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# *Apis cerana* Beekeeping and Sacbrood Disease Management in Vietnam: Review

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## Abstract

Beekeeping status of *Apis cerana* with emphasis of experiences overcoming sacbrood virus disease are presented. Social bee fauna are rich in Vietnam with 6 honeybee species (*Apis laboriosa, Apis dorsata, Apis mellifera, Apis cerana, Apis andrenifomis, Apis florea*); 8 stingless bee species (*Trigona laeviceps, Trigona ventralis, Trigona pagdeni, Trigona gressitti, Trigona fuscobalteata, Trigona capenteri, Trigona scintillans Trigona iridipenis*) and 2 bumble bee species (*Bumbus haemorrhoidalis, B. breviceps*). All of them are native except *A. mellifera* which was introduced in1887. These bees are slated for conservation by the Ministry of Agriculture & Rural Development. Honey and other bee products are mainly harvested from 3 species including *A. cerana, A. mellifera* and *A. dorsata*. The manageable species (*A. cerana* and *A. mellifera*) are increasing in number, reaching about 1,500,000 beehives. Vietnam is the second largest honey exporter in Asia, with a total of about 48,000 tons of honey exported to the international market in 2014. *A. cerana* plays an important role in poverty alleviation in mountainous and remote areas of Vietnam. Honeybee suffers from various diseases of Sacbrood virus disease (SBV), European foulbrood (EFB), Nosema, and parasitic mites of *Tropilaelaps mercedes* and *Varroa destructor*. Most of these diseases can be resolved with bio-control methods. For the parasitic mites, Vietnamese beekeepers usually apply formic acid.

Key words: Social bees, Diversity, Sacbrood viris, Breeding, Caging queen

## Beekeeping with *Apis cerana*

Vietnam is located on the eastern Indochinese Peninsula between the latitudes 8° and 24°N, and the longitudes 102° and 110°E with area of 331,212km$^2$. Due to differences in latitude and the marked variety in topographical relief, the climate tends to vary considerably. The average annual temperature is generally higher in the plains than in the mountains ranging from between 21 and 35°C. In Hanoi and the surrounding areas of Red River Delta, the temperatures are much lower between 15 and 33°C (Fig. 1)

Diversity of social bees is high in Vietnam. Currently 6 species of honey bee are recognized; *Apis laboriosa, Apis dorsata, Apis mellifera, Apis cerana, Apis andrenifomis*, and *Apis florea*. Eight species of stingless bees play important roles in pollination and hive production; *Trigona laeviceps*, *Trigona ventralis, Trigona pagdeni, Trigona gressitti, Trigona fuscobalteata, Trigona capenteri, Trigona scintillans* and *Trigona iridipenis*. However, cold-climate adapted bumble bees are less diverse reported as two species resident; *Bumbus haemorrhoidalis* and *B. breviceps*. All of them are native bees except for the exotic

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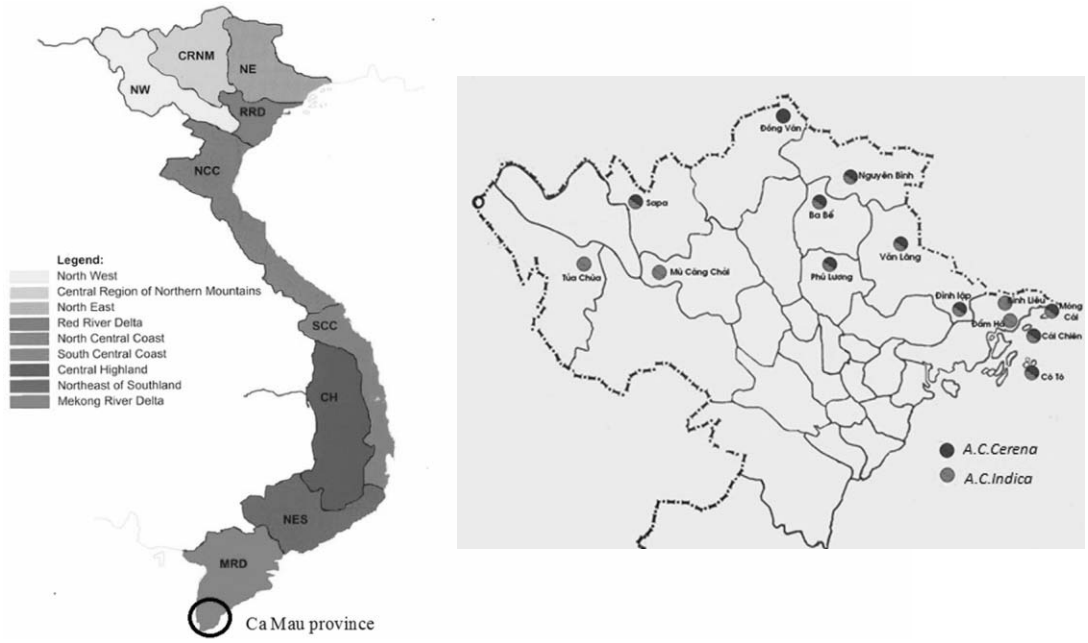


**Fig. 1.** Agro-ecological zonation and distribution of *A. cerana* in Northern Vietnam. Red mark means *A. c. indica* while blue mark does *A. c. cerana*. In some area, both subspecies distributed over varying ratio.

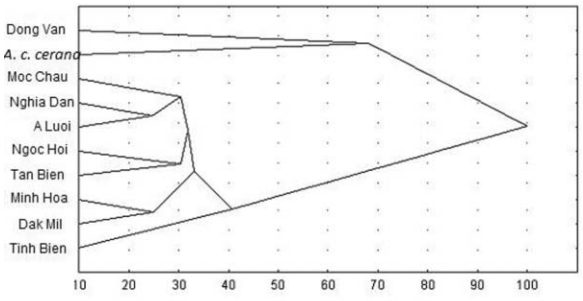


**Fig. 2.** Morphological analyses of *A. c. cerana* populations indicated by regional names in Vietnam and *A. c. cerana* in China marked as *A.c. cerana*.

honeybee *A. mellifera* (Thai, 2008). Eastern honey bee (*Apis cerana*) is distributed across all provinces of Vietnam except the Uminh forest, Ca Mau province (9.4°N, 105.2°E) which is located at the southern tip of the country (Thai, 2008) (Fig. 1). It has been reported that there are two subspecies of *A. cerana* in Vietnam: *A. cerana cerana* in the North and *A. cerana indica* in the South (Ruttner, 1988; Hepburn *et al*., 2001b; Radloff *et al*., 2005b; Radloff and Hepburn, 2010; Abrol, 2013). However, by using DNA and morphological analyses reported that *A. cerana cerana* is distributed only in the Dongvan Karst plateau (Global geological park) in Ha Giang province of Northern Vietnam (Thai 2008) (Fig. 2).

Some biological characteristics such as the length of proboscis, the length and width of the front wing, the length and width of Basitarsus, queen's laying capacity, colony strength of *A. c. cerana* worker bees in Dong van are significantly bigger than that of *A. c. indica* in Hatay (Toan, 2012).

In Vietnam, traditional beekeeping with the Eastern honeybee *Apis cerana* has been practiced for a long time by farmers. In the 8th century, Mr. Pham Le, who was Mandarin of Agricultural Ministry of Vietnam, wrote and issued documents on traditional beekeeping techniques with *A. cerana* (Chinh, 1996). In the 18$^{th}$ Le Qui Don, a poet, and the great scholar in feudal Vietnam described some biological characteristics of *A. cerana* in the encyclopaedia "Van dai loai ngu" (Crane, 1999). At the 3$^{rd}$ Apimondia Conference, (Fougeres ,1902) presented a report on rafter techniques in beekeeping with *Apis dorsata* in the *Melaleuca* forest in Southern Vietnam (Crane,

1999). (Toumanoff, 1933); (Toumanoff and Nanta, 1933) described of beekeeping in Tonkin (North Vietnam), that honeybees are kept in both horizontal log hives and upright log hives. For the honeybee *Apis dorsata* the techniques of sustainable honey harvesting and rafter beekeeping in the *Melaleuca* forest of Southern Vienam are still applied. Honey harvested from traditional logs and *Apis dorsata colonies* are preferred by domestic consumers.

*Apis melliera* colonies were introduced into Vietnam by the French in 1887 (Rialan, 1887). However, they did not survive due to the parasitic mite *Varroa jacobsoni* (Likely to have been renamed *Varroa destructor*) and *Tropilealaps clareae* (Afterward to have been renamed *Tropilealaps mercedesae*) attacked and killed the exotic *A. mellifera* colonies (Woyke, 1996). Beekeeping techniques with moveable frame hives were introduced to the North of Vietnam in 1960 and also greatly assisted in developing beekeeping with the native honeybee *A. cerana* (Chinh, 2012). During the same period, the exotic *A. mellifera* colonies were successfully re-introduced into the South of Vietnam from Hong Kong. After more than 50 years this honeybee species is well adapted to the climate and flower sources in Vietnam (Tam *et al*., 2010).

The two honey bees' species being kept commercially in Vietnam are *A. mellifera* and *A. cerana*. For the native honeybees *Apis cerana*, there are two subspecies including *A. c. cerana* and *A. c. indica*. Subspecies *A. c. cerana* is distributed on the Dongvan plateau, Ha Giang province in the North of Vietnam, and *A. c. indica* is distributed throughout the rest of the country (Thai, 2008). For the honeybee *A. mellifera*, at the beginning the subspecies *A. mellifera ligustica* (Italian bees) was imported to Vietnam. After that other subspecies such as *A. m. capartica , A. m. caucasica* were also imported to Vietnam from Russia. However, they were killed by honey bee mites. In the last decade *A. m. carnica* from Germany and *A. m. ligustica* from New Zealand and Austria were also successfully imported to Vietnam. Therefore, currently *A. m. ligustica, A. m. carnica, A. m. capartica , A. m. caucasica*, and the hybrids among them may be exist in the country.

According to the Vietnam Beekeepers Association (VBA), Vietnam has a total of 1,500,000 honey bee colonies among them there are 1,150,000 *A. mellifera* colonies accounting 76.67% and 350,000 *A. cerana* colonies accounting 23.33%. The quantity of *A. mellifera* colonies increased by approximately 33 times from the levels in 1990 (35,000 *A. mellifera* colonies). The number of beekeepers is 34,000 people, including 6,350 commercial beekeepers, accounting for 18.67%. Vietnamese beekeepers harvest more than 40,000 tons of honey annually. Approximately 90% of the honey harvested from *A. mellifera* colonies is exported to the United States. Meanwhile only 10% is consumed in the domestic market. Domestic honey prices are higher than the average export prices, ranging from 4 to 50 USD/liter. The retail price of honey in the domestic market fluctuates between 10~15 USD/liter, but the price for the export company is only 2 USD/liter. In 2014, Vietnam became the largest honey exporter to the United States with 47,009 tones of honey.

Vietnam has a long history of traditional beekeeping with *Apis cerana*, so it is a natural and comfortable transition for Vietnamese farmers to move into modern beekeeping. Since the 1960's, when modern beekeeping techniques were first introduced into Vietnam, more than 50 years of knowledge and experience has advanced the Vietnamese beekeeping industry a great deal. Thanks to the support of government and non-governmental organizations, beekeeping extension programs are regularly being conducted. Every year the training courses on beekeeping are organized for beginners who live in difference areas of the country to expand and develop beekeeping. Professional beekeepers also attend a variety of short courses on food safety and sanitation, and best management practices for prevention and treatment of bee diseases and parasites without antibiotics or chemicals; Viet GAP (Vietnamese Good Apiculture Practices) has been applied to practical beekeeping. Therefore, Vietnamese beekeepers are highly aware of how to produce high value bee products, because only bee products with good quality are purchased by honeybee

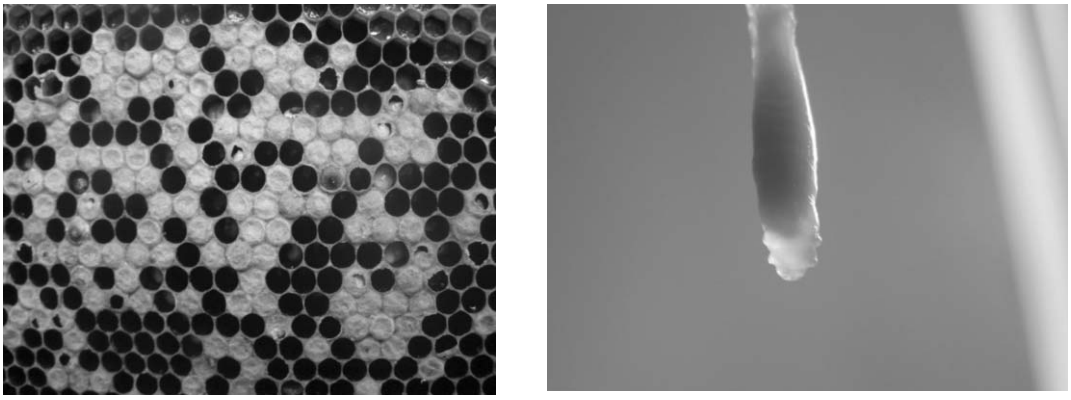

**Fig. 3.** Symptoms of SBV (left) and dead brood (right). The comb surface of diseased *A. cerana* colony with many pointed broods emerging. Brood dead from SBV change color and shape with a sac of liquid on tail of brood (photo: P.H. Chinh).

companies for export. A lot of projects for beekeeping development are funded by NGOs to train poor farmers in mountainous and remote areas. The results of such projects are that many farmers have stable rural income. Up to now traditional beekeeping techniques with log hives are still utilized by farmers even though the resulting honey yield is lower. However, keeping honeybees traditionally means that poor farmers do not need to invest highly and can sell their honey at a high price.

## Sacbrood disease management

Sacbrood is a brood disease caused by sacbrood virus infection. Sacbrood virus (SBV) was first described by White on *A. mellifera* in the U.S. in 1913 (Bailey *et al*., 1964). SBV is one of many insect viruses generally referred to as picornavirus-like (Grabensteiner *et al*., 2001). At present 4 SBV strains have been identified, including sacbrood vius on *A. mellifera* (SBV) (Bailey *et al*., 1964), Thai sabrood virus (TSBV), Chinese sacbrood vius (CSBV) (Bailey *et al*., 1982; Zhang *et al*., 2001), and Korean sacbrood vius (SBV-Kor) (Lee *et al*., 2010). In Vietnam, two strains of the virus have been found on *A. cerana*, CSBV in the north and TSBV in the south. According to (Chinh, 1996), an epidemic of sacbrood disease in *A. cerana* colonies in Vietnam, originated from a high honey producing line of *A. cerana* colonies imported from China. From 1974 to 1978 SBV broke out and spread from the northern provinces to the southern provinces of Vietnam damaging 90% of *A. cerana* colonies (Chinh, 2012).

**Symptoms:** On the surface of the diseased brood comb are sunken covers, uncapped pupae, and many sac-like larvae seemingly twisted in their cells. The infected larvae change in color from pearly white to pale yellow and shortly after death they dry out into gondola-shaped scales (Bailey, 1975). The segmented lines of brood are not clear and dead larvae are typically odorless (Chinh 1990). Fig. 4 shows that brood dead from SBV change color and shape, with sac of liquid on tail of brood.

**Diagnosis:** In the laboratory: SBV diagnosis is based on traditional methods such as using electronic microcopy, serology, and immunology. In recent years, multiplex RT-PCR/RFLP technique has been effectively applied to diagnose early SBV infection (Trung *et al*., 2010; Thai *et al*., 2010; Duong *et al*., 2015; Thu *et al*., 2016).

**In the field:** SBV can be diagnosed based on observations of the colony and clinical symptoms in developing brood. There are very few foraging bees observed at the front entrance of diseased colonies. In the nest, there are more old bees than young. The brood pattern is spotty with sunken caps, uncapped pupae, and a lot of pointed larvae emerging on the surface of brood combs (Chinh, 2012) (Fig. 3).


**Fig. 4.** Replacing queen by a queen from healthy colony (left) or caging the queen in the diseased colony for 8~10 days to make a broodless colony, breaking off the food source of sacbrood virus (right).

## Prevention and treatment

**Prevention:** The colonies must be kept with a good queen, populous number of workers, and enough stored honey. The number of adult bees and combs should be equalized. The combs of a diseased colony should not be combined with a healthy one. Infected colonies must be handled immediately to avoid spreading the disease. Before reusing empty hives, old equipment should be cleaned by washing with water and then exposed to the sun (Chinh, 1990).

**Treatment:** At present, and in common with nearly all viruses found in animals, there are no known direct treatments for virus infections in bees. In Vietnam, herbal extracts are used to treat sacbrood disease on *A. cerana* colonies. S-95, a product extracted from plants has been used to treat diseased colonies. Three months post treatment, experimental colonies did not have a recurrence of infection, while diseased colonies in the control group remained seriously affected. However, in order to conclude accurately about the effectiveness of extracted products the experiments must be repeated with more colonies (Lan *et al*., 1998).

Currently, biological controls are being applied widely (Chinh, 2012). The principle of these methods is to make the colony broodless for 8~10 days, because no larvae lead to any food for the virus (Bailey, 1981). There are two methods to create a broodless colony. One way is to replace the queen of a diseased colony by a queen cell or virgin queen, rearing these from a disease resistant colony, and the other way is to cage the laying queen of the diseased colony for 8~10 days (Fig. 4).

Both methods were combined with eliminating dead brood combs to increase density of worker bees covering the combs. Then the sugar syrup should be fed to bees 3~4 times (at night) continuously or these colonies should be moved to new place with better floral sources. As a result, more than 90% of the diseased colonies were cured. However, the effectiveness of these methods depends on the weather and flower sources. By caging the queen, however, there were some colonies with a recurrence so the replacement queen in the diseased colony must be from resistant stock (Chinh, 1990).

**Disease resistant breeding:** There is some evidence that strains of bees differ in their susceptibility to sacbrood (Bailey, 1967). Colonies headed by imported queens showed a significant increase in larval mortality due to SBV than local colonies maintained under the same conditions (Ball, 1999). Some case studies on *A. cerana* in Vietnam have shown that breeding measures significantly reduced SBV infection rate in the targeted population of *A. cerana* colonies. Queens were reared from colonies that had survived an outbreak, and were used to replace queens in the infected colonies, with promising results in the first generation (Chinh, 2012). However, selected honeybee generations of second and third showed that infection ration of SBV reduced significantly. Disease resistance in

*A. cerana* was applied to a closed population selection from 1989 to 1996, and after four generations, the SBV infection rate was reduced from 23.1% to 2.3%. After 6 generations, the infection rate of the population and the control were 3.2 and 26.7% respectively (Chinh *et al*., 1996). Hybridizing *A. c. cerana* Dongvan with *A. c. indica* Hatay, showed the SBV infection rate of *A. c. cerana* Dongvan and *A. c. indica* Hatay were 5.54% and 2.40% respectively while the infection rate of hybrids was 1.55%, lower than those of both the mother colonies *A. c. cerana* Dongvan and father colonies *A. c. indica* Hatay (Toan, 2012).

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