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Biology of false spider mite, *Raoiella macfarlanei* on *Syzygium cumini* and *Syzygium jambos*: A comparative study of development, behavior, and impact on host plants

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Abstract: A study investigated the traits and life cycle of the pest mite *Raoiella macfarlanei* on two host plants, *Syzygium cumini* and *Syzygium jambos*, at two temperatures. Results revealed distinct developmental patterns: females and males matured faster on *S. cumini* at both 30°C (21.70 and 18.93 days) and room temperature (26.88 and 25.71 days) compared to *S. jambos* (30°C: 24.16 and 21.04 days; room temperature: 29.98 and 28.25 days). Additionally, mated females had shorter preoviposition and oviposition periods on *S. cumini* at room temperature (4.47 and 35 days) and 30°C (3.92 and 27.10 days) than on *S. jambos* (5.53 and 35.40 days at room temperature; 4.16 and 28.00 days at 30°C). Net Reproductive Rate and Mean Generation Time were higher on *S. jambos* (room temperature: 22.11 and 53.39; 30°C: 19.55 and 41.50) compared to *S. cumini* (room temperature: 21.00 and 48.80; 30°C: 18.30 and 38.20). These findings deepen our understanding of *R. macfarlanei's* biology and life cycle in different environments, offering insights into its impact on agricultural ecosystems.

Key words: Biology, demography, host plants, life history studies, *Raoiella macfarlanei*

INTRODUCTION

The Tenuipalpidae, a mite family (Acari) crucial in economics and agriculture, ranges from 190 to 330 micrometers in size. Often mistaken for spider mites, they're distinct for not spinning webs, earning them the name "false spider mites." Dorsoventrally flattened and slow-moving, they vary in color and have a global presence. Exclusive plant feeders, they cause significant damage to a variety of crops, feeding on leaf undersides, midribs, veins, stalks, and even forming galls on host plants (Ghai and Shenhmar, 1984; Sadana, 1985). Feeding activities of mites harm plants by damaging the epidermis and depleting leaves of chlorophyll and nutrients, affecting photosynthesis, growth, and yield (Goyal and Sadana, 1983). Infestation signs include stippling, scars, bronzing, a silvery appearance, and rusty brown or tannish scales (Goyal *et al.,* 1984). Punctures may lead to secondary infections. Mites reduce leaf area and water intake, causing wilting, leaf death, and defoliation, ultimately leading to plant devitalization and death. Tenuipalpidae members have stylet-like chelicerae and a simple palpus without a thumb-claw process. They have three pairs of setae on the propodosoma and 7 to 13 pairs on the hysterosoma. The metapodosoma may have one to several pairs of ventral setae, and the ventral and genital plates may or may not be distinct. They possess claw-like or pad-like true claws with a pad-like empodium bearing tenent hairs. Identifications rely on factors like the number and position of hysterosomal setae and the presence of striations and reticulations on the dorsal and ventral hysterosomal surfaces (Sadana, 1997). The Tenuipalpidae family has 891 described species in 34 genera globally, found across various zoogeographic regions (Mesa *et al*., 2009). In India, Gupta and Mandal (2014) identified 102 species from 15 genera, including 20 species from seven genera in Karnataka.

The false spider mite, *R. macfarlanei* Pritchard and Baker, was first found in 1974 on *Jambosa vulgaris* in Karnataka, India, and later in Kerala and Gujarat. It infests *Syzygium* spp., causing leaf desapping, yellowing, browning, and leaf dryness. They are mainly found on the lower surface of leaves along the midrib, piercing plant tissue and sucking sap. Heavy infestation leads to yellowing and brown patches on the leaves, with older leaves being more affected. Mite populations peak from January to April, persisting throughout the year (Nageshachandra, 1980).

Despite their economic importance, studies on the Tenuipalpidae family are scarce in India and specifically in Karnataka. This study aims to explore the false spider mite fauna associated with fruit plants in Bengaluru and its neighboring regions, focusing on the biological aspects and life parameters of *R. macfarlanei* in relation to different host plants and temperature conditions, offering a deeper understanding of the dynamics of this species in agricultural ecosystems.

MATERIAL AND METHODS

This section covers the methods used for collecting, preserving, extracting, processing, describing, illustrating,

and measuring mite specimens. It also addresses research on the developmental biology, reproduction, and life table parameters of *R. macfarlanei* on *Syzygium* spp. The studies were conducted at the Acarology unit of the Department of Agricultural Entomology, UAS, GKVK, Bengaluru.

Collection, purification and maintenance of mite culture in the laboratory

Leaves infested with *R. macfarlanei* from *Syzygium* trees (*S. cumini* and *S. jambos*) were collected from hostel premises, GKVK and transported to the lab. Thirty random mating pairs of mites, each consisting of single female deutonymph and one to two male mites, were selected from these samples. These pairs were placed on separate 2.5 cm × 2.5 cm leaf sections within 6" Petri plates on moist cotton wads for colonization. One female and one male mite from each section were slide-mounted in Hoyer's medium for taxonomic identification. After identification, the leaf sections with *R. macfarlanei* mites were combined to form a pure starter culture, maintained on host leaves (*Syzygium* spp.) in separate polyethylene trays (25×20×5 cm) with wet foam. To support mite culture multiplication, leaf sections were kept turgid and replaced with fresh ones as needed due to deterioration or loss of color.

Comparative developmental biology of *R. macfarlanei* on two different host plants

The developmental biology study of *R. macfarlanei* occurred in controlled lab conditions, examining two temperature settings: room temperature (21-22°C, 83-88% RH) and a higher temperature of 30°C (74-79% RH). The experiment used two host plants, *S. cumini* and *S. jambos*. In the initial phase, 30 eggs laid on *S. cumini* leaves were collected within a 2 to 4-hour window. These eggs were individually transferred to 30 separate small leaf sections (2.5 x 2.5cm) of *S. cumini*, placed on damp cotton wads inside 6-inch Petri dishes. Two sets of eggs were used: one set developed at room temperature, while the other was placed in a BOD incubator at 30°C.

A parallel procedure was applied to *S. jambos*, involving 30 eggs under two temperature conditions (room temperature and 30°C). Special care was taken to maintain cotton wad moisture through periodic wetting with clean water. Mite development on leaf sections was observed at 3-hour intervals using a stereo zoom microscope, enabling tracking of stages such as incubation, egg hatching, and durations of various immature stages (larva, quiescent I, protonymph, quiescent II, deutonymph, and quiescent III) until adult mite emergence. The resulting adult mites' gender was also recorded. If leaf sections dried or deteriorated, immature mites were transferred to fresh ones for continued observations.

Reproduction and demography of *R. macfarlanei* on *Syzygium* spp.

A similar procedure was employed for *S. jambos*, using 30 eggs for each temperature condition (room temperature and 30°C). Ensuring the cotton wad's moisture, periodic wetting with clean water was meticulously maintained. Mite development on leaf sections was observed at 3-hour intervals through a stereo zoom microscope. This tracking covered stages like incubation, egg hatching, and durations of larva, quiescent I, protonymph, quiescent II, deutonymph, and quiescent III, leading to the emergence of adult mites. The resulting adult mites' sex was also recorded. If leaf sections dried or deteriorated, immature mites were moved to fresh sections, and observations continued.

The objective was to compare the influenmce of host plants on various reproduction attributes, such as the preoviposition period, oviposition period, post-oviposition period, fecundity, and sex ratio. Additionally, we calculated various demographic characteristics or life table parameters, including Mean Generation Time (T), Doubling Time (DT), Finite Rate of Increase (λ), Net Reproduction Rate (R_o), Gross Reproductive Rate (GRR), and Intrinsic Rate of Natural Increase (rm) using the method recommended by Birch (1948).

RESULTS AND DISCUSSION

A thorough investigation into the developmental biology of *R. macfarlanei* was conducted under laboratory conditions, specifically examining two *Syzygium* species and two temperature settings. The study revealed significant variations in developmental timelines, reproduction, and demographic parameters based on gender, host plants, and temperature conditions.

Biology of *R. macfarlanei*

At room temperature (21-22 °C & RH 83-88%)

On *S. cumini*, *R. macfarlanei* female required 218.88, 81.26, 28.52, and 91.17 hours for egg, larval, protonymphal, and duetonymphal stages, respectively. In comparison, the corresponding stages in males took 218.88, 78.00, 89.00, and 97.33 hours. The female's development from egg to adult was significantly longer (26.88 days) compared to the male on *S. cumini*. On *S. jambos*, the female needed 244.0, 116.75, 78.75, and 105.66 hours for the same stages, while the male required 244.00, 52.00, 84.00, and 80.00 hours. The

female's development from egg to adult (29.98 days) was significantly longer than the male (28.25 days) on *S. jambos*. *R. macfarlanei* female completed development in 26.88 days on *S. cumini* and 29.98 days on *S. jambos*, a significant difference. The male also developed faster on *S. cumini* (25.71 days) compared to *S. jambos* (28.25 days), with statistical significance (Table 1).

No literature is available on the biology of *R. macfarlanei* on any of the hosts and the results are discussed in the light of the studies conducted on other related species. Therefore, our study provides valuable insights into the developmental timelines of *R. macfarlanei*, which had not been previously documented in the literature. We compared our findings with related mite species' studies, such as *Raoiella indica*. Nageshachandra (1980) studied the biology of *R. indica* on coconut in the laboratory at ambient temperature ranging from 23.90 to 25.7°C and relative humidity averaging 59.85 per cent. The total developmental period was about 24.50 days and Moutia (1958) studied the life cycle of *R. indica* which occupied 18.00 to 26.00 days with an average of 22.00 days at 24.2°C in February-March and 30.00 to 36.00 days with an average of 33.00 days at 17.9°C in July and August. The work of Zaher *et al*. (1969) on *R. indica* with the host, date palm in Egypt yielded similar results, indicating the consistency of certain mite characteristics across species.

At 30°C (RH 74-79%)

The data on *R. macfarlanei* development in the laboratory on *Syzygium* spp. at 30°C was presented in the Table 2. On *S. cumini*, females required 114.00, 69.39, 88.07, and 89.00 hours for egg, larval, protonymphal, and duetonymphal stages, respectively, while males took 114.00, 52.50, 60.00, and 69.00 hours for the corresponding stages. Females on *S. cumini* had a significantly longer development time (21.70 days) compared to males (18.93 days). On *S. jambos*, females needed 168.00, 76.66, 91.55, and 95.51 hours for the mentioned stages, while males took 168.00, 70.50, 79.50,

Table 1. Development of *Raoiella macfarlanei* on *Syzygium* spp. under laboratory conditions (Temperature: 21-22 °C and Relative Humidity: 83 to 88%)

Developmental Stage	Mean duration of development (hours) on			
	Syzygium cumini		*Syzygium jambos*	
	Female (n = 23)	Male (n = 3)	Female (n = 24)	Male (n = 3)
Egg	218.88±00	218.88±00	244.00±00	244.00±00
Larva	81.26±0.84	78.00±3.00	116.75±2.05	111.00±1.73
Quiescent I	53.86±2.64	51.00±6.00	57.25±4.84	52.00±2.00
Protonymph	78.52±2.35	89.00±2.64	78.75±5.53	84.00±9.16
Quiescent II	48.56±3.28	32.00±5.29	57.36±3.53	62.00±8.54
Deutonymph	91.17±3.47	97.33±1.33	105.66±5.61	80.00±6.55
Quiescent III	73.08±3.28	51.00±3.00	60.87±2.92	45.00±6.24
Total (hours)	645.33±21.87	617.21±23.49	719.65±25.21	678±25.91
T test	Sig.		Sig.	
Development (egg to adult)	26.88 days	25.71 days	29.98 days	28.25 days

n= no. of individuals observed, Sig= significant

and 74.00 hours. *R. macfarlanei* females on *S. jambos* required significantly more time (24.16 days) than males (21.04 days) for development (Table 2).

Development from egg to adult took 21.70 days for females on *S. cumini* compared to 24.16 days on *S. jambos*. For males, the corresponding times were 18.93 days on *S. cumini* and 21.04 days on *S. jambos*, with statistically significant differences (Table 2). At 30°C, *R. macfarlanei* completed development faster than at room temperature on both hosts. On *S. cumini*, total development at 30°C was 21.70 days for females and 18.93 days for males, compared to 26.88 days and 25.71 days at room temperature. On *S. jambos*, at 30°C, development took 24.16 days for females and 21.04 days for males, while at room temperature, it was 29.98 days and 28.25 days, respectively (Table 1 & 2).

No literature is available on the reproductive parameters of *R. macfarlanei* and the results are discussed based on information available on related species. Thus, our study provides a foundation for understanding the reproductive parameters of *R. macfarlanei*, which had not been previously documented and are in accordance with the results of Zaher *et al.* (1969) who reported the preoviposition period (3.30 days) and fecundity (28.10 eggs) per female on *R. indica*. In a laboratory study by Moutia (1958) on an average survival period with a recorded of 27.00 days for mated females of *R. indica* which is almost equal to the duration recorded at 30°C in the present study. These findings offer valuable insights for pest management and ecological studies. However, the present findings contradict the results of Nageshachandra (1980) who studied the preoviposition, oviposition and post oviposition periods of *R. indica* on coconut and recorded 2.07, 40.10 and 6.50 days for the respective durations. The deviation with respect to various durations found in this study may be due to change in the host as well as the mite species.

Life table parameters of *R. macfarlanei*

Reproduction: This mite species exhibits both sexual and asexual reproduction. Unmated females' eggs exclusively yield males, while mated females produce both males and females. Reproduction parameters on two *Syzygium* host species at room temperature and 30°C are detailed in Tables 3.

Mating: Upon reaching sexual maturity after the final moult, both males and females actively sought mates. The male, upon emergence, searched for a female deutonymph, sometimes engaging in courtship during this stage. When encountering a quiescent female

Table 2. Development of *Raoiella macfarlanei* on *Syzygium* spp. under laboratory conditions (Temperature: 30 °C and Relative Humidity: 74 to 79%)

Developmental Stage	Mean duration of development (hours)			
	Syzygium cumini		*Syzygium jambos*	
	Female (n = 28)	Male (n = 2)	Female (n = 27)	Male (n = 2)
Egg	144±00	144±00	168.00±00	168.00±00
Larva	69.39±0.85	52.5±1.50	76.66±1.23	70.5±7.5
Quiescent I	40.87±0.84	34.5±4.5	49.66±1.26	41.00±2.00
Protonymph	88.07±2.11	60.00±3.00	91.55±1.90	79.5±1.5
Quiescent II	45.75±1.68	52.5±1.50	51.66±1.65	37.5±1.5
Deutonymph	89.00±2.12	69.00±00	95.51±1.78	74.00±1.00
Quiescent III	43.92±1.35	42.00±3.00	47.00±1.58	34.50±1.50
Total (hours)	520.8±13.93	454.5±13.84	580.04±16.9	505±17.48
T test	Sig.		Sig.	
Development (egg to adult)	21.70 days	18.93 days	24.16 days	21.04 days

n = no. of individuals observed, Sig = significant

Table 3. Reproduction parameters of *Raoiella macfarlanei* on *Syzygium* spp. at two different temperatures under laboratory conditions

Temperature and Relative humidity	*Syzygium spp.*	Reproduction parameters									
		Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Longevity of mated female (days)	Longevity of male (days)	Unmated female *(n = 30)*	Mated female *(n =30)*			
							Mean no. of eggs/ female	Mean no. of eggs/ female	Mean no. of female offsprings/ female	Mean no. of male offsprings/ female	Sex ratio of the progeny (♂:♀)
21-22°C and 83 -88%	*S. cumini*	4.76	35.00	5.04	44.80	21.62	16.23	23.92	21.76	2.16	1:10.07
	S. jambos	5.53	35.38	5.07	45.98	23.87	17.36	24.23	22.03	2.19	1:10.05
	T test	*	*	NS	NS	*	*	NS	NS	NS	NS
30°C and 74 -79%	*S. cumini*	3.92	27.05	3.84	34.81	15.36	14.16	19.52	17.72	1.80	1:9.84
	S. jambos	4.16	28.00	3.92	36.08	16.82	16.32	21.56	19.64	1.92	1:10.22
	T test	*	*	NS	NS	NS	*	NS	NS	NS	NS

*N.B.: Unmated females produced only male offsprings; n= number observed, * significant @ 5%*

deutonymph, the male settled close and waited for its transition to adulthood. Courtship involved the male holding the female's last pair of legs with its first pair, and they moved together for several hours to two days. As the female approached the moult, the male became more active, positioning itself beneath the female and attempting to mate by holding the hysterosoma with its two anterior pairs of legs and bending its opisthosoma in a 'C' shape.

Preoviposition: During preoviposition, females began feeding immediately after mating and before initiating egg laying. The time lapse between adult emergence and the first egg deposition varied, ranging from 4.76 to 5.53 days at 21-22°C on *S. cumini* and *S. jambos*. At 30°C on both hosts, this period was shorter, ranging from 3.92 to 4.16 days. These differences were statistically significant.

Oviposition: During oviposition, females selected a suitable spot along the leaflet midrib for egg deposition. At room temperature, oviposition took 35.00 days on *S. cumini* and 35.38 days on *S. jambos*. At 30°C, the oviposition period was shorter, lasting 27.05 days on *S. cumini* and 28.00 days on *S. jambos*. These variations were statistically significant.

Fecundity: Fecundity in *R. macfarlanei* varied based on host plant and rearing temperature. Mated females exhibited higher egg-laying at room temperature (23.92 and 24.23 eggs/female on *S. cumini* and *S. jambos*, respectively) compared to 30°C (19.52 and 21.56 eggs/female on *S. cumini* and *S. jambos*, respectively). Unmated females laid fewer eggs at 30°C (14.16 and 16.32 eggs/female on *S. cumini* and *S. jambos*, respectively) than at 21-22°C (16.23 and 17.36 eggs/female on *S. cumini* and *S. jambos*, respectively).

Post-oviposition period: After the adult females stopped laying the eggs, adults lived for 5.04 and 5.07 days at room temperature on *S. cumini* and *S. jambos,* respectively and this period was higher compared to 3.84 and 3.92 days recorded at 30°C on the respective hosts.

Longevity of mated female: The total life span of adult female after emergence from the deutonymph was longer, 44.80 and 45.98 days at 21-22°C on *S. cumini* and *S. jambos,* respectively, compared to 34.81 and 36.08 days recorded at 30°C on the respective hosts. However the differences were statistically non significant (Table 3).

Longevity of male: The total active period of adult male after emergence from deutonymph was 21.62 and 23.87 days on *S. cumini* and *S. jambos,* respectively at room temperature as against 15.36 and 16.82 days recorded on the corresponding hosts at 30°C.

Demography of *R. macfarlanei* on *Syzygium* spp.

Demographic parameters, including mean generation time (T), gross reproductive rate (GRR), net reproductive rate (R0), doubling time (DT), finite rate of increase (λ), and intrinsic rate of natural increase (rm), were derived from the age-specific life table of *R. macfarlanei* on two *Syzygium* species at room temperature (21-22°C) and 30°C (Table 4). Demographic parameters of *R. macfarlanei* on *Syzygium* hosts at room temperature (21-22°C) & 83-89% RH were obtained from 30 mated females. On *S. jambos* and *S. cumini, R. macfarlanei*

Table 4. Demography of *Raoiella macfarlanei* on *Syzygium* spp. at two different temperatures under laboratory conditions

Temperature and Relative humidity	*Syzygium* spp.	Demographic parameters (n=30)					
		Mean Generation Time (T) (days)	Doubling time (Days) (DT)	Net Reproduction Rate (R_o)	Gross reproductive rate (GRR)	Finite Rate of Increase (λ)	Intrinsic Rate of Natural Increase (r_m)
21-22°C and 83 - 88%	*S. cumini*	48.80	11.17	21.03	21.82	1.063	0.062
	S. jambos	53.39	11.95	22.11	22.51	1.059	0.057
30°C And 74 - 79%	*S. cumini*	38.17	9.10	18.29	18.44	1.079	0.076
	S. jambos	41.51	9.67	19.55	19.68	1.071	0.071

n= number observed

showed a mean generation time (T) of 53.39 days and 48.8 days, Ro of 22.11 and 21.03, and similar λ and rm values (1.063, 0.062; 1.059, 0.057) for both hosts. However, doubling time was slightly higher on *S. jambos* (11.95 days) than on *S. cumini* (11.17 days).

At 30°C, demographic parameters on *Syzygium* hosts revealed T of 41.51 days and 38.17 days, Ro of 19.55 and 18.29 for *S. jambos* and *S. cumini*, respectively. Similar λ and rm values (Table 4) were observed on both hosts, but doubling time was relatively higher on *S. jambos* (9.67 days) compared to *S. cumini* (9.10 days). No attempt has been made on the age specific life table parameter of *R. macfarlanei*. To the best of our knowledge, this is the first study to provide insights into age-specific life table parameters for *R. macfarlanei*. However, Teodoro and Reis (2006) studied the reproductive success of *B. phoenicis* on citrus fruits and coffee leaves and reported that the intrinsic rate of the population increase (r_m) was 0.128 and 0.090 females/female/day on citrus fruits and coffee leaves, respectively. Comparisons with related species, such as *B. phoenicis*, underscore the variability in population growth rates within mite species and across different host plants.

Our findings indicate that *R. macfarlanei* is adaptable, demonstrating the capacity to feed, survive, and develop on two species of *Syzygium* at both room temperature (21-22°C) and 30°C. The development period from egg to adult was influenced by the host species and the rearing temperature. The choice of host plant appears to impact the mite's reproductive performance and developmental timeline, with *S. jambos* yielding a higher net reproductive rate (R_o) and a longer mean generation time (T).

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