ACANTHOCEPHALUS BUFONIS (ACANTHOCEPHALA) FROM *BUFO MARINUS* (BUFONIDAE: AMPHIBIA) IN HAWAII

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Summary :

During a survey of the helminth parasites of the introduced toad, *Bufo marinus*, on O'ahu, Hawaii, an acanthocephalan corresponding to *Acanthocephalus bufonis* (Shiely, 1903) was found in the intestinal tract. This is a new host and locality record for *A. bufonis* which has only previously been recorded from amphibians in the Orient. Possible mechanisms for the introduction of *A. bufonis* to Hawaii, and its transmission to the toad, are discussed. Almost 98 % of toads were infected with a mean intensity of 28.6 acanthocephalans per infected toad. There was a significant negative correlation between host length and intensity of infection with subadult toads having significantly higher infection levels than adult male and female toads. Trunk length of both male and female acanthocephalans was significantly related to host length.

KEY WORDS : acanthocephalan, introduced parasite, *Bufo marinus*, *Acanthocephalus bufonis*, Hawaii.

Résumé : OBSERVATION D'ACANTHOCEPHALUS BUFONIS (SHIPLEY, 1903) (ACANTHOCEPHALA) CHEZ LE CRAPAUD *BUFO MARINUS* (BUFONIDAE: AMPHIBIA) À HAWAII

A l'occasion d'une étude sur la faune helminthologique du crapaud *Bufo marinus* introduit dans l'île O'ahu (Hawaï), nous avons trouvé dans le tube digestif un acanthocéphale que nous avons identifié à *Acanthocephalus bufonis* (Shiely, 1903). Il s'agit d'un nouvel hôte et d'une nouvelle localité pour ce parasite connu jusqu'à présent uniquement chez des Amphibiens orientaux. Les mécanismes probables de l'introduction d'*A. bufonis* à Hawaï et sa transmission au Crapaud sont discutés. Presque 98 % des crapauds sont parasités avec une charge parasitaire moyenne de 28,6 acanthocéphales par crapaud infesté. Il existe une corrélation négative significative entre la longueur de l'hôte et l'intensité du parasitisme, les subadultes ayant une charge parasitaire plus élevée que celle des adultes. Il existe aussi un rapport significatif entre la longueur du tronc des adultes (aussi bien mâles que femelles) et la longueur de l'hôte.

MOTS CLÉS : acanthocéphale, parasite introduit, nouvel hôte, *Bufo marinus*, *Acanthocephalus bufonis*, Hawaï.

During a survey of the helminth parasites of the introduced toad *Bufo marinus* in Hawaii, an acanthocephalan corresponding to *Acanthocephalus bufonis* was found. This parasite has not been recorded previously from amphibians in Hawaii. *Mesocoelium incognitum* (Trematoda) is the only parasite known to infect *B. marinus* in Hawaii (Yuen, 1965).

All amphibians in Hawaii have been purposely introduced (Oliver & Shaw, 1953). Thus, any parasites that are reported in amphibians in Hawaii must also have been introduced and successfully adapted to the environment and potential intermediate hosts for transmission.

MATERIAL AND METHODS

Forty-eight *Bufo marinus* (mean Snout-Vent Length 108.0 mm; range 41.0-160.0 mm) were collected from three locations in Honolulu, Hawaii, November, 1994: the grounds of the University of Hawaii at Manoa, Coconut Island Research Station, and an ornamental pond within the grounds of a private residence (suburb of Manoa). Toads were kept overnight in buckets and anaesthetised by chilling before pithing as recommended by Cooper *et al.* (1989).

The stomach and intestinal tract were removed, placed in saline and opened. All acanthocephalans were recovered, counted and fixed in 70 % ethanol. Specimens were placed in temporary wet glycerol mounts for identification and measurement.

During collection of *A. bufonis* specimens from *B. marinus*, it was noted, in many cases, that the intestine was distended due to the large number of acanthocephalans present. To test for crowding effects among the acanthocephalans, worm body measurements (total length, testes length) were correlated against host SVL, intensity of infection and number of female acantho-

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cephalans in an infection. In addition, the relationship between host SVL and the overall intensity of infection were correlated. Differences in the mean intensities of infection between subadult (< 60 mm SVL), adult female and adult male toads were determined by a one-way analysis of variance.

RESULTS

Forty-seven of the 48 (97.9 %) *B. marinus* were infected with *acanthocephalans* in the intestinal tract. Only one toad also had *acanthocephalans* in the stomach which would appear to be due to overcrowding in the intestinal tract (infection of 106 *acanthocephalans* in a 60 mm SVL toad).

The parasite in this study has been tentatively identified as *Acanthocephalus bufonis* because it has a similar number of proboscis hooks of a similar shape and size as those of *A. bufonis* redescribed by Kennedy (1982) for that species (see Table I). The size, shape and spination of the eggs are also similar.

It should be pointed out that some species of *Acanthocephalus* (including *A. bufonis*) were transferred to *Pseudoacanthocephalus* on the basis of the type of acanthor and whether the host was terrestrial or aquatic (see Golvan, 1969). There is still some debate regarding the validity of this move (see Kennedy, 1982). In view of this, and the fact that many of the *acanthocephalan* species parasitizing amphibians resemble each other closely, we have decided to treat all species as from the one genus (*Acanthocephalus*) when establishing an identification and elucidating the host-parasite relationships.

Mean intensity of *A. bufonis* infection was 28.6 (1-164). There was an overall significant negative correlation between host SVL and intensity of infection ($r = -0.49$, $p = 0.01$; Fig. 1). There was a significant difference between the mean intensities of *A. bufonis* infection in subadult toads (mean: 79.8; range: 56-106), adult male

Fig. 1. – Relationship between snout-vent length of *Bufo marinus* and intensity of *Acanthocephalus bufonis* infection.

(20.9; 1-164) and adult female (36.6; 1-82) toads ($F_{244} = 6.41$, $p = 0.004$).

The relationship between host SVL and trunk length of both male ($r = 0.29$) and female ($r = 0.36$) *acanthocephalans* was significant at the 0.01 level (Fig. 2). Host SVL had no relationship with length of testes in male *acanthocephalans*. Intensity of infection had no relationship with worm length or length of testes or number of females per infection. Number of females per infection had no relationship with testes length.

DISCUSSION

This is the first record of *Bufo marinus* as a host for *Acanthocephalus bufonis*. This is also the first record of the parasite on the islands of Hawaii. These records are unusual as both *B. marinus* and

	This study				Kennedy (1982)			
	N	Min	Max	Mean	N	Min	Max	Mean
Hooks 1-4	87	61	110	87	30	78	111	
Hook 5	15	61	88	76	30	48	93	
Roots 1-4	85	42	76	62	30	56	74	
Root 5	17	42	69	59	30	35	59	
Eggs	10	76	87	83		78	89	85
Host		<i>Bufo marinus</i>				<i>Bufo melanostictus</i>		
						<i>Rana cancrivora</i>		
Geographic location		Oahu, Hawaii				Bogor & Sukabumi, Indonesia		

Table I. – Comparison of average measurements of *Acanthocephalus bufonis* collected from *Bufo marinus* in this study and from amphibians from Kennedy (1982).

Date	Species	Origin	Result	Reference
1867	<i>Rana catesbeiana</i>	California	Not successful	Oliver & Shaw, 1953
1879	<i>Rana catesbeiana</i>	California	Successful	Oliver & Shaw, 1953
1895/1896	<i>Rana rugosa</i>	Japan	Successful	Oliver & Shaw, 1953
1895/1896	<i>Bufo b. gargarizans</i>	Japan	Not successful	Oliver & Shaw, 1953
1890s	<i>Bufo boreas balophilus</i>	California	Not successful	Oliver & Shaw, 1953
1925	<i>Rana nigromaculata</i>	Japan	Not successful	Oliver & Shaw, 1953
1932	<i>Bufo marinus</i>	Puerto Rico	Successful	Oliver & Shaw, 1953
1932	<i>Dendrobates auratus</i>	Panama	Successful	Oliver & Shaw, 1953
1935	<i>Rana clamitans</i>	North America	Not successful	Oliver & Shaw, 1953
1980s	<i>Osteopilus septentrionalis</i>	Cuba/West Indies	Successful	McKeown, 1996

Table II. – Introductions of amphibians to the islands of Hawaii.

A. bufonis appear to have been introduced, separately, to the islands of Hawaii. All amphibian species on the islands of Hawaii have been purposely introduced (Oliver & Shaw, 1953). Of

the ten species introduced, only five were successful in establishing long-term populations (Table II). All species, with the exception of *Dendrobates auratus*, have further colonised islands in the Hawaii chain other than the one to which they were originally introduced (Oahu).

Introduction of parasites to Hawaii would have been possible with their hosts because adult amphibians were collected from the country of origin and released as adults in Hawaii. *Acanthocephalus bufonis* has an oriental distribution, being recorded previously from a variety of host species (Ranidae and Bufonidae) from various countries along the western Pacific rim (see Kennedy, 1982; Khan & Ip, 1986). Of the amphibian species introduced to Hawaii, however, *A. bufonis* (as *A. sinensis*, a junior synonym according to Yamaguti (1954)), has been recovered only from *Rana nigromaculata* from China (van Cleave, 1937). *Rana nigromaculata* was introduced to Hawaii from Japan in 1925 but was not successful in establishing a long-term population. It is possible that *R. nigromaculata* introduced *A. bufonis* to Hawaii where it successfully transmitted to other species, such as *R. rugosa*, before transmitting to *B. marinus* post-1932. It is also possible that *A. bufonis* was introduced by *R. rugosa*, although this species has not been recorded as a host for *A. bufonis*. A different scenario is that *A. bufonis* was introduced to Hawaii by an intermediate host, such as a cockroach. Whichever host species was responsible for the introduction of *A. bufonis* to Hawaii will remain a mystery due to the lack of knowledge of the parasites of the introduced fauna. Further studies into the parasitic fauna of other amphibians on Hawaii will help resolve this problem.

There is also the possibility that there are, in fact, only a few species of *Acanthocephalus* world-wide that exhibit very low host-specificity and that the parasite originates, for example, from South American *B. marinus* as did *Mesocoelium incognitum* (see below). There is at least two species of *Acanthocephalus*, *A. lutzi* and *A. correalimai*, known from *Bufo marinus* in Brazil

Fig. 2. – Relationship between snout-vent length of *Bufo marinus* and trunk length of A) male *Acanthocephalus bufonis*, and B) female *Acanthocephalus bufonis*.

(Hartwich, 1956; Macahdo, 1970) and another similar *Acanthocephalus* species from a bufonid in Chile (Fernandez & Ibarra, 1989).

The life cycle of *A. bufonis* is unknown. The correct intermediate hosts, if not the original source of introduction, must be present in Hawaii to enable the successful transmission of the parasite between host individuals.

This would also appear to be the case for the trematode *Mesocoelium incognitum* which was recorded from *B. marinus* in Hawaii by Yuen (1965). This parasite was originally described in *B. marinus* in its native habitat (South America) and has been introduced to Hawaii with its host. Yuen (1965) did not record investigating any other amphibian species in Hawaii, so it is unknown if it has successfully transmitted to other species. No specimens of *M. incognitum* were found to infect *B. marinus* in Hawaii in this study.

The negative correlation between host SVL and intensity of *A. bufonis* infection is most likely due to a change in diet of the toad as it reaches adulthood. The subadult toads (< 60 mm SVL) had significantly higher levels of infection than did either of the adult sexes indicating that the source of infection occurs primarily in this age group. The increasing size of acanthocephalans in larger toads also suggests that worms were growing larger in older hosts and not being replaced with smaller worms. It is possible that the presence of large adults may be excluding the establishment of new recruits in older hosts. As the life cycle of *A. bufonis* is unknown, it is difficult to postulate on what part of the diet subadult toads are specialising in that would lead to significantly different infection levels.

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