

# Distribution and habitats of *Burnupia trapezoidea* (Boettger, 1910) (Gastropoda: Ancyliidae) in South Africa

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## ABSTRACT

This paper deals with the geographical distribution and habitat preferences of *B. trapezoidea*, the third most widespread species of the 14 species of *Burnupia* currently on record in the database of the National Freshwater Snail Collection (NFSC) of South Africa. Although the 121 loci ( $1/_{16}$  square degrees) from which the 445 samples of *B. trapezoidea* were collected are much fewer than the number reported for *B. capensis*, the range of its geographical distribution is almost as widespread as that of *B. capensis*. The limited distribution of *B. trapezoidea* in the Limpopo, Northern Cape and Western Cape Provinces can most probably be attributed to the paucity of perennial water bodies in these areas and the fact that *Burnupia* spp. in general have poor abilities to overcome conditions of desiccation prevalent in these areas. It is therefore not surprising that the majority of samples were collected in perennial rivers and streams. A Random Forest statistical analysis selected water bodies, the presence or absence of marginal and aquatic vegetation, and type of substratum as the most important variables that played a significant role in determining the presence and numbers of specimens of *B. trapezoidea* in a specific area. In this respect, temperature and turbidity, respectively, played a moderate and minor role. Little is known regarding the conservation status of *Burnupia* spp. in general, but habitat degradation and climatic warming could be reasons for concern. However, in extensive on-going biodiversity surveys in two rivers and selected tributaries in the North-West Province, many new distribution records of *B. trapezoidea* are still being created and therefore this species could probably be considered for listing as not endangered. In view of its wide distribution, largely sessile, benthic lifestyle, and ability to bioaccumulate various substances, the feasibility to utilise it as indicator of river ecosystem health in South Africa should be explored.

**Keywords:** Mollusca, Ancyliidae, *Burnupia trapezoidea*, geographical distribution, habitat preferences, conservation status, South Africa

## INTRODUCTION

The first comprehensive study of the Ancyliidae in South Africa was published by Walker (1923), but the presence of this family in this country was already reported many years earlier (Krauss, 1848). Another important contribution regarding knowledge of this family was made in a monographic survey of the South African non-marine Mollusca (Connolly, 1939). These contributions focused mainly on taxonomic characteristics of the Ancyliidae and little information pertaining to the habitat preferences and range of their geographical distribution was made available. Up till the present, 14 species of *Burnupia* have been reported from southern Africa (Brown, 1994; Appleton 2002; Griffiths et al., 2015). However, Brown (1994) mentions the need for investigating the genetic basis of variation among populations and taxa to understand speciation within the Ancyliidae. This view is supported by Appleton (2002), who is of the opinion that revision of this family is needed at both generic and species level.

Of all the species of *Burnupia* currently on record in the database of the National Freshwater Snail Collection (NFSC), a comprehensive account of the distribution and habitat preferences of only two of the most widespread *Burnupia* species in South Africa, namely *B. capensis* and *B. stenochorias*, has yet been published (De Kock and Wolmarans, 2009). The current paper deals with the geographical distribution and habitat

preferences of *B. trapezoidea*, the third most widespread species of this genus in South Africa, as reflected by the records in the database of the NFSC.

## MATERIALS AND METHODS

*Burnupia* species are relatively inconspicuous freshwater limpets. They are usually attached to solid objects on the substratum or marginal and aquatic vegetation in a wide variety of water body types. However, they need to be specifically looked for during surveys. Up until the late 1980s, Health personnel of government institutions and municipalities made substantial contributions to the number of samples in the NFSC. These personnel received special training regarding sampling techniques during workshops organised by staff of the former Snail Research Unit at the Potchefstroom University for Christian Higher Education. All persons involved in these surveys were provided with a printed collector's form compiled by staff of the former Snail Research Unit. The locality of the collection had to be entered and various alternatives regarding the type and conditions of the habitat had to be underlined, according to the judgment of the collector at time of collection. From 1990 up until the present, additions to the NFSC have come mainly from collections made during a number of surveys conducted by scientists and students from the Potchefstroom Campus of the North-West University, where the NFSC is housed.

Identification of the specimens was done by following the diagnostic criteria laid down by Walker (1923), Connolly (1939) and Oberholzer and van Eeden (1969), and was based largely on shell and radula characteristics; however, origin of the samples was also taken into account. Details of the biotopes of all samples

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of *B. trapezoidea*, dating from 1956 to 2016, which could be located on a 1:250 000 topo-cadastral map series of South Africa, were extracted for analysis from the NFSC database.

The 121 loci ( $1/16$  square degrees) in which the collection sites were located were distributed in preselected intervals of mean annual air temperature and rainfall to illustrate the frequency of occurrence of this species within specific intervals. Statistica 12, Nonparametrics, 2 x 2 Tables, McNemar Fischer exact software were used to calculate Chi square values to determine the significance in difference between the frequency of occurrence in, on, or at the range of options for each variable, such as type of water body, type of substratum or temperature interval. An effect size (Cohen, 1977) was calculated for all the different variables discussed in this paper. The effect size is an index which measures the degree of discrepancy between the frequency distribution of a given species in the set of alternatives of a given variable such as water bodies, as compared to the frequency of distribution of all other mollusc species in the database in the set of alternatives for the same variable (Cohen, 1977). According to this author, values for this index in the order of 0.1 and 0.3 indicate small to moderate effects respectively, while values in the order of 0.5 and higher indicate practically significant large effects. A more detailed account of the significance and interpretation of specific values calculated for this index in a given situation is given in our earlier publications (De Kock and Wolmarans, 2005a; b). To determine the importance of the

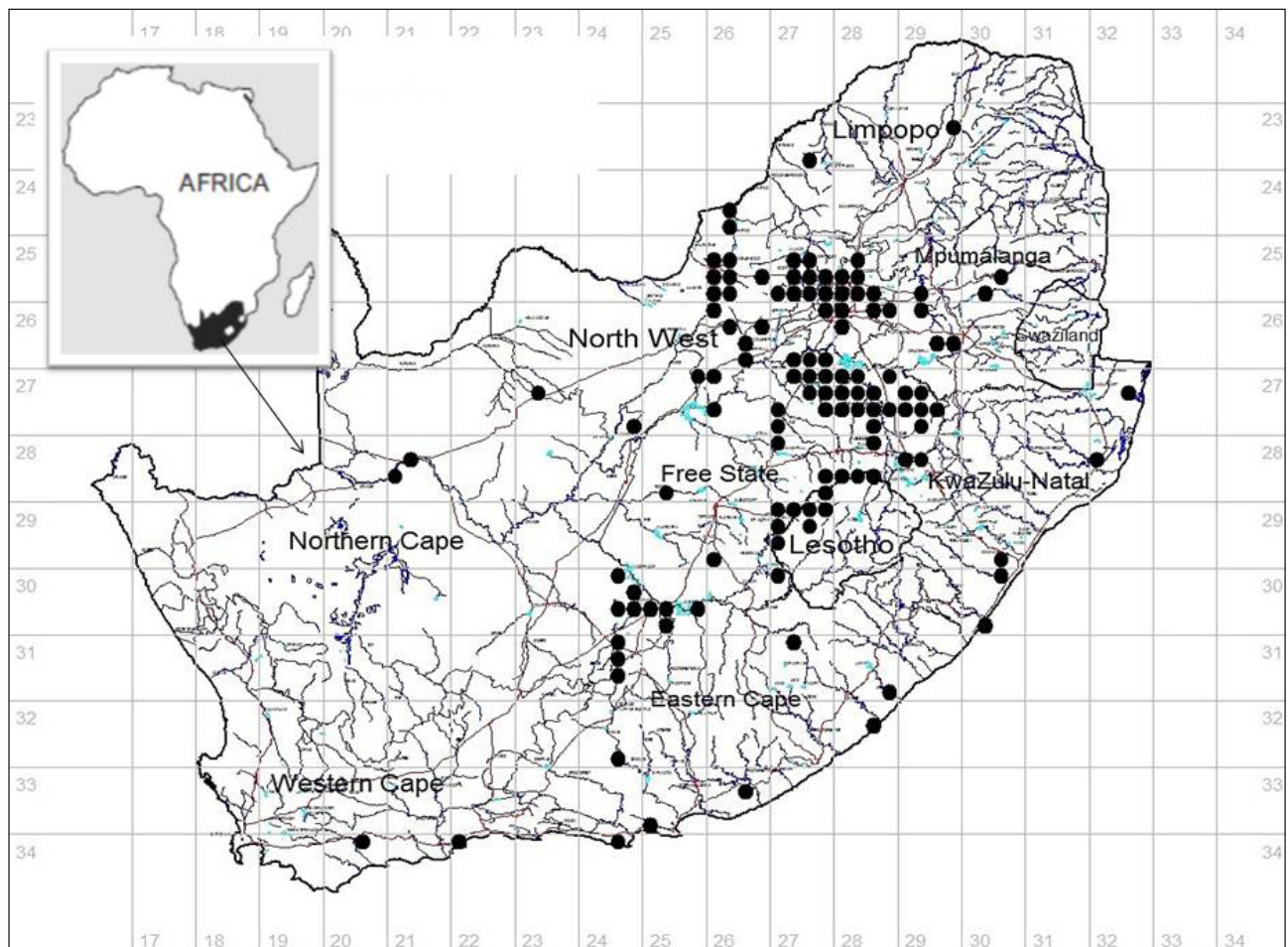
role played by each of the variables recorded in the database on the occurrence, numbers and geographical distribution of *B. trapezoidea*, a Random Forest analysis (Liaw and Wiener, 2002; R Core Team, 2013) was done. The mean decrease in accuracy caused by a variable is determined during the out of bag error calculation phase. The more the accuracy of the Random Forest decreases due to the exclusion (or permutation) of a single variable, the more important that variable is deemed and therefore variables with a large mean decrease in accuracy are more important for classification of the data.

## RESULTS

The 445 samples of *B. trapezoidea* which could be pinpointed on a topo-cadastral map series fell within the 121 loci depicted in Fig. 1.

This species was collected in 10 of the 14 different water-body types represented in the database. The largest numbers of samples came from rivers and streams; however, the six samples collected in springs represented a slightly higher percentage (1.74%) of the total number of times molluscs were reported from this type of water body in the database (Table 1).

The frequency of occurrence in rivers and streams did not differ significantly ( $\chi = 1.46$ ,  $df = 1$ ;  $p > 0.05$ ); however, Chi square values indicated that the frequency of occurrence in



**Figure 1**

Geographical distribution of *Burnupia trapezoidea* in  $1/16$  square degree loci in South Africa as reflected by the 445 records in the database of the National Freshwater Snail Collection

these two water body types differed significantly ( $p < 0.05$ ) from most of the other types of water body. An effect size of 0.44, which is deemed as moderate to large, was calculated for water bodies. The majority of samples were collected in perennial habitats for which the water conditions were described as clear and fresh, while equal numbers of samples were reported from slow-running and standing water (Table 2). The frequency of occurrence in perennial water did not differ significantly from seasonal water ( $\chi = 0.83$ ,  $df = 1$ ;  $p > 0.05$ ). A large value was calculated for the effect of current speed, while both perennial and seasonal water, as well as turbidity, had only a small effect and salinity no effect at all (Table 2).

The majority of samples were reported from water bodies with predominantly stony substrata (Table 3) and the frequency of occurrence on this type of substratum differed significantly ( $p < 0.05$ ) from all other types.

More than 80% of the samples were collected at sites which fell within the interval of mean annual temperature ranging from

16 to 20°C (Table 4) and the frequency of occurrence differed significantly from sites falling within the other two intervals in which samples were collected ( $p > 0.05$ ). More than 70% of the samples were reported from sites falling within the interval of mean annual rainfall ranging from 601 to 900 mm (Table 4). A moderate and a moderate to large effect value were calculated for rainfall and temperature, respectively (Table 4).

The Random Forest analysis (Fig. 2) selected water bodies, the presence or absence of marginal and aquatic vegetation, and type of substratum as the most important variables that played a significant role in determining the presence and numbers of specimens of *B. trapezoidea* in a specific area. In contrast, according to this analysis, temperature had a moderate effect, while current speed and turbidity played only a minor role in this respect.

## DISCUSSION

*Burnupia trapezoidea* was described by Boettger in 1910 from the type locality in Botswana (Brown, 1994), and its occurrence in South Africa was reported 2 years later by Walker (1923).

**TABLE 1**  
**Types of water bodies in which *Burnupia trapezoidea* was found in 445 collection sites recorded during surveys**

Water bodies	A	B	C	D
Channel	1	0.22%	182	0.55%
Dam	74	16.63%	8 452	0.88%
Ditch	1	0.22%	642	0.16%
Pool	1	0.22%	233	0.45%
Pond	5	1.12%	1 632	0.31%
Quarry	1	0.22%	126	0.79%
River	131	29.44%	7 617	1.72%
Spring	6	1.35%	345	1.74%
Stream	124	27.87%	7 410	1.67%
Swamp	7	1.57%	2 080	0.03%

Effect size:  $w = 0.44$  (moderate to large effect)

A: Number of times collected in a specific water body  
 B: % of the total number of collections on record for this species  
 C: Number of times any mollusc was collected in a specific water body  
 D: % occurrence of this species in the total number of collections in a specific water body

**TABLE 3**  
**Substratum types in the habitats of *Burnupia trapezoidea* as described during surveys**

	Substratum types			
	Muddy	Stony	Sandy	Decomposing material
A	114	200	62	9
B	25.62%	44.94%	13.93%	2.02%
C	12 907	8 008	6 880	652
D	0.88%	2.50%	0.90%	1.38%
E	$w = 0.53$ (large effect)			

A: Number of times collected in a water body with a specific substratum  
 B: % of the total number of collections (445) on record for this species  
 C: Number of times any mollusc was collected in a Water body with a specific substratum  
 D: % occurrence of this species in the total number of collections in a water body with a specific substratum  
 E: Effect size values calculated for substratum types

**TABLE 2**  
**Water conditions in the habitats of *Burnupia trapezoidea* as described during surveys**

	Type		Current speed			Turbidity		Salinity	
	Perennial	Seasonal	Fast	Slow	Standing	Clear	Muddy	Fresh	Brackish
A	259	70	33	148	148	262	87	267	8
B	58.20%	15.73%	7.42%	33.23%	33.23%	58.88%	19.55%	60.00%	1.80%
C	22 807	5 386	2 308	9 903	16 192	20 334	6 669	24 446	697
D	1.27%	1.30%	1.43%	1.49%	0.91%	1.29%	1.30%	1.09%	1.15%
E	$w = 0.20$ (small effect)		$w = 0.83$ (large effect)			$w = 0.01$ (small effect)		$w = 0.0$ (no effect)	

A: Number of times collected in a specific water condition  
 B: % of the total number of collections (445) on record for this species  
 C: Number of times any mollusc was collected in a specific water condition  
 D: % occurrence of this species in the total number of collections in a specific water condition  
 E: Effect size values calculated for each factor

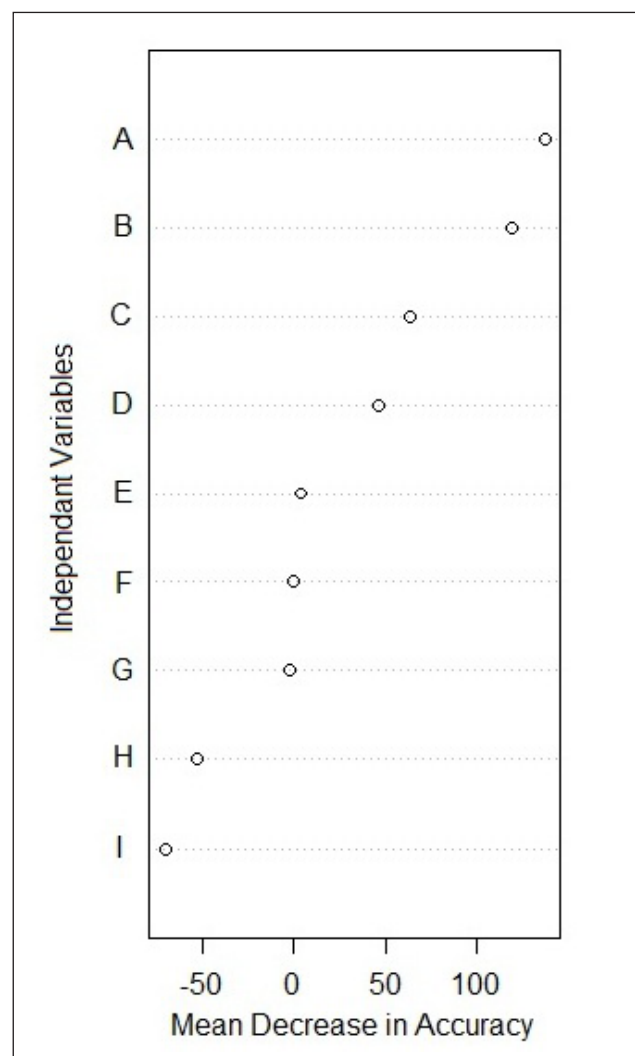
	Temperature intervals (°C)			Rainfall intervals (mm)			
	11 – 15	16 – 20	21 – 25	0 – 300	301 – 600	601 – 900	901 – 1 200
<b>A</b>	69	359	17	7	117	318	3
<b>B</b>	15.51%	80.67%	3.82%	1.57%	26.29%	71.46%	0.67%
<b>C</b>	4 467	24 607	4 783	1 031	12 734	19 227	1 236
<b>D</b>	1.54%	1.46%	0.36%	0.68%	0.92%	1.65%	0.24%
<b>E</b>	$w = 0.40$ (moderate effect)			$w = 0.32$ (moderate effect)			

A: Number of times collected in a locality falling within a specific interval  
 B: % of the total number of collections on record for this species  
 C: Number of times any mollusc was collected in a locality falling within a specific interval  
 D: % occurrence of this species in the total number of collections within a specific interval  
 E: effect size values calculated for each factor

However, the oldest record of this species in the database of the NFSC was collected in 1957 in a stream on the farm Feeshuis 484 in the Soutpansberg district of the Limpopo Province, South Africa. Although the 121 loci from which the samples of *B. trapezoidea* were collected are much fewer than the 257 loci reported for *B. capensis* (De Kock and Wolmarans, 2009), the range of its geographical distribution (Fig. 1) almost as widespread as that of *B. capensis*. The poor distribution of *B. trapezoidea* in the Limpopo, Northern Cape and Western Cape Provinces can most probably be attributed to the paucity of perennial water bodies in these areas and the fact that *Burnupia* spp. in general have poor abilities to overcome conditions of desiccation prevalent in these types of water body (Brown, 1994). Brown (1994) records this species from Kamanyab in Namibia and Ngamiland in Botswana and is of the opinion that it probably occupies much of the range known for this genus, which is in accordance with the considerable overlap of its distribution with those of *B. capensis* and *B. stenochorias* reported by De Kock and Wolmarans (1909). Brown (1994) also mentions that *B. trapezoidea* is 'widely thought to occur only in Africa, but reports of its presence in the southern part of South America cast doubt on this.'

The large and moderate to large effect values which were calculated for types of water bodies and types of substrata, respectively, suggest that these variables played a significant role in establishing the documented geographical distribution of this species in South Africa, a conclusion also substantiated by the results of the Random Forest analysis (Fig. 2). These findings are also in accordance with the results reported for *B. capensis* and *B. stenochorias* by De Kock and Wolmarans (2009). The results of the Random Forest analysis also indicated that temperature and turbidity played a minor role in determining the presence or absence of *B. trapezoidea* in specific areas, findings also supported by the moderate to small effect values calculated for these two variables, respectively (Tables 2 and 4). Statistical analyses indicated that temperature only played a moderate role in the presence or absence of this species in a specific area, which is in accordance with its geographical distribution which shows that it was collected in aquatic biotopes located in some of both the coldest and warmest areas in South Africa (Fig. 1).

The findings that the majority of samples of *B. trapezoidea* were collected in rivers and in biotopes with stony substrata is in accordance with the results of a project currently in progress to assess the ecological health of the Marico River (North



**Figure 2**  
 Results of the Random Forest analysis of the independent variables calculated for the 445 collection sites of *B. trapezoidea*. A: Water bodies; B: Presence or absence of aquatic vegetation; C: Types of substrata; D: Perennial or seasonal water; E: Mean yearly air temperature per locus; F: Brackish or fresh water; G: Mean yearly rainfall per locus; H: Current speed; I: Turbidity

West Province) and the Crocodile River (North West and Limpopo Provinces), which is being conducted by the authors and postgraduate students of the Potchefstroom Campus of the North-West University (Kemp et al., 2016). During these surveys, many specimens of this species were found on stones in in-current and out-of-current biotopes. However, specimens were also found in aquatic and marginal vegetation biotopes, which also substantiate the results depicted in Fig. 2.

The importance of biotope availability for macroinvertebrate communities in South African rivers has already been reported by Dallas (2007) and Odume et al. (2015). The finding that *B. trapezoidea* can utilise benthic, as well as vegetation biotopes and is widely distributed in South Africa, makes it an excellent candidate for the assessment of the bioavailability of metals in river systems in South Africa. It is known that freshwater molluscs can accumulate metals in their soft tissue and also incorporate various mineral and organic substances in their shells (Carrell et al., 1987; Pourang, 1996; Korniusshin, 2000). Laboratory experiments also indicated that *B. stenochorialis* could possibly be exploited as an ecotoxicological indicator in whole-effluent toxicity testing (Davies-Coleman and Palmer, 2004).

According to Lydeard et al. (2004) the largest number of documented extinctions, out of all taxa, are reported for the molluscs. Furthermore, it is estimated that the rate of extinction of freshwater organisms could be as high as 4% per decade (Dudgeon et al., 2006), and knowledge with regard to the conservation status of South African freshwater molluscs is poor (Herbert, 1998). With regard to its conservation status, *B. trapezoidea* is listed as 'data deficient' in the revised edition of the IUCN Red Data List, but Seddon et al. (2011) are of the opinion that habitat loss and degradation could pose a threat to *Burnupia* spp. in general. In view of the fact that members of this genus are sensitive to desiccation and are most frequently found in streams and rivers, global warming could have a negative impact on their survival. A significant decline in species diversity and numbers of gastropods due to climatic warming was indeed reported by Mouthon and Daufresne (2006) in an assessment of the Saône River in France. However, in the extensive on-going biodiversity survey of the two rivers and selected tributaries in the North-West Province mentioned earlier, many specimens of *B. trapezoidea* are still being found at new localities (Kemp et al., 2016), and this species could, therefore, probably be considered for listing as not endangered. In view of its relatively wide distribution, largely sessile, benthic lifestyle, and established ability of molluscs to accumulate various substances, including pollutants, in their soft material and shells, it is recommended that the feasibility to utilise *B. trapezoidea* as an indicator of river ecosystem health in South Africa should be explored.

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