Endoparasites of Vietnamese lizards recorded in the last 50 years (1966–2015)

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ABSTRACT

At present, there is a limited knowledge of amphibian and reptile parasites in Vietnam. To date, 45 species of endoparasite in Vietnamese lizards have been recorded. These species consist of 11 cestode, 12 trematode, 18 nematode, one acanthocephalan and three pentastomid species from 10 host species. As Vietnam is one of the global hot spots for herpetofauna diversity (a recent report documented 385 reptiles and 181 amphibians in the country), it appears that only a fraction of the parasites of lizards in this richly biodiverse territory has been recorded. To facilitate the accurate taxonomical identification of parasites and clarify the taxonomic relationship of parasites from Vietnamese lizards with those from Oriental lizards or lizards of other geographical regions, parasites should be characterized both morphologically and phylogenetically.

Key words: Vietnam, lizard, parasite, helminth, pentastomid, record.

1. INTRODUCTION

Vietnam is one of the global hot spots for reptilian and amphibian diversity. Nguyen and Ho [90] recorded 258 reptiles and 82 amphibians as the herpetofauna of Vietnam in 1996. More recent active surveys on the herpetofauna in the country by Vietnamese herpetologists and collaborative overseas scientists have disclosed more and more species. Nguyen et al. [92] recorded 368 reptiles and 177 amphibians in 2009. While Ziegler and Nguyen [133] reported 385 reptiles and 181 amphibians in 2010. The lizard group, such as the agamids, geckos and skinks, currently comprises a total of more than 120 species, of which at least 57 species were described during the period 1996 to 2010 [81, 90-92, 133]. The major reptile families in Vietnam are Gekkonidae (42 species) and Scincidae (46 species).

In contrast to the active research on herpetofauna or lizard fauna, little is known about the parasites of lizards endemic in Vietnam. To date, parasitological studies have been conducted on only 10 host species, with 45 endoparasite species being found, of which 80.0% (36 species) were parasites of the spiny-tailed house gecko Hemidactylus frenatus (Schlegel, 1836), clouded monitor Varanus nebulosus (Gray, 1831) and water monitor Varanus salvator (Laurenti, 1768). Due to multiple records being published in Vietnamese or in domestic conference books in Vietnam, overseas researchers outside of Vietnam may experience difficulties accessing them. To address this, the present study lists the parasite records from Vietnamese lizards for the benefit of researchers interested in this topic.

2. VIETNAMESE LIZARDS EXAMINED FOR THEIR ENDOPARASITES

We surveyed conference records and scientific
Fig. 1. Map of Vietnam illustrating 61 provinces. The provinces coloured grey denote localities where parasites have been recorded in lizards.
Table 1. Endoparasites of lizards in Vietnam recorded during the period of 1966 – 2015.

<table>
<thead>
<tr>
<th>Lizard species</th>
<th>Number of lizards examined</th>
<th>Cestoda</th>
<th>Trematoda</th>
<th>Nematoda</th>
<th>Acanthocephala</th>
<th>Arthropoda</th>
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</thead>
<tbody>
<tr>
<td>Varanidae</td>
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<tr>
<td>Clouded monitor</td>
<td></td>
<td>Acanthotaenia shipteyi; Acanthotaenia beddardi; Acanthotaenia nilotica;</td>
<td>Encyclometra colubrimumorum; Sanghatrema vietnamensis;</td>
<td>Oswaldocerca sp 2; Herpetostrongylus varani' sensu Nguyen 2002; Raillietascaris varani; Haplorchis pumilio;</td>
<td></td>
<td>Raillietiella orientalia</td>
</tr>
<tr>
<td>Varanus melinus Gray, 1831</td>
<td>23</td>
<td>Acanthotaenia sp; Duthiersia expansa;</td>
<td>Raillietiella frenatus; Mesocoelium brevicaecum;</td>
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<tr>
<td>Water monitor</td>
<td></td>
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<tr>
<td>Varanus salvator Laurenti, 1768</td>
<td>20</td>
<td>Acanthotaenia beddardi; Acanthotaenia nilotica; Acanthotaenia sp;</td>
<td>Encyclometra colubrimumorum; Sanghatrema vietnamensis;</td>
<td>Oswaldocerca sp 2; Raillietascaris varani; Tanque tiara;</td>
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<tr>
<td>Gekkonidae</td>
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<tr>
<td>Golden gecko</td>
<td>65</td>
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<tr>
<td>Gelbob hordeni Stezerbak et Neznamova, 1994</td>
<td>149</td>
<td></td>
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<tr>
<td>Spiny-tailed house gecko</td>
<td>149</td>
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<tr>
<td>Scincidae</td>
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<tr>
<td>Long-tailed mabuya</td>
<td>38</td>
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<tr>
<td>Agamidae</td>
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<tr>
<td>Scale-bellied tree lizard</td>
<td>32</td>
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<tr>
<td>Emma Gray's forest lizard</td>
<td>6</td>
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<tr>
<td>Garden fence lizard</td>
<td>32</td>
<td></td>
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<tr>
<td>Eastern butterfly lizard</td>
<td>20</td>
<td></td>
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<tr>
<td>Vietnamese false bloodsucker</td>
<td>7</td>
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</tbody>
</table>

* Blank denotes no record.
publications in domestic and international journals. According to these sources, parasitological surveys on Vietnamese lizards were often conducted at several places in the Red River Delta, where the Red River flows from Yunnan in southwest China through northern Vietnam to the Gulf of Tonkin, and mountainous provinces of central and southern regions of Vietnam as well as unknown places in the southern region (Fig. 1). We found 45 parasite species recorded from 10 host lizard species, and more than 360 host individuals were examined by Vietnamese researchers as well as their overseas collaborators (Table 1). These host lizards were classified into four families (Table 1 and Fig. 2): Varanidae (Varanus nebulosus and Varanus salvator); Gekkonidae (Gekko badenii and Hemidactylus frenatus); Scincidae (Eutropis longicaudata); and Agamidae (Acanthosaura lepidogaster, Calotes emma, Calotes versicolor, Pseudocalotes brevipes and Leiolepis reevesii).

### 3. PARASITES RECORDED IN VIETNAM- ESE LIZARDS

As mentioned above, 45 species parasitic to lizards were recorded in Vietnam. These species comprised 11 cestodes, 12 trematodes, 18 nematodes, one acanthocephalan and three pentastomids [2, 6, 22, 68, 99, 100, 117-120, 122, 125]. Among them, six species were described as new to science at the time of publication: *Abbreviata deschiensi* Le et Nguyen, 1966; *Pharyngodon duci* Tran et al., 2007; *Spauligodon vietnamensis* Tran et al., 2007; *Thelandros vietnamensis* Bui et al., 2009; *Cosmocercoides tonkinensis* Tran et al., 2015; and *Pseudoacanthocephalus nguyenthileae* Amin et al., 2008. In the following subsections, localities, when defined, are shown by the name of the province and the number plotted on the map (Fig. 1) in parentheses. The incidence (prevalence) and intensity are shown for parasite species where these data were provided, although it was found that this information was generally missing from the Vietnamese reports.
3-1. Cestoda

Eleven recorded species were classified into three families: Anoplocephalidae Cholodkowsky, 1902 (Oochoristica Lühe, 1898 – four spp.); Proteocephalidae La Rue, 1911 (Acanthotaenia von Linstow, 1903 – four spp. and Kapsulotaenia Freze, 1965 – one sp.); and Diphyllobothriidae Lühe, 1910 (Duthiersia Perrier, 1873 – one sp. and Scyphocephalus Riggenbach, 1898 – one sp.).

3-1-1. Oochoristica chinensis Jensen, Schmidt et Kuntz, 1983

Host and location: Hemidactylus frenatus, small intestine [85, 118]

Locality: Yen Bai Province (5); additionally, Hanoi Province (14) [unpublished]

Incidence and intensity: 4.7% (7/149) with 1–5 worms/host

Comment: Anoplocephalid cestodes of the genus Oochoristica, ca. 80 species at present, are cosmopolitan in distribution and predominantly parasitize lizards, but also snakes, turtles and marsupials [31]. The present species was recorded from Japalura swinhonis (the type host) and Eutropis longicaudata (syn. Mabuya longicaudata) in Taiwan [52, 93]. The morphological features of the isolate from common house geckos (H. frenatus) in Vietnam corresponded well with the original description [52].

Since assumptions of strict host specificity and geographical isolation had apparently been used as criteria in determining species of this genus, Criscione and Font [31] conducted an experimental infection of Oochoristica javaensis of lizard hosts distributed in a non-endemic region of the cestode and concluded that members of the Oochoristica may lack strict host specificity.

3-1-2. Oochoristica tuberculata (Rudolphi, 1819)

Lühe, 1898

Syn. Skrjabinochora sobolevi Spasskii, 1948

Host and location: Hemidactylus frenatus, small intestine [85, 118]

Locality: Yen Bai Province (5)

Incidence and intensity: 2.7% (4/149) with 1–3 worms/host

Comment: This cestode is the type species of the genus and is distributed widely in Eurasia and northern Africa (Palaearctic region) by parasitism of a variety of lizards (at least 31 species of 23 genera) as well as snakes (nine species of nine genera) [40, 131]. This species recorded from common house geckos in Vietnam had 28–30 testes per segment, different from the aforementioned O. chinensis with 17–22 testes per segment.

3-1-3. Oochoristica sp. 2

Host and location: Hemidactylus frenatus, small intestine [85, 118]

Locality: Yen Bai Province (5)

Incidence and intensity: 1.3% (2/149) with 1–3 worms/host

Comment: This cestode was small in size (7–9 mm in length and 0.3 mm in width) and had 12–14 testes per segment and a cirrus sac extending 50–58% of the width of the mature segment. Although morphological characters were recorded in detail, the exact taxonomic situation of this species was uncertain [118].

In addition, Nguyen et al. [85] recorded another Oochoristica sp. from Eutropis longicaudata at the same localities in northern Vietnam. This species was different from the four aforementioned Oochoristica
spp. from *H. frenatus*. No detailed information is available.

### 3-1-5. *Acanthotaenia shipleyi* von Linstow, 1903

**Host and location:** *Varanus nebulosus*, small intestine [117]

**Locality:** Southern Vietnam (not specified)

**Incidence and intensity:** 17.4% (4/23) with no intensity information

**Comment:** Members of the genus *Acanthotaenia* have a scolex with an apical muscular organ (piercing organ). The scolex and anterior part of the strobila are covered with a dense network of spines [103]. The uterus has numerous, irregular diverticula. *Acanthotaenia* spp. are parasitic to varanid reptiles in Africa, Australia and the Indo-Pacific region [103, 128], and *A. shipleyi* collected from *Varanus salvator* in Sri Lanka is the type species of the genus. Since the original description of the species was made using immature worms, Yamaguti [127] redescribed it using mature cestodes collected from *Varanus salvator* on Sulawesi Island, formerly known as Celebes, Indonesia. Recently, de Chambrier et al. [37] conducted phylogenetic analyses of proteocephalid cestodes (110 taxa of 54 genera classified in all 13 currently recognized subfamilies, including *A. shipleyi*) using almost complete 28S ribosomal RNA gene (rDNA) nucleotide sequences. Their findings led them to propose a need to revise the systematics of the family based on phylogenetic achievements or newly defined morphological characters suitable for the division of subgroups.

### 3-1-6. *Acanthotaenia beddardi* (Woodland, 1925)

*Schmidt et Kuntz, 1974*

**Host and location:** *Varanus nebulosus* and *Varanus salvator*, small intestine [117]

**Locality:** Vietnam (not specified)

**Incidence and intensity:** 18.6% (8/43) with no intensity information

**Comment:** This species was originally described in *Varanus bengalensis* in India. It was defined as having 60–77 testes per segment and a uterus with 15–20 lateral branches on each side, whereas the aforementioned species, *A. shipleyi*, had 40–65 testes per segment and a uterus with 29–36 lateral branches.

### 3-1-7. *Acanthotaenia nilotica* Beddard, 1913

**Host and location:** *Varanus nebulosus* and *Varanus salvator*, small intestine [117]

**Locality:** Vietnam (not specified)

**Incidence and intensity:** 27.9% (12/43) with no intensity information

**Comment:** This species was originally described in *Varanus niloticus* from Africa, having 75–92 testes per segment and a uterus with 17–25 lateral branches on each side.

### 3-1-8. *Acanthotaenia sp.*

**Host and location:** *Varanus nebulosus* and *Varanus salvator*, small intestine [117]

**Locality:** Vietnam (not specified)

**Incidence and intensity:** 14.0% (6/43) with no intensity information

**Comment:** This species was characterized to have 150–195 testes per segment and a uterus with 25–52 lateral branches on each side, distinct from any known *Acanthotaenia* spp.

### 3-1-9. *Kapsulotaenia sandgroundi* (Carter, 1943)

*Freze, 1965*

**Syn:** *Proteocephalus sandgroundi* Carter, 1943

**Host and location:** *Varanus salvator*, small intestine [117]

**Locality:** Northern Vietnam (not specified)

**Incidence and intensity:** 15.0% (3/20) with no intensity information

**Comment:** The genera *Kapsulotaenia* and *Acanthotaenia* are closely related, although formation of membranous egg capsules only occurs in the former genus [103]. The type species of the genus is the present species, which was fully redescribed by de Chambrier [36] on the basis of the type specimen from *Varanus komodoensis* on Komodo Island, Indonesia, and museum materials from varanid lizards on the Lesser Sunda Islands, Indonesia, and Australia.
3-1-10. *Duthiersia expansa* Perrier, 1873

**Syns.** *Duthiersia crassa* Woodland, 1938; *Duthiersia venusta* Woodland, 1938

**Host and location:** *Varanus nebulosus* and *Varanus salvator*, small intestine [117]

**Locality:** Vietnam (not specified)

**Incidence and intensity:** 18.6% (8/43) with no intensity information

**Comment:** Members of the genus *Duthiersia* are small worms from varanid lizards, not exceeding 200 mm in length, and having a broad and fan-like scolex with bothrial margins frilled or crenulated [21]. Woodland [126] examined numerous specimens from varanids in Africa and Asia, and divided them into *D. fimbriata* (Diesing, 1854) and *D. expansa* Perrier, 1873, respectively, with the suppression of *D. elegans* Perrier, 1873, *D. robusta* Woodland, 1938, and *D. latissima* Woodland, 1938, as junior synonyms of *D. fimbriata*, and similarly *D. crassa* Woodland, 1938, and *D. venusta* Woodland, 1938, as junior synonyms of *D. expansa*. Woodland [126] indicated that the critical differences between these two species, or African and Asian forms, were few except for the shapes of scoleces and the absence or presence of posterior pore openings of the bothrial grooves. Current taxonomy follows his division. Along with the aforementioned *D. expansa* specimens, Tran [117] reported the collection of *D. fimbriata* from Vietnamese varanids at an incidence of 16.3% (7/43). Since the basis for the separation between these two species was not shown in the work [117], the present study omits this record.

The Asian form, i.e. *D. expansa*, is the type species of the genus. It is commonly found in a variety of Asian *Varanus* spp. (*V. bengalensis, V. flavescens, V. komodoensis, V. marmoratus, V. nebulosus, V. nuchalis, V. salvator and V. salvadorii*) or *Iguana* sp. and *Cyclura stejnegeri* (*Iguanidae*) in Indonesia, Thailand, Philippines, China, Malaysia, India, Sri Lanka, Pakistan and Afghanistan [128].

### 3-1-11. *Scyphocephalus bisulcatus* Riggenbach, 1898

**Syns.** *Scyphocephalus secundus* Tubangui, 1968; *Scyphocephalus longus* Sawada et Kugi, 1973

**Host and location:** *Varanus salvator*, small intestine

**Locality:** Nghe An Province (27)

**Incidence and intensity:** No information

**Comment:** The genus *Scyphocephalus* is characterized by a special scolex with rudimentary bothria and an invaginated anterior end forming a sucking organ [21]. This cestode is the type species of the genus, described based on worms from *Varanus salvator* in Java, Indonesia [104]. As detailed above, *S. secundus* from *Varanus salvator* on Leyte Island, Philippines [124] was synonymized by Vlnová [125]. *‘Scyphocephalus jadhavi’* described from the same host species in Andhra Pradesh, India [60] appears to be a species of a distinct genus.

### 3-2. Trematoda


#### 3-2-1. *Plagiorchis molini* Lent et Freitas, 1946

**Host and location:** *Hemidactylus frenatus*, intestine

**Locality:** Quang Tri Province (30)

**Incidence and intensity:** 3.0% (1/33) with 3 worms/host

**Comment:** This plagiorchid species is often found in lacertid lizards such as sand lizards (*Lacerta agilis*) and common wall lizards (*Podarcis muralis*) distributed widely in Europe [70, 71]. Okulewicz et al. [95] found...
P. molini in a Chinese water dragon (Physignathus cocincinus) imported into Poland, suggesting that this species is also distributed in China and Southeast Asia. Plagiorchis elegans (Rudolphi, 1802) Braun, 1902, has also been reported from lacertid lizards [131].

3-2-2. Encyclometra colubrimurorum (Rudolphi, 1819) Dollfus, 1929
Host and location: Varanus nebulosus and Varanus salvator, oesophagus and intestine [99]
Locality: Hanoi Province (14) and southern Vietnam (not specified)
Incidence and intensity: No information
Comment: Members of the genus Encyclometra are trematodes that dwell in the oesophagus, stomach and intestine of snakes in Eurasia [116]. Gupta and Mehrotra [49] differentiated three valid species: E. colubrimurorum (testes tandem or obliquely tandem, with equal intestinal caeca); E. bungara Srivastava et Ghosh, 1968 (testes almost symmetrically placed); and E. asymmetrica Wallace, 1936 (testes tandem or obliquely tandem, with very unequal intestinal caeca). Encyclometra japonica Yoshida et Ozaki, 1929, and E. vitellata Gupta, 1954, were synonymized with E. colubrimurorum and E. asymmetrica, respectively [49]. Metacercariae of E. colubrimurorum are often found in amphibians [7]. In Vietnam, this encyclometrid species was found in snakes (Xenopeltis unicolor and Xenochrophis piscator), as reported in various snakes (Ptyas mucosus, Natrix natrix and Natrix piscator) from other Eurasian areas [51].

3-2-3. Singhiatrema vietnamensis Curran et al., 2001
Host and location: Varanus nebulosus and Varanus salvator, oesophagus and intestine [99]
Locality: Hanoi Province (14) and southern Vietnam (not specified)
Incidence and intensity: No information
Comment: This species was originally described from the small intestine of Chinese water snakes (Enhydris chinensis) and rice paddy snakes (Enhydris plumbea) in Vietnam [32]. It also parasitizes other snakes such as the Taiwan cobra (Naja atra), Chinese ratsnake (Ptyas korros) and banded krait (Bungarus fasciatus). Members of the genus have pyriform bodies with a head-collar with a row of spines, interrupted dorsally [61]. A well-developed ventral sucker is located centrally and the intestinal caeca end at the posterior margin of the ventral sucker.

3-2-4. Euparadistomum varani Tubangui, 1931
Host and location: Varanus salvator, gall bladder [99]
Locality: Hanoi Province (14)
Incidence and intensity: No information
Comment: This discoid dicrocoeliid species with almost full occupation of the body by uterine coils and two testes situated symmetrically at anterolateral positions to the acetabulum was originally described in Varanus salvator from the Philippines, then other places in Southeast Asia, Pacific Islands and Madagascar [28, 44]. In Vietnam, this species was found in the Asian water monitor (V. salvator) in 2003 [99], and more recently in the Asian house shrew (Suncus murinus) [80].

3-2-5. Paradistomum orientalis (Narain et Das, 1929) Bhalerao, 1936
Syns. Dicrocoelium orientale Narain et Das, 1929; Paradistomoides orientale (Narain et Das, 1929) Yamaguti, 1958
Host and location: Eutropis longicaudata and Hemidactylus frenatus, gall bladder [83, 85]
Locality: Hanoi Province (14) and Yen Bai Province (5)
Incidence and intensity: No information
Comment: This oval dicrocoeliid species is a common trematode in the gall bladder of various lizards including Calotes versicolor and Hemidactylus flaviviridis in India. Examining C. versicolor in India, Arora and colleagues [8, 9] found a high prevalence (67/74) of the species in the gall bladder, and from their studies on the intraspecific variations of the specimens concluded several described species to be junior synonyms of P. orientalis. Studying the monthly population dynamics of P. orientalis in C. versicolor in India, Madhavi et al. [76] reported that the frequency distribution of the fluke in the host followed the overdispersion pattern and that crowding effects serve as a major regulatory force for maintaining the equilibrium of parasite densities.
throughout the year. Killick and Beverley-Burton [64] made a taxonomical evaluation of 21 nominal Paradistomum spp. described from Southeast Asian lizards.

3-2-6. *Parabascus lepidotus* Looss, 1907

**Host and location:** Hemidactylus frenatus, intestine [83, 85]

**Locality:** Hanoi Province (14) and Yen Bai Province (5)

**Incidence and intensity:** No information

**Comment:** This trematode is the type species of the genus, originally described from Pipistrellus kuhlii (syn. Vesperugo kuhlii; Chiroptera: Vespertilionidae) in Cairo, Egypt [74]. This Kuhl’s pipistrelle bat is distributed widely around Mediterranean regions (southern Europe and northern Africa) to India, and there are records of this trematode in the regions with the host distribution.

3-2-7. *Postorchigenes ovatus* Tubangui, 1928

**Syn.** *Parabascus ovatus* (Tubangui, 1928) sensu Nguyen et Pham, 2005

**Host and location:** Hemidactylus frenatus, intestine [83, 85, 96]

**Locality:** Yen Bai Province (5)

**Incidence and intensity:** No information

**Comment:** This oval trematode is the type species of the genus, originally described from Hemidactylus frenatus in the Philippines [74, 129]. This species is one of the very common trematodes of geckos in Southeast Asian countries such as Indonesia, Thailand, Vietnam and Philippines [14, 64, 78].

3-2-8. *Diplodiscus mehrai* Pande, 1937

**Host and location:** Varanus salvator, intestine [99]

**Locality:** Hanoi Province (14)

**Incidence and intensity:** No information

**Comment:** This species was originally described from Euphyllyctis cyanophlyctis (syn. Rana cyanophlyctis) in Japan [129], followed by records in various frogs in India [50]. Similarly in Vietnam, this trematode was found in various amphibians including Fejervarya limnocharis (syn. Rana limnocharis), Duttaphrynus melanostictus (syn. Bufo melanostictus), Hylarana nigrovittata, Quasipaa verrucospinosa and Paramesotriton deloustali [86, 110]. The family Diplodiscidae is a small group of paramphistomoids found predominantly in amphibians, but also in reptiles and fish, and characterized by a single testis and a ventroterminal sucker [53].


**Syn.** *Mesocoelium pearsei* sensu Pham et Nguyen, 2003

**Host and location:** Varanus nebulosus and Varanus salvator, small intestine [82, 99]

**Locality:** Hanoi Province (14) and southern Vietnam (not specified)

**Incidence and intensity:** No information

**Comment:** Pham and Nguyen [99] collected a small-sized oval mesocoeliid species from the small intestine of varanid lizards in Vietnam and identified it as *Mesocoelium pearsei* Goto et Ozaki, 1930. Subsequently, however, Nguyen and Ha [82] reidentified it as *M. brevicaecum*. This species was originally described from the small intestine of various amphibians in Japan, such as *Bufo japonicus* (syn. *Bufo vulgaris japonicus*), Pelophylax nigromaculatus (syn. *Rana nigromaculata*), Glandirana rugosa (syn. *Rana rugosa*), Lithobates catesbeianus (syn. *Rana catesbeiana*), Elaphe quadrivirgata and *Plestiodon laticulatus* (syn. *Euneces laticulatus*) [94]. Similarly, the trematode was found in Duttaphrynus melanostictus and *Hylarana guentheri* (syn. *Rana guentheri*) from Vietnam and *D. melanostictus* from Taiwan [39]. As too many species in the genus *Mesocoelium* have been described, Dronen et al. [39] recently undertook their evaluation based on intensive morphological criteria and consequently proposed synonymies of multiple species.

3-2-10. *Meristocotyle provitellaria* Liu et al., 2002

**Syn.** *Meristocotyle* sp. sensu Pham et Nguyen, 2003

**Host and location:** Varanus salvator, small intestine [99]

**Locality:** Hanoi Province (14)

**Incidence and intensity:** No information

**Comment:** Fischthal and Kuntz [44] erected a new genus for their new species *Meristocotyle varani* from *Varanus salvator* in the Philippines. Trematodes of this genus are characterized by the unusual bipartite nature of the ventral sucker; in other words, a horizontally
divided ventral sucker with two lumina. Later, Liu et al. [72] described the second species, *M. provitellaria*, from the same host species in China. The morphological characteristics of *Meristocotyle* sp. from *V. salvator* in Vietnam provided by Pham and Nguyen [99] coincided well with those of *M. provitellaria* detailed by Liu et al. [72], whereas they were less coincident with those of *M. varani* reported by Fischthal and Kuntz [44]. These two studies from the Philippines and China documented that worms were collected from the lungs in addition to the intestine.


Host and location: *Varanus nebulosus* and *Varanus salvator*, small intestine [99]

Locality: Hanoi Province (14) and southern Vietnam (not specified)

Incidence and intensity: No information

Comment: In Southeast Asia including Vietnam, human infections with fishborne zoonotic intestinal trematodes have been increasingly reported in the last two decades, with one of the major causes being *Haplorchis pumilio* [123]. This species is common not only in humans but also in mammals, birds and varanid lizards through the consumption of raw freshwater fish [67, 114]. The original description was made using specimens from white pelicans (*Pelecanus onocrotalus*) in Egypt [129].

3-2-12. *Artyfechinostomum sufrartyfex* Lane, 1915

Syns. *Testisacculus indicus* Bhalerao, 1931; *Artyfechinostomum varanum* Simha et Deshpande, 1964; *Testisacculus indicus* sensu Pham et Nguyen, 2003

Host and location: *Varanus nebulosus*, small intestine [99]

Locality: Southern Vietnam (not specified)

Incidence and intensity: No information

Comment: Echinostomatid trematodes of the genus *Artyfechinostomum* Lane, 1915 (syn. *Testisacculus* Bhalerao, 1927) are characterized by a spinose tegument with very large scale-like spines comparable in size to collar-spines, dorsal collar-spines in double rows, and deeply branched testes [65]. The species was originally described using specimens from the duodenum of the Indian spiny-tailed lizard *Saara hardwickii* (syn. *Uromastyx hardwickii*) in India [18, 129]. Simha and Deshpande [112] collected a dozen specimens from the intestine of a single *Varanus bengalensis* and described a new species, namely *Artyfechinostomum varanum*. Bhardwaj [19] collected and examined two specimens from *Varanus bengalensis* in Jabalpur, India, and erected a new genus and species, *Pseudoartyfechinostomum larveiformis*. Premvati and Pande [101] synonymized all described species under the genera *Artyfechinostomum*, *Neoartyfechinostomum* and *Pseudoartyfechinostomum*, and retained only *A. malayanum* (Leiper, 1911) Mendheim, 1943. Kostadinova [65] essentially followed their revision, but elected *A. sufrartyfex* Lane, 1915 (syn. *A. malayanum*) as the type species of the genus. Based on these interpretations, we decided to replace the name of the parasites ‘*Testisacculus indicus*’ collected by Pham and Nguyen [99] with *A. sufrartyfex* in this article.

3-3. Nematoda

3-3-1. **Cosmocercoides tonkinensis** Tran et al., 2015

Host and location: *Acanthosaura lepidogaster*, large intestine [120]

Locality: Cao Bang (8), Son La (4), Bac Giang (17), Thanh Hoa (26) Provinces

Incidence and intensity: 31.3% (10/32) with 1–29 (geomean 4.1) worms/host

Comment: Currently, ca. 20 species of the genus with caudal rosette papillae, not combined with plectanes, have been described mainly in amphibians worldwide. The morphology of this species was well characterized using both light and scanning electron microscopies. The phylogenetic relationships with related species with available genetic data (*Cosmocercoides pulcher* and *Cosmocercoides dukae*) were also reported [120]. This is the third species from lizard hosts after C. *variabilis* in North America and C. *sauria* in Brazil [10, 23, 47].

3-3-2. **Strongyloides mirzai** Singh, 1954

Host and location: *Varanus nebulosus*, intestine [87]

Locality: Vietnam (not specified)

Incidence and intensity: No information

Comment: This species was originally described using specimens from Indian sand boas (*Eryx johnii*) and Oriental ratsnakes (*Ptyas mucosa*) in India [113]. Likewise in Vietnam, the species was found in a variety of snakes such as Chinese cobra (*Naja atra*), many-banded krait (*Bungarus multicinctus*), banded krait (*Bungarus fasciatus*) and Chinese ratsnake (*Ptyas korros*) [86].

3-3-3. **Kalicephalus sp.**


Host and location: *Varanus nebulosus*, oesophagus [87]

Locality: Vietnam (not specified)

Incidence and intensity: No information

Comment: Nguyen [87] recorded *Kalicephalus* nematodes from the oesophagus of clouded monitors (*Varanus nebulosus*) in Vietnam as *K. macrovulvus*. Caballero, 1954, originally isolated from *Aghistrodon bilineatus* in Guatemala. Schad [108] reclassified the species as *K. inermis* distributed in the Neotropical region. Zhang et al. [132] reported two *Kalicephalus* spp., i.e. *K. guangdongensis* and *K. schadi fotedari*, from the intestine of *Varanus salvator* from Guangdong Wildlife Rescue Centre, Guangdong Province, South China, although these two species resembled each other except for spicule length and other morphometric values, and length and position of the externodorsal ray. As the measurements and drawings provided by Nguyen [87] are not sufficient to determine the species, in this article we describe the species from clouded monitors in Vietnam as *Kalicephalus* sp. Re-examination of the specimens in the future should yield a more precise identification. In addition, *Kalicephalus* (*Kalicephalus*) *costatus indicus* Ortlepp, 1923, from *Varanus bengalensis* in India, *K. (K.) megacephalus* Schad, 1962, from *Varanus indicus* in India and *V. salvator* in the Philippines, and *K. (K.) schadi* Ogden, 1966, from *V. bengalensis* in India or Sri Lanka (London Zoo) have been recorded [12]. Furthermore, a variety of *Kalicephalus* spp. has also been recorded from snakes in Southeast and South Asia [66, 73, 77, 102, 108, 130]. Le and Pham [69], and Oshmarin and Demshin [96] recorded the following *Kalicephalus* spp. from snakes in Vietnam: *K. alatospiculus* from Chinese ratsnakes *Ptyas korros* (syn. *Zamenis korros*), *K. viperae chungkingensis* from Indian cobras *Naja naja*, *K. indicus* from Chinese ratsnakes and radiated ratsnakes *Coelognathus radiata* (syn. *Elaphe radiata*), *K. bungari* (syn. *K. najae* after [12, 108]) from Indian cobras, *K. natricis* from Sri Lankan keelbacks *Xenochrophis asperrimus* (syn. *Natrix piscator*) and *Kalicephalus* sp. from banded kraits *Bungarus fasciatus*. *Kalicephalus natricis* Yamaguti, 1935, originally from *Rhabdophis tigrinus* (syn. *Natrix tigrina*) and *Elaphe quadrivirgata* in Japan, is considered to be a ’species inquirenda’, since multiple species, probably *K. costatus indicus*, *K. brachycephalus*, *K. sinensis* or *K. viperae chungkingensis*, were described under the name ’*K. natricis’* [12, 108].

3-3-4. **Oswaldocruzia sp. 1**

Syn. *Oswaldocruzia agamae* sensu Nguyen et Bui, 2007

Host and location: *Hemidactylus frenatus* and *Eutropis longicaudata*, intestine [85, 88]
Locality: Hanoi Province (14) and Yen Bai Province (5)

Incidence and intensity: No information

Comment: Nominal species of the genus *Oswaldocruzia* are currently more than 80 in number [17, 48, 106]. Ben Slimane et al. [17] attempted to subdivide the genus into five groups based on the disposition of the caudal bursal rays, the morphology of the synlophe and the anatomy of the spicules: 1) Oriento-Ethiopian species, 10 spp.; 2) Neo-Ethiopian species, 11 spp.; 3) Holarctic species, 24 spp.; 4) Continental Neotropical species, 21 spp.; and 5) Caribbean Neotropical species, 8 spp. From Vietnam, *O. mitunagai* Durette-Desset, Nasher et Ben Slimane, 1992, and *O. hoepplii* Hsü, 1935, both from *D. melanostictus* and Ranidae, were noted in the identification key of this comprehensive taxonomic study by Ben Slimane et al. [17]. *Oswaldocruzia hoepplii* sensu Moravec et Sey, 1985, nec Hsü, 1935, was considered to be a junior synonym of *O. mitunagai* (the renamed species of *O. hoepplii* sensu Yamaguti et Mitunaga, 1943, nec Hsü, 1935). Following the systematics of Ben Slimane et al. [17], *O. agamae* Sandground, 1930, is a parasite of agamid lizards distributed in Liberia. As the measurements and drawings provided by Nguyen and Bui [88] are not sufficient to determine the species, in this article we describe the species from geckos in Vietnam as *Oswaldocruzia* sp. Re-examination of the specimens in the future should yield a more precise identification.

3-3-5. *Oswaldocruzia* sp. 2

Host and location: *Varanus salvator* and *Varanus nebulosus*, intestine [87]

Locality: Vietnam (not specified)

Incidence and intensity: No information

Comment: This species was differentiated from the former species based on multiple morphological features, e.g. different development of caudal bursa and rays, different morphology of spicules and different egg dimensions (0.07–0.10 mm by 0.05–0.06 mm vs. 0.06–0.07 mm by 0.03–0.04 mm, respectively).

3-3-6. *Herpetostrongylus varani* sensu Nguyen, 2002

Host and location: *Varanus nebulosus*, intestine [87]

Locality: Vietnam (not specified)

Incidence and intensity: No information

Comment: Although the specific name *'Herpetostrongylus varani'* assigned by Nguyen [87] to the herpetostrongylid nematodes from clouded monitors in Vietnam is retained in this article, an exact specific identification is required in the future. At this time, we are unable to ascertain the exact taxonomy of the present specimens due to Nguyen’s measurements and drawings [87] being insufficient for species determination. For reasons outlined in the next paragraph, it is particularly important to evaluate its possible classification in the genus *Vaucherus* Durette-Desset, 1980.

*Herpetostrongylus varani* Baylis, 1931, was originally recorded from Gould’s monitors (*Varanus gouldii*) in Townsville, North Queensland, Australia [16]. At the same time, another species, *Herpetostrongylus pythonis* Baylis, 1931, was described from *Morelia spilota* (syn. *Python spilotes*) in Australia [16], and later recorded in *Varanus salvator* from Palawan, Philippines [109]. Durette-Desset [41] erected a new genus, *Vaucherus*, for three herpetostrongylid nematode species from Indian and Asian varanid hosts: *V. vaucheri* Durette-Desset, 1980, from *Varanus rudicollis* in Kuala Lumpur, Malaysia; *V. leiperi* (Sharief, 1957) Durette-Desset, 1980, from *Varanus indicus* in Hyderabad, India; and *V. indicus* (Deshmukh, 1969) Durette-Desset, 1980, from *Varanus indicus* in Aurangabad, India. Durette-Desset et al. [42] differentiated the genus *Vaucherus* from the genus *Herpetostrongylus* based on differences in bursal ray arrangements; 2-2-1 type with hypertrophied ray 2, and 1-3-1 type with rays 2 and 3 more strongly developed than 5 and 6, respectively.

3-3-7. *Raillietascaris varani* (Baylis et Daubney, 1922)

Sprent, 1985

Syns. *Amplicaecum varani* Baylis et Daubney, 1922; *Amplicaecum monitor* Khera, 1954; *Amplicaecum iguanae* Wahid, 1961

Host and location: *Varanus salvator* and *Varanus nebulosus*, stomach and intestine [87]

Locality: Vietnam (not specified)

Incidence and intensity: No information

Comment: This species was originally described as *Amplicaecum varani* using specimens from the
intestine of Varanus saliator in Calcutta, India, and several different species from Indian varanids were recorded in the decades that followed [130]. Sprent [115] erected a new genus, Raillietascaris, and unified such species from varanids as junior synonyms of R. varani (Baylis et Daubney, 1922). This species was also recorded from Varanus rudicollis in Borneo, Indonesia, and imported Chinese water dragons in Poland [35, 95, 107].

3-3-8. Tanqua tiara (von Linstow, 1879) Blanchard, 1904

Host and location: Varanus salvator, stomach [87]
Locality: Vietnam (not specified)
Incidence and intensity: No information
Comment: This species was originally described using specimens from the stomach of varanid lizards in South Africa. It was subsequently isolated from Varanus salvator in Sumatra, Varanus gouldii in Australia or New Guinea, Varanus bengalensis in Sri Lanka and Varanus niloticus in the White Nile [15, 29, 130]. Gibbons and Keymer [45] redescribed the species in detail, along with a list of previous records of T. tiara from varanids in Africa through to Asia. Phylogenetic analyses of geographical isolates distributed widely would be very interesting.

3-3-9. Meteterakis varani (Maplestone, 1931) Skrjabin et al., 1961

Host and location: Varanus nebulosus, intestine [87]
Locality: Vietnam (not specified)
Incidence and intensity: No information
Comment: The genus Meteterakis Karve, 1930, currently contains 25 nominal species from Oriental amphibians and reptiles. In Vietnam, Meteterakis striatura (Oshmarin et Demshin, 1972) from yellow pond turtle Mauremys mutica (syn. Clemmys mutica) and Meteterakis japonica (Wilkie, 1930) from a yellowcheek (Elopichthys bambusa) have been recorded [79, 96], although the latter record was considered to be an accidental infection [79]. Meteterakis varani was the third Meteterakis species recorded in Vietnam.

3-3-10. Meteterakis mabuyae Chakravarty, 1944

Host and location: Eutropis longicaudata, intestine [85, 88]
Locality: Hanoi Province (14) and Yen Bai Province (5)
Incidence and intensity: No information
Comment: This was the fourth species recorded in Vietnam after M. striatura, M. japonica and M. varani. In addition, at least two Meteterakis spp. were detected in the large intestine of scale-bellied tree lizards, Acanthosaura lepidogaster, in Vietnam. Specific identification of these species is currently in progress (unpublished).

3-3-11. Strongylurus calotis Baylis et Daubney, 1923

Syns. Ascaridia japalurae Yamaguti et Mitunaga, 1935; Strongylurus brevicaudata sensu Hsü et Hoeppli, 1931, nec Müller, 1894

Host and location: Pseudocalotes brevipes and Calotes emma, large intestine [122]
Locality: Phu Tho Province (12) and Bac Kan Province (7)
Incidence and intensity: 57.1% (4/7) with 1–6 worms/host (P. brevipes); 16.7% (1/6) with no intensity information (C. emma)
Comment: This species is distributed widely in agamid lizards from the Oriental region. Tran et al. [122] confirmed for the first time the distribution of the species in Vietnam. Furthermore, their morphological studies of two isolates from P. brevipes and C. emma in Vietnam demonstrated differences in numbers and arrangements of caudal papillae. However, in combination with genetic characterization, their conspecificity was shown [121, 122]. There are at least four nominal Strongylurus spp. in agamid lizards in the Oriental region: S. chamaeleonis Baylis et Daubney, 1922; S. bengalensis Chakravorty, 1936; S. karawirensis Karve, 1938; and S. japalurae Jiang et Lin, 1980. As there are few critical morphological differences among these described species, they need to be genetically characterized to confirm the validity of their taxonomy.

3-3-12. Hastospiculum varani Skrjabin, 1923

Host and location: Varanus nebulosus, body cavity [87]
Locality: Vietnam (not specified)
Incidence and intensity: No information

Comment: There are five Hastospiculum spp. recorded from varanid lizards [20, 130]: H. varani Skrjabin, 1923, from Varanus griseus in Turkistan and Varanus indicus in India; H. bipinnatum von Linstow, 1899, from Varanus griseus (syn. Psammosaurus griseus) in northeastern Africa; H. macrophallos Parona, 1889, or its junior synonym H. spinigerum Chandler, 1929, from Varanus spp. in Myanmar, India and Russia; H. gouldii Yorke et Mapstone, 1926, from Varanus gouldii in Australia; and H. spiralis Bolette, 1998, from Varanus indicus in Indonesia. As the record in Vietnam was based on a single male specimen from the host [87], more specimens need to be examined for an accurate identification of the species.

3-3-13. Piratuboides varanicola (Mackerras, 1962)

Bain et Sulahian, 1974

Syn. Piratuba varanicola Mackerras, 1962

Host and location: Varanus nebulosus, lungs [87]

Locality: Vietnam (not specified)

Incidence and intensity: No information

Comment: Mackerras [75] described two onchocercid filariae of the subfamily Oswaldifilariae in Australian varanid lizards and newly named them as Piratuba queenslandensis and Piratuba varanicola. Bain and Sulahian [11] moved them from the genus Piratuba (equal spicules in size and shape, a short and simple ovejector, and numerous caudal papillae) to a new genus, Piratuboides, characterized as having subequal spicules, a long but simple ovejector, and a smooth female tail or one with small terminal elevations. The type species of the genus is Piratuboides zeae (Bain, 1974) from skinks of Scincidae in Central America, and Piratuboides huambensis was described from blue-tailed skink Trachylepis quinquetaeniata (syn. Mabuya quinquetaeniata) in Angola [97].

3-3-14. Spauligodon vietnamensis Tran et al., 2007

Host and location: Gekko badenii (syn. Gekko ulikovskii), large intestine [119]

Locality: Gia Lai Province (36) and Tay Ninh Province (46)

Incidence and intensity: 90.0% (9/10) with no intensity information (Gia Lai Province)

Comment: Currently, 51 species have been described worldwide in the genus Spauligodon Skrjabin, Schikhalova et Lagodovskaja, 1960 [27]. Spauligodon vietnamensis recorded in golden geckos from Vietnam was the 44th species assigned to the genus [119].

Golden geckos (Gekko badenii) have a limited distribution in the high mountains of central and southern Vietnam, i.e. Tay Ninh, Kon Tum and Gia Lai Provinces [34, 92]. As two scientific names for golden geckos, G. badenii and G. ulikovskii, were published independently in different scientific journals on 15 May and 15 June, 1994, respectively, the former scientific name has priority.

3-3-15. Skrjabinodon azerbajdzanicus (Sharpio, 1974)

Bursey et Goldberg, 1999

Syn. Spauligodon azerbajdzanicus Sharpio, 1974

Host and location: Hemidactylus frenatus, intestine [85, 88]

Locality: Hanoi Province (14) and Yen Bai Province (5)

Incidence and intensity: No information

Comment: The species was originally described from the green-bellied lizard Darevskia chlorogaster (syn. Lacerta chlorogaster) (Sauria: Lacertidae) in Azerbaijan. Referring to the absence of caudal alae in the description of ‘Spauligodon azerbajdzanicus’ by Sharpio [111], Bursey and Goldberg [24] reassigned the species as Skrjabinodon azerbajdzanicus.

3-3-16. Pharyngodon duci Tran et al., 2007

Host and location: Gekko badenii, large intestine [119]

Locality: Gia Lai Province (36) and Tay Ninh Province (46)

Incidence and intensity: 90.0% (9/10) with no intensity information (Gia Lai Province)

Comment: As with the genera Spauligodon Skrjabin, Schikhalova et Lagodovskaja, 1960, and Skrjabinodon Inglis, 1968 [98], the genus Pharyngodon Diesing, 1861, is confined to reptile and amphibian hosts. Although members of these three genera resemble each other, major differences lie in the presence (Pharyngodon and Spauligodon) or absence (Skrjabinodon) of caudal alae. Caudal alae of Pharyngodon spp. are supported by all
three pairs of genital papillae, whereas those of Spauligodon spp. are supported by the two anterior pairs only. The genus Pharyngodon currently contains 37 species, of which five were recorded from amphibians [25, 26, 43]. Pharyngodon duci recorded in golden geckos from Vietnam was the 35th species assigned to the genus [119].

3-3-17. Thelandros vietnamensis Bui et al., 2009
Host and location: Leiolepis reevesii, intestine [22]
Locality: Ha Tinh Province (28)
Incidence and intensity: 85.0% (17/20) with an average of 25.8 worms/host
Comment: The genus Thelandros is closely related to the aforementioned pharyngodinid genera. Parasites of this genus have three, sometimes four, pairs of genital papillae clearly separated into an anterior group (two pairs) around the cloaca and one posterior pair. There is often a fringed membrane covering the cloaca [98]. Petter and Quentin [98] synonymized Parapharyngodon Chatterji, 1933, with Thelandros Wedl, 1862, but Bursey and Goldberg [25] disagreed with this view based on several morphological differences. According to Bursey and Goldberg [25], 31 species are currently assigned to the genus Thelandros, with only two being described from the Oriental region. In the case of the genus Parapharyngodon, 41 species are assigned, with five being described from the Oriental region. After Bursey and Goldberg’s 2005 article [25], T. vietnamensis recorded in Reeves’ butterfly lizard (L. reevesii) from Vietnam has become the 32nd (and 3rd Oriental) species assigned to the genus [22].

3-3-18. Abbreviata deschiensi Le et Nguyen, 1966
Host and location: Calotes versicolor, stomach [68]
Locality: Binh Thuan Province (43)
Incidence and intensity: No information
Comment: The physalopterid genus Abbreviata Travassos, 1920, has an internolateral tooth and externolateral tooth, and two double pairs of submedian teeth on each pseudolabium [29]. Multiple Abbreviata spp. have been recorded in varanid lizards and snakes [54-59].

3-4. Acanthocephala
Nguyen [89] recently provided a list of 76 acanthocephalan species recorded in Vietnam up to the year 2015. This list comprised 13 spp. from freshwater fish, 21 spp. from marine fish, three spp. from amphibians, five spp. from reptiles, 29 spp. from birds and five spp. from mammals. One recorded species in Vietnamese lizards was classified in the family Echinorhynchidae Cobbold, 1876 (Pseudoacanthocephalus Petrochenko, 1956).

3-4-1. Pseudoacanthocephalus nguyenthileae Amin et al., 2008
Syn. Acanthocephalus sp. sensu Nguyen et al., 2005
Host and location: Hemidactylus frenatus, small intestine [6, 85]
Locality: Bac Kan Province (7)
Incidence and intensity: 4.0% (1/25) with 2 worms/host
Comment: This species was dedicated to Prof. Nguyen Thi Le, a parasitologist of IEBR, VAST [6]. It was also found in amphibians and other reptiles in northern Vietnam, i.e. Hylarana guentheri, Hylarana taipehensis, Duttaphrynus melanostictus, Quasipaa verrucospinosa (syn. Paa verrucospinosa), Polypedates mutus and Naja atra [6, 89]. Amin et al. [6] provided an identification key for 11 valid Pseudoacanthocephalus spp. in the world.

3-5. Arthropoda
The subclass Pentastomida Diesing, 1836 (phylum Arthropoda; subphylum Crustacea; class Maxillopoda Dahl, 1956) is commonly known as tongue worms, parasitizing the respiratory tracts of vertebrates [5, 105]. It is divided into four orders: Cephalobaenida Heymons, 1935 (one family); Porocephalida Heymons, 1935 (four families); Raillietiellida Almeida et Christoffersen, 1999 (one family); and Reighardiida Almeida et Christoffersen, 1999 (one family). The worms have a segmented body covered by a chitinous cuticle and the anterior end bears five appendages, i.e. one mouth and two pairs of hooks for attachment to the host.

Three recorded pentastomid species from Vietnamese
lizards were classified in Raillietiellidae Sambon, 1922 (Raillietiella Sambon, 1910).

3-5-1. Raillietiella frenatus Ali, Riley et Self, 1981

Host and location: Hemidactylus frenatus, lungs [2, 85]
Locality: Hanoi (14), Yen Bai (5), Tuyen Quang (6), Bac Kan (7) Provinces and southern Vietnam (not specified)

Incidence and intensity: 30.9% (46/149) with 1–14 worms/host

Comment: Members of the genus Raillietiella are parasites in the respiratory tract of carnivorous lizards. This species was recorded from H. frenatus in Malaysia, Thailand, Vietnam, Indonesia, Philippines and Taiwan, Japalura swinhonis and Eutropis longicaudata in Taiwan [1, 2, 78], and Hemidactylus platyurus (syn. Cosymbotus platyurus) and Geckyra mutiflata in Indonesia [1, 78]. Barton [13] reported R. frenatus from invasive Asian house geckos (H. frenatus) as well as native geckos, Geckyra australis, in northern Australia, suggesting the possible spread of alien parasites through introduced hosts. Furthermore, Kelehear et al. [63] collected R. frenatus not only from invasive Asian house geckos (H. frenatus) but also from invasive cane toads (Rhinella marina) and native tree frogs (Litoria caerulea) in tropical Australia. Riley et al. [105] and Goldberg and Bursey [46] reported a similar problem, i.e. the invasion of alien parasites through introduced hosts, in Texas and Hawaii, respectively.

Kelehear et al. [62] emphasized the importance of molecular analyses of pentastomes in addition to morphological characterization for valid descriptions of new species, because often the same species adopts different morphological phenotypes of taxonomic importance in different host species.

3-5-2. Raillietiella orientalis (Hett, 1915) Sambon, 1922

Host and location: Varanus salvator and Varanus nebulosus, lungs [84]
Locality: Vietnam (not specified)

Incidence and intensity: 12.8% (2/20 V. salvator and 3/19 V. nebulosus) with no intensity information

Comment: This species has a wide spectrum of snake hosts of Colubridae, Elapidae, Viperidae and Boidae in Southeast Asia, India, Philippines, Taiwan, Japan and China [3, 4, 30]. Kelehear et al. [63] reported high prevalences of this Asian pentastomid species in wild snakes native to the Australian tropics such as Tropidonophis mairii (Colubridae), Acanthophis praelongus (Elapidae), Demansia vestigata (Elapidae) and Liasis fuscus (Pythonidae). They considered these records as a recent translocation of alien parasites via an unknown pathway. In Vietnam, R. orientalis causes outbreaks of serious infection in farmed snakes such as Naja naja and Ptyas mucosus. Dang [33] conducted epidemiological surveys of R. orientalis in Indian cobras (Naja naja) and Asian common toads (Duttaphrynus melanostictus) in the field of Vietnam and found infections at an incidence of 39.6% (44/111) with an average intensity of 6.2 worms/snake (range 1–50) and 0.4% (2/500) with 3 worms/toad, respectively. Furthermore, he demonstrated a direct life cycle of this pentastomid species by an experimental infection. Nguyen et al. [84] recorded the species from two varanid species in Vietnam; however, no detailed description was given. In addition, they reported the recovery of possibly another pentastomid species in these two varanid species.

3-5-3. Raillietiella affinis Bovien, 1927

Host and location: Eutropis longicaudata, lungs [85]
Locality: Hanoi (14), Yen Bai (5), Tuyen Quang (6), Bac Kan (7) Provinces

Incidence and intensity: 30.9% (46/149) with 1–14 worms/host

Comment: This species was first collected from the lungs of Gekko gecko (syn. Gekko verticillatus) in Java, Indonesia, then noted in geckos and skinks from Egypt, Sudan or Hawaii [30]. As an invasive species, Dervin et al. [38] reported R. affinis from the Madagascar giant day gecko, Phelsuma grandis. Human cases of R. affinis infection are also known.

In Vietnam, Nguyen et al. [85] recorded a parasitism of the same gecko species with possibly another Raillietiella sp., different from R. frenatus and R. affinis.
4. DISCUSSION

In this article, we present a list of 45 species of endoparasite of Vietnamese lizards. Specifically, 11 cestode, 12 trematode, 18 nematode, one acanthocephalan and three pentastomid species have been recorded from 10 host species. As shown in Table 1, the majority of endoparasite species (55.6%, i.e. 25/45) was recorded from two varanid lizards, V. nebulosus and V. salvator. These lizard species are widely endemic in Vietnam as well as other Southeast and South Asian countries such as Myanmar, Laos, Thailand, Cambodia, Malaysia and Indonesia for the former species, and India, Sri Lanka, Bangladesh, South China, Myanmar, Laos, Thailand, Cambodia, Malaysia, Singapore, Indonesia and Philippines for the latter species [92]. Table 1 also shows that 14 of the 45 endoparasite species (31.1%) were detected in two gecko species, Hemidactylus frenatus and Eutropis longicaudata (149 and 38 geckos examined, respectively). The remaining six endoparasite species (13.3%) were nematodes described from five agamid species and one gecko species. The reports on these six endoparasite species include five new species descriptions, concentrating on one or two targeted parasite(s). Therefore, it would appear that rather than these lizard host species having only a few endoparasites, more parasites remain to be recorded from them. Indeed, we collected at least two Meteterakis spp. from scale-bellied tree lizards, but due to difficulties with taxonomic differentiation, specific identification has yet to be completed.

Except for two species, Cosmocercoides tonkinensis and Strongylurus calotis from agamid lizards, no molecular analyses accompanied the taxonomical characterization of collected parasites [120, 122]. Strongylurus calotis collected from two different agamid species showed two morphotypes with different numbers or arrangements of caudal papillae, which are believed to be of taxonomic importance to separate Strongylurus species [121, 122]. When the geographical and/or ecological isolation of host species are distinct and multiple morphotypes of parasites from them are noted, molecular characterization of parasites can support our specific differentiation or leave invaluable clues to other scientists for future research. As mentioned above, Kelehear et al. [62] emphasized the taxonomic importance of molecular analyses of pentastomes in addition to morphological characterization for accurate species differentiation. Furthermore, recent worldwide spreads of invasive parasites accompanying hosts beyond geographical borders make molecular characterization of isolated parasites a key technology in understanding their exact taxonomic situation, i.e. invasive species or native species.

At the beginning of this review, we highlighted the rich herpetofauna diversity of Vietnam (385 reptiles and 181 amphibians). However, only a fraction of the parasites of reptiles has been recorded in this richly biodiverse territory. Additionally, most of the specimens recorded in the past are no longer available. Parasitological surveys, if actually possible, on multiple lizard hosts in a territory with rich herpetofauna diversity may disclose the ecological relationships among different categories of host lizards in Vietnam or clarify the taxonomic relationship of parasites from Vietnamese lizards with those from lizards of other neighbouring or remote regions. In this sense, it is again recommended that parasites are characterized both morphologically and genetically.

Research on parasite diversity in Vietnam, as having been conducted as large-scale surveys in the country, exclusively used a classical descriptional approach on parasites based on morphological criteria. With this approach, it is often difficult to evaluate morphological variation, as having been experienced in many categories of parasites. Consequently, more recent parasitological research has applied molecular genetic technologies to surveys and parasite characterization, enabling synonymization of morphological variants or detection of cryptic species with an identical morphological manifestation. Furthermore, with the latest taxonomic approaches, we can determine the phylogenetic position of observed parasites or evolitional relationships with related taxa. Usability of these advanced molecular approaches is dependent on the calibre of the background genetic data of the targeted species as well as related species. In contrast to parasites of medical and veterinary importance, the depository of molecular genetic data
of lizard or amphibian parasites is sparse at present. General interest in the biodiversity of local nature or worldwide spread of invasive parasites via translocation of vertebrates beyond natural borders may enhance our particular understanding of all organisms including parasites. We are still a long way from disclosing the full repertoire of endoparasite fauna of lizards from Vietnam.

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ベトナム産トカゲの内部寄生虫：過去50年間（1966−2015）の記録

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要 約

ペットナムの両生類、爬虫類の寄生虫について現在までに得られた知見は限られている。これまでに45種の内部寄生虫がベトナム産トカゲから記録されている。その内訳は、条虫11種、吸虫12種、線虫18種、鉤頭虫1種、舌虫類3種で、宿主となるトカゲは10種を数える。ベトナムが両生類・爬虫類相が世界屈指の豊富さを誇ることを考えると（最近の報告によると、ベトナム国内から記録された爬虫類は385種、両生類は181種とされている）、宿主の生物多様性に比して寄生虫相の研究は遠く及んでいないと考えざるを得ない。今後も正確な寄生虫種の同定を行うとともに、ベトナム産トカゲから得た種と近隣地域あるいは世界から報告された種との異同や類縁性を明確にする研究が取り組まれねばならないが、その実施に際しては形態学的種同定とともに系統分類学的特徴づけが必要である。

Key words：ベトナム、トカゲ、寄生虫、蠕虫、舌虫、記録