Department of **Employment, Economic Development and Innovation**

Asian Honey Bee (*Apis cerana javana*) in Cairns, Far North Queensland

Foraging, nesting and swarming behaviour

Report of field observations April 2007-September 2011

Report by Shirin Hyatt, BQCC, Technical Advisor

Queensland Government

Contents

Executive Summary

Three hundred and thirty nests as well as one hundred and fifty six swarms of *Apis cerana javana* have been detected as part of the Asian Honey Bee Program in the Cairns region between April 2007 and September 2011 and various aspects of those nests and swarms were recorded. This report presents key findings from those observations.

A number of floral sources have been identified as 'favourites' for the *A. cerana javana* in Far North Queensland. These include Sensitive Weed (*Mimosa pudica*), Golden Cane (*Dypsis lutescens*), Weeping Willow (*Leptospermum brachyandrum.*), Singapore Daisy (*Sphagneticola trilobata*), Bottle Brush (*Callistemon.*), Morning Star (*Turnera subulata*), Mad Hatter (*Cuphea* sp.), Coral Vine (*Antigonan* sp.*)* and Lychee flowers *(Litchi chinensis*).

A. cerana javana in the Cairns region tend to begin foraging before 7.30 am for a majority of the year. The foraging range of this bee in Far North Queensland is generally up to 500 m, but may be up to 3 km. Approximately 70-80% of nests detected over the past three years have been found less that 400 m from initial discovery of foragers.

When *A. cerana javana* and *A. mellifera* are foraging on the same floral source, one species usually dominates. The foraging behaviour of *A. cerana javana* can be very vigorous, and they are probably inferior pollinators when compared to *A. mellifera* for certain plants. *A. cerana javana* will rob resources from native insects and *A. mellifera* nests. In Gordonvale, *A. cerana javana* nests are concentrated near the sugar mill. This may be attributed to the odour from the sugar mill and presence of sugar products.

A. cerana javana will nest in tree hollows, compost bins, garden sheds, weep holes in buildings, roofs of buildings, brickwork in walls, stationary vehicles, pot plants and letterboxes. Nesting sites may be re-used following nest destruction. Average nesting height of *A. cerana javana* is 4.45 m with 81% of nests detected at a height of 5 m or less. Average hanging height for swarms is 2.7 m with 95% of swarms detected at 5 m or less.

Based on the analysis of 90 nests and 65 swarms, the average size of *A. cerana javana* nests is 2 182 bees and for swarms, the average is 2 676 bees. Many swarms however (almost 50%) contained less that 2000 bees.

A. cerana javana may swarm up to a distance of 10 km in 'invasive' mode, and may produce more than three reproductive/migration swarms per year. The swarming activity for *A. cerana javana* is greatest between May and November/December.

These characteristics are generally comparable to those reported from its overseas range.

Introduction

Asian honey bees, *Apis cerana*, are honey bees from southern and south-eastern Asia with a variety of sub-species found in China, India, Indonesia, Japan, Malaysia, Nepal, Bangladesh, the Solomon Islands and Papua New Guinea.

An established nest of Asian honey bees was first detected in Cairns, Far North Queensland in 2007. The strain of Asian honey bee identified in Cairns is the *Apis cerana javana* strain, which originates from Java, Indonesia, and is now spread throughout Papua New Guinea and the Solomon Islands. A response was immediately implemented in the Far North managed by Biosecurity Queensland to establish the extent of the incursion with a view to eradicating this exotic bee species and any exotic parasites they might carry.

There are two main risks associated with Asian honey bees. The first is from the honey bee itself which competes with the European Honeybee (*Apis mellifera*) which is used for honey production and for managed pollination services in Australia (Goswami and Antony 2010). The second risk stems from the parasites and diseases that the Asian honey bee may carry, particularly varroa mites. Other risks include environmental risks via displacement of native species and lifestyle risks from swarms and nests of the pest bee in residential areas (Carr 2011, Ryan 2010).

Limited biological, behavioural or ecological information has been documented or recorded for *Apis cerana javana* in either its natural environment in Java and parts of the world where it has become newly established. This is probably because the discovery and invasion of this strain of *Apis cerana* is relatively new and the unlike many other *Apis cerana* strains, this bee is unable to be exploited for honey production and has been of minor interest to most researchers.

Studies that have been conducted on *Apis cerana* (mostly by Dennis Anderson from CSIRO) relate to the varroa mites that they can carry. Adri (1985) completed a thesis on *Apis cerana javana* but this document is written in Indonesian and has not been translated into English. Ample scientific information has been published on the biological, ecological and behavioural characteristics of other *Apis cerana* strains from a wide range of Asian regions. Many studies have shown plasticity in biology and ecology of *Apis cerana* across its geological range, and attributes shown at one location in Asia may not apply at another locations. It is worthwhile to compare previous studies to field observations from the Cairns region.

Four hundred and eighty-six nests and swarms of *Apis cerana javana* have been detected in the Cairns region between April 2007 and September 2011. Field staff are chiefly involved in conducting surveillance activities (sweeping, checking traps, attending to public calls, capturing swarms) which ultimately results in the detection of *Apis cerana* foragers and the subsequent discovery of their nest. Field staff currently destroy *Apis cerana javana* nests found on the edges of the current known infested area as well as in high priority areas (ports, transport corridors etc.).

This report is based on field observations made, and data collected, by field staff involved in the Asian Honey Bee Program over the last three years of the Asian Honey Bee Program. The information relating to biology, ecology and behaviour is limited: a majority of the information is from specific swarm or nest site details relevant to a ‘find and destroy’ or eradication program. Useful data recorded for the purpose of this report included nest and swarm heights, locations (natural versus man made), make up (drone and worker numbers) and months of the year that swarms were detected.

New funding recently allocated to the Asian Honey Bee Program will provide the opportunity for scientific research which will present a more comprehensive insight into the ecology, biology and behavioural attributes of *Apis cerana javana* and how these attributes may relate to the invasion in Far North Queensland. This research will also enable the development of effective management tools for the ongoing management of this pest in Australia. Enhanced data collection by field staff will support the Transition to Management Program.

Field observations of foraging habits of *Apis cerana javana*

Observations of the foraging habits of *Apis cerana javana* over the lifetime of the Asian Honey Bee Program in Cairns have been made by Biosecurity Queensland field-staff while conducting routine surveillance activities.

The following sections detail significant observations.

Preferred floral sources

A. *cerana javana* seem to be mostly opportunistic in the floral sources that they choose to forage on and will forage on the closest suitable nectar or pollen source to the nest. Field observations show that they tend to be detected frequently on the same few varieties of flora. There have been a number of flowering trees, plants, shrubs and weeds that have been identified as 'favourites' for the *A. cerana javana* in Far North Queensland at various times of the year. These floras mainly include; Sensitive Weed (*Mimosa pudica*), Golden Cane (*Dypsis lutescens*), Weeping Willow (*Leptospermum brachyandrum.*), Singapore Daisy (*Sphagneticola trilobata*), Bottle Brush (*Callistemon.*), Morning Star (*Turnera subulata*), Mad Hatter (*Cuphea* sp.), and Coral Vine (*Antigonan* sp.*).* Sensitive weed and Morning Star flowers only provide a suitable source of nectar or pollen in the morning. Lychee flowers *(Litchi chinensis*) seem to be a firm favourite when in full flowering season.

An early pollen study carried out in June 2007 on a single colony of *A. cerana javana* in Cairns, found that the bees were foraging on a very narrow range of plants and these plants mainly included exotics. *Mimosa pudica* was listed as one of the major pollen sources evident in the pollen samples analysed (Macphail, 2007). On Hainan Island in China, *A. cerana cerana* also have a preference for certain types of plants. Pollen analysis revealed that *Mimosa pudica* and *Sonneratia* spp. are the most important pollen and nectar providers for the bee during the months of October and November, even though many other plants grow in the area and bloom at this time of the year (Yao et al., 2006). Additionally, Oldroyd and Wongsiri (2006) found that foragers of different species of bees specialise on particular floral sources. This observation is probably dependent on worker size and also the energetic requirements of the bee (Oldroyd and Wongsiri, 2006).

Temperature dependent foraging behaviour

Due to the tropical climate in the Cairns area, weather conditions for the majority of the year remain hot and humid and foragers from *A. cerana javana* nests tend to begin foraging very early in the morning – generally before 7.30am. Oldroyd et al. (1992) have also observed *A. cerana* foraging early in the day, just before dawn, on king palms in tropical Thailand. On extremely hot days (>30°C), *A. cerana* have proved difficult to detect foraging in the field. During the winter months (June to August) *A. cerana javana* nests tend to send out their first 'wave' of foragers later in the day. Foraging *A. cerana javana* may not be observed until the sun is high in the sky and temperatures have warmed up to at least to 25ºC.

The thermoregulation behaviour of *A. cerana* may explain some of the foraging patterns described from the field in Cairns. *A. cerana* possess very effective nest thermoregulation systems (Oldroyd and Wongsiri 2006). Colonies of *A. cerana* maintain their brood nest temperature in the range of 33°C – 35.5°C, even while ambient temperatures may vary between 12°C and 36°C (Kraus et al. 1998). In extremely hot or cold conditions workers are required to remain in the nest and sustain thermoregulation; they do not forage under these conditions. In particularly hot weather *A. cerana* will behave similarly to European Honeybees (*Apis mellifera).* They will spread out over the comb, dissipating their metabolic heat. Some bees will ventilate the colony by fanning their wings whilst others will expose water and dilute nectar to the airstream generated by the fanners – thus achieving evaporative cooling. Large numbers of workers may also leave the colony and cluster in a shady spot near the nest entrance outside (Oldroyd and Wongsiri 2006).

In order to fly, a honey bee needs to achieve a thoracic temperature of at least 27°C (Dyer and Seeley 1987, cited in Oldroyd and Wongsiri 2006). In cold weather, *A. cerana* have been observed using metabolic heat to warm brood nests (Oldroyd and Wongsiri 2006).

Foraging in unfavourable conditions

Unlike *A. mellifera*, *A. cerana javana* in FNQ forage normally during light to even medium rainfall (whilst the rain is actually falling) on floral sources or feeding stations that are within 100 m of their nest. Flight frequency to and from their nest to forage are not affected. When there are periods of heavy rain (mostly during the months of November to March/April), *A. cerana javana* will forage in large numbers as soon as rain stops falling.

The main focus of an undomesticated *A. cerana* colony is to swarm and survive (Anderson 2005). They do not hoard excess honey and therefore constantly require resources for the colony to survive. This may force the bees to forage in unfavourable conditions.

Foraging ranges

A. cerana generally forage within 500 m of their nest and, in many cases, they are found foraging 200 m or less from their nest. When foragers are detected through routine surveillance (sweeping, traps, public notifications), they are beelined, and their nests are subsequently detected and destroyed. An estimate of about 70- 80% of the nests detected over the past three years in the Cairns region have been found less than 400 m from the site of initial discovery of foragers.

The foraging ranges of *A. cerana* have been studied extensively in various parts of Asia (Punchihewa et al. 1985, Dyer and Seeley 1991, Sasaki et al. 1993, Naug and Arathi 2005). In order to determine typical foraging ranges, these studies have used beelining methods and distance calibration curves based on the distances being indicated by dances in the nest for natural foraging sites. Dyer and Seeley's (1991) research shows that for *A. cerana,* half of the dances indicated foraging sites less than 196m from the colony and 95% of dances indicated food less than 1km from the colony. Punchihewa (1985) found that *A. cerana* in Sri Lanka may fly as far as 750 m, but that 300 m is more typical. In Japan the average foraging range for *A. cerana* was estimated to be 2.1 km (Sasaki, Takahashi and Sato 1993). These findings are consistent with the field observations noticed for *A. cerana javana* in Far North Queensland.

Dominance of one apis species on a floral source

When *A. cerana* and *A. mellifera* are foraging on the same floral source, often one species of bee tends to dominate, rather than the intermingling - sometimes even on just one side of the tree/bush. This has also been observed on sugar feeding stations. It is very unlikely that an *A. cerana javana* will forage on a sugar feeding station that is occupied by the *A. Mellifera* and vice versa.

These observations in Cairns supports the theory that if *A. cerana javana* become widely established in Australia and if increasing competition with *A. mellifera* for floral resources results, the two species of bees probably will not pollinate the same crops or flowers. Rather there may be reduced bee visitation for some crops and flowers whilst others might even gain (Carr 2011, Lee 1995).

Resource partitioning has also been observed in Borneo where different species of honeybees seem to forage at different heights in the same tree (Rinderer, Marx, et al. 1996 – cited in Oldroyd and Wongsiri 2006). This may be due to the availability of nectar. Wongsiri and Oldroyd (1996) suggest that while all species can exploit flowers of high nectar secretion, larger bees cannot exploit the less profitable flowers on a tree. Another possibility is that larger bees risk overheating when foraging in direct sunlight, preferring to forage in shadier parts of the stratum. *A. mellifera* foragers need to stop foraging or start dumping heat by exposing nectar on the tongue as an evaporative cooler at ambient temperatures above 30°C (Heinrich 1979)

Dynamic foraging behaviour

Our observations indicate that *A. cerana* forage in a vigorous manner, usually visiting flowers for a few seconds and quickly 'jumping' continuously from one flower to another. They do not spend the same time foraging meticulously on floral sources that *A. mellifera* do. This behaviour has been particularly observed on callistemon flowers where *A. cerana* will 'scoot' over a flower and then go to the next flower. This has been noticed whether they are collecting pollen or nectar. *A. mellifera* are more likely to spend time carefully going over the flower and may even spend up to 30 seconds on a flower before moving on to the next. *A. mellifera* seem to concentrate their effort on a major nectar resource whilst *A. cerana* appear to forage from a variety of minor sources.

This behavior implies that *A. cerana* may be inferior pollinators when compared with *A. mellifera.* Generally, it seems that *A. mellifera* tends to collect greater amounts of pollen as well as spending longer lengths of time on or within the flower, increasing the likelihood of successful pollination.

Robbing behaviour

A recent report discussing the potential environmental impacts of *A. cerana javana* in Australia suggests that *A. cerana* do not rob stored food from other colonies and that this particular behaviour is more characteristic of *A. mellifera* (Carr 2011). However there have been numerous field observations that contradict this finding in Far North Queensland.

On four separate occasions field staff have witnessed *A. cerana javana* in Far North Queensland robbing the resources from nests/hives of other bees and insects. Closer inspection of a suspected *A. cerana javana* nest during beelining activities actually revealed a nest of *Camponotus* sp. (sugar ants) that was being robbed. Similarly a public report of bees nesting in a pile of firewood, turned out to be the nest of the native stingless bee (*Trigona* sp.) that was being robbed of its resources by *A. cerana javana.* This particular nest was completely robbed of honey and destroyed within a couple of hours. A local beekeeper who has a honey processing business in the Cairns suburb of Bungalow has twice observed *A. cerana javana* robbing his *A. mellifera* hive frames post honey extraction. Biosecurity Queensland field staff have witnessed these occurrences first hand.

In agreement with these observations from the Cairns region, Anderson (2005) also reports that *A. cerana* is renowned for its aggressive robbing of honey and pollen from *A. mellifera* nests. Lawrence and Anderson (2007) state that *A. cerana* has killed off *A. mellifera* colonies through competition for floral sources and its aggressive robbing behaviour. Additionally, Annan (2004) describes how *A. cerana* in the Solomon Islands would loiter around domesticated *A. mellifera* hive entrances and sneak past the guards and rob resources from the hives. It seems that robbing behaviour of *A. cerana javana* will most likely be of great concern if the bee becomes widely established, especially in regards to disease spread.

Displacement of native insect species as well as *A. mellifera* may result from the establishment of *A. cerana*.

Attraction to sugar

It may be possible that *A. cerana* are attracted to the odour and presence of sugar (and sugar byproducts) from sugar-cane mills and from sugar shipment areas. Gordonvale is a region 25 km south of Cairns where a large sugar mill operates for about 6 months of the year. When the mill is in operation a strong sugar odour engulfs the small town and surrounds. This mill was established in 1896, and there are a multitude of open spaces that would allow bee foragers to enter and exit almost any part of the mill.

More than 28 nests or swarms have been located within roughly 600 m from the Gordonvale sugar mill, with at least ten nests being located within buildings or trees in the mill grounds. Perhaps this phenomenon relates to the presence of ample and attractive food supply inadvertently provided by the mill.

Swarms and nests have also been detected in the immediate vicinity of docks in the Cairns area where sugar is loaded onto ships for export, with one swarm being discovered hanging from a conveyor belt that transfers sugar onto ships. A report compiled by the Queensland Department of Primary Industries – Animal and Plant Health Unit which was based on observations from a trip to Lae, Papua New Guinea, declared that the presence of *A. cerana* on Lae wharves was seasonal and directly related to the cane harvest and shipping of sugar (Shields 2000).

These Word templates have been designed by Corporate Communications for all staff who will be writing, preparing or approving documents for publication, such as books, proceedings, papers or technical reports. This includes all material published in either printed or electronic form.

Nesting behaviour of *Apis cerana javana* and field observations in far north Queensland

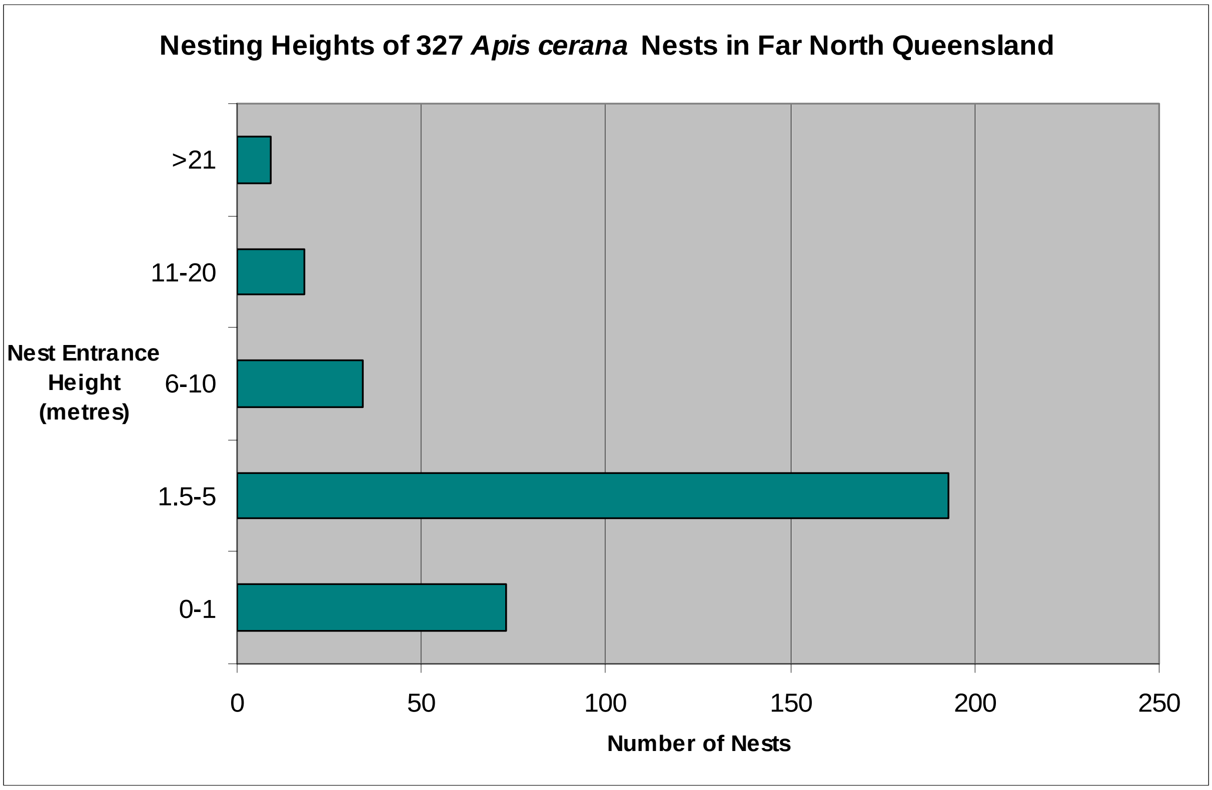
Apis cerana javana nests are detected by Biosecurity Queensland through the specialised process of beelining or through reports from the public. Three hundred and thirty nests have been detected in Far North Queensland between April 2007 and September 2011. Nesting behaviour and *in situ* nest characteristics for *A. cerana javana* have been studied by field staff whilst carrying out destruction procedures and laboratory analysis has revealed the biological make-up of nests.

Significant observations include:

Nesting heights

Nest entrance heights for 327 *A. cerana* nests in Far North Queensland have been recorded (there were another three nests detected where nest entrance height was not recorded). Generally nesting height for *A. cerana* is considerably low and none of the nests were located at a height above 30 metres from the ground. The average nesting height was found to be 4.45 m (Figure 1). Fifty nine percent of nests (193 nests) were detected between 1.5 and 5 metres from the ground.

FIGURE 1



Other studies from Asia have also found that *A. cerana* tend to nest at fairly low levels as well. Oleh (1989) studied 14 nests of *A. cerana* in Indonesia and found that nest entrances were from 0 to 1.5 m above ground, with a majority of the nests being in the bottom of tree trunks. Cavities chosen lower in the trunk of a tree may be stronger and more robust that those at the top of a tree and probably provides greater shelter (Oleh 1990). Other studies have indicated that *A. cerana* mainly nests between 1-2 m from the ground in Sumatra and Thailand (Inoue, Adri and Salmah 1990, Seeley, Seeley and Akratanakul 1982). These observations suggest that height is not a defence against predators.

Oleh (1989 and 1990) also studied the entrance number, entrance size, and cavity size of *A. cerana* nests – however this information has not been collected for the nests discovered in Cairns.

Location of nests

There does not seem to be a great difference in *A. cerana's* preference to nest in artificial structures compared to natural structures in Far North Queensland. Nesting location was recorded for 334 nests. Of these nests, 174 were located in a man-made structure, whilst 160 were located in a natural structure. Man-made structures in which *A. cerana* were found nesting included compost bins, garden sheds, weep holes in buildings, roofs of buildings, brickwork in walls, stationary vehicles, pot plants and letterboxes. Natural structures in which nests were located were predominantly native trees including gum trees, and other forest trees. Nests have also been located in mango trees.

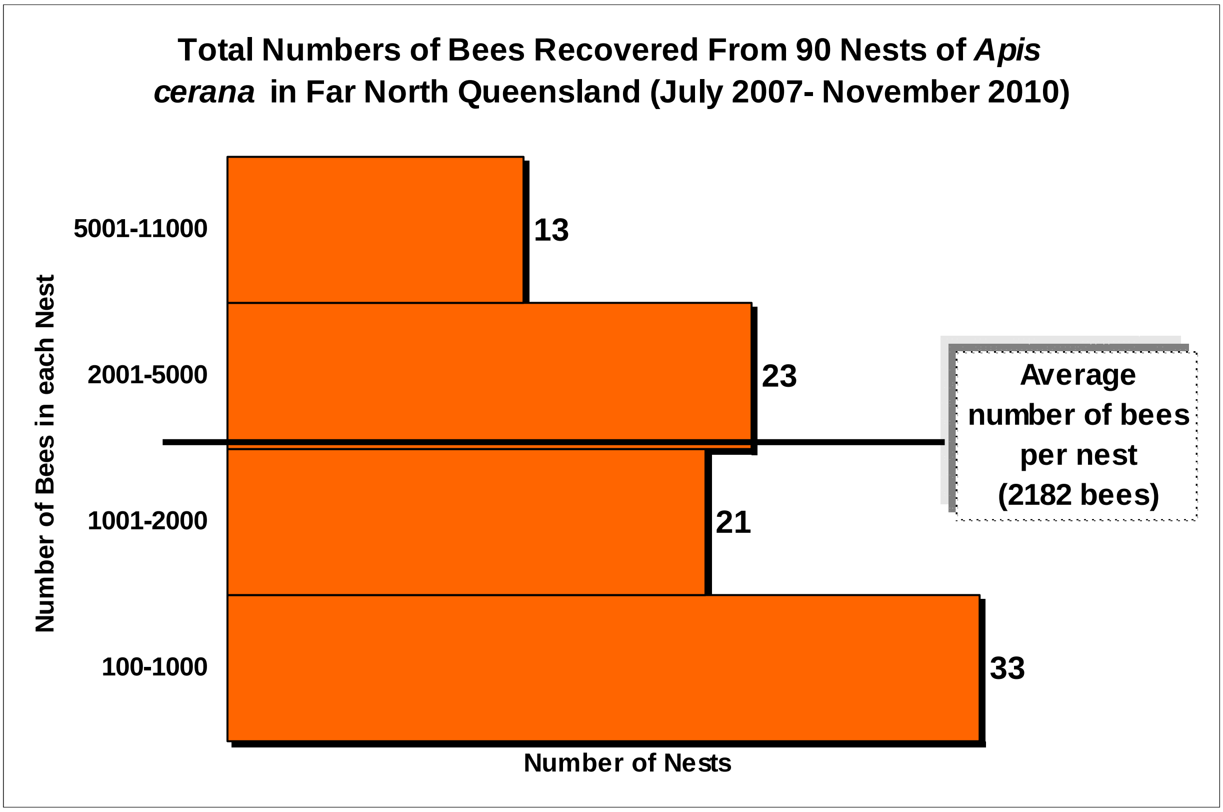
In their natural environment *A. cerana* have specialist predators including ants, wasps, birds, and mammals, particularly bears, monkeys, martens and humans. The primary defence strategy of a honey bee colony against predators, adverse weather, and excess solar radiation, is finding a suitable nest location. Optimally a nest should be built where it is both shielded from the view of potential predators and inaccessible to them. Choosing a location protected from direct sunlight, wind and rain is very important for survival (Oldroyd and Wongsiri 2006). Nest selection will obviously vary hugely according to local predators and conditions. In Australia, predators have not co-evolved with *Apis* spp. bees, and *A. cerana javana* in Cairns has appear to have adopted nesting habits from its natural environment. Nesting cavities are probably chosen based on the proximity of suitable foraging sources, weather protection, and cavity size. Cavities should be large enough not to constrain the growth of the colony. When the density of nests becomes high, *A. cerana* use suboptimal cavities (Oldroyd and Wongsiri 2006).

In the Cairns experience, *A. cerana* nests have been located within small cavities in predominately residential areas. This may of course be due to the fact that the presence of the public's 'eye' is much greater in residential areas compared to forested areas and because inhabited areas are more accessible for field surveillance activities. There is great debate regarding the likelihood that *A. cerana* can nest 'in the hills' and whether or not they are able to survive in densely forested areas with limited floral resources. On the other hand, *A. mellifera* are rarely found nesting in man-made structures in residential areas. Approximately 90% of nests of the *Apis* species in found in residential areas by BQ staff are confirmed as *A. cerana* rather than *A. mellifera* which are principally found nesting in trees within large cavities. These findings highlight the invasive tendency of *A. cerana* within residential areas and the likely nuisances that these bees will cause to the public as they continue to nest in man-made structures and become established in Far North Queensland.

Size of nests

The data collected concerning specific nest size and nest biological make-up, has been extremely limited. From the 330 nests detected between April 2007 and September 2011, there were 90 nests detected between July 2007 and July 2010 for which there were reliable records kept regarding the total number of bees per nest. The total number of mature bees recovered from each of these nests after they were destroyed was recorded. The 90 nests used in this analysis were also nests that could be completely extracted (comb and bees are totally removed from the nesting cavity). While it is not always possible to collect every single bee, care is taken to gather as many bees from the nesting cavity as possible. The data show that a majority of the destroyed nests contained between 100 and 1000 bees (33 nests), 23 nests contained 2001-5000 bees, 21 nests contained 1001-2000 bees and 13 nests contained between 5001 and 11000 bees (Figure 2). The average number of bees per nest was 2182.

FIGURE 2



There does not seem to be a great deal of literature published on the specific sizes of *A. cerana* colonies, and the limited information available provides variable results. A recent report (Koeniger, Koeniger et al. 2010)described a full sized colony of *A. cerana* as containing about 1500 bees in Borneo. Other studies in Indonesia have reported average colony sizes between 3500 and 23 000 bees (Inoue, Adri and Salmah 1990). While care was taken with the data selected for this report, it is possible that results shown for nest sizes of *A. cerana* in Cairns may be biased due to incomplete bee counts. On the other hand, these results may show that colony sizes of *A. cerana javana* in Cairns are relatively small, possibly resulting from low availability of suitable nest cavities which has been reported to affect colony size (Carr 2011). The abundance of small/young nests in the Cairns region may also be attributed to the extensive efforts of the Asian Honey Bee Eradication Program.

Make up of nests

Based on information gathered from 59 nests, the greatest number of worker bees in a nest was found to be 10,706 (this nest had 237 drones), with an average number of 2,590.5 workers per nest. The greatest number of drone bees was found to be 403 (this nest contained 5807 workers). The average number of drones in each nest was 57 (Table 1). The number of workers in an *Apis cerana javana* nest is not closely correlated with the number of drones in the same nest.

TABLE 1

Bee	Numbers of Bees* Recorded for each Nest (n=59)		Average Number of Bees per Nest
	Lowest	Highest	
Worker Bees	41	10,706	2,590.5
Drone Bees	0	403	57

*bees counted were mature bees extracted from the nest (not immature bees from comb cells)

Most nests contained between 100 and 1,000 worker bees, 13 nests contained 1,001-2,000 workers and 16 nests contained between 2,001 and 5,000 workers. Larger nests were rare.

Drones were present in 88% of the nests analysed. For the nests with no drones, it was found that worker numbers were relatively high (majority between 1,500 and 9,000 workers.) Most nests contained 1-5 drones (16 nests), many contained between 6 and 50 drones (14 nests) and 51-100 drones were found in 10 nests. Nests containing more than 100 drones were uncommon.

No information was found within the literature describing the composition of drones and workers for *A. cerana* nests found in other parts of the world. Work on *A. mellifera* nests may be relevant to *A. cerana* nest composition. Page and Metcalf (1984) report that the number of worker colony members in an *A. mellifera* nest grows logistically depending on survival rates and resource availability. During rapid expansion of colony growth, drones are produced. Drones are usually produced and maintained only when colonies can support them and when queens are potentially available for mating. Prior to a nest swarming, there are significantly more drones and fewer workers present in the colony (Page and Metcalf (1984). Small colonies (new nests) raise few or no drones - drones are raised later within the breeding cycle.

The numbers of drones and workers in the *A. cerana javana* nests analysed from the Cairns region may be related to whether or not the nest had recently swarmed, was building up colony resources and preparing to swarm, or perhaps due to the strength of the nest and availability of suitable resources. *A. cerana* nests from Cairns that contained no drones were possibly young nests.

Other nest/nesting characteristics

An interesting observation is the that *A. cerana javana* colonies re-occupying a specific nesting site or cavity following the removal/eradication of a preceding nest (where all bees and comb have been removed). Most of the 15 cases have involved a member of the public calling and reporting that the ‘‘bees are back’’. Generally, the new colony of *A. cerana javana* have moved into the same building cavity where a nest was successfully eradicated some weeks or even months before. Sometimes, a cavity close to where a previous nest was detected (e.g on another side of the house) became occupied. In a park in the Cairns Central Business District, three *A. cerana javana* nests have been located over a period of about 6 months in Lorikeet nesting holes on different branches within the same Melaleuca tree. Also a residence in Innisfail attracted two swarms to the same window sill on separate occasions after a nest had been extracted in the corner wall of the window some four weeks prior. This is a common occurrence for *A. mellifera,* but notably this species is usually only attracted to previously occupied cavities containing abandoned combs, which they willingly utilize (Schmidt 2001. A study conducted by Asada (1993) found that when a colony of *A. cerana* has moved from a nesting location, the site sometimes became occupied by another colony later.

A. cerana do not seem to guard their nest entrances with as much vigour as *A. mellifera*, being more likely to retreat into their nesting cavities when they are ‘bumped’ or ‘tampered with’ at the entrance by field staff. They do become aggressive however when the nest has been split open, or when bees are able to escape from the nest during spraying/destruction activities.

The bee activity surrounding the nest entrance of *A. cerana* and a feral nest of *A. mellifera* is very dissimilar. *A. cerana* tend to fly with speed straight through the nest entrance and into the depths of the cavity in which they are nesting and similarly, when exiting the nest they will fly straight out after leaving the comb. They do not normally land on the entrance of the nest and crawl inside the cavity towards their comb, or crawl out to the exit and then fly off, like *A. mellifera* tend to. Also due to the smaller size of *A. cerana* colonies, the frequency of bees entering and exiting a nesting cavity is usually much lower than for *A. mellifera*, and there seems to be less of a ‘line-up’ of bees flying around the entrance waiting to enter the nest. This demonstrated behaviour of *A. cerana* aids in the preliminary field identification of their nests, but at the same time this behaviour can make initial nest detection difficult due to limited visible activity surrounding the nest entrance.

A single nest of *A. cerana javana* in Cairns was examined in detail to obtain data on comb and bee size characteristics (P. Drew, Industry Volunteer, 2011). In general, cell sizes for comb from *A. cerana* nests are considerably smaller than cell sizes from *A. mellifera* nests, as are individual bees within the colonies from each species (Table 2).

TABLE 2: Comparative size characteristics of *A. cerana javana* and *A. mellifera*

Characteristic	*A. cerana javana*	*A. mellifera* (Taber and Owens 1970)
Worker cell diameter	3.77 mm	5.2 mm
Drone cell diameter	4.69 mm	6.4 mm
Queen cell diameter	8.21 mm	
Worker bee	11 mm	
Drone	14 mm	
Queen	15 mm	

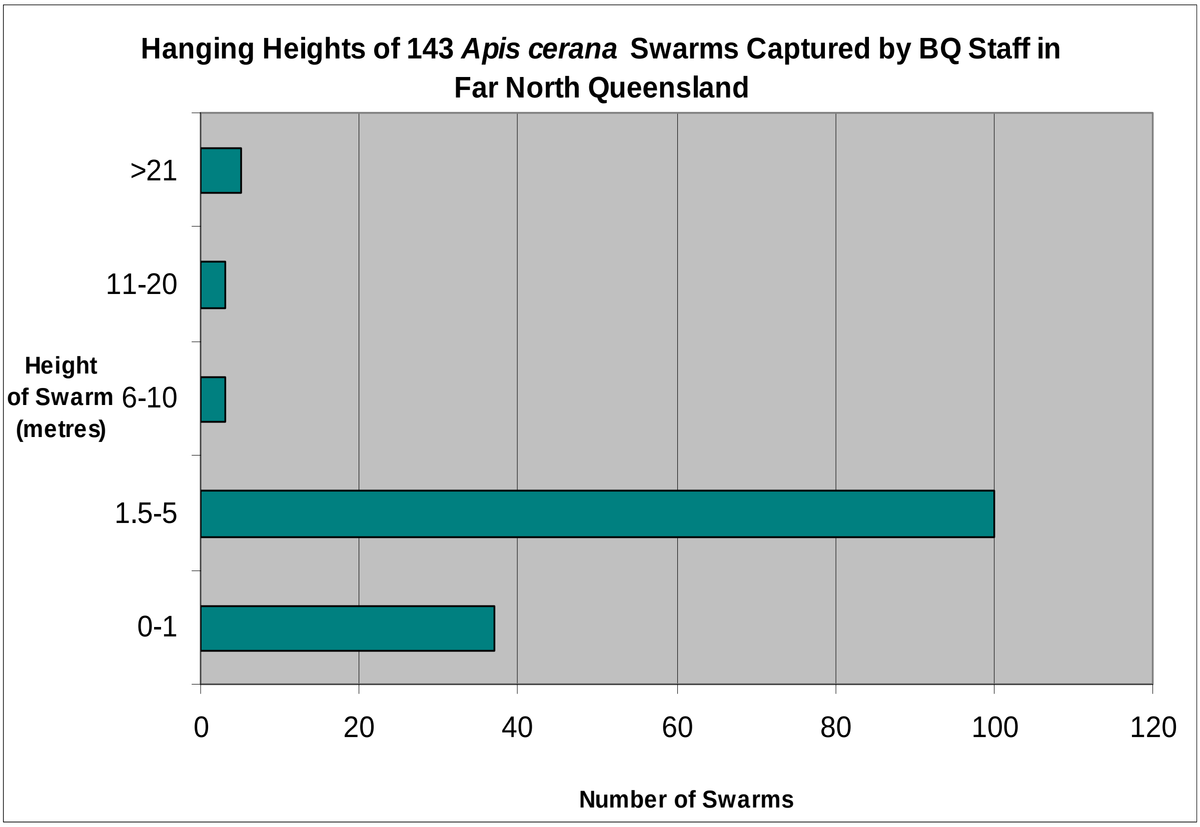
Swarming behaviour *of Apis cerana javana*

Swarms of *Apis cerana javana* are typically detected by the public and reported to Biosecurity Queensland. Field staff then capture/destroy the swarm. One hundred and fifty six swarms have been detected in Far North Queensland between April 2007 and September 2011. Swarming behaviour and swarm characteristics for *A. cerana javana* have been studied by field staff whilst carrying out destruction events and laboratory analysis has revealed the biological make-up of swarms.

Swarm heights

The hanging heights for 148 *A. cerana* swarms in Far North Queensland have been recorded. The average height of swarms above ground was 2.7 m (Figure 3). The majority of swarms (66%) were detected at a height of between 1.5 and 5 metres from the ground. This is also the preferred nesting height of *A. cerana* in Far North*.* Only 7% of swarms were located above 6 metres (Figure 3).

FIGURE 3



Reason for swarming

The behaviour of swarms of the *A. cerana javana* after they have left the natal nest is not well studied, and flying heights or hanging heights of *A. cerana* swarms have never been published. Oldroyd and Wongsiri (2006) infer that the process of reproductive swarming is similar to that for *A. mellifera*. Swarms of *A. cerana* settle 20-30 m away from the natal nest, stay there for a few days, and then depart presumably for a new nest site, just as *A. mellifera* would. A few hypotheses have been proposed to explain what causes reproductive swarming in the Apis species. These include a surplus of young bees resulting in too much brood food, crowding of adult workers and limited space for brood, and reduced transmission of queen mandibular pheromone among workers (Qiang et al. 2009). These factors as well as colony size and worker age distribution may all play roles in swarming stimulation; however none of them alone consistently induces swarming (Qiang et al. 2009).

Not all swarming in *A. cerana javana* is related to reproduction. Because *A. cerana* do not store large amounts of honey, their strategy is to put their biological surplus into reproductive swarms rather than storing the honey that may be stolen at any time by predators (Oldroyd and Wongsiri 2006). The small honey stores makes the colony vulnerable to starvation if there is a prolonged shortage of nectar and pollen. The response of *A. cerana* to declining resources is to abandon the existing nest and migrate to areas where food is more abundant (Oldroyd and Wongsiri 2006). In tropical areas *A. cerana* readily move in the face of food shortage or disturbance (Punchihewa 1994, cited in Oldroyd and Wongsiri 2006). It is more typical for small, newly settled colonies to do this: larger nests may require more interference before moving (Hepburn and Radloff 2011). Personal observations by Oldroyd and Wongsiri (2006) confirmed that in tropical areas *A. cerana* can exist as mobile clusters of broodless and combless adults for several weeks at a time.

Swarm distance and frequency

The swarming frequency or swarming distance is largely unknown for *A. cerana* in their natural environment*.* Swarming distances of *A. cerana* are not predictable (Hepburn and Radloff 2011). A presentation delivered by Biosecurity Queensland to the Technical Advisory Panel of the Plant Health Committee on 29th October 2010 (De-Jong, 2010) maintained that swarming distances in *A. cerana* vary depending on whether the colony is in 'invasive' mode or in 'colonisation' mode. The information presented noted that in 'invasive' mode, swarming distances of *A. cerana* may be up to 10 km whereas in 'colonisation' mode, distances are probably much shorter. Reproductive swarming of one, two or three swarms per colony per year has been reported in Japan (Carr 2011), but information for tropical parts of the world is scarce. Migratory swarming or absconding behaviour would depend on the local conditions surrounding each nest. Frequency would vary considerably according to nest strength, availability of resources, frequency of disturbance and weather conditions. An Field staff in Gordonvale near Cairns observed *A. cerana javana* colony moving as a response to attack from green ants (*Oecophylla* sp.). Another colony that took up residence inside a bird cage also in the Gordonvale area, relocated as a result of human disturbance. This swarm moved into a tree a few blocks away about half an hour later. Of the 143 swarms that have been detected in Cairns to September this year, it is unknown which were reproductive swarms and which were migratory swarms.

Locations of swarms

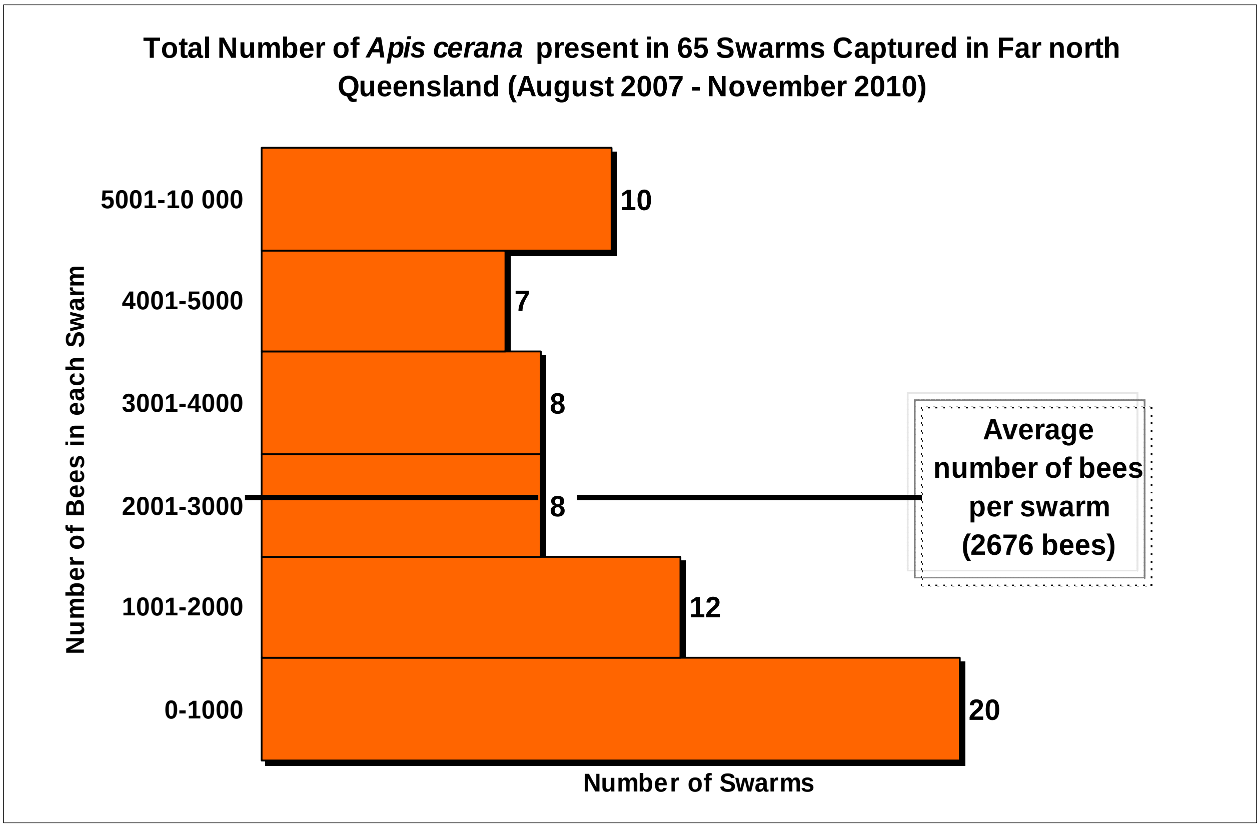
A. cerana javana swarms have been detected on both natural and man-made structures in Far North Queensland. Swarming location was recorded for 141 swarms. Of these swarms, 78 were located hanging on or in a man-made structure, whilst 63 were located hanging in or on a natural structures. Swarms of *A. cerana* have been found on man-made structures such as machinery, fences, letterboxes, light poles, rubbish bins, street signs, window sills, bridges, and buildings, stationary vehicles. Natural structures on which swarms have been located are predominantly shrubby trees or bushes. *A. cerana javana* swarms have frequently been located hanging from Callistemon tree branches and may be related to the coarse texture of the bark of these trees.

Size of swarms

The total number of bees per swarm was recorded for 65 of the 150 swarms detected between April 2007 and September 2011) before they were destroyed.

About one third of swarms analysed contained between 100 and 1000 bees (20 swarms), 12 swarms contained 1001-2000 bees, 8 swarms contained 2001-3000 bees, 8 swarms contained 4001-5000 bees and 10 swarms contained 5001-8000 bees (Figure 4). The average number per swarm was 2676 bees When capturing a swarm, roughly 80% of the bees belonging to the swarm can be collected.

FIGURE 4



No literature was found regarding the size of *A. cerana* swarms in other studies. Inspecting various photos of *A. cerana* swarms in Oldroyd and Wongsiri (2006) suggests that swarm sizes are fairly similar to typical swarms in Cairns.

Make-up of swarms

For the 65 swarms used in the analysis for Figure 4, records for 38 of them provided details of worker versus drone counts. Based on these 38 swarms, the greatest number of worker bees in a swarm was found to be 6, 800 (this swarm had 275 drones), with an average number of 2486 worker bees per swarm. The greatest number of drone bees was found to be 1833 (this swarm contained 5018 workers) (Table 3). The average number of drones in each swarm was 186. The number of workers and drones in an *A. cerana* swarm are not closely correlated.

TABLE 3:

Bee	Numbers of Bees Recorded for each Swarm		Average Number of Bees per Swarm
	Lowest	Highest	
Worker Bees	466	6,800	2,486
Drone Bees	0	1,833	185.5

Most swarms contained between 500 and 2000 worker bees (nine swarms had 501-1000 workers, and nine swarms had 1001-2000 workers). Seven swarms contained 3001-4000 workers and five swarms contained between 5001 and 7000 workers. Two swarms were very small, containing less than 500 worker bees.

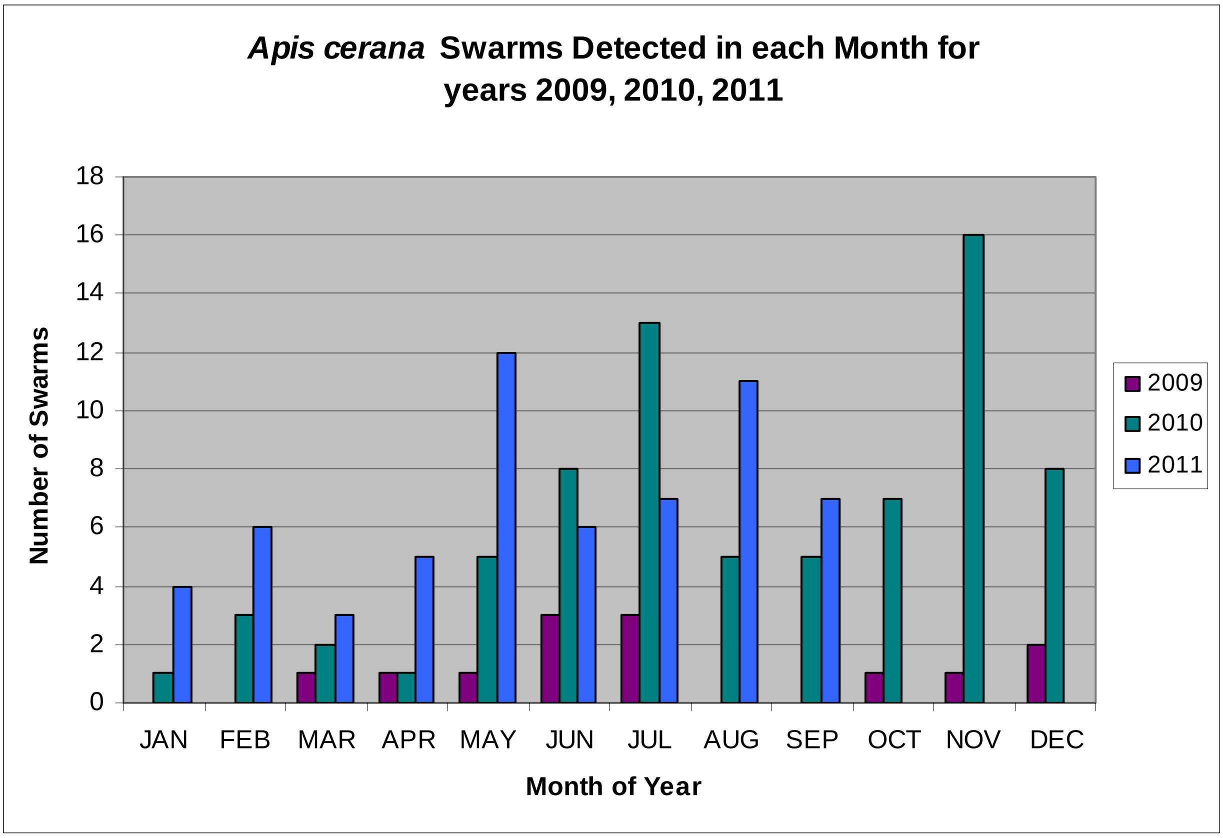
Drones were present in all swarms. Most had between 101 and 500 drones. Seven swarms contained 51-100 drones, six swarms contained 11-20 drones, five swarms contained 1-10 drones. Two swarms contained more than 500 drones.

Literature covering the subject of *A. cerana* swarm make-up from other parts of the world is scarce, however there has been some previous work done on *A. mellifera*. For *A. mellifera*, the number of drones remaining in the parental colony after a swarming event is much greater than the number of drones leaving with a swarm. Omhalt (1988) estimated that 2.5% of the total drone population from an *A. mellifera* nest will leave with a seasonal swarm. Swarm size and make-up of *A. cerana* swarms are probably related to the size of the parental colony and how many swarms have left the colony before. With *A. mellifera* the first swarm to leave the hive (the prime swarm) is usually the largest and can contain 50-60% of all the workers. The prime swarm is often followed by one or more secondary swarms (casts) each with a smaller number of worker bees. Eventually, the colony may be left with only 10-25% of the original bee population (Fries et al. 2003).

Other swarms/swarming characteristics

The swarming behaviour of *A. mellifera* has been studied extensively with distinct 'swarming seasons', especially in temperate regions where there may be only brief periods of favourable weather for swarming. Hepburn and Radloff (2011) report that mating and reproductive swarming in honeybees depends on the availability of ample nectar and pollen and the mating season generally depends on flowering cycles. Most swarms detected in the Cairns region are through reports from the public. Numbers of swarms detected over the last 3 years for each month of the year are graphed in Figure 5 to establish whether *A. cerana javana* shows any seasonal or annual trends in swarming activity.

FIGURE 5



A. cerana javana does not show any outstanding tendency to swarm at a particular time of the year in the Cairns region. The degree of swarming in the height of the wet season (Jan-Mar) may be lower than at other times.

An additional field observation regarding swarming behaviour is that swarms of *A. cerana* will not fly when there is a (relatively) cold spell in the Cairns region. If a swarm has settled overnight under these conditions, it will wait until mid morning when temperatures have warmed up before taking flight and moving to a suitable nest site. This is because bees need to reach a specific individual thoracic temperature in order to fly. Heavy rain has been observed to knock swarms to the ground; the fate of these swarms is unknown.

Acknowledgements

Thank you to Dr Joe Scanlan and Dr Mark Cozens for useful comments on previous drafts of this report.

References

Adri., (1985). *Komposisi Koloni Lebah Madu Apis cerana javana* F. Thesis. University of Andalas, West Sumatera, Indonesia.

Anderson, D. (1995) *Assessment of the Varroa Mite and the Asian Bee incursion in the Solomon Islands.* Hive Lights, Canadian Honey Council. Vol 18(1): 15-22.

Annan, N. (2004). *The Solomon Experience with Asian Honey Bees.* The Australian Beekeeper. http://theabk.com.au/article/solomon-experience-asian-honey-bees.

Asada, S (1993) *Nesting habit of Apis cerana japonica in Shonan area of Kanagawa Prefecture.* Honeybee Science 14(4): 165-169.

Carr, A. J. (2011) *Asian Honeybee: Possible Environmental Impacts.* Report prepared for the Department of Sustainability, Environment, Water, Population and Communities. Sustineo Pty Ltd. Canberra

De-Jong, W. (2010) *Technical considerations to consider when determining the target area for surveillance to trace swarms or nests of the Asian Honeybee, Apis cerana, from a starting point.* Biosecurity Queensland, Power Point Presentation to Technical Advisory Panel of the Plant Health Committee, 29th October 2010.

Drew, P (2011) Comments on Gordonvale *Apis cerana javana* Comb from Drum. Observation Report by Industry volunteer, Asian Honey Bee Program, July 2011.

Dyer, F. C., and T. D. Seeley (1991). *Dance Dialects and Foraging Range in Three Asian Honey Bee Species.* Behavioural Ecology and Sociobiology, Vol 8(4): 227-233

Fries, I. H. Hansen, A. Imdorf and P. Rosenkranz (2003) *Swarming in Honey Bees (Apis mellifera) and Varroa destructor Population Development in Sweden.* Apidologie 34: 389-397.

Goswami, S. and G. Antony (2010). *Expected socio‐economic impacts of the establishment of Asian Honeybees in Australia*. Brisbane, Biosecurity Queensland.

Heinrich, B., (1979). *Keeping a Cool Head: Honeybee Thermoregulation.* Science 205:1269-1271.

Hepburn, H. R., and S. E Radloff (2011) *Honey Bees of Asia.* Springer, Berlin Heidelberg.

Inoue, T., Adri, and S. Salmah (1990) *Nest site selection and reproductive ecology of the Asian Honey Bee, Apis cerana indica, in central Sumatra.* In Natural History of Socail Wasps and Bees in Equatorial Sumatra ed. S. F. Sakagami, R. Ohgushi, and D. W. Roubik, pp. 219-232. Hokkaido University Press: Sapporo.

Koeniger, N., G. Koeniger, et al. (2010) *Honey Bees of Borneo.* Kota Kinabalu, Natural History Publications,(Borneo).

Kraus, B., H. H. W. Velthuis, and S. Tingek. (1998). *Temperature profiles of the brood nests of Apis cerana and Apis Mellifera colonies and their relation to varroosis.* Journal of Apicultural Research 37: 175-181.

Lawrence, L. and D. Anderson (2007) *Exotic pests pose pollination threat.* Farming Ahead 180: 34-36.

Lee, B. (1995). *Mites, Bees, and Plagues That Are and Might Be*. Partners in research and Development. Canberra, ACT, ACIAR. 8: 2-9.

Macphail, M.K., (2007). *Pollen Analysis of Pollen from a Colony of the Asian Bee Apis cerana, Found in Cairns, Northeast Queensland* - Palynological report prepared for Department of Primary Industries, Brisbane. Department of Archaeology & Natural History, Research School of Pacific & Asian Studies, Australian National University, Canberra, ACT 0200.

Naug, D., and H. S. Arathi. (2005). *Sampling and decision rules used by honeybees in a foraging arena.* Animal Cogn. 10: 117-124.

Oleh (1989) *Nesting Habit of Apis cerana F. in Nature,* Buletin Penelitian Kehutanan 5(1):21-26

Oleh (1990) *Nest Characters of Apis cerana in Three Different Altitudes.* Buletin Penelitian Kheutanan 5(4): 345-355.

Oldroyd, B. P., T.E. Rinderer, and S. Wongsiri. (1992). *Pollen resource partitioning by Apis dorsata, A. cerana, A. amdreniformis, and A. florea in Thailand.* Journal of Apicultural Research 31: 3-7.

Oldroyd, B. P. and S. Wongsiri (2006). *Asian Honey Bees: Biology, Conservation, and Human Interactions.* Cambridge, Massachusetts, Harvard University Press.

Omholt, S (1988) *Drone production in honeybee colonies: Controlled by a longlasting inhibitory pheromone from the drones?* Journal of Theoretical Biology 134:(3) 309-318

Page, R and Metcalf, R (1984) *A population Investment Sex Ratio for the Honey Bee (Apis mellifera)*, American Naturalist, 124: 680-702

Punchihewa, R. K., (1994) *Beekeeping for honey production in Sri Lanka.* Sri Lanka Department of Agriculture: Peradeniya.

Punchihewa, R. K. W., N. Koeniger, P. G. Kevan and R. M. Gadawaski. (1985). *Observations on the Dance Communication and Natural Foraging Ranges of Apis cerana, Apis dorsata, and Apis florea in Sri Lanka.* Journal of Apicultural Research 24: 168-175.

Quieng, H., Z. Zhi-Jiang, Y. Wei-Yu and H. Kang, (2009) *Decision Making of Palticity of Swarming Honeybees (Apis cerana cerana).* Research Journal of BioTechnology 4(1): 11-14.

Ryan, T. (2010). *Estimating the Potential Public Costs of the Asian Honey Bee Incursion*. Canberra, ACT, Rural Industries Research and Development Corporation (RIRDC).

Sasaki, K., H. Takahashi, and Y. Sato. (1993). *Comparison of the dance dialect and foraging range between Apis mellifera and Northern Most Subspecies of A. cerana in Japan.* Honeybee Science 14:49-54.

Shields, J. (2000) *Overseas Travel Report – Potential for migration of Asian Honey Bee , Apis cerana, from Lae, Papue New Guinea to Australia. Options for minimising the risk.* Queensland Department Of Primary Industries, Animal and Plant Health Science.

Seeley, T. D., R. H. Seeley, and P. Akratanakul (1982) *Colony defence strategies of the honeybees in Thailand,* Ecological Monographs 52: 43-63.

Schmidt, J. O. (2001) *Hierarchy of Attractants for Honey Bee Swarms.* Journal of Insect Behaviour 14: 469-477.

Taber III, S., Owens C (1970) *Colony founding and initial nest design of honey bees, Apis mellifera L*, Animal Behaviour, 18: 625-632.

Yao, Y., Bera, S., Wang, Y., Li, C., (2006). *Nectar and Pollen Sources for Honeybee (Apis cerana cerana Fabr.) in Qinglan Mangrove Area, Hainan Island, China.* Journal of Integrative Plant Biology, 48(11): 1266-1273.

Appendix A: Preferred foraging sources for *Apis cerana javana* in far north Queensland

Coral vine (*Antigonan sp.*)

Morning star (*Turnera sublata*)

Sensitive week (*Mimosa pudica*)

Weeping willow (*Leptospermum brachyandrum*)

Weeping willow (*Leptospermum brachyandrum*)

Singapore daisy (*Sphagneticola trilobata*)



Golden cane (*Dypsis lutescens*)



Bottle Brush (*Callistemon sp.*)


Mad Hatter (*Cuphea sp.*)