_0 = l/m_s$, being the number of females that produce a female during a generation or during their lifespan (Rabinovich, 1980); (2) intrinsic rate of increase, $r_n$ being the maximum exponential multiplication rate of a whole population, and calculated as $1 = l_m \exp(-r_n)$ (Birch, 1948); (3) finite rate of increase, $\lambda = \exp (r_n)$ being the number of females that produce one female per day (Birch, 1948); and (4) generation time, $T = X l m_s / R_0$ being the time that passes between first and next generation oviposition (Rabinovich, 1980).

The Jackknife nonparametric resampling method was used to compare the parameters of the life table between species, estimating the mean, variance, and standard error (Meyer et al., 1986; La Rossa and Kahn, 2003) with the LIFETABLES software, SAS (Maia et al., 2000), and SAS® (SAS Institute, 2007). The biological parameters were subsequently compared with the Tukey test ($P<0.05$).

**RESULTS**

The time of postembryonic development of *C. picanus* observed was less compared to the other two predatory species ($F = 134.54$, df = 2, $p < 0.01$) when fed mobile immature *O. yothersi* (Table 1). With regard to the longevity of phytoseiids fed with mobile immature *O. yothersi*, *C. picanus* showed a greater duration of the adult stage than *A. graminis* and *G. occidentalis*, thus indicating that the supply of *O. yothersi* protonymphs and deutonymphs had a positive influence on the postembryonic development of *C. picanus* ($F = 167.30$, df = 2, $p < 0.01$).

In relation to the percentage of immature phytoseiids that developed to the adult stage, a survival rate of 100% was registered for *C. picanus*, 86% for *G. occidentalis*, and only 10% for *A. graminis*.

By feeding *O. yothersi* eggs, the postembryonic development of *C. picanus* and *A. graminis* increased with respect to the predators fed with immature red mites, whereas *G. occidentalis* only reached the larval stage. Furthermore, *C. picanus* showed a 13% survival rate and *A. graminis* 6.6% in the immature stage (Table 1). It was confirmed that in the immature stage, *C. picanus*, *A. graminis*, and *G. occidentalis* do not consume adult females of the avocado red mite (Table 1).

Using avocado var. Hass pollen, the duration of the postembryonic development was found to be shorter for *A. graminis* than *C. picanus* ($F = 27.55$, df = 1, $p < 0.01$). Regarding longevity of the evaluated species, *A. graminis* individuals were significantly more long-lived ($F = 148.18$, df = 1, $p < 0.0001$) than *C. picanus*. Survival of immature phytoseiids that reached the adult stage was not significantly different between *A. graminis* (66.6%) and *C. picanus* (43.3%) ($F = 3.38$, df = 1, $p = 0.0713$), though *G. occidentalis* did not consume pollen and only developed to the larval stage (Table 2).

Using *H. incana* pollen, egg-adult development was observed to be less for *A. graminis* than *C. picanus* ($F = 177.21$, df = 1, $p < 0.01$), although longevity was significantly greater for *A. graminis* ($F = 345.48$, df = 1, $p < 0.0001$) than *C. picanus*. Furthermore, *A. graminis* showed a 60% survival rate of individuals in the immature stage that developed into the adult stage, whereas *C. picanus* registered a statistically similar 46.6% ($F = 1.05$, df = 1, $p = 0.3087$) (Table 2).

In terms of *C. picanus* longevity, a significant difference was obtained for the individuals fed with mobile immature...
red mites (60.03 days) as compared with administering an exclusive diet of avocado var. Hass pollen (40.46 días) \((F = 62.74, \text{df} = 1, p < 0.0001)\) and \(H. \text{incana} (22.5 \text{ días}) \((F = 251.41, \text{df} = 1, p < 0.0001)\), thus indicating that these two latter diets are a feeding alternative when prey is scarce.

On the other hand, \(A. \text{graminis}\) registered a significantly greater longevity when fed avocado var. Hass pollen \((78.10 \text{ días}) \((F = 91.36, \text{df} = 1, p < 0.0001)\) and \(H. \text{incana} (84.94 \text{ días}) \((F = 86.85, \text{df} = 1, p < 0.0001)\) compared with feeding on mobile immature red mites \((18 \text{ días})\) (Table 1, Table 2).

On a water diet, \(C. \text{picanus}\) and \(A. \text{graminis}\) developed up to the protonymph stage. In contrast, \(G. \text{occidentalis}\) only reached the larval stage. Furthermore, \(C. \text{picanus}\) showed a longer duration in the protonymph stage compared with \(A. \text{graminis} (F = 1158.03, \text{df} = 1, p < 0.01)\) (Table 2).

As for depredation on immature \(O. \text{yothersi}, G. \text{occidentalis}\) registered consumption of the avocado red mite in the larval stage although \(C. \text{picanus}\) and \(A. \text{graminis}\) did not present depredation in this stage \((F = 457.40, \text{df} = 2, p < 0.01)\), indicating that \(G. \text{occidentalis}\) needs to be fed to continue its postembryonic development. On the other hand, \(C. \text{picanus}\) and \(G. \text{occidentalis}\) registered less depredation in the protonymph stage than \(A. \text{graminis} (F = 32.58, \text{df} = 2, p < 0.01)\), a behavior also observed in deutonymphs \((F = 13.77, \text{df} = 2, p < 0.01)\). Nevertheless, unmated \(C. \text{picanus}\) adults showed a greater depredation rate compared with unmated \(A. \text{graminis}\) and \(G. \text{occidentalis}\) adults \((F = 71.96, \text{df} = 2, p < 0.01)\) (Table 3).

A greater depredation rate of mated \(A. \text{graminis}\) females on immature \(O. \text{yothersi}\) was observed as compared with \(C. \text{picanus}\) and \(G. \text{occidentalis} (F = 306.67, \text{df} = 2, p < 0.01)\) (Table 3).

Life table parameters

\(C. \text{picanus}\) females showed gradual mortality over time in contrast with \(A. \text{graminis}\) and \(G. \text{occidentalis}\) which concentrated almost 80% mortality in 7 days (Figure 1). Furthermore, greater longevity was noted for \(A. \text{graminis} (25.7 \text{ días})\) and \(C. \text{picanus} (25.43 \text{ días})\) females in contrast with \(G. \text{occidentalis} (22.56 \text{ días}) (F = 5.44, \text{df} = 2, p = 0.006)\). The three survival curves recorded for the distinct species were type I, thus indicating that mortality was mainly concentrated in long-lived individuals (Rabinovich, 1980).

There is no significant difference in the oviposition rate between the evaluated phytoseiid species \((F = 1.47, \text{df} = 2, p = 0.236)\) (Figure 2). Comparing female fertility, \(C. \text{picanus}\) had a higher value than \(G. \text{occidentalis}\) and
whose eggs were almost entirely infertile (Figure 3).

The life table parameters of the three phytoseiids fed with immature *O. yothersi* showed that *C. picanus* showed higher $R_0$, $r_m$, and $\lambda$ than *G. occidentalis* ($F = 233.58$, $df = 3$, $p < 0.0001$; $F = 2390.05$, $df = 3$, $p < 0.0001$; $F = 215.61$, $df = 3$, $p < 0.0001$), whereas *A. graminis* revealed $R_0 = 0.27$ indicating that the population of this species decreases over time (Table 4). The biological parameters of *C. picanus* show that the population grew 25.41 times in 12.46 days ($T$), and for each female of the actual generation there will be 25.41 females in the next generation. Furthermore, for each female present on a given day, there will be almost 1.29 ($\lambda$) females the next day. Therefore, at any particular point in time, the number of females in the *C. picanus* population will increase at such a rate that a population growth of 25% ($r_m$) is expected from one day to the next. Moreover, comparing $R_0$, $r_m$, $T$, and $\lambda$ of *C. picanus* with *O. yothersi*, it is observed that only the latter attains a higher $R_0$ ($F = 233.58$, $df = 3$, $p < 0.0001$), while the predator registered higher $r_m$ and $\lambda$. In addition, generation time was significantly lower for *C. picanus* ($F = 215.61$, $df = 3$, $p < 0.0001$) demonstrating that it multiplied more rapidly than the red mite population (Table 4).

### DISCUSSION

Consumption records during the postembryonic development of the three phytoseiids in the *O. yothersi* egg, immature, and adult female stages indicated that protonymphs and deutonymphs of the avocado red mite are differentially predated by *C. picanus*, *A. graminis*, and *G. occidentalis*. This influenced the predation rate by morphology, prey stage, and the predators’ mouth parts (Croft et al., 2004), since the integuments of *O. yothersi* adult females are more difficult to penetrate than those of immature prey (Kishimoto y Takagi, 2001; Furuichi et al., 2005).

Regarding consumption, Ragusa et al. (2000) established that *C. picanus* fed with *Tetranychus urticae* C.L. Koch (Tetranychidae) eggs reach the adult stage in approximately 4 days, demonstrating a positive influence of this prey in the development of the phytoseiid compared with *O. yothersi*. This would be explained by *T. urticae* egg morphology: spherical and easy to handle by the phytoseiids. In contrast, *O. yothersi* eggs adhere to the surface of the avocado leaf making it difficult to capture, and consequently less attractive as food (Vantornhout, 2006).
The established classification with regard to alternative food was confirmed by pointing out *C. picanus* and *A. graminis* as type III generalists and *G. occidentalis* as a recognized type II specialist preferring the *Oligonychus* genus (Shrewsbury and Hardin, 2003; Croft et al., 2004). Both generalists would be more adapted to conditions of food scarcity than *G. occidentalis* which need to feed on mites in order to develop. Ragusa et al. (2000) gave *Oxalis* sp. and *Ricinus* sp. pollen to *C. picanus* exhibiting survival rates of 52% and 44%, respectively in the immature stage. When fed with avocado var. Hass pollen, 43.3% of the population survived, converting it into an ideal alternative food in the absence of the red mite, and demonstrating another comparative advantage over *G. occidentalis*. It is also worth mentioning that *G. occidentalis* in commercial orchards is easily displaced by type III generalist phytoseiids. Slow and smaller-sized, it can also be transformed into prey for phytoseiids, and easily depredated by coleopters belonging to the *Stethorus* and *Oligota* genera (Colfer et al., 2003). Therefore, possible field releases of *G. occidentalis* could only be carried out when the *O. yothersi* population is high in the orchard, without being able to avoid the physiological damage provoked by the red mite on avocado leaves.

When *O. yothersi* population density is low and within a context of habitat management, it would be possible to carry out preventive releases of *C. picanus* starting in September using *H. incana* pollen, as well as avocado pollen, as an alternative food, since this Brassicaceae is associated to avocado orchards in the Valparaíso Region and could be used as a refuge in hillside commercial plantations (Bouras and Papadoulis, 2005; Palevsky et al., 2007b).

Mated *A. graminis* females showed a high rate of total consumption, but their eggs were infertile with no descendants over time compared with *C. picanus* that hatched almost 100% of its eggs. Regarding this phenomenon, several authors have pointed out a likeness...
to sequestration or extraction of secondary metabolites from plants, that is, specialist phytophages such as *O. yothersi* would be extracting alelochemicals from the avocado which would then be stored in their bodies as a defense against their predators, thus affecting in distinct ways the three evaluated phytoseiid species (Aregullín and Rodríguez, 2003; Collier et al., 2007; Zhu-Salzman et al., 2008). For this reason, it is necessary to carry out studies to confirm the presence of these toxic substances found in the red mite and predators. On the other hand, phytophages that have a broad range of host plants do not have the capacity to extract these toxic substances (Trigo, 2000; Termonia et al., 2001). Nishida (2002) points out that these substances extracted from the plants are biochemically transformed before being stored in the bodies of lepidopters. It must also be mentioned that endosymbiotic fungi are present in the plants and influence the tri-trophic interactions (plant-pest-natural enemy), affecting predator development, survival, and reproduction for the production of toxic alkaloids (mycotoxins) (De Sassi et al., 2006).

It must be mentioned that studies evaluating predators based on consumption or female fertility rates do not determine a potential control of the pest and provide incomplete information. High consumption rates do not imply high female fertility and fecundity, since *A. graminis* showed higher consumption and an oviposition rate similar to *C. picanus* and *G. occidentalis*. However, evaluating fecundity, *C. picanus* had a higher mean of eggs able to develop to the adult stage. It is therefore necessary to determine key biological parameters in ideal conditions to observe the biotic potential of the species of interest.

Establishing life and fecundity tables of predators and prey are fundamental to evaluate the efficiency and potentiality of a natural enemy on a specific pest (Naranjo, 2001; Gabre et al., 2005; Vantornhout et al., 2005; Ozman-Sullivan, 2006; Collier et al., 2007; Reis et al., 2007; Ferrero et al., 2007; Broufas et al., 2007). The above-mentioned information along with consumption registers generate assumptions of potential predator efficiency in the orchard (Chi and Yang, 2003; Kishimoto, 2003; Hosseini et al., 2005; Gotoh et al., 2006). This knowledge is relevant particularly for the assessment of natural enemies that are commercially produced (O’Neil et al., 1998).

In reference to the biological parameters, intrinsic rate of increases ($r_m$) indicates the capacity of the population to multiply in one generation, relating net reproductive rate ($R_0$) on generation time ($T$) (Rabinovich, 1980), implying the potential control of a natural enemy on a specific

### Table 3. Total consumption by *Cydnodromus picanus, Amblyseius graminis*, and *Galendromus occidentalis* of mobile immature *Oligonychus yothersi* during postembryonic development and longevity of predator mites.

<table>
<thead>
<tr>
<th>Prey</th>
<th>Phytoseiid state</th>
<th><em>C. picanus</em></th>
<th><em>A. graminis</em></th>
<th><em>G. occidentalis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile immature</td>
<td></td>
<td>0.00 ± 0.00b</td>
<td>0.00 ± 0.00b</td>
<td>1.73 ± 0.10a</td>
</tr>
<tr>
<td><em>O. yothersi</em></td>
<td></td>
<td>2.00 ± 0.14b</td>
<td>4.17 ± 0.32a</td>
<td>3.43 ± 0.11b</td>
</tr>
<tr>
<td>Protonymph</td>
<td></td>
<td>2.63 ± 0.11b</td>
<td>3.93 ± 0.38a</td>
<td>2.50 ± 0.12b</td>
</tr>
<tr>
<td>Deutonymph</td>
<td></td>
<td>59.20 ± 1.66a</td>
<td>39.66 ± 2.02b</td>
<td>34.88 ± 1.34b</td>
</tr>
<tr>
<td>Unmated adult</td>
<td></td>
<td>142.76 ± 0.34b</td>
<td>298.53 ± 7.44a</td>
<td>90.30 ± 3.49c</td>
</tr>
</tbody>
</table>

Values with different letters in the rows indicate significant differences according to Tukey (p < 0.05).

### Table 4. Life table parameters of the *Cydnodromus picanus, Amblyseius graminis, Galendromus occidentalis* predator mites, and the avocado red mite *Oligonychus yothersi*.

<table>
<thead>
<tr>
<th>Biological parameters</th>
<th><em>C. picanus</em></th>
<th><em>A. graminis</em></th>
<th><em>G. occidentalis</em></th>
<th><em>O. yothersi</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_0$</td>
<td>25.41 ± 1.14b</td>
<td>0.27 ± 0.01d</td>
<td>16.25 ± 0.68c</td>
<td>39.66 ± 1.84a</td>
</tr>
<tr>
<td>$r_m$</td>
<td>0.25 ± 0.00a</td>
<td>-0.06 ± 0.00d</td>
<td>0.19 ± 0.00c</td>
<td>0.22 ± 0.00b</td>
</tr>
<tr>
<td>$T$</td>
<td>12.46 ± 0.16d</td>
<td>20.75 ± 0.31a</td>
<td>14.62 ± 0.25c</td>
<td>16.36 ± 0.19b</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.29 ± 0.00a</td>
<td>0.93 ± 0.00d</td>
<td>1.20 ± 0.00c</td>
<td>1.25 ± 0.00b</td>
</tr>
</tbody>
</table>

Values with different letters in the rows indicate significant differences according to Tukey (p < 0.05).

$\text{SE}: \text{standard error. } n: \text{number of individuals. } R_0: \text{net reproductive rate. } r_m: \text{net intrinsic rate of increase. } T: \text{mean generation time. } \lambda: \text{finite rate of increase.}$
pest (Persad y Khan, 2002; Kontodimas et al., 2007). In theory, associating predator intrinsic rate of increase on the prey intrinsic rate of increase, shown by the equation \( r_m^{\text{predator}} / r_m^{\text{pest}} \geq 1 \), will indicate an efficiency potential to regulate the pest population. Other important parameters must also be considered such as longevity, predatory capacity, and early prey detection ability in selecting efficient biological control (Fiaboe et al., 2007).

*Cydnodromus picanus* achieved a higher \( r_m \) than the red mite, signifying that this population has the capacity to control *O. yothersi* across generations, that is, this species of phytoseiid is an efficient natural enemy of the phytophage mite, and its potential use should be evaluated in the integrated management of avocado mites.

Regarding phytoseiid field releases, all the factors that can influence its effectiveness on a specific phytophage mite must be considered, such as domatia of the host plant (morphological structures of the leaf: depressions, tricomes, cavities between the midrib, and secondary veins that provide refuge for the predator mites generating mutualism) (Matos et al., 2004), chaetotaxia of the predator (length of the dorsoventral setae) (Croft et al., 2004), alternative food availability (Bouras and Papadoulis, 2005), host plant, and leaf area (Collier et al., 2007).

**CONCLUSIONS**

Given the phytoseiid species under evaluation: *C. picanus, A. graminis, and G. occidentalis*, it can be concluded that:

*C. picanus* and *G. occidentalis* complete their postembryonic development and are able to reproduce by feeding on immature avocado red mites in laboratory conditions, both considered as potential predators of *O. yothersi*. However, *G. occidentalis* requires prey in the larval stage for its development and without using alternative food.

*A. graminis* has no descendants when feeding on mobile immature *O. yothersi*. However, its population could be increased in the orchard through a habitat management program since it survives by feeding on avocado var. Hass and *H. incana* pollen as alternative food.

A new predator-prey interaction was established under laboratory conditions (*C. picanus-O. yothersi*). Field releases in the spring of *C. picanus* upheld its potentiality as a predator of the avocado red mite in the context of Integrated Pest Management.

**RESUMEN**

Parámetros de tabla de vida y tasa de consumo de *Cydnodromus picanus* Ragusa, *Amblyseius graminis* Chant y *Galendromus occidentalis* (Nesbitt), sobre la arañita roja del palto *Oligonychus yothersi* (McGregor) (Acari: Phytoseiidae, Tetranychidae). En Chile la arañita roja del palto *Oligonychus yothersi* (McGregor) es la plaga más importante a nivel foliar en huertos comerciales afectando la fisiología de la hoja, siendo necesaria la búsqueda de nuevos enemigos naturales que interactúen a bajas densidades poblacionales de *O. yothersi*. Se evaluó en condiciones de laboratorio (27 ± 1,93 ºC, 87 ± 3,61% H.R. y un fotoperíodo de 16:8 (L: O)) sobre discos de hojas de palto (Persea americana Mill.) var. Hass (Ø = 5 cm) la potencialidad de ácaros depredadores *Cydnodromus picanus* Ragusa, *Amblyseius graminis* Chant y *Galendromus occidentalis* (Nesbitt), suministrando huevos inmaduros y hembras adultas de *O. yothersi* separadamente, registrando desarrollo...
postemembranario, consumo y parámetros de tabla de vida. El desarrollo postemembranario de *C. picanus* fue significativamente menor (5,46 días) en comparación a *A. graminis* (7,33 días) y *G. occidentalis* (8,69 días) al ser alimentados con inmaduros de *O. yothersi*. Los parámetros de tabla de vida de *C. picanus* fueron tasa neta de reproducción $R_0 = 25,41$, tasa finita de crecimiento $\lambda = 1,29$ y tiempo generacional $T = 12,46$. La tasa intrínseca de crecimiento ($r_m$) fue significativamente mayor para *C. picanus* ($r_m = 0,25$) frente a *G. occidentalis* ($r_m = 0,19$), mientras que *A. graminis* presentó una $r_m = -0,06$ indicando que su población no tiene descendencia. El $r_m$ registrado por *C. picanus* en condiciones de laboratorio es un indicador del potencial que tiene como depredador sobre *O. yothersi*, y permite suponer que en condiciones de campo el patrón de reducción poblacional de la plaga podría mantenerse.

**Palabras clave:** desarrollo postemembranario, depredación, polen, control biológico.

**LITERATURE CITED**


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