This data does not include the two animals that died during the course of the experiment. There appears to be no sex difference in the histological appearance of the glands. The changes in weight and histological appearance of the adrenal gland of the diamond-back water snake are similar to, but less extensive than those changes reported for the western diamond-back rattlesnake (Allen, Grumbeck and Shetlar 1961), and appear to be manifestations of the General Adaptation Syndrome of Selye (1937).

SUMMARY AND CONCLUSIONS —

Histological changes and increases in weight were noted in the adrenals of the diamond-back water snakes (*N. rhombifera*) subjected to stress. The increase in the per cent body weight of the adrenals, while not statistically significant, is thought to be biologically significant, particularly when considered in the light of the change in the histological appearance of the glands.

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Diet of the Giant Toad, *Bufo marinus* (L.), in Fiji

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In 1936, the Giant Toad, *Bufo marinus* (L.), was brought from Hawaii to Fiji. It soon became established near Suva and was colonized at other points throughout the group with the hope that it would help control beetles attacking sugarcane, banana, and other crops. During the years since the establishment of the toad, nine articles or notes have appeared in the Fiji Agricultural Journal

(Jack, 1936; Simmonds, 1937 and 1957; Lever, 1937, 1938a, 1938b, 1939, 1944; and Turbet, 1938) describing its habits and diet. However, only 14 toads were dissected, these containing 49 gastropods, 19 myriapods, and 387 insects. Of the 14 toads, 43% had consumed gastropods; 36%, myriapods; and 86%, insects. It was also noted (Turbet, 1938) that the tadpoles ate algae, not prawns or mosquito larvae, and (Simmonds, 1957) that adult toads occasionally ate their own young and sometimes choked to death trying to swallow young mynahs or chickens.

In this study, representative samples of toads were collected in agricultural locations during the period from September 1960 through March 1962. One hundred toads were dissected and the contents of their stomachs identified. The data obtained were then analyzed to determine the effects of location on diet and the economic importance of toad predation.

Collections

The first collection was made in a coconut plantation at Vuna on the island of Taveuni. Twenty toads were caught, two at 10 a.m. on 13 October 1960 and 18 between 5:00 and 5:30 a.m. 14 October. Ground cover consisted of weeds and closely grazed grass, with scattered cow dung and piles of coconut husks.

Two collections were made in the lawn and garden areas of the Principal Agricultural Station at Koronivia on Viti Levu. Samples of 15 were taken at 6:30 a.m., 9 August 1961 and 8:00 a.m., 5 March 1962.

A collection of 20 was made in banana groves at Koronivia between 1:00 and 2:00 a.m. on 1 December 1961. Five were caught in or near a grove interplanted with cocoa and leguminous trees, but the rest came from a grove in which the predominant ground cover was Para grass.

One collection was made in the sugar growing zone of Viti Levu. Fifteen toads were captured between 12:45 and 1:45 a.m., 27 Febuary 1962, on roads running through cane fields near Lautoka.

Finally, a collection of 15 was made between 9:00 and 9:30 a.m., 8 March 1962, in a rice field at Koronivia. At the drier end of the field, rice seed had been drilled mid-December, 1961, but, in the portions where there was standing water, rice seedlings had been transplanted during late December and early January.

In all cases, dissections were done the same morning as collections. Prior to dissection, the toads were measured, then decapitated. Usually only stomach contents were examined, but when the stomach was nearly empty, the rectum was also dissected.

TABLE *I.*—Identity and Number of Prey of the Giant Toad.

PLATYHELMINTHES
TURBELLARIA
Tricladia
1 Land planarian
ANNELIDA
CHAETOPODA
Oligochaeta
15 Earthworms
MOLLUSCA
GASTROPODA
Pulmonata
68 *Subulina octona*
17 Heliciform snails
32 Vaginulid slugs
Streptoneura
3 ?*Melania* sp.
ARTHROPODA
CRUSTACEA
MALACOSTRACA
Isopoda
3 Pillbugs
Decapoda
2 Crabs (1 hermit) - Lever (1944)
MYRIAPODA
CHILOPODA
5 Centipedes
DIPLOPODA
57 Yellow-spotted black millipedes, *Orthomorpha coarctata*
46 Small white millipedes
38 Large red millipedes, *Trigoniulus lumbriciuus*
ARACHNIDA
ARANEIDA
5 Spiders (1 wolf)
ACARINA
39 Mites, most *Fuscuropoda* sp.
SCORPIONIDEA
1 Scorpion - Lever (1939)
INSECTA
PTERYGOTA
Orthoptera
3 Crickets (1 *Acheta oceanica*)
6 Cockroaches
2 Coconut Stick Insect, *Graeffea crouani*, eggs (1 hatched, 1 inviable)
Dermaptera
8 Earwigs, most *Chelisoches morio*
Hemiptera
48 True bugs, including:
22 *Geotomus pygmaeus*
21 *Pachybrachius* sp.
1 *Brachyplatys pacificus*
1 Pentatomid
23 Leafhoppers, including:
12 *Nilaparvata lugens*
2 *Chloriona furcifera*
1 *C. kolophon*
2 *Tettigoniella spectra*
1 Derbid
Odonata
2 Dragon flies - Lever (1938a)
Neuroptera
1 Lacewing larva
Diptera
4 Maggots
1 Puparium
2 Red-eyed black flies
Lepidoptera
166 Caterpillars, including:
1 ?*Hymenia recurvalis*
127 *Pseudaletia separata*
16 *Spodoptera mauritia*
4 *Prodenia litura*
2 *Euclidisema alycone*
1 Pupa
1 Moth
Coleoptera
10 Curculionids, including:
4 *Cosmopolites sordidus*
3 *Elytroteinus subtruncatus* - Lever (1938b)
1 *Acalles* sp. - Lever (1938b)
1 *Orochlesis* sp. - Lever (1938a)
4 Rutelids, *Adoretus versutus*
1 Helodid, *Scirtes natovensis*
4 Tenebrionids
1 Cerambycid
7 Hydrophilids, including:
5 *Hydrophilus gayndahensis*
1 Dytistid, *Hyphydrus lyratus*
1 Nitidulid, *Carpophilus* sp.
25 Aphodiids, ?*Aphodius* sp.
13 Scarabaeids, *Copris incertus prociduus*
1 Carabid
4 Coccinellids, including:
3 *Coccinella transversalis*
10 Elaterids, ? *Simodactylus* sp.
13 unidentified beetles
Hymenoptera
368 Ants, including:

62 *Odonotomacus haematoda*
56 *Tapinoma melanocephalum*
55 *Pheidole megacephala*
1 *Camponotus* sp.
4 Wasps, including:
2 *Polistes olivaceus*
1 Ichneumonid, *Netalia* sp.
1 Braconid
300 Bees, *Apis mellifera* - Lever (1944)

CHORDATA
VERTEBRATA
AMPHIBIA
Young toads - Simmonds (1957)
AVES
Young chickens and mynahs - Simmonds (1957)
2 Mice, possibly regurgitated by cats)

Results

In length (snout to vent), the toads ranged from 1″ to 6″ and averaged just under 3″. Gravid females were noted in every sample, their length ranging from 3″ to 6″ and averaging 4½″.

Dissection results are summarized in Table I. The 14 previously recorded dissections are included, references being given for those prey not recovered during the present study. Not included in the tabulation are the various leaves, twigs, and pebbles which toads inadvertently swallow.

Five phyla were represented, with 4 major subphyla and 7 classes of the arthropods. Insects of 9 orders were among the prey. The most numerous prey were ants, bees, caterpillars, millipedes, beetles, snails, bugs, slugs, and leafhoppers. It appears that the toad will eat almost any terrestrial animal, although it is more apt to consume those active at ground level during the night.

Discussion

Effects of location and season on diet.—Considering only the 100 toads dissected during the present study, striking effects of location on diet can be demonstrated. An analysis based on the three main types of prey is shown in Table II. Insects, mostly ants and caterpillars, were commonly consumed at all locations except the cane roads. There, millipedes and gastropods were more important components of the diet than elsewhere. No millipedes were consumed in the rice field, although they were found on the Agricultural Station, many in the banana groves and some in the lawns and gardens.

Table II.—Analysis by Location

Location	Number per 10 Toads		
	Gastropods	Myriapods	Insects
Lawns and Gardens	7	2	51
Coconut Plantation	13	5	75
Banana Groves	6	30	69
Cane Roads	21	40	4
Rice Field	2	..	90
Percentage containing such prey	42%	40%	82%

Comparisons at the specific level also show location effects. The snail, *Subulina octona*, occurred in all areas except the rice field. Different species of ants predominated in each area, although the Bulldog Ant, *Odonotomacus haematoda*, was found everywhere except the rice field. Dung Beetles, *Copris* and ?*Aphodius*, were noted only in the coconut plantation; the Indian Rose Beetle, *Adoretus versutus*, only in lawns and gardens; and the Large Water Scavenger Beetle, *Hydrophilus gayndahensis*, only in the rice field; although the Banana Weevil, *Cosmopolites sordidus*, was found both in the banana groves and the lawns and gardens. Caterpillars of *Prodenia litura* were found in all 3 Koronivia locations but those of the Rice Armyworm, *Pseudaletia separata*, were either in the Para grass of the banana grove or in the rice field, and those of the Lawn Armyworm, *Spodoptera mauritia*, were only in the lawns and gardens.

One seasonal comparison was possible, that being between the two collections made in lawns and gardens at Koronivia. As shown in Table III, there was a slight shift in consumption from insects to gastropods. *Pheidole megacephala, Odonotomacus haematoda, Chelisoches morio,* and *Geotomus pygmaeus* appeared in both samples. Absent in the first but common in the second were *Spodoptera mauitia* and *Pachybrachius* sp.

TABLE III.—Analysis by Season

Season	Number per 10 Toads		
	Gastropods	Myriapods	Insects
Mid-winter (Aug. '61)	4	2	64
Late Summer (Mar. '62)	10	1	38

Economic Importance of Toad Predation.—In order to evaluate the economic importance of the toad, it was first necessary to classify its prey on economic criteria. This was not easy, especially with omnivorous species. In Table IV, four categories were used. "Important pests" included slugs, heliciform snails, caterpillars, and certain beetles. "Millipedes" were considered separately since, although they may occasionally damage living plants, they are generally useful scavengers and humus formers. "Ants" also deserved separate treatment since they prey on many pests but become pests themselves when they damage seedlings or foster homopterans. The final category, "beneficial predators," included centipedes, spiders, earwigs, and lacewings, as well as predatory beetles and wasps.

The comparison in Table IV indicates that toads consumed more "important pests" than "beneficial predators" in all locations except the coconut plantation. However, only in the rice field did

invertebrates in the "important pest" category predominate. There, large numbers of rice caterpillars and leafhoppers were consumed.

Elsewhere, either ants or millipedes were the most common type of prey.

TABLE IV.—Economic Importance in Relation to Location

No. consumed per 10 toads in:	Important Pests	Millipedes	Ants	Beneficial Predators
Lawns and Gardens	8	2	31	2
Coconut Plantation	2	5	c.100	6
Banana Groves	15	30	50	3
Cane Roads	10	38	2	4
Rice Field	28	..	10	1
Percentage of toads consuming such prey in:				
Lawns and Gardens	40%	13%	80%	20%
Coconut Plantation	20%	45%	65%	35%
Banana Groves	65%	65%	65%	15%
Cane Roads	40%	87%	7%	33%
Rice Field	67%	0%	27%	7%

The results of all 114 dissections are summarized in Table V. Three inclusive categories are used, most of the prey coming under "beneficial." Exclusion of bees and ants (because only one case of bee-eating was recorded, and ants are sometimes pests) leaves 42 beneficial invertebrates consumed and 27% of the toads guilty of such predation. If such exclusion is not permissible, the toad must be considered, at best, economically neutral.

SUMMARY

The diet of the Giant Toad, *Bufo marinus* (L.), in Fiji was found to include representatives of 5 phyla. Gastropods, myriapods, and insects predominated. A comparison of toads collected in 5 agricultural locations showed dietary differences at specific and higher levels. Since both harmful and beneficial invertebrates were consumed at all locations, it can be concluded that the toad is economically neutral.

TABLE V.—Summary of Economic Importance

Economic Classification		Number eaten by 114 toads:	Percentage of toads with such prey:
Phytophagous:			62%
	slugs	32	
	snails	17	
	crickets	3	
	roaches	6	
	leafhoppers	23	
	true bugs	48	
	caterpillars	166	
	beetles	19	
		314	
Scavenging:			66%
	earthworms	15	
	snails	71	
	crabs	2	
	mites	2	
	pillbugs	3	
	millipedes	146	
	beetles	48	
		287	
Beneficial:			65%
	parasitic wasps	2	
	predators	40	
	ants	368	
	bees	300	
		710	

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