Tarsonemidae of China: a review of progress on the systematics and biology, with an updated checklist of species*

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Abstract

This paper reviews the research on the taxonomy, biology and control of mites in the family Tarsonemidae in China, with an updated checklist of 105 species belonging to 16 genera and 3 subfamilies. Major contributions to the Chinese fauna of the Tarsonemidae were made by Yang Qing-Shuan, Ding Ting-Zhong and colleagues in Shanghai, Lin Jian-Zhen and his colleagues in Fujian, Tseng Yi-Hsiung and Ho Chyi-Chen in Taiwan, and Yin Sui-Gong and his students in Liaoning. There have been relatively few studies on the biology and control of the Tarsonemidae in China and these are briefly reviewed.

Key words: Tarsonemidae, pests, faunistics, biology, control, mainland China, Taiwan

Introduction

The family Tarsonemidae is an important family of the Prostigmata displaying a great diversity of ways of life. Many tarsonemid species are fungivores, algivores and herbivores, others are parasites of insects and possibly symbionts of insects, and a few species are predators of other mites (Lindquist, 1986). Some phytophagous tarsonemids are pests of agricultural crops and members of the genus *Acarapis*—being endoparasites of the honey bees—are important pests in apiculture (Jeppson et al., 1975; Delfinado & Baker, 1982).

The Tarsonemidae is a large family of worldwide distribution. More than 580 species belonging to some 43 genera are known in the world and many others are yet to be discovered (Lin & Zhang, 2002 and unpublished data). The family consists of three subfamilies: Pseudotarsonemoidinae, Acarapinae and Tarsoneminae. Most of the described species are distributed in the Tarsoneminae, which includes two large genera *Tarsonemus* (over 270 species) and *Steneotarsonemus* (over 70 species).

In this paper, we review the progress of research on the systematics, biology and control of the Tarsonemidae in China and provide an updated checklist of species. It is hoped that this review will help stimulate further studies of this important family of mites in China and also facilitate access to Chinese literature on the Tarsonemidae for researchers outside China.
Historical review of taxonomic research

The first record of tarsonemid mites in China is probably by Li (1952), who reported Steneotarsonemus (Steneotarsonemus) bancrofti Michael, 1890 occurring on sugarcane in Taiwan. Liu et al. (1957) described the occurrence of an un-named species of Tarsonemus in bronchiectasis sputum.


It is in the 1970s that there was a surge of interests in the Tarsonemidae due to their roles as pests on crops, especially rice in southern China. In Taiwan, Lo & Chao (1972) studied the broad mite Polyphagotarsonemus latus (Banks) infesting bean plants in greenhouses. Teng (1976) reported the occurrence of this species in mainland China. Yang (1978) reported broad mites damaging tea and pepper, and a species of Steneotarsonemus damaging rice in southern China. Three years later Yang (1978) as well as Zhang & Pan (1975) briefly described Steneotarsonemus spinki infesting rice in Guangdong. The latter followed up with a more detailed account of its occurrence, injury, morphology and control methods (Zhang & Pan, 1978). In Taiwan, Lo & Ho (1977) initiated the study on S. spinki and they also found another species—Steneotarsonemus furcatus De Leon—infesting rice in Taiwan (Lo & Ho, 1979). Tseng (1978a, b) also worked on the Tarsonemidae in Taiwan.

The 1980s saw the descriptions of many new species by three research groups in China. Tseng & Lo (1980) published a taxonomic study of the Tarsonemidae in Taiwan, describing five new species and several new records. Lin & Y.-X. Zhang (1982) described Tarsonemus fuzhouensis Lin & Zhang from rice in Fuzhou—it was later synonymized with bilobatus Suski, 1965 (Lin & Zhang, 2002). They also studied its life history, biology and control of this species in Fujian (Lin & Zhang 1982, 1983a,b, 1984, 1985). The acarology team (mainly Yang & Ding) at Fudan University in Shanghai published several early papers on the taxonomy of the Tarsonemidae in mainland China. Ding & Yang (1984) described Steneotarsonemus (Steneotarsonemus) zhejiangensis Ding & Yang from rice in Zhejiang. Yang, Ding & Zhou (1987) described three new species of Daidalotarsonemus from Shanghai. They and their colleagues also published several popular papers introducing tarsonemid taxonomy to pest control workers (Ding & Yang, 1983; Yang et al., 1983; Su & Ding, 1984; Ding, 1985; Yang & Liang, 1986).


In this decade, there has been a decline in the number of research workers and output on the Tarsonemidae in China. Lin and colleagues described only six new species (Lin, 2000; Lin & Chen, 2004; Lin & Zhang, 2006; Lin et al., 2009).

The current known fauna of the Chinese Tarsonemidae (see the updated checklist below) consists of three subfamilies, 16 genera and 105 species, which is just over one-sixth of the world total in
terms of the number of described species. Two big genera—*Tarsonemus* 48 species and *Steneotarsonemus* 22 species—together account for two-thirds of all Chinese species. Because described species of tarsonemids in China are collected from some provinces, it is expected that many tarsonemid species of China are yet to be discovered and described when extensive surveys are conducted in all parts of China, especially Southwest China (e.g. Xizhang) and Northeast of China (e.g. Jilin, Liaoning, and Heilongjiang). Some species will needed to be examined and revised: e.g., *Acarapis woodi* was reported by Fan (1964); however it has not been collected and identified later by other researchers in China.

**Biology and control**

The biology and control of most tarsonemids in China have not been reported. However, a few species are of economic importance in China and there have been a great deal of papers on the biology and control of these species. Lin & Zhang (1999, 2002) annotated most references about these studies. Here we provide brief summaries for two key species in China with a focus on recent and/or important papers on their biology and control.

*Polyphagotarsonemus latus* (Banks)

This species is one of the major pests of tea, citrus and vegetable crops in China. Several studies examined various aspects of the life history and biology of this species (Li et al., 1985; Li & Li, 1986; Chen et al., 1989; Chen et al., 1989; Zhi & Guan, 2001a, b). Zhi and colleagues (Zhi & Guan, 2001; 2002a, b) studied the life table of this mite on pepper leaves at 25°C and 85–90% RH in the laboratory and estimated the intrinsic rate of increase, finite rate increase, net reproduction rate, the mean generation and population doubling time being 0.295, 1.343, 25.494, 13.851 and 2.351 days, respectively; the fecundity was 31.2±8.3 eggs per female and the female: male sex ratio was 3.11. When the mites were fed eggplants in the laboratory, Gui & Meng (1998) estimated the intrinsic rate of increase, finite rate increase, net reproduction rate, mean generation time and population doubling time being 0.258, 1.295, 19.395, 11.473 and 2.682 days, respectively. Studying the life table at different temperatures, Li & Li (1986) found the optimal temperature of 25°C and Chen et al. (1989) estimated it to be 26°C. Li et al. (1985) examined the effects of both temperature and relative humidity on broad mite life history; they showed that the developmental zero of the egg, larva and nymph was 13.01, 10.12 and 13.43 degree, respectively and the effective thermal sum of a life cycle of the mite was about 64.11 degrees-days. They also showed that the thermal death point of the broad mite female at relative humidity 80% was 43.6°C. In Taiwan, Ho (1991) compared development of this mite on three plant species—lemon, tea and pepper—at 25°C and a 13 hours photoperiod in the laboratory, and showed that developmental period from egg to adult averaged 3.5 and 3.2, 3.6 and 3.9, 4.1 and 4.1 days for female and male individuals respectively on the young leaf of lemon, tea and pepper.

Ecological studies on Chinese Tarsonemidae are relatively few. Dai et al. (1989) used the pest population increase rate of the broad mite to forecast the growth and decline of its population in the field. Li (1990) reported that the distribution pattern of the broad mite was aggregated as the density was below 0.5271, but it became uniform distribution as the density increased.

Several papers explored chemical control (Xie et al., 1992) and cultural control of *P. latus* (Liu et al., 1996; Gui et al., 2001; Jiang et al., 2003) in China.

Xie et al. (1992) found that Liuyangmycin diluted 4000 times to 25 ppm gave the most effective and economical control of *P. latus* in comparison with other three concentrations tested (i.e. 50 ppm,
16.7 ppm and 12.5 ppm). They also found that the control effect in the first three weeks remained above 98%, which was equivalent to that with 200 ppm Dicofol.

Liu et al. (1996) tested the effects of tea varieties on the population dynamics of *P. latus* and found significant differences among mean mite numbers on different varieties in the field (highest on var. Zaobaijian and lowest on var. 906) and indoor developmental duration (of females, longest on var. Shuyong 3 and shortest on var. Shuyong 1), fertility (maximum on var. Zaobaijian and minimum on var. 906) and intrinsic rate of increase (highest on var. Shuyong 3 and lowest on var. Shuyong 1). They concluded that the var. Shuyong 1 and 906 were obviously resistant to the yellow mite.

Gui et al. (2001) studied the resistance of different growth stages of eggplant to *P. latus* and found no significantly difference. Gui et al. (1999) tested 27 varieties of eggplants and found significant difference in their resistance to *P. latus*, with four varieties highly resistant to mites. Gui et al. (2007) further examined the relationship between leaf pubescence and mite injury in these 27 varieties and they found a positive correlation between the pubescence density on the reverse surface of eggplant leaves and the resistance of eggplants to *P. latus*.

Jiang et al. (2003) increased the diversity of plants in the tea farm by introducing non-tea plants (plum, pear or peach) as inter-plants. They found that inter-planting modified the micro-environment and reduced mite damage, and the rate of mite reduction in the order: forest tree + tea > pear + tea > peach + tea > plum + tea.

*Steneotarsonemus (Steneotarsonemus) spinki* Smiley

This species is one of the important pests of rice in southern China. A couple of studies in Taiwan examined the life history of this species. In laboratory tests, Chen et al. (1979) showed that the mite need 17.0, 4.0 and 2.8 days to complete its development from egg to adult stage at 25°C, 28°C and 30°C, respectively. The adult female and male lived for 15 days and 7.6 days at 25–28°C; both sexes lived for 5 days at 30°C. The pre-oviposition period was 2 days at 30°C, 7 days at 28°C and 13 days at 25°C. Each female could lay from 0 to 78 eggs during its life span, with an average of 30.8 eggs. Lo & Ho (1980) studied this species both in the laboratory and in the field; in laboratory tests, this mite required 3 and 20 days to complete its development from egg to adult stage and each female could lay 59.5 and 20.0 eggs at 30°C and 20°C, respectively. In the field it emerged about early May and its population increased to a high level during August and October, and then declined until harvest. Rice plants infested with this mite showed a significant increase in sterility rate and decrease in panicle neck compared with plants without mites.

Wen (1980) developed a method to rear tarsonemid mites free of fungi. Sterilized mites were introduced onto the internal surface of one end of the sheath segment of healthy rice plant, whose other end was submersed in a small glass tube containing 2 ml of a mixed solution of $10^{-3}$ M benzyladenine, 100 ppm benomyl and 100 ppm streptomycin. All the mite-inoculated rice sheath segments were placed in an incubator at 25°C and 96.9% relative humidity. Eggs of tarsonemid mites could hatch at 95% of relative humidity or above it.

A couple of studies examined the natural enemies and control of *S. spinki* (Lo & Ho, 1980; Jiang et al., 1994). Lo & Ho (1984) studied the predatory mite—*Lasioseius youcefi* Athias-Henriot—as a natural enemy of *S. spinki* and found that the predatory mites had shorter developmental period, higher food intake and better reproductive output when feeding on the eggs of *Tarsonemus* sp. than when feeding on eggs of *S. spinki*. They also noted that the pesticides Hokbal 40% E. C., MIPC 20% E. C. and Fenitrothion 50% E. C. were less harmful to the predatory mites. Jiang et al. (1994) found in paddy fields in the middle of November in Guangzhou area that some rice varieties are resistant to *S. spinki*.
Checklist of the Tarsonemidae of China

Family TARSONEMIDAE
Subfamily PSEUDOTARSONEMOIDINAE
Tribe PSEUDOTARSONEMOIDINI

Polyphagotarsonemus latus (Banks, 1904)—Chen, 1957
Pseudotarsonemoides scolyti Smiley & Moser, 1974—Lin et al., 1995

Tribe TARSONEMELLINI

Ficotarsonemus protabilis Ho, 1994
Ficotarsonemus wongi Ho, 1994

Subfamily ACARAPINAE
Tribe ACARAPINI

Acarapis externus Morgenthaler, 1931—Lin et al., 1995

Subfamily TARSONEMINAE
Tribe TARSONEMINI

Daidalotarsonemus biovatus Lin & Liu, 1995
Daidalotarsonemus cornutus Lin, Chen & Zhang, 1998
Daidalotarsonemus digital Lin, Chen & Zhang, 1998
Daidalotarsonemus duolamella Lin, Chen & Zhang, 1998
Daidalotarsonemus euonymus Yang, Ding & Zhou, 1987
Daidalotarsonemus hexagonus Yang, Ding & Zhou, 1987
Daidalotarsonemus notoschism Lin & Liu, 1994
Daidalotarsonemus serissae Yang, Ding & Zhou, 1987
Fungitarsonemus borinquensis Cromroy, 1958—Tseng & Lo, 1980
Fungitarsonemus lodici (DeLeon, 1956)—Lin et al., 1995
Iponemus asiaticus Lindquist, 1969—Lin & Zhang, 1989
Iponemus leionotum Lindquist, 1969—Lin & Zhang, 1989
Neotarsonemoides triquetrus Lin & Zhang, 1996
Rhynchotarsonemus sp.—Lin & Zhang, 1985
Tarsonemoides rakowiensis Kropczynska, 1965—Hsu & Li, 1985 (as Tarsonemus granarius)
Tarsonemus bambusae Yin, Bei, Liu, Yu, Shi & Yang, 1998
Tarsonemus bifurcatus Schaarschmid, 1959—Lin, Zhang & Ji, 2002
Tarsonemus bihamus Lin, 2000
Tarsonemus brevicorpus Lin, 1999—Tseng & Lo, 1980; Tseng, 1984 (as Chelotarsonemus minutus); Lin & Zhang, 1999
Tarsonemus caucasicus Sharonov & Mitrofanov, 1986—Lin, Zhang & Ji, 2002
Tarsonemus changbaiensis Yin, Bei, Liu & Tong, 1996
Tarsonemus confusus Ewing, 1914—Ding & Yang, 1983
Tarsonemus cornus Ito, 1964—Lin et al., 1996; female description by Lin & Zhang, 1996
Tarsonemus dubius Delfinado, 1976—Lin et al., 1995
Tarsonemus floricolus Canestrini & Fanzago, 1876—Tseng, 1978b; Tseng & Lo, 1980; Tseng, 1984

Tarsonemus floridanus (Attiah, 1970)—Ding & Yang, 1983

Tarsonemus fusarii Cooreman, 1941—Ding, 1985

Tarsonemus gramineus Cromroy, 1958—Tseng & Lo, 1980; Tseng, 1984

Tarsonemus idaeus Suski, 1968—Yin et al., 1998

Tarsonemus inornatus (Attiah, 1970)—Ding & Yang, 1983

Tarsonemus insignis Delfinado, 1976—Ma & Wang, 1992

Tarsonemus ips Lindquist, 1969—Lin et al., 1995

Tarsonemus kaibeni Lin, Zhang & Liu, 1999

Tarsonemus lacustris Schaarschmidt, 1959—Ding & Yang, 1983

Tarsonemus lanceatus Lin & Zhang, 1995

Tarsonemus micronodulus Yin, Bei, Liu & Tong, 1996

Tarsonemus minusculus Canestrini & Fanzago, 1876—Lin et al. year?

Tarsonemus minutus (Attiah, 1970)—Ding & Yang, 1983

Tarsonemus misakai Ito, 1962—Lin et al., 1996

Tarsonemus montanus Yin, Bei, Liu & Tong, 1996.

Tarsonemus myceliophagus (Hussey, 1963)—Yang & Liang, 1986

Tarsonemus nakayamai Ito, 1964—Ma & Wang, 1992

Tarsonemus nidicolus Delfinado, 1976—Yin et al., 1998

Tarsonemus paragranarius Piao & Wang, 1992

Tarsonemus paraunguis (Attiah, 1970)—Ding & Yang, 1983

Tarsonemus randsi Ewing, 1939—Lin et al., 1995

Tarsonemus rhorus Kaliszewski, 1993—Lin et al., 1996

Tarsonemus sasai Ito, 1962—Lin et al., 1995

Tarsonemus scaurus Ewing, 1939—Ma & Wang, 1992

Tarsonemus shenyangensis Yin, Bei, Liu, Yu, Shi & Yang, 1998

Tarsonemus smithi Ewing, 1939—Tseng & Lo, 1980

Tarsonemus stricketti Smiley, 1967

Tarsonemus subcorticalis Lindquist, 1969—Lin et al., 1995

Tarsonemus takaoensis Ito, 1964—Lin et al., 1995

Tarsonemus talpae Schaarschmidt, 1959—Ding & Yang, 1983

Tarsonemus tegmen (Lin & Zhang, 1995)

Tarsonemus yali Lin & Zhang, 2006

Tarsonemus uniunguis Lin & Zhang, 1995

Tarsonemus virigineus Suski, 1969—Yin et al., 1996

Tarsonemus waitei Banks, 1912—Yang & Liang, 1986

Tarsonemus wangi Lin & Zhang, 1989

Tarsonemus zonghuii Lin, Zhang & Liu, 1999

Xenotarsonemus belemnitoides (Weis-Fogh)—Lin et al., 1995

Xenotarsonemus biangulus Lin, 2000

Xenotarsonemus ligula Lin & Zhang, 1996

Xenotarsonemus sensus Lin & Zhang, 1994

Xenotarsonemus uliginosus Willmann, 1942—Lin et al., 1996

Xenotarsonemus wani (Tseng & Lo, 1980)

Xenotarsonemus xiufui Lin, Zhang & Liu, 1999

Tribe HEMITARSONEMINI
Hemitarsonemus biconvexa Lin & Zhang, 1994
Hemitarsonemus furcalis Lin & Zhang, 1995

Tribe STENEOTARSONEMINI
Dendroptus edwardi Delfinado, 1978—Yin et al., 1998
Dendroptus tricollis Lin & Chen, 2004
Dendroptus olea Lin, Xu & Zhong, 2000
Ogmotarsonemus liui Lin & Zhang, 1993
Steneotarsonemus (Mahunkacarus) badulini—Yin et al., 1998
Steneotarsonemus (Mahunkacarus) gibber Suski, 1890—Yin et al., 1998
Steneotarsonemus (Neosteneotarsonemus) arcticus Lindquist, 1986—Lin & Zhang, 1994
Steneotarsonemus (Neosteneotarsonemus) guangzensis Lin, Zhang & Liu, 1995
Steneotarsonemus (Neosteneotarsonemus) mirabilis Tseng & Lo, 1980—Tseng, 1984
Steneotarsonemus (Neosteneotarsonemus) trisetus Lin & Zhang, 1995
Steneotarsonemus (Parasteneotarsonemus) phyllophorus (Ewing, 1924)
Steneotarsonemus (Steneotarsonemus) acricorn Lin & Zhang, 1995
Steneotarsonemus (Steneotarsonemus) bancrofti Michael, 1890—Li, 1952
Steneotarsonemus (Steneotarsonemus) chiaoi Tseng & Lo, 1980—Tseng, 1984
Steneotarsonemus (Steneotarsonemus) furcatus De Leon, 1965—Lo & Ho, 1979; Tseng, 1984
Steneotarsonemus (Steneotarsonemus) konoi—Yin et al., 1998
Steneotarsonemus (Steneotarsonemus) phragmitidis—Ding & Yang, 1983
Steneotarsonemus (Steneotarsonemus) pulchellus Tseng & Lo, 1980
Steneotarsonemus (Steneotarsonemus) rivalis (Tseng & Lo, 1980)
Steneotarsonemus (Steneotarsonemus) saccharum Lin, Chen & Zhang, 2009
Steneotarsonemus (Steneotarsonemus) spinki Smiley, 1967—Zhang & Pan, 1975; Tseng, 1978a; Tseng, 1984
Steneotarsonemus (Steneotarsonemus) spirifex—Lin & Zhang, 1982; Tseng, 1984
Steneotarsonemus (Steneotarsonemus) stipa Lin & Liu, 1999
Steneotarsonemus (Steneotarsonemus) subfurcatus Lin & Zhang, 1990
Steneotarsonemus (Steneotarsonemus) vasiljevae Sharonov, 1983—Lin, Zhang & Liu, 1999
Steneotarsonemus (Steneotarsonemus) zhejiangensis Ding & Yang, 1984

Acknowledgements

We thank Dr Qing-Hai Fan (Plant Health & Environment Laboratory, Investigation and Diagnostic Centre, Ministry of Agriculture and Forestry, New Zealand) and an anonymous reviewer for critical reviews of the manuscript and comments. J.-Z. Lin was supported by Fujian Science and Technology Innovation Platform and Public Good Project of Ministry of Agriculture of China. While this paper was prepared, the Z.-Q. Zhang was supported by Foundation for Research, Science and Technology, New Zealand.

References


TARSONEMIDAE OF CHINA


