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Short Communication

Internet-Sold Snail *Pomacea canaliculata* and *Achatina fulica* Might Transmit *Angiostrongylus cantonensis* in Mainland China

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ABSTRACT

In China, snails *Pomacea canaliculata* and its new breed the gold snail, *Achatina fulica* and its new breeds the white jade snail, have been sold on the Internet in recent years. We concluded that 24,853 sales of *P. canaliculata* and *A. fulica* had been made through the Internet selling platform before 2019. Further surveys indicated that 51% sellers were located in endemic areas of *Angiostrongylus cantonensis*. However, no *A. cantonensis*-positive snails were found among Internet-sold snails. Laboratory animal infection experiments proved that all 4 breeds of snails could transmit *A. cantonensis*. Internet sales of the 4 snails are of bio-safty temporarily but still present a high risk to spread angiostrongyliasis in China; moreover. Internet sales of *P. canaliculata* and *A. fulica* should be brought to the attention of concerned administrations in China.

Angiostrongyliasis is an important worldwide parasitic disease caused by the nematode *Angiostrongylus cantonensis*. In humans, *A. angiostrongylus* is the most common cause of meningoencephalitis or eosinophilic meningitis (Lv *et al*., 2008; Wang *et al*., 2008). The global geographic distribution of *A. cantonensis* includes China, South Asia, the Americas, etc. The life cycle of *A. cantonensis* is typically complex. To complete its life cycle, the parasite needs two hosts, rat as the terminal host and snail as the middle host. In China, the two main snail vectors are *Pomacea canaliculata* (Karraker *et al*., 2014; Yang *et al*., 2013) and *Achatina fulica* (Lv *et al*., 2009; Song *et al*., 2016).

The freshwater snail *P. canaliculata* is also known as the golden apple snail or the channeled apple snail. This snail is among the top 100 of the "World's Worst Invasive Alien Species" and it invaded China in the 1980s (Yang *et al*., 2010). In nature, apple snails exhibit a diversity of shell colors, from gold to black (Estebenet *et al*., 2006; Yusa, 2004). In China, gold-shelled *P. canaliculata* has been called the gold snail for its shell color.

The land snail *A. fulica*, also known as the African snail and the giant African snail, is the most prevalent invasive snail too (Lv *et al*., 2009). At present, the giant African snail is widely distributed in southern China. In some places, the albino breed of *A. fulica* (white jade snail) has been cultured as a food source, forming the snail-farming industry (Qin *et al*., 2007).

In recent years, online shopping and purchasing have become a popular, quick and fashionable way of consumption in China. Live snails can be sold and bought online, including *P. canaliculata* and *A. fulica*, as well as gold snails and white jade snails.

In this study, internet selling of *P. canaliculata*, the gold snail, *A. fulica* and the white jade snail is being reported for the first time, and their infection status has been examined. In addition, *A. cantonensis* transmission mediated by *P. canaliculata* and *A. fulica* has been

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determined by animal infection experiments.

Materials and methods

Relevant information of online sales was collected from the Taobao sales platform, the earliest and largest Internet shopping platform in China (website: https://www.taobao.com/) using the keywords of snail, apple snail, white jade snail and gold snail. The natural endemic area of *A. cantonensis*, especially the geographical distribution of *P. canaliculata* and *A. fulica,* was obtained from published articles (Wang *et al*., 2008; Lv *et al*., 2009; Song *et al*., 2016).

Forty wild type *P. canaliculata*, gold snails, wild type *A. fulica* and white jade snails were bought from the Internet. Their infection status was detected both directly under a microscope and indirectly by enzyme digestion. Ten-gram snail meat was grinded and digested at 37 °C, 1.5 h. Then the digest was filtered by 260 mesh filter and the sediment on the filter was taken for microscopic examination. The digest composition was 1000 ml distilled water, 7 ml hydrochloric acid, pepsin 5 g (He *et al*., 1983).

Microscopic detection was conducted after the snail was cracked and the lung sac of the snail was cut from the body. Worm nodules found in the lung sac were used for morphological examination of worms inside the nodules to determine *A. cantonensis* infection status. Enzyme lysis of snails was undertaken as previously described.

To determine the 4 breeds of snails' ability to transmit *A. cantonensis*, artificial animal infection examinations were conducted. In short, 4 groups of snails were formed, and each group had 20 snails that were 20 g in weight. Each snail was infected with 1000 larvae of *A. cantonensis* individual, and larvae that developed in the snail were collected 10 dpi (days post infection). Collected larvae were used to infect Sprague-Dawley rats (SD rats), with 200 larvae for each rat. Rat stool examination was conducted under a microscope 40 dpi to determine the infection status of *A. cantonensis*.

Results and discussion

According to the data obtained from the internet selling platform, a total number of 24,853 snail sales had been made by 2019. Most of the sales, that is, 19,662, were of the apple snail (Table I). The remaining 5191 sales were of the giant African snail. Some sellers did not provide information in detail, and the snails they sold were divided into unspecified groups. Besides, 51% of all selling (12,668) took place in endemic regions.

The geographical information of 2 species and 4 breeds are shown in Figure 2.

Fig. 1. Four transmitters of *Angiostrongylus cantonensis.* A: Wild type *Pomacea canaliculata*, with black shell; B: Gold snail, a breed of *Pomacea canaliculata*, with golden shell; C: Wild type *Achatina fulica*, with black foot; D: White jade snail, a breed of *Achatina fulica*, with white foot.

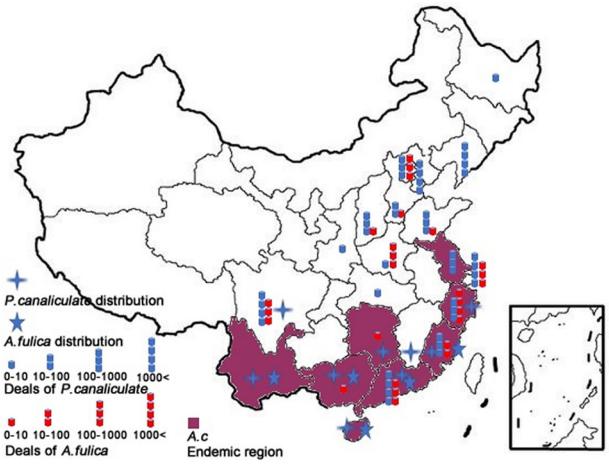

Fig. 2. Endemic regions of *A. cantonensis* and its two snail transmitters and sales made on the internet.

Neither worm nodules in the lung sac nor larvae 3 stage of *A. cantonensis* were found by snail dissection or enzymolysis. No *A. cantonensis* was detected among none of 4 snail group, indicating that all 4 breeds of snail bought on the Internet were *A. cantonensis* negative.

Table I. Snails sold on the internet in China.

Location	Snails sold on the internet					
	P. canaliculata	**Gold snail**	***P. canaliculata* or gold snail**	***A. fulica***	**White jade snail**	***A. fulica* or white jade snail**
Endemic regions						
Guangxi	0	0	0	1	0	0
Guangdong	1094	19	1719	77	413	4
Hunan	0	0	0	0	2	0
Fujian	6	0	701	0	0	49
Zhejiang	80	0	38	66	2764	190
Shanghai	134	11	4531	29	415	0
Jiangsu	64	0	186	68	0	7
Sub-total	12,668 (51%)					
Non-endemic regions						
Shandong	388	0	15	3	0	0
Tianjin	1018	14	395	0	0	0
Beijing	87	0	807	0	582	0
Hebei	0	0	27	8	0	0
Shanxi	138	0	42	0	0	0
Henan	4	0	4	0	358	0
Shaanxi	0	0	7	0	0	0
Hubei	4	0	0	0	0	0
Sichuan	909	0	178	0	139	11
Liaoning	343	2	6688	0	0	0
Heilongjiang	0	0	9	0	0	0
No identified location	0	0	0	0	5	0
Total sales	4269	46	15347	252	4678	261
Total	24,853					

Animal experiments proved that all 4 snail breeds could be infected by the 1st satge larvae of *A. cantonensis*, and the 3rd stage larvae obtained from the snail host could infect SD rats without a difference in ability, suggesting that all 4 snail breeds could be transmitters of *A. cantonensis*.

In China, angiostrongyliasis has become an important parasitic disease in many southern provinces, including Yunnan, Hainan, Guangxi, Guangdong, Fujian, Zhejiang, Jiangsu and Hunan (Lv *et al*., 2008; Wang *et al*., 2012). Historical angiostrongyliasis outbreaks have occurred in Zhejiang, Fujian, Yunnan, Heilongjiang, Liaoning, and Beijing many times. At present, two species of invasive snails, *P. canaliculata* and *A. fulica,* are becoming the most important transmitters of *A. cantonensis* in China. In most provinces, wild type *P. canaliculata* is strictly monitored to avoid human infection and spread of the disease by the local CDC (Center for Disease Control and Prevention). However, Internet sales of snails lack monitoring.

Recent analysis has shown that the natural distribution of *P. canaliculata* includes Sichuan, Yunnan, Guangxi, Guangdong, Fujian, Zhejiang, Jiangxi, Hunan, and Hainan. *A. fulica* is mainly distributed in Yunnan, Guangxi, Guangdong, and Fujian.

Although all 4 breeds of snail bought on the Internet were *A. cantonensis* negative, animal experiments showed that all 4 breeds could transmit *A. cantonensis*. We believe that the 4 breeds of internet-sold *A. fulica* and *P. canaliculata* present a risk of transmission of *A. cantonensis* for the following reasons: (1) the sources of internet-sold snails lack supervision; some internet-sold snails might be collected from the wild in endemic regions, and some snails might even be *A. cantonensis* positive. Internet selling might cause new infections. Taking *P. canaliculata* as an example, the *A. cantonensis* endemic

region, natural habitat, and internet sellers are commonly distributed in Guangdong, Fujian and Zhejiang. There is no report indicating that *A. fulica* has invaded Zhejiang, but many snail farms have been established in the cities of Jinhua and Jiaxing, Zhejiang. This will be discussed in another paper. Local snail internet sellers might collect wild snails for sale with a high risk of transmitting *A. cantonensis*. (2) Although most of the snails were bought as pets and aquarium cleaners, some snails might escape or be dumped into the wild, leading to new spreading of these invasive snails. Internet selling might carry the risk of new introductions of snails, even damaging ecological systems and leading to new endemic regions of angiostrongyliasis.

Conclusion

Overall, this is the first report on the internet-sold *A. cantonensis* intermediate hosts, namely wild type of *P. canaliculata, A. fulica*, the gold snail and the white jade snail. Raw data indicated that 24,853 sales had been made by 2019. Besides, current surveys found no *A. cantonensis*-positive snails among internet-sold snails, suggesting that all internet-sold snails were biosafe temporarily. However, laboratory animal infection experiments exhibited that all 4 breeds of snails could transmit *A. cantonensis*. It is our strong recommendation that internet sales of all 4 snail breeds be strictly monitored.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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