Invasion pathway and potential risks of a bamboo-nesting carpenter bee, *Xylocopa tranquebarorum* (Hymenoptera: Apidae), and its micro-associated mite introduced into Japan

Kimiko Okabe,1,* Hayato Masuya,1 Kazuhide Kawazoe2 and Shun’ichi Makino1

1 Forestry and Forest Products Research Institute; Tsukuba, Ibaraki 305–8687, Japan
2 JR Tokai Takashimaya Co., Ltd.; Nagoya, Aichi 450–6001, Japan

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Abstract
Despite plant quarantine systems, many organisms have been unintentionally introduced by the rapid expansion of international trade. *Xylocopa tranquebarorum*, a large species of carpenter bee that nests in bamboo shoots, was introduced into Japan approximately 5 years ago and, along with its specifically associated mite, has established populations in Toyota and Nagoya in Aichi Prefecture and Anpachi in Gifu Prefecture. Because *X. tranquebarorum* only nests in dead bamboo shoots and because its associated mite differs from the mite species associated with *X. tranquebarorum* in Taiwan but is morphologically similar to the species described in India, Indonesia, and China, we suspect that *X. tranquebarorum* and its mite were introduced via processed bamboo shoots from continental Asia. Because the most probable pathway of associated microorganisms is host introduction, biological and ecological information, such as an inventory of symbionts, is crucial to avoid the risk of invasive symbiotic microorganisms. Although *X. tranquebarorum* may become a pest in the bamboo industry if its distribution is expanded by human transport, its associated mite is suspected to be of low risk as house dust but to have a high contamination risk for the Japanese endemic mite, *Sennertia alfkeni*, associated with native Japanese carpenter bees.

Key words: Cleptoparasite; fungivore; house dust; phoresy; symbiont

INTRODUCTION

International trade has rapidly expanded worldwide, resulting in the concomitant transport of alien species (Meyerson and Mooney, 2007; Hulme, 2009). Although quarantine systems cover many traded goods, microorganisms are often unintentionally introduced, frequently causing devastating consequences within the novel environment.

Whereas plants and vertebrates tend to be intentionally introduced across borders as crops and/or pets, invertebrates and microorganisms are typically introduced because the quarantine system failures or because of a lack of knowledge (e.g., horticultural plants: Reichard and White, 2001; microorganisms and others in China: Xu et al., 2006; forest herbivorous insects: Gandhi and Herms, 2009). Although microorganisms such as fungi, nematodes, and mites are monitored by plant quarantine offices in Japan based on their pest status, small organisms have been unintentionally introduced because searches of associated organisms (usually called hosts) and assessments of their potential pest risk have never been conducted as quarantine targets (Goka et al., 2001; Okabe and Goka, 2008). Due to the extreme difficulty of controlling and eradicating such organisms, important preventative measures should include both potential risk assessments in terms of crops, hygiene, and ecological impacts and pathway analysis to develop effective control measures, reexamine the current quarantine system, and determine effective eradication measures (Pimentel, 2002; Perrings et al., 2005).

Large carpenter bees belonging to the genus *Xylocopa* have diversified within tropical and subtropical regions and expanded their distributions to temperate regions (Hurd and Moure, 1963). Sev-
eral species are suspected to have invaded oceanic islands, as only a few species exist within island groups and the distances between the original and close relative’s habitats are relatively short. For example, *Xylocopa sonorina* Smith was allegedly transferred by humans from North America to tropical Pacific islands, including Hawaii (Hurd, 1958). Mites are associated with most species of carpenter bees, often exhibiting host specificity or at least narrow host ranges; these mite species belong to the Mesostigmata (*Dinogamasus* and *Hypoaspis* of Laelapidae), Prostigmata (*Cheletophyes* of Cheyletidae and *Tarsonemus* of Tarsonemidae), and Astigmata (*Sennertia* of Caetodactylidae and *Horslia* of Acaridae) (O’Connor, 1993; Eickwort, 1994; Klimov and O’Connor, 2008). Mutualisms may exist between carpenter bees with acarinaria (external pouch-like structures that facilitate phoretic mite transfer with the bees) and their associated mites, but most interactions are considered cleptoparasitism, with mites feeding on the host pollen loaf and feces (Abrahamovich and de Alzuet, 1990; Eickwort, 1994; Okabe et al., 2008). The mite life cycle is well synchronized with that of its host: mites leave a host to migrate into a nest during the initial stage to anytime afterward, molt to a feeding stage to consume provisioned pollen and host feces after the host larva has consumed the pollen loaf, molt to deutonymphs during host pupation, and attach to the host for dispersal (Abrahamovich and de Alzuet, 1990; Okabe et al., 2008). In Japan, five species large carpenter bees are associated with one mite species, *Sennertia alfkeni* (Oudemans) (Okabe and Makino, 2005; Okabe et al., 2008); however, molecular analyses have revealed five host-specific genetic lineages of the mite, suggesting long evolutionary associations between each pair (Kawazoe et al., 2008a, b).

*Sennertia dissimilis* Zakhvatkin, associated with *Xylocopa nasalis* Westwood (from Japan and probably originating from a Southeast or East Asian country occupied by Japan at the collection time), *Sennertia horrida* (Vitzthum) with *X. nasalis* (from India, Indonesia, and Japan at the time of collection), and *Sennertia potanini* Zakhvatkin with *Xylocopa tranquebarorum* (Swederus) (from western China) are all described as species of bamboo-nesting large carpenter bees of the subgenus *Biluna* (Zakhvatkin, 1941; Klimov and O’Connor, 2008). Currently, the biology and ecology, including the exact distributions of carpenter bees of *Xylocopa* subgenus *Biluna* and their associated mites are unknown. An additional bamboo-nesting carpenter bee, *Xylocopa appendiculata circumvolans*, is distributed (Kamio, 2007; Yata, 2007). The exotic bee has established populations in Toyota, Aichi Prefecture (Okada and Takeda, 2009; this study) and has likely expanded its distribution to Nagoya (Ohkusa, personal communication) (Fig. 1). *Xylocopa tranquebarorum* is associated with a mite belonging to *Sennertia*, the deutonymph of which is morphologically similar to but genetically different from the Japanese large carpenter bee mite, *S. alfkeni* (Kawazoe et al., 2010). Hereafter,
the introduced species is referred to as *Sennertia* nr *alfkeni*. Although the original habitat(s) is unknown, this bee is unlikely to have originated from Taiwan (although the Japanese name of *X. tranquebarorum* is directly translated to “Taiwanese bamboo-nesting large carpenter bee”), where *X. tranquebarorum* is associated with *S. horrida*; instead, based on its associated mite species, it probably arrived from Southeast and/or East Asia (Kawazoe et al., 2010).

Although the introduced *X. tranquebarorum* attacks commercial bamboo products for nesting purposes, the risks posed by the associated mite are not as direct because thus far no *Sennertia* mites have been considered pests. However, potential mite problems include the following: introduced mites may lead to the collapse of the interaction between endemic *X. a. circumvolans* (Smith) and *S. alfkeni*, perhaps via a mite host switch, and *S. nr alfkeni* may become house dust by surviving without the host and vectoring fungi. Therefore, as a risk assessment of *S. nr alfkeni*, we investigated the life cycle of the introduced mite to examine the possibility of an association between *X. a. circumvolans* and *S. nr alfkeni*, and to determine if the mite could survive without the host, with particular focus on deutonymphal molt to tritonymphs in the absence of the host. We also investigated the potential of the mite as a vector of fungi.

**MATERIALS AND METHODS**

**Information related to carpenter bee invasion.** To record the expansion of this species, we also collected information on observations of *X. tranquebarorum* from the published literature and entomologists near Toyota, Aichi Prefecture, where the carpenter bee was first reported.

**Experiments.** Nests of the exotic *X. tranquebarorum* were collected from several points along the Yahagii River in Toyota on 29 May 2009 (Fig. 1). A few nests were collected from natural bamboo forests, but most nests were found in commercial bamboo shoots at a bamboo timber yard. The nest portion between bamboo joints was removed in the field, and 2 days later in the laboratory, the nest was opened by cutting it in half lengthwise. The diameter of each nested shoot was recorded. The number of cells in a nest and the numbers of juvenile bees and mites in each cell were counted. Cut shoots with or without mites were stored separately in a closed container and maintained outdoors under a roof at ambient temperature until adult bee emergence. To use living mites in experiments, adult carpenter bees were maintained with phoretic mites in a cage (45 cm per side, constructed of a wooden frame and synthetic fiber mesh) and were provided diluted honey and sugar water soaked in cotton.

We conducted three laboratory experiments to examine the potential risks of the mite: comparisons of the developmental period of *S. nr alfkeni* to that of *S. alfkeni*, which was originally associated with the Japanese carpenter bee *X. a. circumvolans* to investigate the possibility of a host switch by the invasive mite; fungal sampling in nests to evaluate the potential house dust risk via a mite vector; and assessments of the necessary conditions for the deutonymphal molt to determine the risk of both a host switch and to contributing to house dust.

To assess the mite developmental periods, pairs of *S. nr alfkeni* were isolated from bee nests and placed in transparent plastic vials (1.6 cc, 35 mm in length) with a small piece of wet filter paper and about 1 g fresh pollen loaf from a *X. tranquebarorum* cell. Ten vials were prepared and maintained at 25°C. Each pair was transferred daily into another vial with the same contents. Vials containing mite eggs were also maintained at 25°C, and mite development was checked once daily. The mite developmental period was estimated from mass rearing, assuming that the first larva became the first protonymph within the population.

To collect fungi associated with the carpenter bee and the mite, we collected 20 tritonymphal mites from two nests in which fungal contamination had occurred but that lacked host juveniles (likely because they had been abandoned before oviposition or because bee offspring had died at an early stage). The body surface of 20 mites from each nest was soaked in 70% ethanol for 30 min and in a diluted Twin 80 solution (one drop in 10 cc distilled water) for 30 min to remove and/or kill fungal materials on mites. After cleaning in distilled water for about 1 min, 10 mites were transferred onto a malt agar (MA) plate (90 mm in diameter) to collect feces. Ten squashed mites were then transferred onto another MA plate to cultivate internal fungal materials. Plates were maintained at.
20°C for 1 month to identify living fungi inside of mites. To examine mite host specificity, we assessed whether deutonymphal mites could molt without hosts (some insect-associated mites need to ride on specific phoretic hosts before molting; e.g., Okamoto et al., 1991) and with fungi collected from bee nests. The experiment was also conducted using deutonymphal molts with or without chilling treatment at 5°C (some astigmatid mites overwinter as deutonymphs; e.g., Hayashi et al., 2009), but all deutonymphs maintained with or without hosts died 1 month later. Deutonymphal mites originated from several adults in a cell and were reared in a vial with a bee pollen loaf. Vials were maintained for 30 days at ambient temperature. Subsequently, 20 mites were transferred to another vial with a piece of bamboo (5×20 mm) and an about 0.5 g pollen loaf; this procedure followed that used to molt deutonymphal S. alfkeni to tritonymphs (Okabe et al., 2008). Twenty mites that had molted to deutonymphs on a carpenter bee and that had been maintained for 5, 30, or 60 days on the bees were transferred to a vial with the same contents as described above. We collected 20 mites from each of five different carpenter bees for a total of 100 mites for the experiment. Vials were maintained at 25°C, and mites were checked once per week to determine if they had molted to tritonymphs, until all deutonymphs had died.

Statistics. The mortality of carpenter bee juveniles with and without mites was compared using one-tailed Fisher’s exact tests. After testing for normal distribution using Kolmogorov-Smirnov tests, mite developmental periods between sexes and between species [data for S. nr alfkeni originated from this study and data for S. alfkeni were obtained from Okabe et al. (2008)] were compared using Mann-Whitney U-tests. All statistical analyses were conducted using the statistical package STATISTICA 06J (StatSoft Inc., 2005).

RESULTS

Information related to carpenter bee invasion

The bamboo-nesting carpenter bee has been reported in Toyota, Aichi Prefecture (white circle in Fig. 1) and in Anpachi, Gifu Prefecture (westernmost black circle in Fig. 1). Since 2006, X. tranquebarorum has been observed every season in Toyota (Yamagishi and Okada, personal communication). In January 2009, Okada and Takeda (2009) reported overwintering of the carpenter bee in Toyota. In 2009, X. tranquebarorum was also observed in Nagoya, located between Toyota and Anpachi (Ohkusa, personal communication; Fig. 2). During bee collections in the field, we found one to several nests per bamboo stand (ca. 100–500 m²) but easily found over 25 nests at a timber yard specializing in bamboo shoots; however, whether these commercial shoots were imported or domestically transferred was unclear.

![Fig. 2. The amount of bamboo (includes both processed and unprocessed) imported to Japan from each major export country (Taiwan and China). Minor export countries that are not shown include Thailand, South Korea, and Vietnam.](image-url)
Life history traits of invasive X. tranquebarorum

Bamboo with carpenter bee nests appeared fresh and had probably been cut within a few months. We collected 33 nests at four different sites (three natural bamboo stands and one timber yard) within 4 h (Table 1). At each site, multiple carpenter bees were provisioning their nests, but most nests (25) were collected from the timber yard. The stages of nests varied from having only an entrance (but not yet provisioned) to having at most seven provisioned cells. Because many of the nests contained eggs and 22 cells were unfinished, most collected nests were incomplete. In four nests, we collected adult females that had not yet provisioned. The average inner diameter of nests was $14.5 \pm 1.22$ cm ($\pm$SD, $n=19$). When nests were opened, 26 offspring (eggs or early instars) were dead within mite-laden cells, and three were dead in mite-free cells (Fisher’s exact test, $p=0.2468$). A total of 123 cells contained bee stages ranging from eggs to final instar larvae (final instar larvae were those that had already consumed the pollen loaf). Adult bees emerged between 20 and 28 July. Males emerged after all females from the same nest had emerged. The sex ratio differed slightly between mite-laden and mite-free nests (Fisher’s exact test, $p=0.4929$).

Life history traits of associated organisms

The mite life cycle was observed in maintained nests: mites migrated into a cell at the beginning of host provisioning; quickly turned into tritonymphs and adults; laid an egg mass usually on a partition wall of a cell; fed on the pollen loaf and then on host feces, which perhaps contained fungal particles; protonymphal mites aggregated on a pupal host; and deutonymphal mites attached to a newly emerged host (see Fig. 3 for mites on a pupa and emerged host). Perhaps because the typical number of mites had increased under artificial conditions, bees emerging late from a nest were heavily covered with deutonymphs (Fig. 3b). Under conditions

<table>
<thead>
<tr>
<th></th>
<th>No. of nests</th>
<th>No. of provisioned cells</th>
<th>No. of cells with bees</th>
<th>No. of emerged bees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mite-laden</td>
<td>22 (1)</td>
<td>101</td>
<td>87</td>
<td>49 (33)</td>
</tr>
<tr>
<td>Mite-free</td>
<td>10 (3)</td>
<td>22</td>
<td>20</td>
<td>5 (4)*</td>
</tr>
</tbody>
</table>

*a Total number of nests (number of un provisioned nests).

b Total number of emerged adults (number of emerged females).

* Sex ratio between mite-laden and mite-free offspring was tested using Fisher’s exact test; $p<0.05$.

Fig. 3. Mite aggregates on a host carpenter bee. (a) Protonymphal (whitish round particles) and deutonymphal (brown particles) aggregates on the surface of a female pupa. (b) Deutonymphal aggregates attaching to a male for phoresy.
of both 25°C and ambient temperature, mites maintained separately from the host but with a host pollen loaf and commercial pollen collected by honeybees turned into deutonymphs at nearly the same time as mites maintained with the host. The developmental period did not significantly differ between female and male mites (Mann-Whitney U-test: \( p > 0.100 \); Table 2). Due to the mass rearing method, juvenile (including egg) mortality was not evident. Larval and male developmental periods of \( S. \) \textit{nf} \textit{alfkeni} mites significantly differed from those of \( S. \) \textit{alfkeni} mites (Table 2).

Two unidentified fungal species, \textit{Candida} sp. and \textit{Cladosporium cladosporioides} (Fres.) de Vries, were collected from carpenter bee nests at the final stage (bees had became pupae or had emerged). In cells with fungi, we were able to detect the dark color of fungal materials within the mite gut contents through the idiosomal outer skin. The effects of the fungi on bee development were unclear, but fungal contamination (e.g., powdery spores) was conspicuous in failed cells and nests.

Regardless of whether they had attached to the host, deutonymphs of \( S. \) \textit{nf} \textit{alfkeni} never molted to tritonymphs.

**DISCUSSION**

Japan consistently imported bamboo from 1981 to 2006, but the extent of imports has gradually declined since 1994 (Fig. 2; information was obtained by National Statistics Center (e-Stat), http://www.e-stat.go.jp/SG1/statst/GL71050103. do?sessionid=YYJYtKwcyLYyWN2kThGCP93jz2R tRG2QrtMdbD2LRytdPdtQ7hQwm7J!146332371!1827439296?_toGL71050103&_listID=0000 1044766&forwardFrom=GL71050101 and the Forestry Agency). Whether bamboo was processed or unprocessed (“processed bamboo” means, for example, that bamboo was well dried, cut into pieces, and/or processed into an ornament) was not reported in the available statistics. Bamboo-exporting countries have also changed: the main export country shifted from Taiwan to China in the 1990s, and in 1997, Vietnam, instead of Thailand, began to export bamboo to Japan. For over 10 years prior to the first report of \( X. \) \textit{tranquebarorum} invasion, over 90% of bamboo was exported from China, excluding Taiwan. Because bamboo was not a major imported good in Japanese seaports, no specific information on the amount of imported bamboo was available to the public. Although we could not trace imported bamboo within the country using the statistical data, Chiba, Kyoto, and Aichi prefectures house the most bamboo timber companies (Matsuno, 2006). Two such companies in Aichi Prefecture primarily imported bamboo from China and transported it throughout almost the entire country.

The invasive pathway of the carpenter bee and its associated mite remains unclear, but these historical data suggest that the two species likely originated in bamboo material from an Asian country or countries. We suspect that because the mite species associated with \( X. \) \textit{tranquebarorum} both genetically and morphologically differs from \( S. \) \textit{horrida}, which is associated with the same bee species in Taiwan, but is morphologically similar to \( S. \) \textit{potanini} from continental Asia (Kawazoe et al., 2010), and because there have been few recent imports from Taiwan, \( S. \) \textit{nf} \textit{alfkeni} likely originated from the continental Asian region. Whether \( X. \) \textit{tranquebarorum} expanded its distribution from Anpachi and Toyota to Nagoya (midway between the two cities) or was distributed from Toyota to Anpachi, including Nagoya, remains unclear. Further monitoring is needed to better clarify the distribution of the species.

In Japan, Phyllostachys bamboo is a popular material traditionally used for processed goods, construction posts, and plant stakes in agriculture. The

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**Table 2. Developmental period of \textit{Sennertia nr alfkeni} associated with exotic \textit{Xylocopa tranquebarorum} (mean±SE) reared at 25°C**

<table>
<thead>
<tr>
<th></th>
<th>Egg</th>
<th>Larva</th>
<th>Protonymph</th>
<th>Tritonymph</th>
<th>Egg to adult (♀)</th>
<th>Egg to adult (♂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n )</td>
<td>36</td>
<td>24</td>
<td>19</td>
<td>21</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>Developmental period (d)</td>
<td>4.8±0.15</td>
<td>4.3±0.16**</td>
<td>5.8±0.29</td>
<td>4.1±0.21</td>
<td>19.0±0.29</td>
<td>19.6±0.30*</td>
</tr>
</tbody>
</table>

Each developmental period was compared to that of \( S. \) \textit{alfkeni} in Okabe et al. (2008) and significant differences are indicated by * (\( p<0.05 \)) and ** (\( p<0.001 \)).
average inner diameter of the carpenter bee nest (13–15 cm) is nearly equivalent to that of one of the most popular bamboo species, *Phyllostachys bambusoides* Sieb. et Zucc. The carpenter bee did not appear to prefer very fresh bamboo, perhaps because mortality is higher in fresh bamboo; we observed that offspring failed to develop in a fresh nest \((n=1)\). Together, our results suggest that the carpenter bee may have been introduced with processed (dried before being loaded for export) bamboo; the carpenter bee is a potential pest in the bamboo industry; and harm to humans via accidental stings can be expected in agricultural fields and perhaps in botanical gardens, where bamboo is often planted.

The preferred nesting materials of *X. tranquebarorum* also indicate that the bee was probably accidentally introduced while nesting in relatively dry, processed bamboo. Beetles such as *Purpuricenus temminckii* (Guérin-Méneville) (Cerambycidae) and *Dinoderus minutus* (Fabricius) (Bostrychidae) are listed as domestic dried bamboo pests (Uchimura, 2004). Many insects bore into deadwood in forests (e.g., Coulson and Witter, 1984), and species ranging from termites, moths, sawflies, and beetles have been listed as timber and lumber pests (Nobuchi and Suzuki, 1993). In Japan, imported live plants and timber must be examined under the current plant quarantine system, but such investigations are not required for imported lumber and processed wood materials. Thus, xylophagous insects feeding on the core of deadwood escape quarantine and gain the opportunity to establish populations, often becoming pests of building materials. For example, a termite species, *Incisitermes minor* Hagen (Blattaria, Termitidae), is suspected to have been introduced with imported woods and wooden furniture, and a wood-boring beetle, *Lycus planicollis* LeConte (Coleoptera, Lycitidae), may have been introduced with dried lumber infected after the drying process during storage for export (Goto, 2003; Ohmura and Tokoro, 2003). In North America, invasive wood-boring insects directly and indirectly affect many ecological processes (Gandhi and Herms, 2009). Furthermore, wood packaging is recognized as a critical pathway of invasive wood-associated organisms and is now regulated by the International Standards for Phytosanitary Measures No.15 (Reaser et al., 2008; IPPC https://www.ippc.int/servlet/BinaryDownloaderServlet/133703_E.pdf?filename=1240490152156_ISPM_15_Revised_2009_E.pdf&refID=133703). We conclude that processed wood represents an important pathway of exotic insect introduction, particularly those inhabiting dried wood. Additionally, unintentionally introduced insects may serve as an invasive pathway for symbiotic microorganisms by vectoring them.

Although *S. nr alfkeni* is morphologically similar to the Japanese mite *S. alfkeni*, genetic analysis separated the two species, and the former is considered to have been introduced with *X. tranquebarorum* (Kawazoe et al., 2010). The Japanese carpenter bee, *X. a. circumvolans*, sometimes damages wooden buildings through the construction of nests (Sakagami and Maeta, 1986), but its associated mite has only generated scientific, and not public, interest. However, mites, particularly astigmatids, are infamous house dust components and allergic agents (e.g., Hughes, 1976). The mite associated with *X. tranquebarorum* feeds on pollen and bee feces and, as a result, may accidentally ingest fungal contaminants of the bee nest. Because mite numbers were very high under artificially controlled conditions, as seen in pupal and emerged bees (Fig. 3), we suggest that the mite will achieve high numbers if the carpenter bee constructs indoor nests or if the mite spreads indoors. This possibility suggests that *S. nr alfkeni* may pose a house dust risk but only under certain conditions. Because the mite deutonymphs did not molt under artificial conditions with or without hosts, we suspect that the mite requires a certain stimulus, perhaps provided by the host, to become a deutonymph, as seen in the house dust mite *Lardoglyphus konoi* (Sasa et Asanuma) and its phoretic host beetle (Okamoto et al., 1991) as well as in *Hemisarcoptes* mites and *Chilocorus* beetles (Houck, 1999). Therefore, we conclude that *S. nr alfkeni* will not become house dust when separated from its host, even if *X. tranquebarorum* (and the mite) becomes common in Japan.

Because we did not exhaustively assess the life history traits and life cycle of *S. nr alfkeni*, we can only suggest that this species is capable of switching hosts from *X. tranquebarorum* to *X. a. circumvolans* based on the similarity between *S. nr alfkeni* and *S. alfkeni* in the mite developmental period. Other life history traits were also very similar be-
tween the two species; for example, both mites left the host during host provisioning and quickly changed feeding stages, and both became deutonymphs during host pupation and attached to emerged hosts, but many of the deutonymphs as well as feeding stages remained in nests after hosts had left and overwintered with the hosts (Okabe et al., 2008; this study). Thus, if the life cycle of *X. tranquebarorum* is very similar to that of *X. circumvolans*, mites that switch hosts could survive. Because *X. a. circumvolans* overwinters in existing cavities, abandoned nests of *X. tranquebarorum* provide the opportunity for a host switch of *S. nr alfkeni* (Okabe et al., 2008). Although a test cross between mite species was not conducted (colonies of *S. alfkeni* were not available), long-term concerns include genetic contamination if the two species can mate and/or the replacement of one species via a host switch. Furthermore, the pathogenicity of *S. nr alfkeni* or its associated microorganisms to native Japanese carpenter bees, including *X. a. circumvolans*, remains unknown.

The invasion of organisms associated with alien species poses both direct and indirect risks. For example, *Varroa* mites, which are infamous parasites of the European honeybee, are suspected to have been introduced from Asia into Europe and South and North America during phoretic overwintering (Eickwort, 1988). Fungi, nematodes, and mites are common associates of bark beetles as symbionts in beetle galleries and are dispersed by phoresy on the beetles (Cardoza et al., 2008). Because some mites are predacious, parasitic, or hyper-phoretic hosts of blue stain fungi (Klepiug et al., 2001), accidental introductions of phoretics and possible future phoretic host switches, as seen in the *Varroa* mites, may impact beetle populations and forest dynamics. As observed with the well-known destructive tree wilt pathogens, Dutch elm disease and the pine wilt nematode, vector switches often lead to the collapse of endemic vegetation (Gibbs, 1978; Mamiya, 1988). The eradication of microorganisms, including mites, is extremely difficult. Once a host switch occurs between *X. a. circumvolans* and *S. nr alfkeni*, eradicating the mite will be nearly impossible without eradicating the native Japanese bee species. A similar situation may also occur on other islands on which cryptic species of *S. alfkeni* have been distributed; therefore, we highly recommend the control of *X. tranquebarorum* and its associated mite during this initial invasive stage.

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**REFERENCES**


Sakagami, S. F. and Y. Maeta (1986) *From Loneliness to Un-...