Biochemical Effects of Cultivated and Wild Jute Species on Life Stages of the Broad Mite, Polyphagotarsonemus latus (Prostigmata: Tarsonemidae)

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Source: Florida Entomologist, 98(4) : 1044-1049

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.098.0406

Biochemical effects of cultivated and wild jute species on life stages of the broad mite, *Polyphagotarsonemus latus* (Prostigmata: Tarsonemidae)

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Abstract

We studied the life cycle of the broad mite, *Polyphagotarsonemus latus* (Banks) (Prostigmata: Tarsonemidae), on 2 cultivated jute species (*Corchorus olitorius* L. and *Corchorus capsularis* L.; Malvales: Malvaceae) and 5 wild species (*Corchorus aestuans* L., *Corchorus pseudo-olitorius* Islam & Zaid, *Corchorus fascicularis* Lamarck, *Corchorus tridens* L., and *Corchorus trilocularis* L.) under laboratory conditions. Results showed that the egg incubation period, larval and nymphal durations, and adult male and female longevities of *P. latus* varied significantly on different jute species. The larval period (mean ± SD) was significantly shorter (57.00 ± 2.07 h) on *C. olitorius* than on *C. fascicularis*, *C. aestuans*, and *C. tridens* (68.00 ± 1.58 to 72.00 ± 1.30 h). The phenol content was greatest in *C. trilocularis* (61.92 ± 1.91 µg/g), and it was 16.26 ± 1.34 µg/g and 20.45 ± 1.43 µg/g in *C. olitorius* and *C. capsularis,* respectively. The polyphenol oxidase content was smallest in *C. capsularis* (0.99 ± 0.10 µg/mL) as compared with 2.38 ± 0.15 µg/mL in *C. fascicularis*. The protein content in the wild species was significantly less than in the cultivated species. In the wild species, the peroxidase content varied from 3.93 ± 0.17 to 7.08 ± 0.16 µg/mL, and it was 3.23 ± 0.12 to 3.70 ± 0.14 µg/mL in the cultivated species. The leaf biochemical constituents of jute species were correlated with mite life stages and incidence. The larval period and adult female longevity had significantly negative correlations with polyphenol oxidase content and positive correlations with protein content. The greatest mite population was observed on *C. olitorius*, and the smallest mite population was observed on *C. trilocularis*, at 50 d after sowing. The mite populations increased on all the jute species except *C. trilocularis* at 50 d after sowing. Based on the duration of life stages, the present study showed that among the 7 species of jute, the cultivated *C. olitorius* was the most suitable host for broad mites. It is evident that biochemical leaf constituents have an important role in the growth and buildup of mite pests in these crops. On the basis of the relative resistance and susceptibility of the jute species, appropriate interspecific crosses may provide a platform for developing resistant varieties for broad mite management.

Key Words: adult longevity; *Corchorus*; correlation; nymphal period; phenol; peroxidase

Resumen

Se estudió la biología del ácaro ancho, *Polyphagotarsonemus latus* (Banks) (Prostigmata: Tarsonemidae) en 2 especies cultivadas de yute (*Corchorus olitorius* L. y *C. capsularis* L.; Malvales: Malvaceae) y 5 especies silvestres (*C. aestuans, C. pseudo-olitorius, C. fascicularis, C. tridens, C. trilocularis*) en condiciones de laboratorio. El estudio reveló que el período de incubación de huevos de *P. latus* sobre diferentes especies varió de 45.0 h en *C. capsularis* a 51.0 h en *C. olitorius* en comparación con 46.0 h y 53.0 h en *C. trilocularis* y *C. fascicularis,* respectivamente. El período larval total fue significativamente menor en *C. olitorius* (57.0 h.) En comparación con *C. pseudo-olitorius* (59.0 a 72.0 h). La longevidad de los ácaros adultos en las especies cultivadas fue menor que en las especies silvestres, excepto en *C. fascicularis*. El contenido de fenoles mas alto fue en *C. trilocularis* (61.92 mg/g) y fue 16.26 mg/g y 20.45 mg/g en *C. olitorius* y *C. capsularis*, respectivamente. La actividad del polifenol oxidasa fue menor 0.99 g/mL en *C. capsularis* y 1.12 g/ml en *C. olitorius* en comparación con 2.38 g/ml en *C. fascicularis*. El contenido de proteína en las especies silvestres fue significativamente más bajo en comparación con el de las especies cultivadas. En las especies silvestres, el contenido de peroxidasa varió de 3.93-7.08 g/ml y fue de 3.23 a 3.70 g/ml en las especies cultivadas. La actividad del polifenol oxidasa tuvo una correlación significativamente positiva con la duración del periodo larvario mientras que el contenido de proteína mostró una correlación negativa con la duración del periodo larvario. Los contenidos de fenol y peroxidasa mostraron una correlación negativa con la duración del período de ninfa. En contraste con el período larval, la longevidad del macho adulto se correlacionó negativamente y positivamente con el polifenol oxidasa y el contenido de proteína, respectivamente.

Palabras Clave: longevidad de adultos; ácaro blanco; *Corchorus*; correlación; período larval; fenol; peroxidasa; contenido de proteína

The broad mite, *Polyphagotarsonemus latus* (Banks) (Prostigmata: Tarsonemidae), is a highly polyphagous pest that is reported to infest more than 100 different plant species, including jute (Beattie & Gellatley 1983; Hath 2000). In the jute crop, *P. latus* is one of the important pests, and nymphs and adults suck the cell sap from the undersurface of young leaves, which curl ventrally in due course of time. Furthermore, the infested leaves do not grow to their full size, and they turn coppery-brown and drop prematurely (Pradhan & Saha 1997). The attack is confined mostly to new growth and results in curling of leaf margins, firmness of infested leaves, necrosis of growing tips, aborted buds, malformed pods, and growth inhibition. As a consequence, the vertical vegetative growth of the crop is arrested, internode lengths are reduced, side branches are enhanced, and significant yield loss occurs (Grinberg et al. 2005). Tossa jute (*Corchorus olitorius* L.) suffers

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more due to *P. latus* infestation than white jute (*Corchorus capsularis* L.) (Malvales: Malvaceae) (Das 1989). The yield loss due to this pest has been estimated to reach 42% depending on the level of infestation (Pandit et al. 2002).

Although chemical control is effective against the broad mite, frequent use of pesticides reduces the natural enemy population and causes resurgence and resistance problems. The development of alternative strategies for sustainable management of this pest in jute crop is urgent. Variation in host plant traits, including food quality, presence of feeding deterrents, and toxic chemicals, is an important factor in limiting insect populations. Understanding the variation in food quality among related host plants could have useful implications for the management of the broad mite. Furthermore, assessment of biochemical components of the host plant species would help in better understanding the mechanism of host suitability. In this context, identification of sources of resistance is one of the options to develop resistant or tolerant plant varieties for sustainable management of the broad mite in jute.

Not much is known about plant defense responses to small arthropods, such as broad mites, that pierce single plant cells and feed on intracellular fluids (Grinberg et al. 2005). Although there are studies on the biology of broad mites on different host plants (Al-Ani & Al-Jboory 2008; van Maanen et al. 2010; Montasser et al. 2011), there are few studies of biochemical constituents such as phenols, chlorophyll, and proteins that may influence resistance to mite attack. Ahmed et al. (2000) conducted studies on chilli pepper (*Capsicum* species; Solanales: Solanaceae) with varieties that are resistant, susceptible, and highly susceptible to mite infestation, but no such studies have been conducted to address the possible effect of cultivated and wild species of jute on the life cycle of broad mites. Hence, we conducted the present investigation to study the life cycle of the broad mite on wild and cultivated species of jute to identify possible source of resistance.

Materials and Methods

The study was conducted in the laboratory and glasshouse of the ICAR–Crop Protection Division at the Central Research Institute for Jute and Allied Fibre (CRIJAF), Kolkata, West Bengal, India, during the period from Feb to Jul 2013.

EXPERIMENTAL PLANTS

The seeds of 2 cultivated jute species *Corchorus olitorius* ('JRO204') and *Corchorus capsularis* ('JRC321') and of 5 wild jute species *Corchorus aestuans* L. ('WCIN174'), *Corchorus pseudo-olitorius* Islam & Zaid ('WCIN182'), *Corchorus fascicularis* Lamarck ('WCIN123'), *Corchorus tridens* L. ('WCIN188'), and *Corchorus trilocularis* L. ('WCIN186') (Malvales: Malvaceae) were procured from the seed bank of the Central Research Institute for Jute and Allied Fibres (CRIJAF) for research on mite growth. They were sown during Feb 2013 in earthen pots (37.5 cm upper × 15.5 cm lower radius × 27 cm height), which were one-third filled with a mixture of farmyard manure and soil. All plants were maintained by following standard agronomic practices to produce healthy crops under glasshouse conditions. Also, another set of these host plants was simultaneously sown in earthen pots to study the effects of broad mite infestation on the biochemistry of different jute species. These plants also were maintained as per standard agronomic practices under natural field conditions for the establishment of natural mite populations.

BROAD MITE CULTURE

The broad mite population was maintained on 30-d-old cultivated jute *C. olitorius* ('JRO204') in another glasshouse. Mites were collected in Feb 2013 from unsprayed jute plants on the CRIJAF Research Farm, similar to methods described by Palevsky et al. (2001). The potted plants were then inoculated with leaves infested with broad mites. Before initiating our experiments, we reared the mites on jute plants for 2 wk to obtain a sufficient mite population, and this population was used for life cycle studies.

LIFE CYCLE OF THE BROAD MITE

The life cycle of *P. latus* was studied on 7 species of jute (wild species: *C. aestuans*, *C. pseudo-olitorius*, *C. fascicularis*, *C. tridens*, *C. trilocularis*; cultivated species: *C. olitorius*, *C. capsularis*) using the leaf arena method described by Abou-Setta & Childers (1987). The experiment was conducted in a completely randomized design in a biological oxygen demand (BOD) incubator at 27 ± 1 °C, 75 ± 5% RH, and a 16:8 h L:D photoperiod. The method included placing 2 unfolded second jute leaves, which were 35 d old, upside down on filter paper placed over a thin layer of sponge. The sponge was placed over a layer of cotton saturated with water in a foam dish. The leaf stalk was directed downward to reach the saturated cotton. Ribbons of filter paper immersed in Vaseline (petroleum jelly) were placed 1 cm apart from and surrounding the plant leaf to prevent mites escaping from the leaf. Water was added when needed to keep humidity constant. Five pairs of adult broad mites from glasshouse culture were transferred to a replicate of an "arena leaf" of 1 of the 7 host plant species for 48 h. Eggs laid by females were observed until the larvae hatched. The hatched larvae were placed on fresh arena leaves and examined twice daily to determine the duration of larval and nymphal stages and the longevity of emerging males and females. The entire experiment was replicated 5 times.

ANALYSIS OF LEAF BIOCHEMICAL CONTENTS

For biochemical analysis, unfolded second leaf samples were collected from each species at 35 to 40 d after sowing (DAS), and all biochemical analyses were repeated 5 times. Total protein, total phenol, peroxidase, and polyphenol oxidase contents were estimated according to Lowry et al. (1951), Bray & Thorpe (1954), Summer & Gjessing (1943, modified), and Augustin et al. (1985), respectively. The levels of protein and phenol in the sample were calculated and expressed as µg/g sample. The peroxidase absorbance was measured at 430 nm. To measure polyphenol oxidase, the change in absorbance at 410 nm between 30 s and 180 s of incubation was plotted in graphical form, and the enzyme activity was calculated from the linear part of the curve.

RELATIVE BROAD MITE INFESTATION ON JUTE SPECIES

The experiment was conducted in a completely randomized design with 5 replications. Each pot with a jute species was treated as 1 replication. These plants were kept free from acaricides to allow the natural mite population to establish. Three unfolded second leaves from each replication of the 7 jute species were collected to observe mite populations at intervals of 15 d starting at 35 DAS. The number of mites per cm^2 on the ventral surface of each leaf was counted under a stereomicroscope.

STATISTICAL ANALYSES

Data on the broad mite's life cycle parameters and its populations were subjected to analysis of variance (ANOVA) with the AGRES statistical package version 3.01 (AGRES 1994). Differences between the life cycle parameters in relation to various biochemical constituents were separated with Duncan's multiple range test ($P < 0.05$) using the AGRES package. Simple correlation analysis was used to determine the relationship between leaf biochemical contents in these 7 jute species and the mite biological parameters using MS Office Excel software, version 2010. Significances of correlation coefficients (r) were tested with t-tests at ($n - 2$) degrees of freedom.

Results

LIFE CYCLE OF THE BROAD MITE ON CULTIVATED AND WILD SPECIES OF JUTE

The life cycle of *P. latus* passes through egg, larva, quiescent nymph, and adult stages (Table 1). The incubation period of broad mite eggs on different jute species varied significantly from 45.00 ± 1.58 h (mean ± SD) on *C. capsularis* to 51.00 ± 1.71 h on *C. olitorius* ($F = 7.36$; df = 6, 28; $P < 0.05$). Among the wild species, it varied from 46.00 ± 1.48 h on *C. trilocularis* to 50.00 ± 1.94 h on *C. fascicularis*. Likewise, mite larval duration was significantly shortest (57.00 ± 2.07 h) on *C. olitorius*, which was statistically at par with the other cultivated species *C. capsularis* (60.00 ± 1.48 h) and the wild species *C. trilocularis* (60.00 ± 1.92 h) and *C. pseudo-olitorius* (59.00 ± 1.81 h) (Table 1). The significantly longest larval durations of 68.00 ± 1.58, 71.00 ± 1.64, and 72.00 ± 1.30 h were recorded on *C. aestuans*, *C. tridens*, and *C. fascicularis*, respectively ($F = 7.36$; df = 6, 28; $P < 0.05$) (Table 1).

The duration of the quiescent nymphal stage was longest on *C. fascicularis* (34.00 ± 1.14 h), which was significantly longer than on all the wild species (24.00 ± 1.30 to 31.00 ± 1.30 h) and the cultivated species *C. olitorius* (27.00 ± 2.07 h) and *C. capsularis* (24.00 ± 1.14 h) ($F = 7.36$; df = 6, 28; $P < 0.05$) (Table 1). The longevity of female adults varied from 50.00 ± 2.07 to 204.00 ± 9.75 h and was significantly the longest on *C. olitorius* and shortest on *C. pseudo-olitorius* ($F = 7.36$; df = 6, 28; $P < 0.05$). However, adult female longevity did not differ significantly among the cultivated jute species. Adult male longevity was shortest (41.00 ± 1.64 h) on *C. fascicularis* and longest (160.00 ± 8.67 h) on *C. olitorius* (Table 1). In general, adult female longevity was longer than adult male longevity on jute species except on *C. pseudo-olitorius.* Both of the cultivated species favored the survival of adults as compared with the wild species.

BIOCHEMICAL ANALYSIS OF CULTIVATED AND WILD SPECIES OF JUTE

The absolute and relative amounts of analyzed leaf biochemical constituents differed among the jute species (Table 2). The phenol content (mean ± SD) in the wild species of jute varied from 42.67 ± 2.40 µg/g in *C. aestuans* to 61.92 ± 1.91 µg/g in *C. trilocularis* (Table 2). Significantly less phenol was found in *C. olitorius* and *C. capsularis*, which contained 16.26 ± 1.34 µg/g and 20.45 ± 1.43 µg/g, respectively ($F = 7.36$; df = 6, 28; $P < 0.05$) (Table 2). The polyphenol oxidase content was less (0.99 ± 0.10 and 1.12 ± 0.06 µg/mL, respectively) in *C. capsularis* and *C. olitorius* as compared with the wild species (1.21 ± 0.04 to 2.38 ± 0.15 µg/mL) (Table 2). Among the wild species, the protein content was least in *C. fascicularis* (15.06 ± 0.83 µg/g) and the most in *C. tridens* (19.82 ± 0.93 µg/g) (Table 2). The levels of protein in the cultivated species were greater, i.e., 22.00 ± 1.58 in *C. olitorius* and 20.31 ± 1.18 µg/g in *C. capsularis* (Table 2). The peroxidase content varied from 3.23 ± 0.12 µg/mL in *C. capsularis* to 7.08 ± 0.16 µg/mL in *C. trilocularis* (Table 2). Wild species of jute contained the largest amounts of phenol, polyphenol oxidase, and peroxidase, and the cultivated species had the greatest protein contents.

CORRELATIONS BETWEEN MITE LIFE CYCLE AND PLANT BIOCHEMICAL CONTENTS

The biochemical constituents, i.e., total phenol, total protein, polyphenol oxidase, and peroxidase, in leaves were correlated with the different life stages of *P. latus* (Table 3). The polyphenol oxidase content had a significantly negative correlation ($r = -0.914$) with the larval period, whereas the protein content had a significantly positive correlation ($r = 0.762$) with it. Similarly, phenol ($r = -0.443$) and peroxidase ($r = -0.352$) contents showed moderately negative correlations with the nymphal period. Likewise, adult female longevity was significantly negatively correlated ($r = -0.867$) with polyphenol oxidase content and positively correlated ($r = 0.574$) with protein content. Polyphenol oxidase and protein content had similar effects on adult male longevity.

BROAD MITE POPULATION ON JUTE SPECIES

The relative infestation of broad mite populations on 7 jute species differed significantly from one another, except for *C. aestuans*

Table 1. Effects of various species of jute (*Corchorus*) on the life cycle of the broad mite, *Polyphagotarsonemus latus*.

		Duration of stages (h)				
					Adults	
Host plant	Accession number	Eggs	Larvae	Nymphs	Male	Female
		Wild jute species				
C. fascicularis	WCIN123	50.00 ± 1.94ab	72.00 ± 1.30a	25.00 ± 1.48c	41.00 ± 1.64f	90.00 ± 2.92b
C. aestuans	WCIN174	48.00 ± 1.30abc	68.00 ± 1.58a	31.00 ± 1.30b	86.00 **± 2.34**c	104.00 ± 3.24b
C. pseudo-olitorius	WCIN182	49.00 ± 1.92abc	59.00 ± 1.81b	30.00 ± 1.14b	68.00 ± 2.07d	50.00 **± 2.07**c
C. trilocularis	WCIN186	46.00 **± 1.48**bc	60.00 **± 1.92**b	34.00 **± 1.30**c	140.00 **± 6.51**b	187.00 **± 8.90**a
C. tridens	WCIN188	47.00 **± 2.07**abc	71.00 **± 1.64**a	24.00 **± 1.14**a	53.00 **± 3.00**e	105.00 **± 3.34**b
		Cultivated jute species				
C. olitorius	JRO204	51.00 **± 1.71**a	57.00 **± 2.07**b	27.00 **± 2.07**bc	160.00 **± 8.67**a	204.00 **± 9.75**a
C. capsularis	JRC321	45.00 **± 1.58**c	60.00 **± 1.48**b	24.00 **± 1.14**c	142.00 ± 3.28b	192.00 **± 8.14**a
Critical difference*	—	4.22	3.24	3.22	3.70	38.87

Means (± SD) in a column followed by different letters are significantly different ($P < 0.05$, Duncan's multiple range test).
*$P = 0.05$.

Table 2. Biochemical analysis of cultivated and wild species of jute (*Corchorus*).

Host plant	Accession number	Leaf biochemical content			
		Phenol (µg/g)	Polyphenol oxidase (µg/mL)	Protein (µg/g)	Peroxidase (µg/mL)
Wild jute species					
C. fascicularis	WCIN123	55.56 ± 2.00e	2.38 ± 0.15e	15.06 ± 0.83a	5.84 ± 0.44d
C. aestuans	WCIN174	42.67 ± 2.40c	1.63 ± 0.11c	17.58 ± 0.74b	5.44 ± 0.16c
C. pseudoolitorius	WCIN182	47.54 ± 1.65d	1.23 ± 0.07b	18.63 ± 0.86bc	5.73 ± 0.08cd
C. trilocularis	WCIN186	61.92 ± 1.91f	1.21 ± 0.04b	17.34 ± 0.73b	7.08 ± 0.16e
C. tridens	WCIN188	43.53 ± 1.17c	1.71 ± 0.09d	19.82 ± 0.93cd	3.93 ± 0.17b
Cultivated jute species					
C. olitorius	JRO204	16.26 ± 1.34a	1.12 ± 0.06b	22.00 ± 1.58e	3.70 ± 0.14b
C. capsularis	JRC321	20.45 ± 1.43b	0.99 ± 0.10a	20.31 ± 1.18d	3.23 ± 0.12a
Critical difference*	—	5.95	0.32	1.10	0.63

Means (± SD) in a column followed by different letters are significantly different ($P < 0.05$, Duncan's multiple range test).
*$P = 0.05$.

and *C. capsularis* ($F = 7.36$; df = 6, 28; $P < 0.05$) (Table 4). Among wild jute species, *C. trilocularis* harbored significantly smallest mite populations (19.49 mites/cm^2) and *C. aestuans* the most dense mite populations (64.24 mites/cm^2). Mite populations on cultivated species (*C. olitorius* and *C. capsularis*) varied significantly from one another and were significantly greater than those on wild species, with the exception of population densities on *C. capsularis* being similar to those on the wild species *C. aestuans* (Table 4). Considering growth stages of the plants and the species of jute, the most dense mite populations were observed on *C. olitorius* (171.88 mites/cm^2), and least dense mite populations (24.33 mites/cm^2) were observed on *C. trilocularis* at 50 DAS. By 50 DAS, the mite populations had increased on all the jute species except *C. trilocularis* (24.33 mites/cm^2). However, mite populations steadily declined from 50 DAS onwards (Table 4). The interaction effect of crop duration and broad mite population was significant.

Discussion

The mite *P. latus* oviposits eggs singly on the ventral surface of leaves. Fully fed larvae enter into an inactive quiescent stage from which adult males or females emerge with 4 pairs of legs. The levels of the biochemical constituents contained in the jute species affected the broad mite's life parameters. The results of the present study on the life cycle of *P. latus* on different jute species with respect to the egg incubation period, the larval period, the quiescent nymphal period, and adult longevity were in close agreement with those of Almaguel et al. (1984), Karmakar (1997), Dhooria (2005), and Al-Ani & Al-Jboory (2008) regarding eggs; Vieira & Chiavegato (1998), Vieira (2001), and Al-Ani & Al-Jboory (2008) regarding nymphs; and Vieira & Chiavegato (1998) and Namvar & Arbabi (2007) regarding adults.

In the present study, the duration of the larval stage was significantly shortest (57.00 ± 2.07 h) on *C. olitorius* and was longest on *C. fascicularis* (72.00 ± 1.30 h). Correlation analysis showed that protein content was positively correlated with larval duration, which can be explained by the greater protein content in *C. olitorius*. This elevated protein content may have accelerated larval development. The observation in the present investigations that greater protein content supports the multiplication of mites was also supported by several other studies that reported a positive role of protein in population build-up of different mite species, namely *Tetranychus bimaculatus* Harvey, *Tetranychus urticae* Koch, *Panonychus ulmi* (Koch) (Prostigmata: Tetranychidae), and *Brevipalpus obovatus* Donnadieu (Prostigmata: Tenuipalpidae) (Tulisalo 1971; Sadana & Goyal 1983). On the other hand, higher polyphenol oxidase in *C. fascicularis* might have hindered the rate of larval growth. As seen in other studies, the greater protein contents in the cultivated species of jute likely facilitated population establishment by invigorating the mite life cycle through increased fecundity and accelerated growth rates of immature stages. High protein content provided essential elements for growth of mite populations, whereas elevated phenol contents impaired the developmental stages of the broad mite and prevent its infestations of rose and chilli crops (Henneberry & Taylor 1962; Ahmed et al. 2000).

Among the wild jute species, *C. fascicularis* caused the longest quiescent nymphal duration (34.00 ± 1.14 h), whereas *C. tridens*, *C. trilocularis*, *C. capsularis*, and *C. olitorius* allowed shorter durations,

Table 3. Correlations (*r*) between leaf biochemical contents of jute species with life cycle parameters of the broad mite.

Mite life stage (h)	Correlation coefficient (*r*)			
	Phenol	Polyphenol oxidase	Protein	Peroxidase
Egg incubation time	0.089	−0.107	−0.083	0.179
Larval period	0.168	−0.914*	0.762*	0.261
Nymphal period (quiescent)	−0.443	0.109	0.142*	−0.352
Adult male longevity	−0.243	−0.865*	0.747	−0.201
Adult female longevity	0.014	−0.867*	0.574*	0.006

*Significant at $P < 0.05$.

Table 4. Broad mite population densities (mites/cm²/leaf) on different jute species (*Corchorus*) at different crop growth stages.

Jute Species	Accession number	Mite population (mites/cm²/leaf)[a]				Mean[b]
		35 DAS	50 DAS	65 DAS	80 DAS	
Wild jute species						
C. fascicularis	WCIN123	54.66	98.41	13.55	3.06	42.42d
C. aestuans	WCIN174	69.55	157.33	25.66	4.43	64.24b
C. pseudo-olitorius	WCIN182	57.10	113.77	16.99	0.96	47.21d
C. trilocularis	WCIN186	41.77	24.33	11.18	0.66	19.49e
C. tridens	WCIN188	67.88	132.99	24.66	6.30	57.96c
Cultivated jute species						
C. olitorius	JRO204	97.66	171.88	52.77	21.63	85.98a
C. capsularis	JRC321	92.66	104.44	45.55	9.86	63.13b
Mean[b]	—	68.75b	114.73a	27.19c	6.70d	—
Critical differences[c]	—	S = 6.89, D = 5.4, D*S = 13.78				

[a]DAS, days after sowing.
[b]Means of species and crop durations followed by different letters are significantly different ($P < 0.05$, Duncan's multiple range test).
[c]Critical difference ($P = 0.05$) for S, main effect of species; D, main effect of crop-growth duration; and D*S, interaction.

ranging from 24.00 ± 1.30 to 27.00 ± 2.07 h. This may be due to the high phenol and peroxidase content in *C. fascicularis*. These substances are toxic to mites and hence detrimental to mite development. The correlation analysis showed that polyphenol oxidase content was negatively correlated with larval duration and adult longevity. The longevity of adult females ranged from 50.00 ± 2.07 h on *C. pseudo-olitorius* to 204.00 ± 9.75 h on *C. olitorius.* Longevities of adult females (except that on *C. fascicularis*) of *P. latus* were similar to those reported by Dhooria (2005), Kavitha et al. (2007), and Al-Ani & Al-Jboory (2008). Likewise, the adult male longevity was in close agreement with that previously reported on chilli, mung bean, and potato (Srinivasulu et al. 2002; Dhooria 2005; Al-Ani & Al-Jboory 2008). By contrast, Das & Singh (1998), Vieira & Castro (1999), and Chauhan et al. (2002) found that the life cycle of *P. latus* was 5.00, 3.02, and 4.17 d on jute, cotton, and mulberry, respectively, which were similar to those found on *C. fascicularis*, *C. aestuans*, *C. tridens*, and *C. capsularis* in the present experiments.

Of the wild jute species, *C. trilocularis* harbored the significantly smallest mite population (19.49 mites/cm²), whereas *C. aestuans* harbored the greatest population (64.24 mites/cm²) under natural conditions, and this might be due to the high leaf phenol content (61.92 ± 1.92 µg/g) combined with the low protein content (17.34 ± 0.73 µg/g) in *C. trilocularis*. Borah (1987) noticed that higher phenol content lowered infestation of *P. latus* in chilli. Ahmed et al. (2000) found that phenol and protein contents in chilli leaves were correlated negatively and positively, respectively, with mite incidence. Based on the duration of life stages, the present study showed that among the 7 species of jute, the cultivated *C. olitorius* (JRO 204) was the most suitable host for broad mites.

In conclusion, host plant species had a significant effect on the life cycle of the broad mite. The higher protein content of the 2 cultivated species seemed to enhance male and female longevity and may have allowed more reproduction. The various phenol content levels of the different wild species of jute seem likely to be important in the life cycle and reproductive potential of the mites, which indicates the antibiosis mechanism of resistance. Thus, the relative resistances and susceptibilities of the jute species under study against the broad mite are now better understood. Accordingly, appropriate interspecific crosses may provide a platform for developing resistant or tolerant jute varieties for broad mite management.

Acknowledgments

The authors acknowledge the director of the Central Research Institute for Jute and Allied Fibres (CRIJAF), Kolkata, India, for providing the facilities to carry out the research at Crop Protection Division.

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