

PREVALENCE OF *SOLENOPSIS INVICTA* (HYMENOPTERA: FORMICIDAE) VENOM ALLERGIC REACTIONS IN MAINLAND CHINAYIJUAN XU^{1,*}, JUN HUANG², AIMING ZHOU¹ AND LING ZENG¹¹Red Imported Fire Ant Research Center, South China Agricultural University, Guangzhou 510642, China²Flower Research and Development Center, Zhejiang Academy of Agricultural Sciences, Hangzhou, 311202, China

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ABSTRACT

To evaluate the damage and epidemiologic features of immediate allergic reactions to *Solenopsis invicta* stings in mainland China, a literature survey, and an internet search were done to obtain data; which were statistically analyzed. This pest became established in mainland China in 2004. We found that the most important reason for the high frequency of stings of people by the red imported fire ant is the pest's wide and rapidly expanding distribution in 4 provinces of southern mainland China. More than 1/3 of people in ant-infested areas have suffered stings, and people of both sex and of all age groups are highly likely to be stung. All people who have been stung experience itchiness, and almost all experience flare and wheal, while nearly 10% experience fever, some experience dizziness, generalized urticaria or other systemic reactions including anaphylactic shock, which can cause death. Scratching of the itchy areas predisposes the sufferers to secondary infections. The data demonstrate that the allergic reactions to red imported fire ant stings are a serious public health problem, which should be addressed by government and the public.

Key Words: red imported fire ant, allergy, internet search, literature survey

RESUMEN

Se realizó una encuesta de la literatura y una búsqueda en el Internet para obtener los datos para evaluar el daño y las características epidemiológicas de las reacciones alérgicas inmediatas a las picaduras de la hormiga, *Solenopsis invicta*, en el sur de China continental; estos datos se analizaron estadísticamente. Esta plaga se estableció en el sur de China continental en el 2004. Se encontró que la razón más importante para la alta frecuencia de personas con picaduras de la hormiga roja de fuego importada es la amplia y rápida expansión de la distribución de esta plaga en 4 provincias del sur de China continental. Más de un tercio de todas las personas en áreas infestadas de hormigas han sufrido picaduras, y personas de ambos sexos y de todos los grupos de edad son muy propensos a ser picadas. Todas las personas que han sido picadas experimentaron una picazón, y casi todas presentaron una roncha, mientras que casi un 10% presentó fiebre, algunos pacientes pueden experimentar mareos, una urticaria u otras reacciones sistémicas, incluyendo el shock anafilático, que puede causar la muerte. El rascado de las áreas afectadas, predispone a los pacientes a infecciones secundarias. Los datos demuestran que las reacciones alérgicas a las picaduras de la importada hormiga roja de fuego es un problema serio a la salud pública, que debe ser atendido por los gobiernos y el público.

Palabras Clave: hormiga roja de fuego, alergia, búsqueda de literatura, paginas electrónicas

It is well known that some aggressive ants, such as the imported fire ant (*Solenopsis* spp.), the jumper ant (*Myrmecia pilosula* F. Smith, 1858), and the needle ant (*Pachycondyla chinensis* Emery, 1895) can endanger public health by stinging and causing anaphylaxis (Cho et al. 2002; Douglas et al. 1998; La Shell et al. 2010). Such ants are strongly aggressive, and the venom from their stings contains proteins, which have the potential to cause local or systemic allergic reactions in man (Solley et al. 2002; Xu et al. 2011). The physical reactions to the fire ant's sting are

different for different people; but an important reaction is the manifestation of severe cellulitis, which presents together with skin redness, swelling, pustules, urticaria, edema, skin necrosis, allergic shock, or the worse, death (deShazo & Banks 1994; deShazo et al. 1984).

Given the worldwide spread of fire ants, many reports about fire ant attacks in invaded areas can be found. For example, in 1998 within just the state of South Carolina, 3.3 million people received hospital-based treatment for fire ants stings, including 660 with anaphylactic shock,

and 2 deaths (Cohen 1992). In the cities of South-east USA, almost 40% of the residents may be stung by fire ants each yr, while the proportion is even higher in rural areas (deShazo & Williams 1995). After the survey of 77 family members in Georgia, USA, it was found that half of residents stung by fire ants sting were under the age of 20 years; and the probability of being stung declined as the residents became older (Adams & Lofgren 1981).

Recently, sporadic cases of allergic reactions after stings by *S. invicta*, the red imported ant, have been frequently reported in mainland China (Lu et al. 2007; Rong 2005; Xiao et al. 2006). Since it invaded China (Zeng et al. 2005), most reported cases of *S. invicta* allergy in China have been anaphylactic reactions along with some deaths to these reactions. However, the prevalence of allergic reactions to *S. invicta* venom in the ant-infested areas in China has not been determined. Therefore, we conducted an internet search and a literature survey to assess and evaluate the damage and epidemiologic features of immediate allergic reactions to *S. invicta* stings in mainland China.

METHODS

Internet Search and Literature Survey

In this study an internet search and a literature survey were used to obtain relevant data on injuries to humans from stings of *S. invicta*. We obtained the distribution of fire ants from the website of The Invasive Species Specialist Group (ISSG), a global network (<http://www.issg.org>), and used Microsoft Office Excel XP to create distribution maps. We searched the internet for news reports about fire ants from 2005 to 2011 using the Chinese language search platform, Baidu (www.baidu.com). We used "fire ants" in Chinese as key words together with others related to attacks on humans. We obtained accounts of physical reactions to fire ant stings by searching the website of the China National Knowledge Infrastructure (<http://www.cnki.net>), and obtained 3 journal paper analyses based on questionnaire surveys about red imported fire ant stings (Rong 2005; Wu et al. 2005; Xiao et al. 2006). With the data of these reports, we undertook further analyses of allergic reactions caused by fire ant sting in mainland China.

Statistical Analysis

All statistical analyses were conducted using the SPSS 13.0 software package. Chi-Square test was used to compare the frequencies of with allergic reactions to *S. invicta* fire ant stings of females and males. Differences in percentages of people in different age ranges stung by *S. invicta* were ana-

lyzed by analysis with variance. Data expressed as percentages were arcsine transformed before applying ANOVA, and a least significant differences (LSD) test was used to evaluate the significance of differences between individual means.

RESULTS

Current Distribution of *Solenopsis invicta* and Reported Incidents of Stings

According to the internet reports, *S. invicta* fire ants have been found to sting people in Guangdong, Guangxi, Fujian and Hunan Provinces; and the recorded numbers of occurrences were 13, 4, 2, 1 respectively (Fig. 1). The red imported fire ant had invaded the Chinese mainland at the end of 2004. Based on internet news reports, we found that since 2005 concern about the fire ant menace to public health has been a growing trend. Especially in the 3 most recent years, nearly 50% of the news reports about fire ants have been focused on injuries inflicted on members of the public; so that it appears that overall magnitude of injury caused by the red imported fire ant in mainland China is increasing (Fig. 2).

Analyses of Clinical Reactions in Public after Stings by *S. invicta*

The number of samples in the 3 questionnaire-based reports published in professional journals (Rong 2005; Wu et al. 2005; Xiao et al. 2006) are 3485, 4908 and 308 respectively, and the respective fire ant infestation rates were 27.8%, 8.5% and 93.8%. These varied rates may be related to the sample size, survey locations, and other factors.



Fig. 1. Information on *Solenopsis invicta* recorded in four recently invaded provinces of mainland China, i.e., Guangdong (GD), Guangxi (GX), Fujian (FJ) and Hunan (HN). Data on the distribution of *S. invicta* were assembled by The Invasive Species Specialist Group (ISSG), and downloaded from the web site of this global network, <http://www.issg.org>.

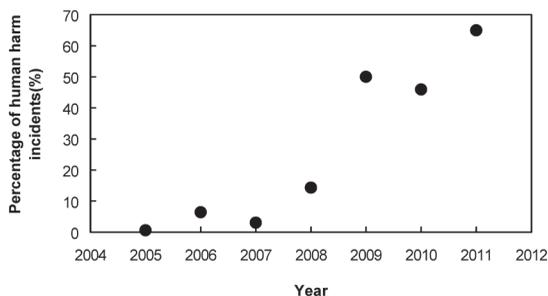


Fig. 2. Stings of *Solenopsis invicta* as a percentage of human harm incidents recorded in all internet news reports, which were found by searching the website of the Chinese language search platform, Baidu, i.e., www.baidu.com, for the period from 2005 through 2011.

A substantial proportion of the population has been stung by fire ants or the insects suspected to be fire ants in the fire ant endemic areas. In fire ant infested areas it appears that about 1/3 of the people have been stung by fire ants, and this rate is considered to be a serious threat to public health (see Fig. 3). *Solenopsis invicta* stings numerous people of both genders. Thus in the information we assembled, of the percent of people that have suffered stings 53.6% were males and 46.4% were females (Fig. 4), but these rates were not significantly different ($\chi^2 = 0.64$, $P = 0.424$).

Differences in the rates of being stung by *S. invicta* of different age groups of people ($F = 1.013$, $df = 6$, $P = 0.456$) were not significantly different (Fig. 5). The survey showed that people stung by *S. invicta* experienced the following symptoms in the corresponding percentages: itching (100%); flare (98.43%), wheal (95.9%), fever (9.93%), dizziness (4.5%) and generalized urticarial and other severe allergic reactions (0.73%) (Fig. 6).

DISCUSSION

Clinical reactions to stings of *S. invicta* may be classified as local, systemic (including anaphylaxis), and "others". Three types of local reactions are generally recognized: the wheal-and-flare reaction, the sterile pustule, and the large local reaction (deShazo et al. 1984; Kemp et al. 2000). Systemic reactions may range from cutaneous manifestations (generalized urticaria, angioedema, pruritus, erythema) to potentially life-threatening manifestations of fever, dizziness, bronchospasms, laryngeal edema, or hypotension (deShazo et al. 1984). Our study shows that in recent years, the incidence of fire ant stings has gradually increased, which is a threat to public health. In mainland China about 1/3 of the people in the places where the imported red fire ant occurs have been stung by this pest. Most people who are stung suffer from the various clinical responses like itching, and flare and wheal. What

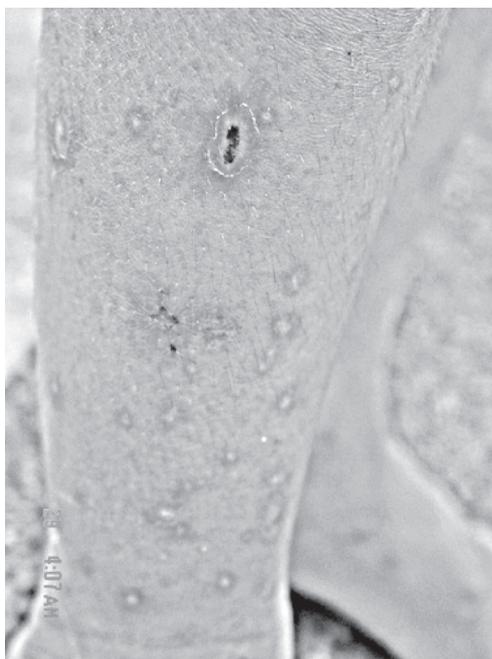


Fig. 3. Left. Scars of sting injuries on the leg of adult person (photo by Yijuan Xu). Right. wheal-and-flare reactions on the leg and buttocks of a child in which immediately following each *Solenopsis invicta* sting an irregular blanching wheal appeared, surrounded by a zone of redness (photo by Ling Zeng).

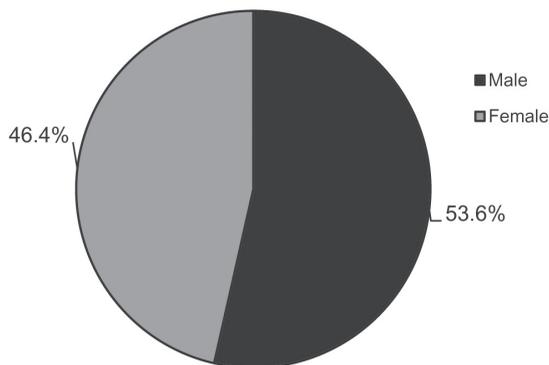


Fig. 4. Percentage of human males and females stung by *Solenopsis invicta* in mainland China (samples number: $n_1 = 3485$, Rong 2005; $n_2 = 4908$, Wu et al. 2005; $n_3 = 308$, Xiao et al. 2006).

cannot be ignored is that some people when stung have significant allergic reactions by fire ants; and their symptoms may include fever, dizziness, and generalized urticarial, etc. In addition, in mainland China occasional reports have been filed on severe symptoms of shock (Lu et al. 2007) or even death (Zhang et al. 2006). No significant differences were found rates of people being stung with respect to their sexual gender or age. Nevertheless different people respond differently to fire ant stings. Nearly 10% of people reacted with fever and dizziness, and around 1% experienced some systemic allergic reaction.

According to the survey, the red imported fire ant presents a greater threat to rural residents than to urban residents (Wu et al. 2005; Xiao et al. 2006), which may be due to the reasons that follow: 1) Farmers working the land have less awareness of the potential of this pest to harm them and their family members, and they are more vulnerable because often they are bare-footed and naked to the waist when conducting the farm operations of land preparation, such as planting, weeding, harvesting, etc. 2) There are great numbers of red imported fire ant nests with large populations on farm land (Xu et al. 2006). 3) If the red imported fire ant invade the cities, their

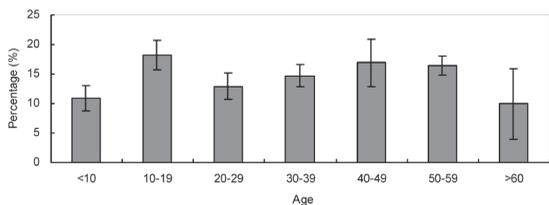


Fig. 5. Percentages of people in different age groups stung by *Solenopsis invicta*. Data were collected in mainland China (samples number: $n_1 = 3485$, Rong 2005; $n_2 = 4908$, Wu et al. 2005; $n_3 = 308$, Xiao et al. 2006).

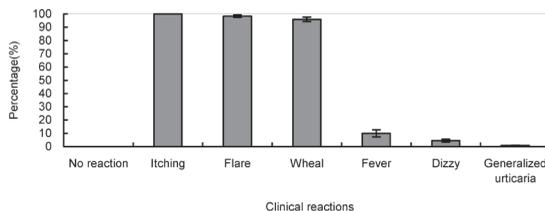


Fig. 6. Clinical reactions of people to stings of *Solenopsis invicta* in mainland China (samples number: $n_1 = 3485$, Rong 2005; $n_2 = 4908$, Wu et al. 2005; $n_3 = 308$, Xiao et al. 2006).

habitats are limited mostly to the green belt or to golf courses, etc., which always evoke greater concern and inspire greater efforts to apply pest suppressive treatments. In contrast most residents in the rural areas are not adequately aware of the spread of the red imported fire ant, and they have not devised approaches to conducting farm operations to reduce their probability of being stung. Previous reports have indicated that the red imported fire ant is likely to establish throughout the vast region south of the Yangtze River in China (Chen et al. 2006; Du et al. 2007). Such a wide distribution of red imported fire ants in South China portends a broad threat to public health in much of the nation. Currently, the red imported fire ant is rapidly expanding its range in South China, and is increasingly causing harm to public health (Xu et al. 2009). In South China, the red imported fire ant has not only invaded rice fields, vegetable fields, orchards, bamboo groves, open spaces, slopes, water source protection areas, but it also has damaged parks, golf courses, forests, grasslands, athletic tracks, and the grounds of residential schools, residential communities and schools. The pest is very commonly found on the lawns with ample exposure to sunshine. They occupy and degrade hedges and planting of shade trees (Zeng et al. 2005). With the acceleration of urbanization in China, the transport of a large quantities of seedlings of trees, shrubs and turf will expose a progressively wider public to the red imported fire ant, and cause progressively more sting cases. Therefore, the public must learn to recognize and avoid the pest's habitat. In addition, people must learn proper measure for treating stings, and learn to desist from scratching pustules, which worsens the symptoms and facilitates secondary infections. Since it is impossible for fire ants to be eradicated in the near term, entomologists must undertake appropriate research to mitigate this problem. Likewise medical personnel need to improve the treatment methods for the allergies and systemic problems caused by the red imported fire ant (Kemp et al. 2000). Above all, it is believed that the wide dissemination knowledge concerning the red imported fire ant greatly benefit public health and well-being.

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