THE MARINE TOAD, *BUFO MARINUS*, IN PAPUA NEW GUINEA

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ABSTRACT

In an attempt to assess the economic effect of Bufo marinus, *two different types of agricultural areas were selected for survey. Routine collections were made at a cocoa plantation near Popondetta in the Northern District of Papua New Guinea, and at the Plant Quarantine Station, Laloki, in the Central District of Papua New Guinea. The stomach contents of all individuals were identified at least to family level and more precisely if possible. An assessment was then made of the economic status, i.e., beneficial or harmful, of each grouping. The results indicate that in certain situations the presence of* Bufo marinus *can be beneficial.*

INTRODUCTION

The marine toad, *Bufo marinus* is a native of the lowlands of central and northern South America.

This toad is a savanna species with a propensity for eating insects and other arthropods, and has been introduced into many tropical countries as a biological control measure against pests which attack commercial crops.

Bufo marinus was first introduced into Papua New Guinea in February, 1937 at the Department of Agriculture, Stock and Fisheries' experimental station at Keravat, near Rabaul, New Britain, in an effort to control the Sweet Potato Moth, *Hippotion celerio*, a serious pest at the time. A considerable degree of success was achieved in Keravat as it was reported that there was a 100 per cent control of the moth (Lear, 1970).

There does not appear to be any record of its introduction into Papua New Guinea although it is believed that prior to World War II, the Department of Public Health brought the toads to Port Moresby for use in pregnancy tests. In this role the toad was not successful, and was either released or escaped.

The purpose of the present study was to examine areas in which *Bufo marinus* was already established, and where the food taken was more likely to be of economic importance in order to further study the usefulness, if any, of the toad in Papua New Guinea.

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It will be appreciated that there are considerable difficulties in "pigeon-holing" the majority of organisms in terms of economic importance. What may be termed a pest in one area, could well be of no significance in another.

Distribution and Reproduction

The following brief summary has been taken from Zug *et al.* (1974). *Bufo marinus* has spread throughout the lowlands and islands of Papua New Guinea below the 300 metre contour, with the exceptions of the Sogeri Plateau 600 metres altitude, and Wau Valley (786 metres). It was also introduced to Goroka (1525 metres), but did not survive there.

Bufo marinus has not been found in the Gulf District or, with the exception of Daru Island, in the Western District. *Figure* 1, taken from Zug *et al.* is a distribution map of the toad in Papua New Guinea.

As the minimal critical temperature for *Bufo marinus* is 15° C (Stuart, 1951) it is unlikely that the toads will move into the highlands above the 1475 metre contour, where the air temperature frequently falls below 15° C. This would bear out their disappearance from Goroka.

Since *Bufo marinus* appears to have been remarkably successful in colonising areas into which it has been introduced, especially urban areas, and since *Bufo marinus* does not have any known predators in Papua New Guinea, it would seem that temperature could be the most

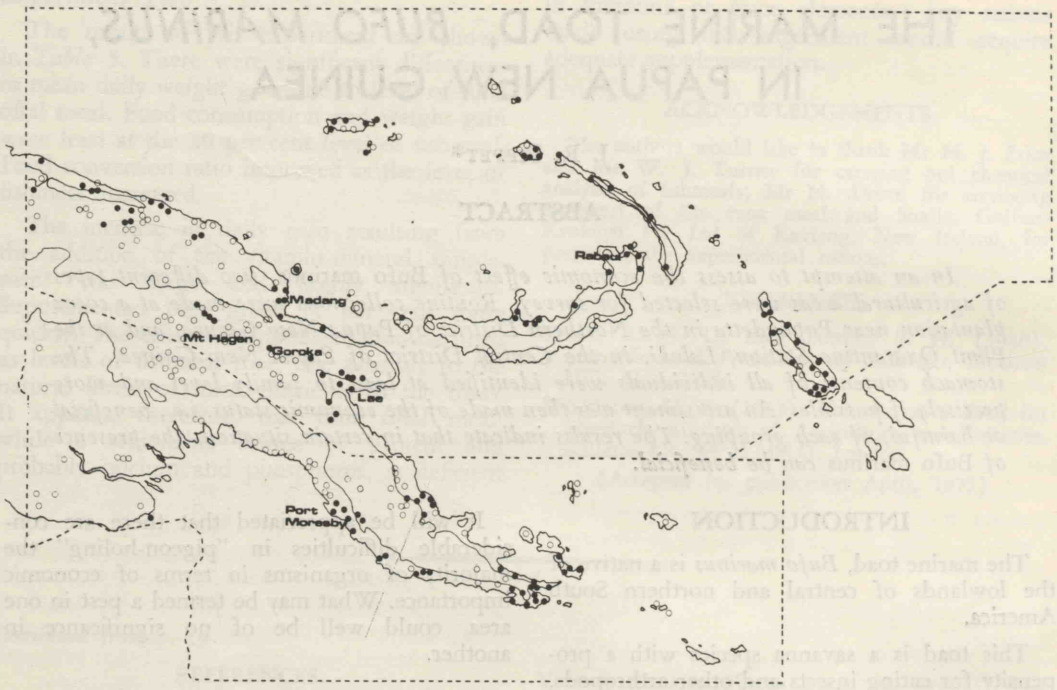

Figure 1.—Distribution of *Bufo marinus* in Papua New Guinea. The continuous line on the mainland and larger islands shows the approximate 300 m contour. *Bufo* present ● *Bufo* absent °

important factor in restricting it to elevations where the air temperature does not frequently fall below 15 degrees.

Bufo marinus will breed in almost any body of water, either fresh or brackish. Although preferring standing water it will breed in rivers. As some of the toads are able to breed throughout the year they are able to take advantage of any heavy rains, which trigger their breeding cycle.

About 10,000 jet-black eggs imbedded in a gelatine-like substance are laid in long ropes of up to 23 metres in length. These ropes are curled around vegetation at the water's edge. The eggs hatch within two to three days and the tadpoles take about thirty days to complete their metamorphosis (Oliver, 1949). The newly developed toad is about 6 mm long. The toadlets usually stay in the vicinity of their pond for about four days feeding on ants and small flies, they then disperse into the surrounding vegetation.

The female may have two breeding cycles during the year.

METHODS

Over a two-year period collections were made in seven different localities. In 1971-72 collections were made bi-monthly at the Waigani Sewage Farm 14 kilometres north-west of Port Moresby and along a 10 kilometre stretch of the Brown River Road bordered by forest and 24-34 kilometres north-west of Port Moresby. As neither of these areas is of any agricultural importance, we concentrated during 1973 on two diverse areas which are agriculturally more significant.

1) The DASF quarantine station on the alluvial plains of the Laloki River, 15 kilometres north-west of Port Moresby, in an area used for growing vegetables.
2) A cocoa plantation at Serovi, near Popondetta, in the Northern District.

Collections were made at monthly intervals on the last quarter of the lunar phase between 2000-2100 hours. Fifty *Bufo marinus* were taken monthly at Popondetta; the numbers taken at Laloki varied between 17-50 depending on the number it was possible to pick up in the time available.

Toads collected at Popondetta were injected with formalin and flown to Port Moresby for examination, whilst those collected at Laloki were deep frozen on the night they were captured.

All toads were weighed, measured (snout-vent length) and sexed. The fat body was also recorded, and the ovaries of the females were weighed and classed according to their degree of maturity. Stomach contents were weighed and classified, at least to family level and if possible to species. They were then classified as either harmful, neutral or beneficial according to their economic importance. The classification was based on the experience of the DASF entomologists for the more important pests of Papua New Guinea, whilst Imms (1964) and CSIRO (1970) were used for determining minor pests.

In order to gauge the variety of insects in the area an ultra-violet light trap was run at the Laloki collecting station, weather permitting. The trap was started after the collection of *Bufo marinus* had been made and ran until the following morning, approximately 11 hours running time.

Tables 1 and 2 show the numbers and type of prey taken by *Bufo marinus* at Laloki and Popondetta respectively. In each case the four largest groups are Coleoptera (296 individuals at Laloki/824 individuals at Popondetta), Lepidoptera (302/453), Hemiptera (143/375), Orthoptera (132/87) and Myriapoda (6/176). The reason for Laloki having a greater proportion of Orthoptera as opposed to other orders, is probably due both to the extensive use of cover crop prior to ploughing and planting and the type of crop grown, i.e., market garden produce, which appear to be particularly favoured by grasshoppers, at least in the Port Moresby area.

Light trapping at Waigani Sewage Farm gave an average biomass of 6 grams, often consisting mainly of moths which had been attracted to the light, and were seldom found in the stomachs of toads collected prior to the setting of the light trap.

At Laloki only spasmodic light trapping was carried out, and the results are inconclusive. However, the biomass of the catch was more than double that of the Waigani Sewage Farm, being 13.6 grams. Here again a considerable number of Lepidoptera was taken, although the analysis of the stomachs show relatively few imagos in comparison with the numbers attracted to the light trap.

Prey taken from the stomachs of captured *Bufo marinus* was so far as practical divided into three categories: beneficial, neutral and harmful. *Tables* 3 and 4 list the number of individuals and their suggested economic category.

In the Laloki area (*Table* 3) the harmful species exceeded the combined total of the beneficial and neutral in both numbers and biomass, whilst in the Popondetta area (*Table* 4) the number of beneficial and neutral species exceeds that of the harmful species, although the biomass of the latter is very much greater than that of the beneficial and neutral species combined.

DISCUSSION

Bufo marinus is omnivorous and will grab at anything which moves and is small enough to swallow. It was originally thought that the toads were only attracted to moving objects, regardless of whether they were edible or not (Oliver in Alexander, 1964). Alexander (1964) also refers to the toads' taste for dog food. Our studies have confirmed this for Papua New Guinea as it is a very common sight in the urban areas of Papua New Guinea to see toads around a dog's dish eating the left-overs of canned pet food and rice.

At the Waigani Swamp Pond where the population of *Bufo marinus* appears to have reached saturation point, we found that the majority of the population was both undersized and emaciated, nor was it uncommon to find up to 20 per cent of the night's catch with either stomachs crammed full of grass and leaves, or empty.

It would seem that the toads whose stomachs were full of grass had purposely eaten the vegetation, since there were no insects amongst the grass.

The catch from the light trap bears out the paucity of insects available to the toads over 7-8 months of the year.

In none of the other areas from which collections were made did we find toads with their stomachs full of grass and nothing else. It is naturally quite common to find pieces of vegetation in the stomach contents of *Bufo marinus*, such pieces have been ingested when the toad snapped at its prey.

Table 1.—Stomach contents of ***Bufo marinus*** taken at Laloki between January and December, 1973. Number of individuals 351. Mean stomach contents 1.5 g

ANNELIDA
OLIGOCHAETA
1 earthworm

MOLLUSCA
GASTROPODA
1 snail

ARTHROPODA
CRUSTACEA
ISOPODA
2 slaters

MYRIAPODA
CHILOPODA
3 centipedes

DIPLOPODA
6 millipedes

SCORPIONES
1 scorpion

ARACHNIDA
ARANEAE
12 spiders

ACARINA
1 mite

INSECTA
BLATTODEA
BLATTIDAE
4 cockroaches

ISOPTERA
26 termites

ORTHOPTERA
GRYLLIDAE
64 crickets *Acheta commoda*

ACRIDIDAE
64 short-horn grasshoppers

TETTIGONIIDAE
4 long-horn grasshoppers

HEMIPTERA
2 FLATIDAE
5 CICADIDAE Cicadas
16 MIRIDAE
5 REDUVIIDAE Assassin bugs
1 ENICOCEPHALIDAE *Oncylocotis*
26 COREIDAE
1 PLATASPIDAE
45 CYDNIDAE
50 PENTATOMIDAE Shield bugs

COLEOPTERA
30 CARABIDAE including
5 Cicindelinae Tiger beetles
1 *Pheropsophus verticalis*
2 HYDROPHILIDAE
8 STAPHYLINIDAE

82 SCARABAEIDAE including
3 Cetoniinae
9 Melolonthinae Chafers
30 *Aphodius*
29 Hybosorinae

33 ELATERIDAE, Click beetles including
17 *Lacon*
2 *Heterodes*
2 *Colacon*

4 BOSTRYCHIDAE
5 LANGURIIDAE
18 COCCINELLIDAE Ladybirds
13 TENEBRIONIDAE
4 LAGRIIDAE
2 ANTHICIDAE
16 CERAMBYCIDAE Longhorn beetles
54 CHRYSOMELIDAE including
3 Cassidinae Tortoise beetles
1 BRENTHIDAE
6 APIONIDAE *Cylas formicarius*

18 CURCULIONIDAE Weevils including
2 *Oribius*
2 *Leptopius squalidus*

DIPTERA
2 (1 larva, 1 adult)

LEPIDOPTERA
12 moths
290 Larvae, including
82 SPHINGIDAE including
59 *Herse convolvulus*
198 NOCTUIDAE including
152 *Spodoptera*
60 *Plusia*
17 GEOMETRIDAE *Ectropis*

HYMENOPTERA
395 including
2 VESPIDAE
4 SPHECIDAE
1 ICHNEUMONIDAE
385 FORMICIDAE mainly *Pheidole*

CHORDATA
SQUAMATA
SCINCIDAE
1 skink

Table 2.—Stomach contents of *Bufo marinus* taken at Serovi Plantation, Popondetta, Northern District, from March to November, 1973. Number of individuals 405. Mean stomach contents 2.3 g

ANNELIDA
OLIGOCHAETA
3 earthworms

MOLLUSCA
GASTROPODA
17 snails, 2 spp

ARTHROPODA
CRUSTACEA
ISOPODA
2 slaters

MYRIAPODA
CHILOPODA
2 centipedes

DIPLOPODA
172 millipedes, 3 spp

ARACHNIDA
ARANEAE
28 spiders

ACARINA
2 ticks

PHALANGIDA
1 harvestmen

INSECTA
BLATTODEA
BLATTIDAE
16 cockroaches

ISOPTERA
94 termites

DERMAPTERA
20 earwigs, including
9 Forficulidae
8 Labiidae

ORTHOPTERA
GRYLLIDAE
48 crickets *Acheta commoda*

ACRIDIDAE
2 short-horn grasshoppers

TETTIGONIIDAE
31 long-horn grasshoppers

GRYLLOTALPIDAE
1 mole cricket

PYRGOMORPHIDAE
5 specimens

COLEOPTERA
67 CARABIDAE
1 DYTISCIDAE
4 HYDROPHILIDAE
27 STAPHYLINIDAE Rove beetles
3 LUCANIDAE Stag beetles
2 PASSALIDAE
220 SCARABAEIDAE including
94 Hybosorinae
4 *Aphodius*
54 Coprinae
5 Dynastinae *Papuana*
57 Melolonithinae Chafers
1 Rutelinae
1 BYRRHIDAE Pill beetle
1 HETEROCERIDAE
1 RHIPICERIDAE
123 ELATERIDAE Click beetles including
4 *Aeolus*
9 *Colacon*
4 *Corodius*
14 *Compsolacon*
83 *Lacon*
3 *Lanelater*
18 EUCNEMIDAE
1 LYCIDAE
2 ANOBIIDAE
10 BOSTRYCHIDAE
42 NITIDULIDAE
2 EROTYLIDAE
5 COCCINELLIDAE
19 LANGURIIDAE
40 TENEBRIONIDAE
2 LAGRIIDAE
57 CERAMBYCIDAE Longhorn beetles
14 CHRYSOMELIDAE Leaf beetles
2 ANTHRIBIDAE
10 BRENTHIDAE
6 APIONIDAE *Cylas formicarius* (Sweet Potato Weevil)
146 CURCULIONIDAE, Weevils, including
48 *Pantorhytes szent-ivanyi*
25 Cryptorrhynchinae sp
2 Cossoninae sp
1 *Oribius* sp
13 *Leptius* sp including
10 *Leptopius squalidus*

Table 2 *continued next page*

Table 2.—continued

HEMIPTERA
- 3 FLATIDAE
- 1 CERCOPIDAE
- 31 CICADIDAE emerging nymphs
- 1 MEMBRACIDAE
- 70 MIRIDAE
- 8 REDUVIIDAE Assassin bugs including
  - 1 Emesinae
- 1 PYRRHOCORIDAE
- 248 DINIDORIDAE *Megymenum papuense*
- 10 PLATASPIDAE
- 12 PENTATOMIDAE Shield bugs

DIPTERA
- 76 Larvae, including
  - 1 STRATIOMYIDAE
  - 3 TIPULIDAE Crane flies

LEPIDOPTERA
- 105 moths
- 348 caterpillars, including
  - 242 GEOMETRIDAE
    - 167 *Ectropis*
    - 75 *Hyposidra*
  - 8 NOCTUIDAE *Plusia*
  - 10 AGARISTIDAE
  - 23 LYMANTRIIDAE

HYMENOPTERA
- 982 including
  - 1 VESPIDAE
  - 1 APOIDEA
  - 1 ICHNEUMONIDAE
- 954 FORMICIDAE various spp

CHORDATA
- SQUAMATA
  - SCINCIDAE
    - 2 skinks

Amongst the more unusual objects found in the stomachs of these toads were: cigarette butts, a small cork, feathers, two small *Bufo marinus* (SVL 32 and 33 mm), skinks, and quite large pieces of gravel.

Bufo marinus is only able to prey upon animals within its reach at and near ground level. This therefore is one of the limiting factors in its use as a biological control. As the incidence of pest species in commercial plantations or market gardens is likely to be higher than either neutral or beneficial species, the toad may be regarded as beneficial in these situations.

Minor outbreaks of caterpillar pests at Laloki were kept in check by toad predation. *Bufo marinus* also made considerable inroads on the Pentatomid *Megymenum papuense* a minor pest of curcurbits, at Serovi Plantation.

Bufo marinus cannot increase indefinitely in the niche it has found in Papua New Guinea, as the population is limited by the availability of habitat and the concomitant competition for food. It is essentially an urban and open habitat species with poor representation in rain forest areas. When the savanna population increases beyond the food carrying capacity many individuals suffer extreme emaciation and die.

In Papua New Guinea, habitat and density appear to play an important part in the ultimate size reached by the adult. *Table* 5 shows the average size of all toads caught in the seven areas from which they were collected as well as the size and weight of the largest individuals.

Toads taken from the Waigani Sewage Farm, where the population has reached a high density, include individuals with atrophy of the liver, whilst others had cysts on the walls of their stomach and intestines. In 1965 a similar situation was observed at Keravat (DASF, 1965).

In practically all areas of the Pacific into which the toad has been introduced, as maximum population density is approached the size of the individuals decreases (Alcala, 1957).

In the two areas covered by this survey, *Bufo marinus* appears to be beneficial. The results of the investigation carried out by Zug *et al.* in non-economic areas show the toad to be neutral in so far as prey consumed is concerned.

It must not be forgotten that in toad-infested areas the introduction of other methods of biological control, such as parasitic wasps, may be jeopardised by the non-selective feeding habits of *Bufo marinus* which can devour both pest and predator with equal avidity.

Table 3.—Economic importance of prey consumed by 350 *Bufo marinus* at Laloki, Central District, Papua New Guinea January to December, 1973

	Number of individuals		
	Beneficial	Neutral	Harmful
ANNELIDA	1		
MOLLUSCA			1
ARTHROPODA			
CRUSTACEA		2	
ISOPODA			
MYRIAPODA	3		6
SCORPIONES	1		
ARACHNIDA	12		1
INSECTA			
BLATTODEA		4	
ISOPTERA			26
ORTHOPTERA			132
HEMIPTERA	6	47	82
COLEOPTERA	59	64	183
LEPIDOPTERA		12	290
HYMENOPTERA	7	385	
VERTEBRATA			
SQUAMATA			
SCINCIDAE	1		
	90	514	721

Table 4.—Economic importance of prey consumed by 450 *Bufo marinus* at Serovi Plantation, Popondetta, Northern District, Papua New Guinea March to November, 1973

	Number of individuals		
	Beneficial	Neutral	Harmful
ANNELIDA	3		
MOLLUSCA			17
ARTHROPODA			
CRUSTACEA	2		
ISOPODA			
MYRIAPODA	2		
DIPLOPODA			172
ARACHNIDA		29	2
INSECTA			
BLATTODEA		16	
ISOPTERA			94
DERMAPTERA	20		
ORTHOPTERA			87
HEMIPTERA	9	48	355
COLEOPTERA	190	228	402
DIPTERA	3	76	
LEPIDOPTERA		105	348
HYMENOPTERA	3	954 (ants)	
VERTEBRATA			
SQUAMATA			
SCINCIDAE	2		
	261	1429	1477

It is recommended that further introductions of *Bufo marinus* into new areas be discouraged until further research has been conducted on its interaction with the endemic fauna of Papua New Guinea, such as snakes, *Dasyurus* and frogs.

F. Parker (pers. comm.) states that over the past few years there has been a marked reduction in the number of Papuan Black Snakes *Pseudechis papuanus* in the Port Moresby area. This is possibly due to the snake catching toads in mistake for the various local frogs which are their normal diet. There have been reports of the carnivorous marsupial *Dasyurus* sp. having died through attacking toads (J. Waithman pers. comm.), also Breeden (in Lear, 1970) states that since the introduction of *Bufo marinus* into Northern Queensland the number of Quoll *Dasyurus* sp. has declined.

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Table 5.—Meansurements of *Bufo marinus* from seven localities in Papua New Guinea

Locality	Total Number	Snout Vent Length mm Mean ± sd	Largest Individual		
			S.V. Length mm	Weight g	Sex
Waigani Sewage Farm, 14 km NW Port Moresby	915	83 ± 11	112	145	M
Brown River Road, 24-34 km N Port Moresby	33	102 ± 8	152	445	F
Laloki Plant Q'tine Station, 15 km N Port Moresby	351	87 ± 20	125 125	243 198	F M
Serovi Plantation, Popondetta, Northern District	405	91 ± 14	126	271	F
Talasea, West New Britain	30	92 ± 13	137	326	F
Daru, Western District	90	77 ± 8	98	117	F
Varirata National Park, 21 km N Port Moresby	17	88 ± 11	105	100	M

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