# *TOUMEYELLA PARVICORNIS* (HEMIPTERA: COCCIDAE), CAUSING SEVERE DECLINE OF *PINUS CARIBAEA* VAR. *BAHAMENSIS* IN THE TURKS AND CAICOS ISLANDS

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Abstract

Since it was first formally recorded there in 2005, the Nearctic pine tortoise scale *Toumeyella parvicornis* (Cockerell) (Hemiptera: Coccidae) has caused severe decline of the Caribbean pine, *Pinus caribaea* var. *bahamensis* (Grisebach) W. H. Barrett & Golfari, in the pine forests on the Turks and Caicos Islands (TCI). The scale infestations reduce host vigor, cause dieback and high levels of mortality. Honeydew excreted by the insects enables the growth of associated sooty molds to smother the under-storey plants inhibiting their growth. Surveys carried out on the islands suggest that the entire Caribbean pine population in the TCI is under immediate threat from this invasive pest, with potentially devastating effects on the pineyard ecosystem. The biology, distribution, impact and economic importance of the pine tortoise scale are reviewed.

Key Words: Pine tortoise scale, Caribbean pine, invasive species

Resumen

La cochinilla *Toumeyella parvicornis* (Cockerell) (Hemiptera: Coccidae) fue primeramente observada en los pinares de Pino del Caribe *Pinus caribaea* var. *bahamensis* (Grisebach) W. H. Barrett & Golfari en las Islas Turcas y Caicos en 2005. Desde entonces mucho daño ha sido causado por este insecto en estas islas. La infestación de cochinillas reduce el vigor de los pinos, causa defoliación y su muerte regresiva. El crecimiento del sotobosque es inhibido por la camada de hongos de hollín y la secreción de mielecilla de los insectos que cubren sus hojas. Estudios realizados en las Islas Turcas y Caicos indican que las poblaciones de pinos y el ecosistema de los pinares están gravemente amenazados por la infestación de la cochinilla. La biología, distribución geográfica y la importancia económica de la cochinilla *Toumeyella parvicornis* son revisadas en esta publicación.

Translation provided by the authors.

The Caribbean pine, *Pinus caribaea* Morelet, is a hard pine native to Central America, Cuba, Jamaica, the Bahamas, and the Turks and Caicos Islands (TCI). There are 3 distinct varieties of which *P. caribaea* var. *bahamensis* (Grisebach) W. H. Barrett & Golfari (Pinaceae) is endemic to the Bahaman Archipelago, where it occurs in the Northern Bahamas and in TCI. This pine is the National Tree in TCI, a United Kingdom Overseas Territory (UKOT) in the West Indies. It is the dominant species in the pine forest ecosystem, also known as pineyards in TCI and pine rocklands in the Bahamas and Florida, which are predominantly open savannahs subject to regular burning caused naturally by lightning strikes (Greaves 1978). The Caribbean pine, its distribution and ecology, are described by Farjon & Styles (1997), although the average tree height (8.5 m) and diameter (DBH 11.1 cm) in TCI are much lower than given by Farjon & Styles. The total area of pineyards on TCI is 1,723 ha (Pine Cay 106 ha, Middle Caicas 1150 ha and North Caicos 467 ha) (Earle-Mundil 2010), and they are ecologically important as they provide habitats for many unique plants and animals. For example, one of TCI's endemic plant species, *Stenandrium carolinae* Leonard & Proctor, and the critically endangered TCI Rock Iguana, *Cyclura carinata* Harlan, are found in the pineyards (Earle-Mundil 2010; Iverson 1978).

In 2005, a joint UK Overseas Territories Conservation Forum (UKOTCF), Turks and Caicos Na-

tional Trust (TCNT) and Royal Botanic Gardens, Kew (Kew), field trip discovered that the Caribbean pines on Middle Caicos were heavily infested by a scale insect (Hamilton 2007). Field observations suggested that the introduced pest reduced host vigor and seed production, caused dieback and resulted in high levels of tree mortality (Figs 1 & 2). The insects excreted copious quantities of honeydew, which served as a medium for the growth of sooty molds, smothering much of the under-storey plants, such as *Lysiloma latsiliquum* (L.) Benth., *Sabal palmetto* (Walt.) Lodd., *Swietenia mahogani* (L..) Jacq. and *Thrinax morrissi* (H. Wendl.) C. Lewis & Zona (Green 2011), and inhibiting their growth. Samples of the scale insect were submitted to The Food and Environment Research Agency (FERA), where it was identified as the pine tortoise scale *Toumeyella parvicornis* (Cockerell) (Hemiptera: Coccidae). This was the first time that this Nearctic scale insect species had been found in the Caribbean region and the first time it had been recorded on Caribbean pine (Ben-Dov 2011). Further surveys during April 2006 on Middle Caicos, Pine Cay and North Caicos by Kew staff suggested that the entire Caribbean pine population in TCI was under immediate threat from this pest, with potentially devastating effects on the pineyard ecosystem.

The purpose of this communication is to report the effect of the pine tortoise scale on the Caribbean pine and pineyard ecosystem in TCI. The biology, geographical distribution and economic importance of the pine tortoise scale are also reviewed.

Scale insects are one of the most commonly transported groups of insect in plant trade and one of the most successful invasive groups of insects (Miller & Miller 2003; Pellizzari & Dalla Montá 1997; Thomas 2004; Smith et al. 2007). The introduction of the pine tortoise scale into TCI is just one of a series of introductions of non-native scale insects into the Caribbean region that have had a major negative impact. Recent examples include the papaya mealybug *Paracoccus marginatus* Williams & Granara de Willink, which has become a pest in Antigua, St Kitts and Nevis, and the British and US Virgin Islands (Miller et al. 1999); and the pink hibiscus mealybug *Maconellicoccus hirsutus* (Green), which since 1994 has spread widely in the Caribbean (Williams 1996). The latter species attacks more than 330 plant species (Chong 2009), including many agricultural and horticultural crops, and caused estimated economic losses, which include crop losses, costs of control, and impact on trade, of $18.3 million (USD) in Grenada (1995-1998), $280,000 in St. Kitts (1995-1997), $5.1 million in Trinidad (1995-1997), $67,000 in St. Lucia and St. Vincent, and $3.4 million in the Grenadines

Fig. 1. Caribbean pine trees on North Caicos, Turks and Caicos Islands—range of damage caused by pine tortoise scale.

Fig. 2. Caribbean pine trees on North Caicos, Turks and Caicos Islands—trees killed by pine tortoise scale.

(Kairo et al. 2000). Yet despite the potential environmental and agricultural importance of invasive scale insects they have hardly been studied in many Caribbean countries.

Voucher specimens of the pine tortoise scale are deposited at FERA.

## Identification

The following description is based on samples of *T. parvicornis* collected in TCI. The eggs are ovoid, pinkish, almost transparent, and about 0.4 mm long. First-instar nymphs, commonly called crawlers, are oval, reddish and have 6 short legs. Older nymphs are legless, oval and convex. Adult females are either oval in shape when feeding on the bark, or elongate when on the needles, strongly convex, reddish-brown with black or dark brown stripes, or speckled with dark spots. They become uniform dark brown with maturity (Fig. 3). When present at high density the adult females overlap each other on the twigs or needles. They attain a maximum length of 4.4 mm and width of 3.9 mm. The male tests (a wax cover that protects the immature stages) are oval, white, translucent, and about 3.0 mm long. Adult males are winged but rarely seen.

*Toumeyella parvicornis* was first described by Cockerell (1897) from specimens collected in Florida on loblolly pine *Pinus taeda* L. and *P. australis* Michx.f.. The latter is now a synonym of longleaf pine *P. palustris* Mill. and will not be used further in the text. There are currently 16 species assigned to the genus *Toumeyella* (Ben-Dov 2011; Williams & Kondo 2008) and *T. parvicornis* is easily separated from all other species by the unique character of dorsal bilocular pore aggregations (Williams & Kondo, 2008).

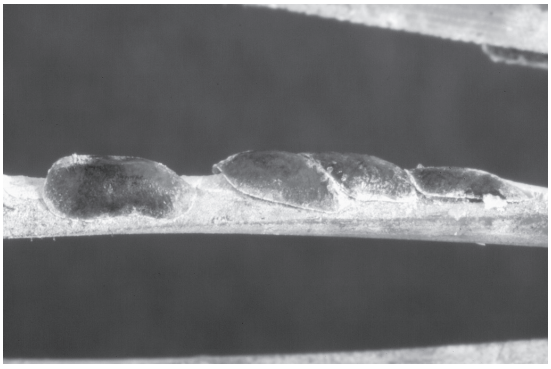

Fig. 3. Mature adult female pine tortoise scales.

Detailed morphological descriptions and illustrations of the adult female are provided by

Williams & Kosztarab (1972), Hamon & Williams (1984) and by Kosztarab (1996). There are distinct bark and needle forms (both forms were common on TCI). Keys for the identification of *Toumeyella* species of northeastern North America are provided by Kosztarab (1996), for Florida by Hamon & Williams (1984), for Virginia by Williams & Kosztarab (1972), and for Mexico by Kondo & Pellizzari (2011).

### Geographical Distribution

*Toumeyella parvicornis* is native to the Nearctic region (Ben-Dov 2011), occurring from Mexico (Myartseva & Ruíz-Cancino 2000), throughout much of the United States of America (central and eastern US from North Dakota east to New York and south to Texas through Florida, and California) (Clarke et al. 1992; Cockerell 1897; Cooper & Cranshaw 2004; Stimmel 1984), and into south-central Canada (Bradley 1973). It has recently been introduced into the Neotropical region: TCI and Puerto Rico (Segarra-Carmona & Cabrera-Asencio 2010). The pathway of introduction into TCI is suspected to have been the import of live, cut pine trees from the USA for use as Christmas trees during the past 2 decades.

### Host Plants

*Toumeyella parvicornis* feeds exclusively on *Pinus* species (Pinaceae) including: jack pine *P. banksiana* Lamb., lodgepole pine *P. contorta* Douglas, shortleaf pine *P. echinata* Mill., slash pine *P. elliotti* Engelm., spruce pine *P. glabra* Walter, mugo pine *P. mugo* Turra, *P. palustris* Mill., Scots pine *P. sylvestris* L., *P. taeda* L,; and Virginia pine *P. virginiana* Mill. (Bradley 1973; Cockerell 1897; Cooper & Cranshaw 2004; Hamon & Williams 1984; Miller & Williams 1995; Williams & Kosztarab 1972). It is now recorded on *P. caribaea* var. *bahamensis* and *P. caribaea* var. *hondurensis* (Sénéclauze) W. H. Barrett & Golfari in the Caribbean (Segarra-Carmona & Cabrera-Asencio 2010).

### Biology

*Toumeyella parvicornis* is univoltine towards the northern limit of its range in Canada (Rabkin & Lejeune 1954; MacAloney 1961), Colorado (Cooper & Cranshaw 2004) and northeastern USA (Kosztarab 1996). Four generations per year in southern Georgia have been observed with first generation crawlers present in late Apr to early May, and 5 or more generations could be possible in the tropics (S. R. Clarke, Forest Health Protection, USDA Forest Service, personal communication).

The following biology is based on observations made in the USA. Each adult female lays about 500 eggs, which are protected under the female's body. The crawlers hatch within a few h, crawl out from under the female, and disperse. Many walk to new areas on the same host, but others are carried to new hosts by wind, and possibly on the feet of birds (Wilson 1971). The crawlers settle and become sedentary nymphs. They insert long stylets into the host and feed on the sap. A white, powdery substance develops on the margins of the young nymphs, and in about 2 wk sexual differentiation becomes apparent. About 1 wk later, the smaller male nymphs are fully developed. They pupate and emerge as small, winged adults. They immediately search out and fertilize teneral female adults, then soon die. The fertilized females continue to develop and in early generations begin oviposition. In the final generation, the scales overwinter as fertilized females. They resume activity in the spring and begin oviposition at about the time the buds begin to swell.

Detailed life cycle studies have yet to be undertaken in TCI. Field observations have found several life stages occurring in TCI at different periods of the yr (e.g. in Jan, Apr and Jun); therefore, it is suspected that the insect has adopted a multivoltine life-cycle in TCI as the insects do not need to overwinter because of the marine tropical climate with relatively constant temperatures throughout the year. This change in the insects' phenology could help explain the devastation of the pine trees seen across the TCI pineyards, as the trees could be under attack throughout the year.

### Natural Enemies

*Toumeyella parvicornis* is usually controlled in North America by natural enemies (Hamon & Williams 1984) including several species of coccinellids that consume the young scales and eggs under the mature females. They include *Brachyacantha ursina* (Fabricius), *Chilocorus bivulnerus* Mulsant, *Coccinella novemnotata* Herbst, *C. transversoguttata* Faldermann, *C. trifasciata* L., *Hyperaspis binotata* (Say), *H. congressis* Watson, *H. signata* (Olivier) and *Scymnus lacustris* LeConte (Bradley 1973; Kosztarab 1996; Wilson 1971). *Hyperaspis congressis* is reported to be the most abundant coccinellid in association with the scale (Wilson 1971). The larvae of the pyralid moth *Laetilia coccidivora* (Comstock) can significantly reduce heavy scale populations (MacAloney 1961; Wilson 1971). Chalcidoid parasitoids recorded attacking the scale include the aphelinids *Aphytis* sp., *Coccophagus albicoxa* Howard, *C. immaculatus* Howard and *C. quaestor* Girault, and the encyrtid *Microterys fuscicornis* Howard (Cooper & Cranshaw 2004; Kosztarab 1996; Myartseva & Ruíz-Cancino 2000; Peck 1963).

No known natural enemies have so far been positively recorded in the TCI; however, large

congregations of *Cycloneda sanguinea* L. (Coleoptera: Coccinellidae) have been seen around infested pine trees (FERA 2011). Other studies have observed that this species is a general predator, having a varied and opportunistic diet which includes scale insects, aphids, moths, weevils, and many other insects (Araujo-Siqueira & Almeida 2006; Michaud 2001; Stuart et al. 2002). Therefore, it is possible that they could be feeding on the abundant pine tortoise scale eggs and nymphs in the pine trees. This hypothesis needs further investigation to determine if the *C. sanguinea* are feeding on the scale insects.

## Economic Importance and Environmental Impact

*Toumeyella parvicornis* periodically causes mortality of seedlings and saplings of hard pines and severe damage to pole stands in North America (MacAloney 1961; Rabkin & Lejeune 1954; Wilson 1971; Kosztarab 1996). Feeding of the nymphs and adult females on the twigs causes branches to die (flagging). Heavily attacked trees turn yellow and finally die. In most heavily infested jack pine stands, a few trees escape attack completely, apparently because of an inherited immunity (Wilson 1971). The honeydew eliminated by the scale insects serves as a medium for the growth of black sooty molds, which cover leaves and branches, and give infested trees a black shiny appearance. The sooty molds hinder photosynthesis and contribute to tree weakening. Ants often feed on the sugary honeydew.

Some resistance to pesticides has been observed for this scale insect, with infestations of this scale appearing on loblolly pine in Georgia, USA, following five applications of pyrethroids (Clarke et al. 1992).

The situation in the TCI has been particularly severe. Scale infestations have caused such high levels of mortality of Caribbean pine that some areas contain no live trees or seedlings; others still support some live pines amongst dead and moribund trees. The combination of high infestation levels on seedlings (needles become smothered in overlapping adult females) and massively reduced cone production by mature trees, threatens on-going recruitment into the pine population, with the prospect that the tree could be lost altogether from many areas. The loss of trees is already resulting in visible habitat change in TCI pineyards as many areas are becoming dominated by broadleaf species. As well as further impacts of the pest itself, lightning-induced fires may be more frequent and intense in areas with greater concentrations of dead trees and fuel load, leading to further losses. In 2009, an escaped, dry-season agricultural fire spread through the North Caicos pineyard destroying the majority of the remaining young trees (DECR 2010). It is probable that this devastating impact of the pine tortoise scale on the pine forests has resulted from a combination of a lack of natural enemies and warm climatic conditions.

The TCI Caicos Pine Recovery Project (CPRP) lead by DECR and Kew aims to ensure the survival of the Caribbean pine in TCI, by providing accessible material for researchers and for germination trials, propagation and cultivation protocols. The project is establishing *ex situ* pine tree collections in TCI and Kew, mapping and monitoring the extent of pine tortoise scale infestation and the occurrence of resistant trees, and establishing an international CPRP working group.

## Discussion

The introduction of non-native species that become invasive can lead to a reduction in the resilience of biodiversity in the ecosystems of the world. This is due to invasive species being an important direct driver of ecosystem change according to the Millennium Ecosystem Assessment (2003). To guide global policy, the Secretariat of the Convention on Biological Diversity (2000) promotes bio-security through the establishment of procedures and rules for the safe use, handling and transfer of living modified organisms (capable of growing) as detailed in the Cartagena Protocol on Biosafety. It is essential for countries, particularly those with vulnerable island ecosystems to have plant health quarantine measures in place to prevent the introduction of invasive species. The Turks and Caicos Islands Government has committed to expanding the agricultural sector, including pest prevention and plant quarantine efforts. This work is currently carried out by the Environmental Health Department and is often delegated to the Department of Environment and Coastal Resources. Future management of plant health and quarantine services may be assigned to the Department of Agriculture. The Director of Agriculture sits on the Caicos Pine Recovery Working Group and arranged for the Caicos Pine Recovery Project Manager to attend a 2011 USDA/ APHIS-led training program on Plant Quarantine Principles and Procedures. This training resulted in an agreement to investigate the development of a quarantine program for Turks and Caicos Islands between interested government departments as the TCI Government is currently reviewing legislation, specifically the Animals (National and International Movement and Disease Prevention) Bill 2010, which will enable the country to develop quarantine measures for animals. Plant health and quarantine measures are yet to be addressed.

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