REVISTA DO INSTITUTO DE MEDICINA TROPICAL DE SÃO PAULO

JOURNAL OF THE SÃO PAULO INSTITUTE OF TROPICAL MEDICINE

ORIGINAL ARTICLE

http://dx.doi.org/10.1590/S1678-9946201759015

# Scientometrics of zoonoses transmitted by the giant African snail *Achatina fulica* Bowdich, 1822

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## ABSTRACT

The dissemination of the giant African snail *Achatina fulica* in several countries has triggered a great number of studies on the mollusk, including those on zoonoses related to health in humans. The current research is a scientific survey on articles published in four databases, namely, PubMed, Bireme, Scielo and Lilacs. Results indicate that Brazil has a prominent position in international scientific production on this subject, with focus on *Angiostrongylus cantonensis* occurrences.

**KEYWORDS**: Health promotion. Public health. Epidemiology. *Angiostrongylus* infection.

## INTRODUCTION

The rapid spread of the giant African snail *Achatina fulica* Bowdich, from 1822 worldwide has caused a great concern not merely due to environmental aspects but particularly to the dissemination of diseases in humans. *Achatina fulica*, one of the hundred most harmful invading species on the planet[1], native to East Africa, is known to have a highly predatory food and reproduction habits and have contributed to the extinction of native fauna and the decrease in biodiversity. The mollusk may cause heavy economical liabilities due to its proliferation in cash crops, gardens and kitchen gardens[2].

The giant African snail was illegally introduced in Brazil during an agricultural and cattle-breeding fair that took place in the municipality of Curitiba, *Paraná* State, Brazil, between 1988 and 1989, as a commercial alternative to the mollusk *Helix aspersa* Müller, described in 1774 and used in French cuisine in the preparation of escargot dishes. A second introduction of the African snail may have occurred in the *Goiás* State, in 1996, for the same reason. The commercial bankruptcy of breeders caused its inadequate release in the environment and, consequently, its dissemination to other Brazilian States[2-5].

Due to its feed and reproduction habits, *A. fulica* finds an ideal habitat for its deployment and dissemination in environments modified by human activities. In fact, the giant African snail is abundant in areas featuring high population density[2,6]. In addition, it should be underscored that the mollusk is a threat to public health since it harbors parasite vectors such as the nematodes *Angiostrongylus cantonensis* (Chen, 1935) which is the etiological agent of eosinophilic meningitis, and *A. costaricensis* (Morera & Céspedes, 1971) which causes abdominal angiostrongyliasis[2,5,7].

Adult worms live inside the pulmonary arteries of certain rodent species such as *Rattus norvegicus* (Berkenhout, 1769), *R. rattus* (Linnaeus, 1758) and *R. exulans*

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**Received:** 1 August 2016

**Accepted:** 13 February 2017

(Peale, 1848)[8-10]. Several species of mollusks have been reported as intermediate hosts in the biological cycle of *A. cantonensis*[3,5,11], *Bradybaena similaris* (Férussac, 1821), *Pomacea lineata* (Spix, 1827), *Sarasinula linguaeformis* (Semper, 1885), *Sarasinula marginata* (Semper, 1885), *Subulina octona* (Bruguière, 1792), *Parmarion martensi* Simroth, 1893, *Laevicaulis alte* (Férussac, 1822), *Limax maximus* Linnaeus, 1758, *Euglandina rosea* (Férussac 1821), *Oxychilus alliarius* (Miller, 1822) and *A. fulica*[12].

The mollusks which are intermediate hosts of *A. costaricensis* include Veronicellidae slugs[5,8], mainly *Phyllocaulis variegates* (Semper, 1885), *Sarasinula plebeius* (Fischer, 1868), and *S. linguaeformis*. Birds and mammals (including humans) are accidental hosts[11] and acquire infection by the consumption of intermediate hosts (e.g. snails and slugs) or paratenic hosts (e.g. fishes, frogs, lizards and some crustaceans) infected with third stage larvae[8,13]. Although abdominal angiostrongyliasis is a parasitic infection, frequently asymptomatic or presenting very mild symptoms, severe forms of the disease involve intense abdominal pain which may cause lesions in the liver and intestinal perforations, requiring immediate surgery[13-15]. No reports on *A. fulica* naturally infected by *A. costaricensis* exist in the Americas, but its susceptibility was experimentally proven. Cases of human infections by the nematode occur from the United States of America (USA) to the North of Argentina and in the Brazilian States of Rio Grande do Sul, Santa Catarina, *Paraná*, *São Paulo*, Minas Gerais, *Espírito Santo* and the Distrito Federal[3,12].

Eosinophilic meningitis is a clinical condition characterized by an inflammatory response after the *A. cantonensis* larvae have reached the central nervous system, and the harboring in the meninges may cause nausea and headache, and in more severe cases, neurologic dysfunction, coma, and death[11,13,15]. The *A. cantonensis* larvae can also reach the ocular globes, causing a condition called ocular angiostrongyliasis[16].

Although the parasite was originally described in China in the 1960s[13], *A. cantonensis* has been reported in several regions such as the Pacific islands (Hawaii, Tahiti and Celebes), Southeastern Asia (Vietnam, Thailand, Sumatra, Malaysia, Indonesia, Taiwan and the Philippines), India, Australia, Japan and Madagascar, and American countries such as Cuba, Jamaica, Ecuador, the USA, Haiti and Brazil[3,7,13]. Rodents and mollusks infected by the parasite, including *A. fulica*, have been detected in the Brazilian States of Amazonas, Bahia, *Ceará*, *Espírito Santo*, *Pará*, *Paraná*, Pernambuco, Rio de Janeiro, Santa Catarina, *São Paulo* and the Distrito Federal[11]. Several cases of infected people have been reported lately, especially in China, Taiwan and the USA[17].

Three cases involving eosinophilic meningitis occurred in the *Espírito Santo* State, Brazil: two cases in the municipality of Cariacica, and a third case in the municipality of Vila Velha, in 2007. These were the first records of the disease in Brazil[7], even though there was a suspect case in Rio de Janeiro, in 2006. A fatal case involving a 26-year-old woman was reported in the municipality of Olinda, Pernambuco State, Brazil, in 2009[13]. Dozens of others suspect and confirmed cases have been reported in several Brazilian towns[13].

However, the above number may have been underestimated due to a deficient knowledge on the epidemiological aspects of the parasites transmitted by the giant African snail and their occurrence in Brazil. One must underscore that the continuous dissemination of the mollusk throughout Brazil, especially in urban areas in which it has great adaptability and dispersion, is a considerable risk for the increase of clinical cases of the disease[6,13].

Scientometric studies constitute a reliable method since they serve a double purpose: they provide indexes on the degree of development within a branch of knowledge and disseminate research work undertaken. These studies have foregrounded quantitative and qualitative analyses in scientific production, especially in the health field[18,19].

Through scientometric studies, current analysis contributes towards a survey of Brazilian and international scientific publications on the giant African snail and the diseases transmitted by the mollusk, so that studies can be undertaken focusing relevant or still neglected aspects. Current research may also foreground the elaboration of public policies for the prevention, identification and treatment of the concerned zoonoses.

## MATERIALS AND METHODS

Scientometrics have foregrounded current methodology for the planning, collection and analysis of data. Articles related to the giant African snail and to human diseases were accessed through Brazilian and international databases, and classified according to the publication date, title of the electronic journal, qualification on the *WebQualis*, study site and main aim.

The consulted databases comprised the *United States National Library of Medicine* (PubMed) available at *http://www.ncbi.nlm.nih.gov/pubmed*; the *Scientific Eletronic Library Online* (Scielo), available at *http://www.scielo.br/*, the Latin American and Caribbean Literature in Health Sciences (Lilacs), available at *http://lilacs.bvsalud.org/* and Latin-American and Caribbean Information Center in Health Sciences, available at *http://bvsalud.org/*. The research was undertaken in June 2016, with no restrictions

with regard to the publication period. The main search term was the snail scientific name, *Achatina fulica,* and its variation, *Lissachatina fulica.* Portuguese terms such as "Caramujo africano" and "Caramujo gigante africano", as well as some terms in English "giant African snail" and "African snail" were used, but as a support, only. However, no results were obtained for this secondary denomination.

Dual articles were excluded, and the analysis of titles and abstracts did not relate snails to any human zoonosis involving human health.

The classification of articles according to the qualification extracts of the Qualis system (A1, A2, B1, B2, B3, B4, B5 and C) used preferentially the interdisciplinary evaluation area. Journals without an evaluation area were qualified according to the main aim, provided in the abstract and the available assessment areas. Information on the country and city/ town in which the sample collection or study area occurred (indicated in the titles and abstracts) was considered. In exceptional cases in which the title or abstract failed to give information, the place of publication based on the corresponding author's address were considered. Classification by the main aim was foregrounded on the nematodes *Angiostrongylus cantonesis* and *A. costaricensis*, or both, and these data were subjected to current analysis.

## RESULTS

Research in the initial phase identified 1,933 articles. However, the terms "Caramujo africano", "Caramujo gigante africano", "African snail" and "giant African snail" were not taken into account to perform the analysis and discussion since they merely provided already indexed results for the terms "*Achatina fulica*" and "*Lissachatina fulica*".

Only 62 out of the 760 articles initially obtained from the terms above complied according to the inclusion criterion of the research, or rather, they related the African snail to the transmission of abdominal angiostrongyliasis and eosinophilic meningitis. In fact, approximately 8% of the studies retrieved from the four databases were thereafter assessed.

Table 1 displays the number of articles on each term at the four databases, Scielo, PubMed, Bireme and Lilacs, and the number of articles of interest after the exclusion.

PubMed was the major database with the greatest number of publications, totaling 394 articles and 56 remaining articles after the application of the exclusion criteria. Bireme ranked second with 321 publications. However, only three articles complied with the inclusion criteria. Scielo database provided 10 initial articles and 3 remaining ones after exclusion. All articles on the Lilacs database were excluded due to duality.

Although the first article associating the giant African snail with human diseases was published in 1966, the theme was underscored only in the 2010s, concentrating 35% of all the articles published. The most significant year was 2012 with seven publications, mostly reported by Chinese researchers (Figure 1). On the other hand, Brazilian publications started to be relevant from 2000, as only one article was published by Brazilians between 1997 and 2000.

Brazil ranks second due to the great number of scientific publications on diseases transmitted by the giant African snail, or rather, approximately 20% of the world publications. Only China exceeds this percentage, corresponding to 34% of the studies worldwide.

Among studies on the subject written in Chinese, four were published in Taiwan. In the case of the USA, several articles deal with the giant African snail in Hawaii, the archipelago State belonging to the USA, through which the mollusk was introduced in 1939[3].

Publications listed under French territories refer to studies undertaken in *La Reunion*, *Mayote*, French Guiana and French Polynesia, all of them, ultramarine departments of France, respectively in the Indian Ocean, South America and Pacific Ocean (Figure 2).

**Table 1** - Total number of articles (N) per term, according to the database, and the number of remaining articles (n) after the exclusion analysis criterion. Abbreviation: Port = Portuguese, Eng = English

| Search terms/ Databases | *Achatina fulica* | *Lissachatina fulica* | *Caramujo africano* (Port) | *Caramujo gigante africano* (Port) | African Snail (Eng) | Giant African Snail (Eng) | After exclusion |
|---|---|---|---|---|---|---|---|
| | N (n) | N (n) | N (n) | N (n) | N (n) | N (n) | N (n) |
| Scielo | 10 (3) | 0 (0) | 3 (0) | 4 (0) | 2 (0) | 8 (0) | 27 (3) |
| PubMed | 389 (56) | 5 (0) | 0 (0) | 0 (0) | 392 (0) | 189 (0) | 975 (56) |
| Bireme | 318 (2) | 3 (1) | 55 (0) | 7 (0) | 289 (0) | 187 (0) | 859 (3) |
| Lilacs | 35 (0) | 0 (0) | 10 (0) | 5 (0) | 14 (0) | 8 (0) | 72 (0) |
| Total | 752 (61) | 8 (1) | 68 (0) | 16 (0) | 697 (0) | 392 (0) | 1,933 (62) |

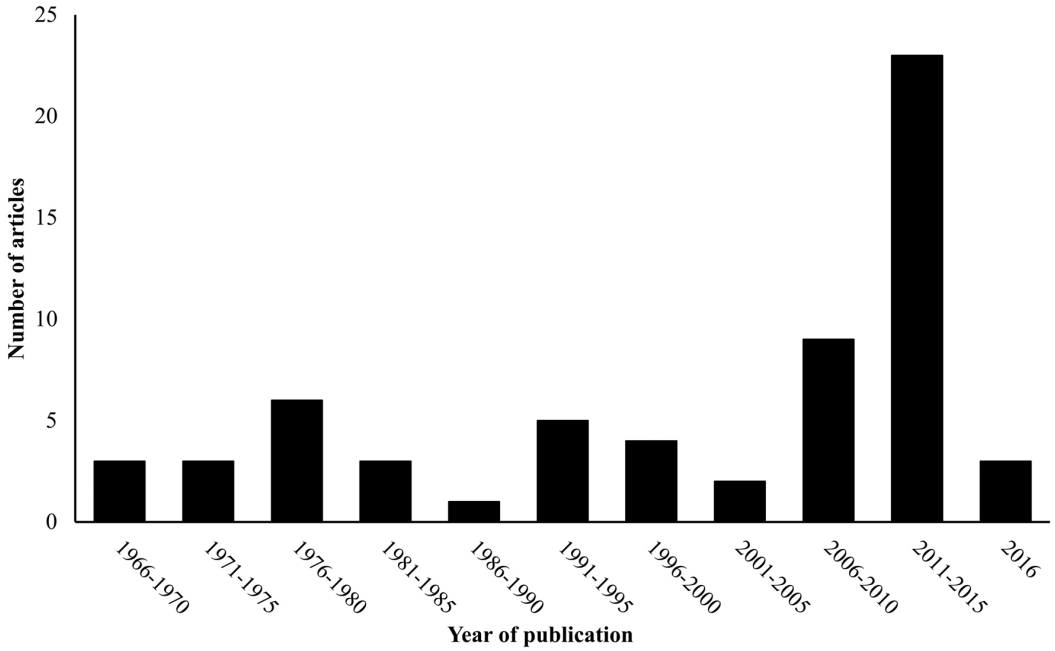


**Figure 1** - Number of article published per period.

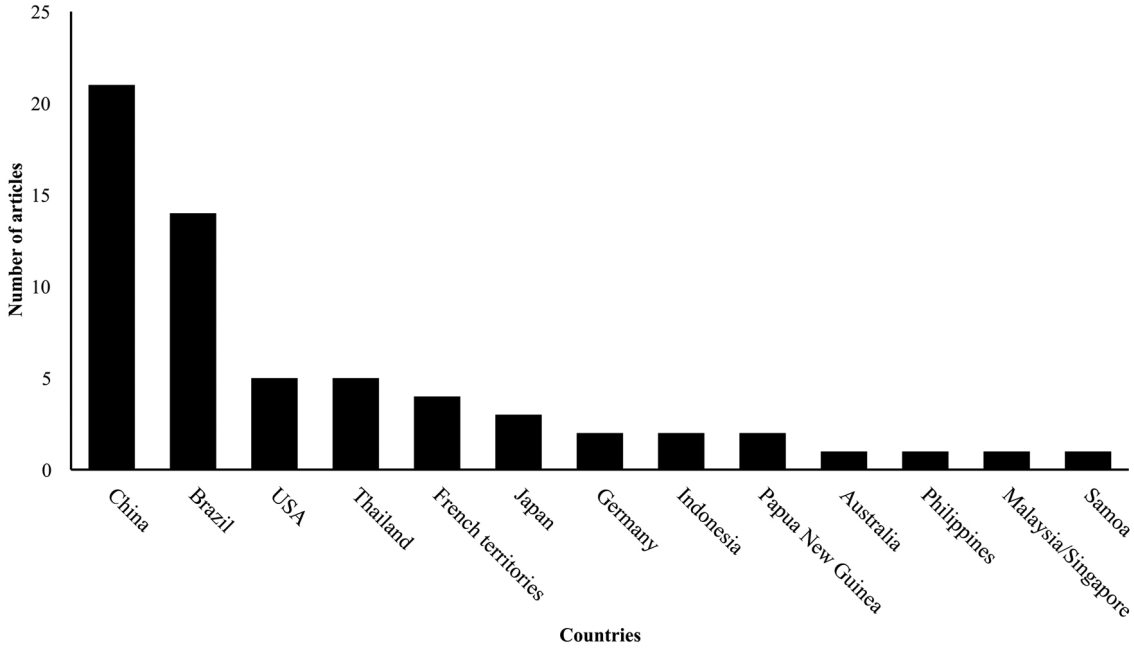


**Figure 2** - Number of articles according to the countries where studies were undertaken.

Rio de Janeiro, Brazil, is the Brazilian State featuring the greatest number of studies on the theme. The study on the African snail in *Espírito Santo* State refers to the first report of snails naturally infected by *A. cantonensis* in Brazil (Figure 3)[7].

The analysis on the articles main aim clearly revealed a predominance of studies on *A. cantonensis*, the etiological agent of eosinophilic meningitis, with slightly more than 1% for studies on *A. costaricensis.*

Quality assessment of journals according to the category of journals according to the Qualis system revealed that most articles do not belong to journals listed on the WebQualis system. *The Southeast Asian Journal of Tropical Medicine and Public Health* alone concentrated 15% of publications, although not ranked by the system.

Other articles were published in journals ranked A1, A2, B1 and B2, with a predominance of the A2, with 40% of publications in this category (Figure 4).

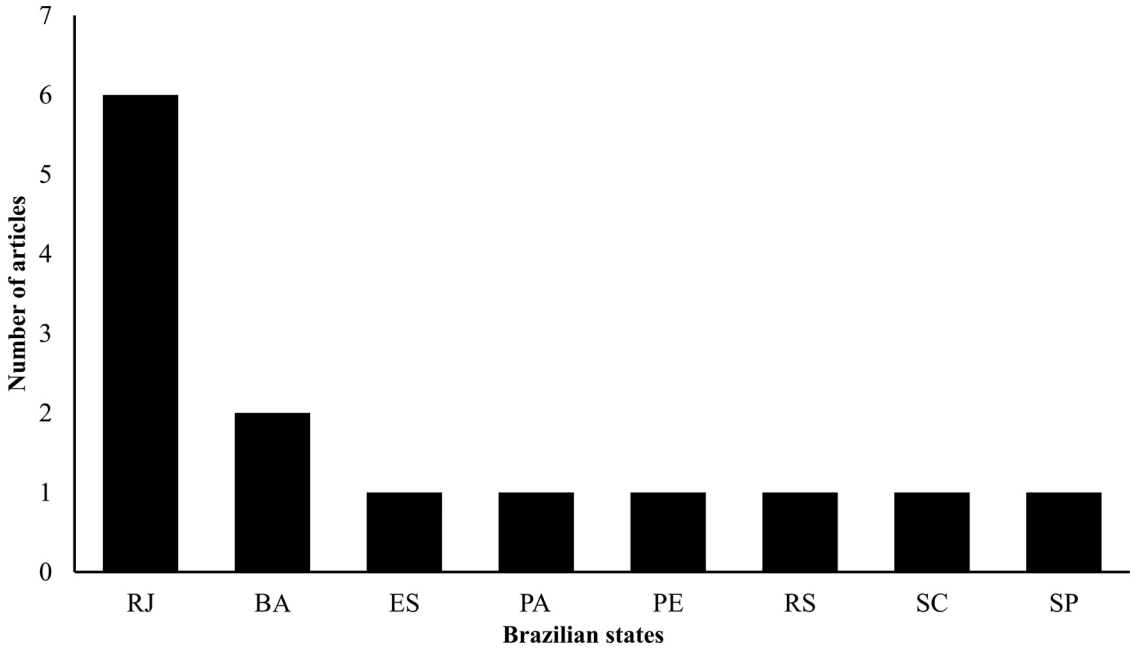


**Figure 3** - Number of Brazilian articles according to the state in which studies were undertaken. RJ = Rio de Janeiro; BA = Bahia; ES = *Espírito Santo*; PA = *Pará*; PE = Pernambuco; RS = Rio Grande do Sul; SC = Santa Catarina; SP = *São Paulo*.

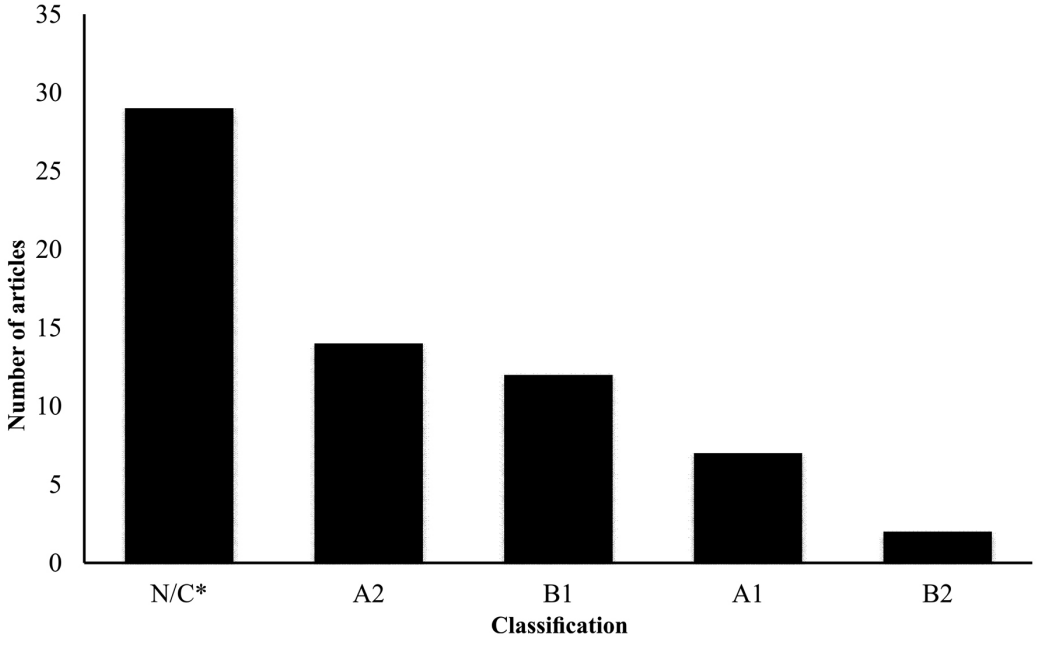


**Figure 4** - Number of articles according to category assessment of the Qualis/Capes system. *N/C = journals with no classification by the Qualis/Capes system.

## DISCUSSION

Scientometric results on the giant African snail and zoonoses linked to the mollusk show that Brazil has a significant role on the subject, due to its second place with the greatest concentration of electronic articles on the theme. Moreover, the only articles on *A. fulica* by *A. costaricensis* have been published by Brazilian researchers, even though most articles published in the country deal with *A.cantonensis*[5,12].

Rio de Janeiro State has sponsored the greatest number of research works on the subject. Although snails infected by *A. cantonensis* have been reported in the municipality of *São Gonçalo*[20], one should bear in mind that the main health

research center, the *Oswaldo Cruz* Foundation (Fiocruz) in the country is located in this federal State.

As a rule, study sites coincide with the geographic regions in which cases of eosinophilic meningitis or of snails infected by *A. cantonensis* have been reported during the last decades, such as Southeastern Asia, islands in the Pacific Ocean, countries on the American continent, Australia and Japan[3,13].

The first scientific article on the role of the giant African snail (*A. fulica*) in the transmission of zoonoses was published in 1966[21], even though most articles on the subject were published only after 2000, particularly in the 2010s.

Analysis on the main aims revealed the great interest of scientists for occurrences related to *A. cantonensis,* to the detriment of *A. costaricensis*, perhaps due to mild symptoms of abdominal angiostrongyliasis and to the low susceptibility of *A. fulica* to infection by the nematode, since other invertebrates, mainly Veronicellidae slugs, participate in its cycle as main intermediate hosts[12].

According to Qualis/CAPES stratifications, the quality of publications turns out to be partially inconclusive since most publications occurred in journals not listed on the WebQualis system. On the other hand, articles published in journals evaluated by the Qualis system proved to be of considerably high quality.

## ACKNOWLEDGEMENTS

The authors would like to thank the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) and the *Instituto Cesumar de Ciência, Tecnologia e Inovação* (ICETI) for the scholarship and funding of the current research. FHO received a postdoctoral fellowship from *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES).

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