SOME EVIDENCE OF THE PREDATION OF HAMILTON'S FROG (*LEIOPELMA HAMILTONI* (McCULLOCH)) BY TUATARA (*SPHENODON PUNCTATUS* (GREY)) ON STEPHENS ISLAND

D. G. NEWMAN

Wildlife Service, Department of Internal Affairs, Wellington

SUMMARY: Based on a single observation some evidence is presented suggesting that predation of Hamilton's frog by tuatara is occurring on Stephens Island, 40° 40′ S, 174° 00′ E in Cook Strait. Bones of the left hind limb of a frog were identified from a tuatara dropping collected from the frogs' habitat. Because of the tenuous state of the island's frog population, factors thought to limit the incidence of predation and the distribution of the frog are discussed. A future management proposal is outlined.

INTRODUCTION

The New Zealand frog genus *Leiopelma* (Fitzinger) has attracted much attention because of its primitiveness, but so far research on the three extant species has been largely confined to morphological, developmental, taxonomic and physiological topics. Little ecological research has been undertaken probably because of the difficulty in locating specimens (they are small, nocturnal and generally occupy remote areas). Distributions of all species are unknown and, for the reasons outlined above, are likely to remain so.

During 1971 Crook, Atkinson and Bell combined to publish a report on the known habitats of Hamilton's frog (*Leiopelma hamiltoni*). For many years this frog was thought to be was confined to a small (0.25 hectare) heap of boulders near the summit of Stephens Island in an area known as the "frog bank" but in 1961 it was provisionally identified as the frog occurring in a 15 hectare remnant of coastal forest on Maud Island, 41° 02′ S, 173° 54′ E in the Marlborough Sounds (Stephenson, 1961: Crook *et al.*, 1971). Fig. 1).

Hamilton's frog is the rarest of New Zealand's three species and may be one of the rarest frogs in the world (Bull and Whitaker, 1975). Along with the other species of *Leiopelma*, it is absolutely protected under the Wildlife Act 1953. Any factor, of whatever cause, that could possibly threaten its continued survival is therefore of great interest to the New Zealand Wildlife Service (the body responsible for administering the Wildlife Act).

Stephens Island is perhaps best known for the presence of high densities of tuatara (*Sphenodon punctatus*); they have never been recorded from Maud Island. As tuataras had often been observed on the "frog bank" it was thought likely that they ate frogs (tuataras are known predators of small reptiles — skinks and geckos). In an attempt to verify this Wildlife Service staff, when visiting the island, systematically collected fresh tuatara droppings found on and in the vicinity of the "frog bank" to determine if there was evidence of predation.

METHODS AND RESULT

Fourteen fresh droppings have been collected during seven trips made to the island since May 1975. Of these only one, collected during May 1975, contained pieces of bone that appeared to be from

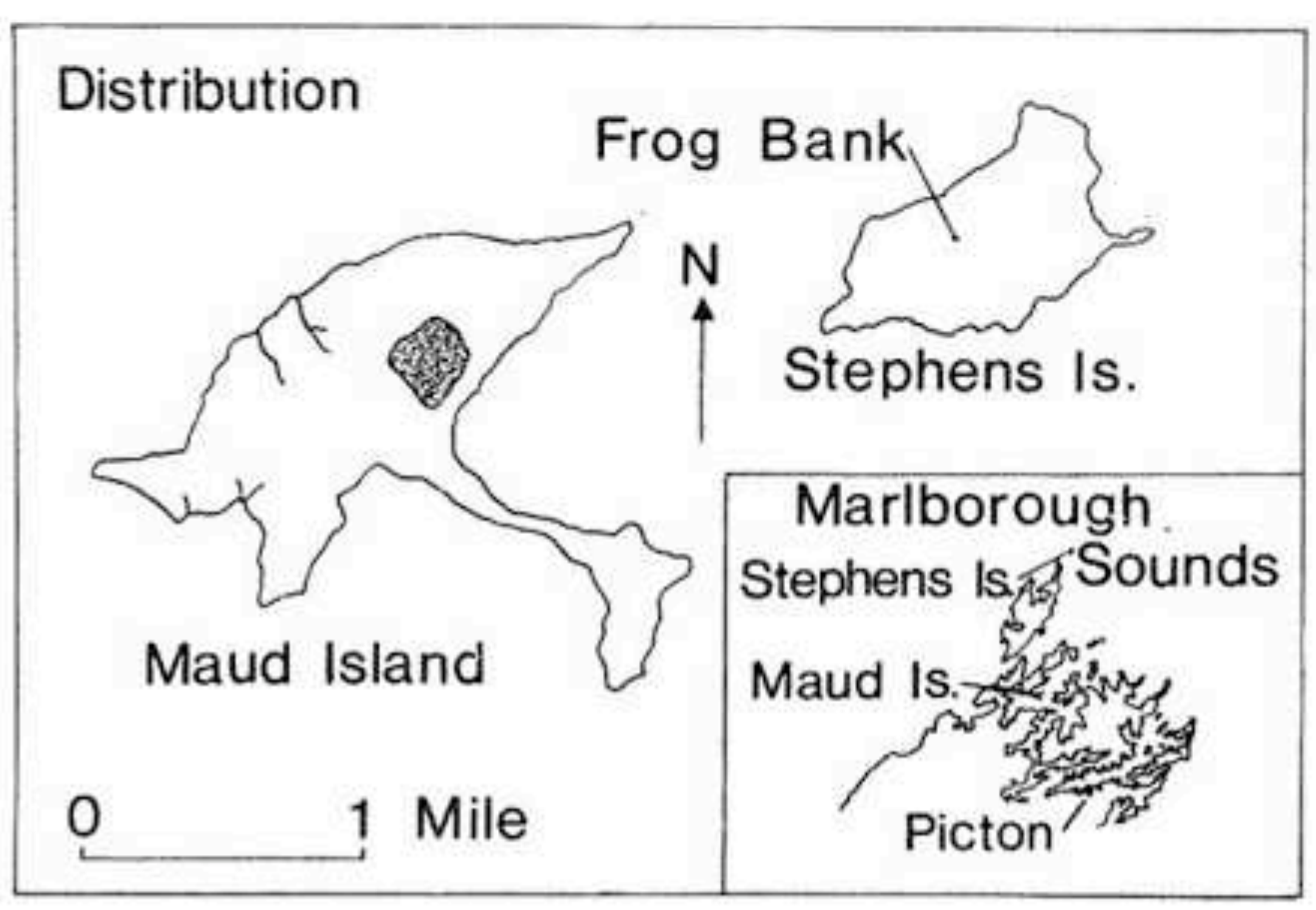

FIGURE 1. *The known distribution of Hamilton's frog.*

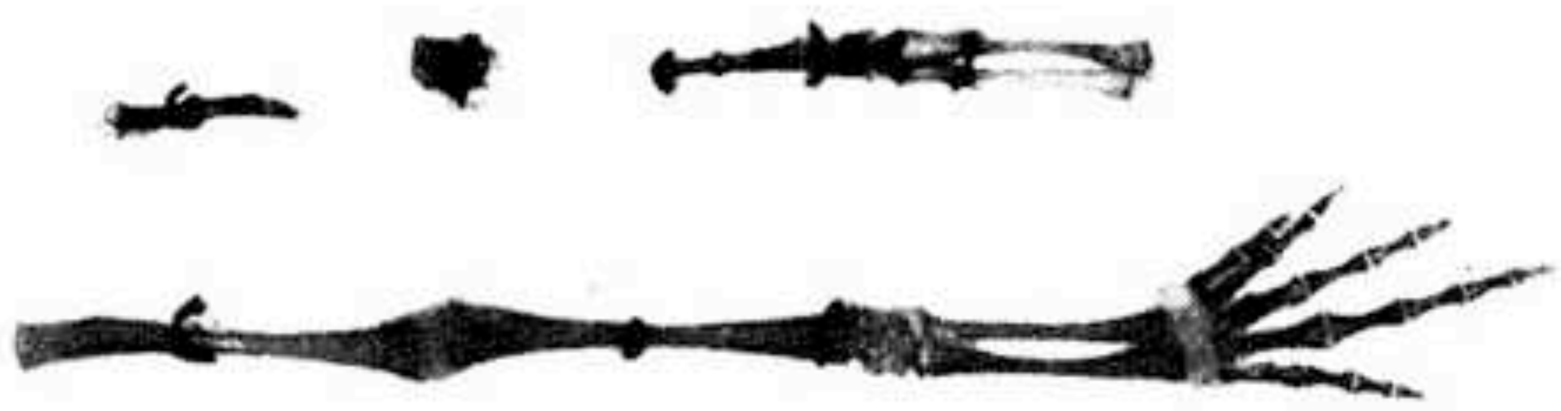

FIGURE 2. *Bone fragments recovered from a tuatara dropping compared with an alizarin transparency of the right hind limb of a Maud Island frog. Photo by B. Lester.*

a frog. These bone fragments were sent to Dr E. M. Stephenson, of Sydney University, an authority on the genus *Leiopelma.* In verifying identification, she considered the bones to be part of a left hind limb of Hamilton's frog (Stephenson, *in litt.*). She compared the pieces of bone with an alizarin transparency of the right hind limb of a Hamilton's frog from Maud Island (Fig. 2).

Dr Stephenson thought that the condition of the proximal bones of the tarsus (astragalus and calcaneum) of the Stephens Island material was remarkably good. After soaking briefly in glycerol, she found that even the distal epiphyseal cartilage was recognisable. Although several smaller elements are not included in the photograph, two metatarsals appeared to be represented (Stephenson *in litt.*).

DISCUSSION

In view of their known diet, the finding of frog bones in a tuatara dropping came as no real surprise but, of course, gave no conclusive proof of predation. Tuataras may feed on carrion but the "remarkably good condition" of the material suggests that the bone fragments came from an animal that had died recently and not from one that had been dead for some considerable time. Dawbin (1962) and other authors (e.g. von Wettstein, 1931) have observed that tuataras depend mainly on sight rather than on smell or hearing to detect food, and they seldom react to an object until some movement occurs. A dead frog, one would expect, should be motionless. It would seem therefore more likely that the bone fragments came from a predated frog and not from one that had "died recently" of natural causes.

The significance of tuatara predation on the number of frogs on Stephens Island would be difficult to assess. Frog and tuatara populations must, however, have co-existed in isolation there for a very long time. The island was most recently connected to the mainland during the last glacial period (Atkinson and Bell, 1973), a connection that was finally lost about 10 000 years ago (Fleming, 1975).

Factors thought to limit the incidence of predation and the distribution of the frog on Stephens Island are:

1. Protection offered by habitat.

The frogs' Stephens Island habitat offers abundant shelter, the narrow crevices between the rocks of the "frog bank" are inaccessible to tuataras. In this regard it is interesting to note that although the frog occurs in a remnant area of coastal forest on Maud Island; on Stephens Island, in a somewhat similar, but much smaller area (ca. 0.5 hectare) of coastal forest, less than 100 metres from the "frog bank" frogs have never been found in spite of repeated searches. While both areas are, or have been, dominated by kohekohe *(Dysoxylum spectabile),* the Stephens Island forest lacks the rocky ground cover that is a feature of the Maud Island forest. The lower rainfall received by Stephens Island

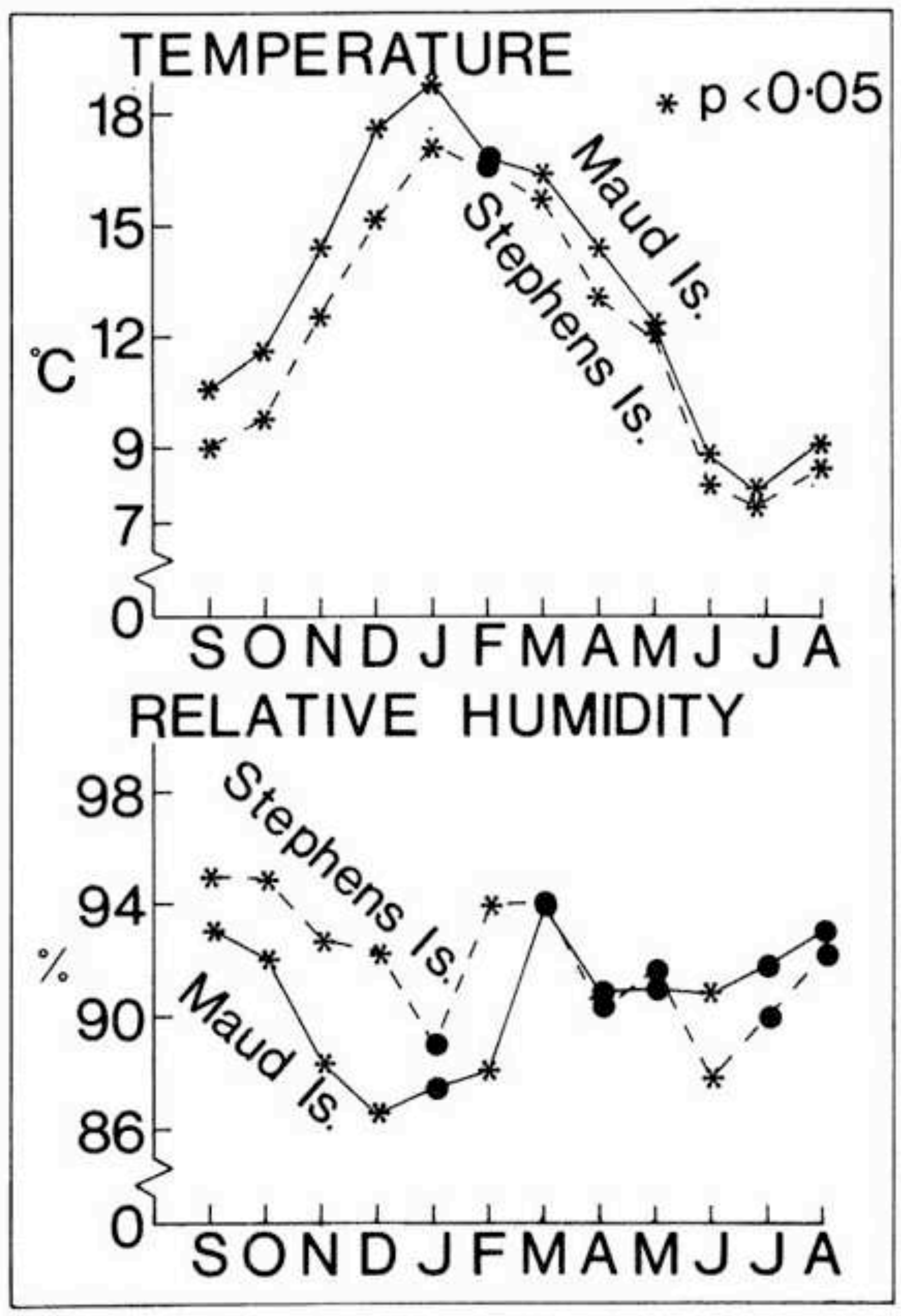

FIGURE 3. *Mean monthly temperature and relative humidity values collected from the floors of the Stephens Island and Maud Island remnant forest areas.*

and the less dense and lower canopy of its smaller remnant forest suggest that this area was subject to drier conditions than the forests of Maud Island. To test this possibility micro-climate data were collected from the two areas and compared. Recording instruments were placed in double-louevred Stephenson screens set up on the floors of the respective remnant forest areas.

Results showed that, if anything, the Stephens Island forest floor is cooler and generally more humid than the floor of the Maud Island remnant forest (Fig. 3). This situation was a reflection of the differences in altitude of the two meteorological stations (Stephens Island: 300 m. a.s.l.; Maud Island: 90 m. a.s.l.). Clouds often enveloped the summit of Stephens Island and helped to maintain moist conditions. Preliminary results of work on the surface activity of frogs indicates that they favour cool but humid conditions, which suggests that it is not climate, in itself, that restricts the distribution of the frog on Stephens Island.

In times of drought, frogs must have ready access to damp refuges. These could be found in the crevices of decaying tree stumps and fallen logs, niches which are available in the Stephens Island forest. In the Maud Island forest, frogs are often encountered on and in old rotting tree trunks, occasionally at quite considerable heights (over 2 metres above the ground). E. M. and N. G. Stephenson (1957), in reporting on native frog habitats in the Coromandel Peninsula, stated that in vegetation clothing Mt Moehau, where stones were not common, *Leiopelma archeyi* was typically found beneath or even inside decaying logs.

Further, on the Tokatea Ridge, in grassland which had established after the clearing and burning of bush, they found specimens under logs. Why, then, are frogs absent from comparable niches in the Stephens Island forest? Could tuatara activity be one of the principal reasons? Tuataras certainly forage for food in trees at night, often ascending through hollow trunks. They have also been known to live under logs for considerable periods—one even spent several months under the meteorological screen that had been set up on the floor of the Stephens Island forest. Tuatara activity may, therefore, play a role in restricting the frogs' present distribution on Stephens Island.

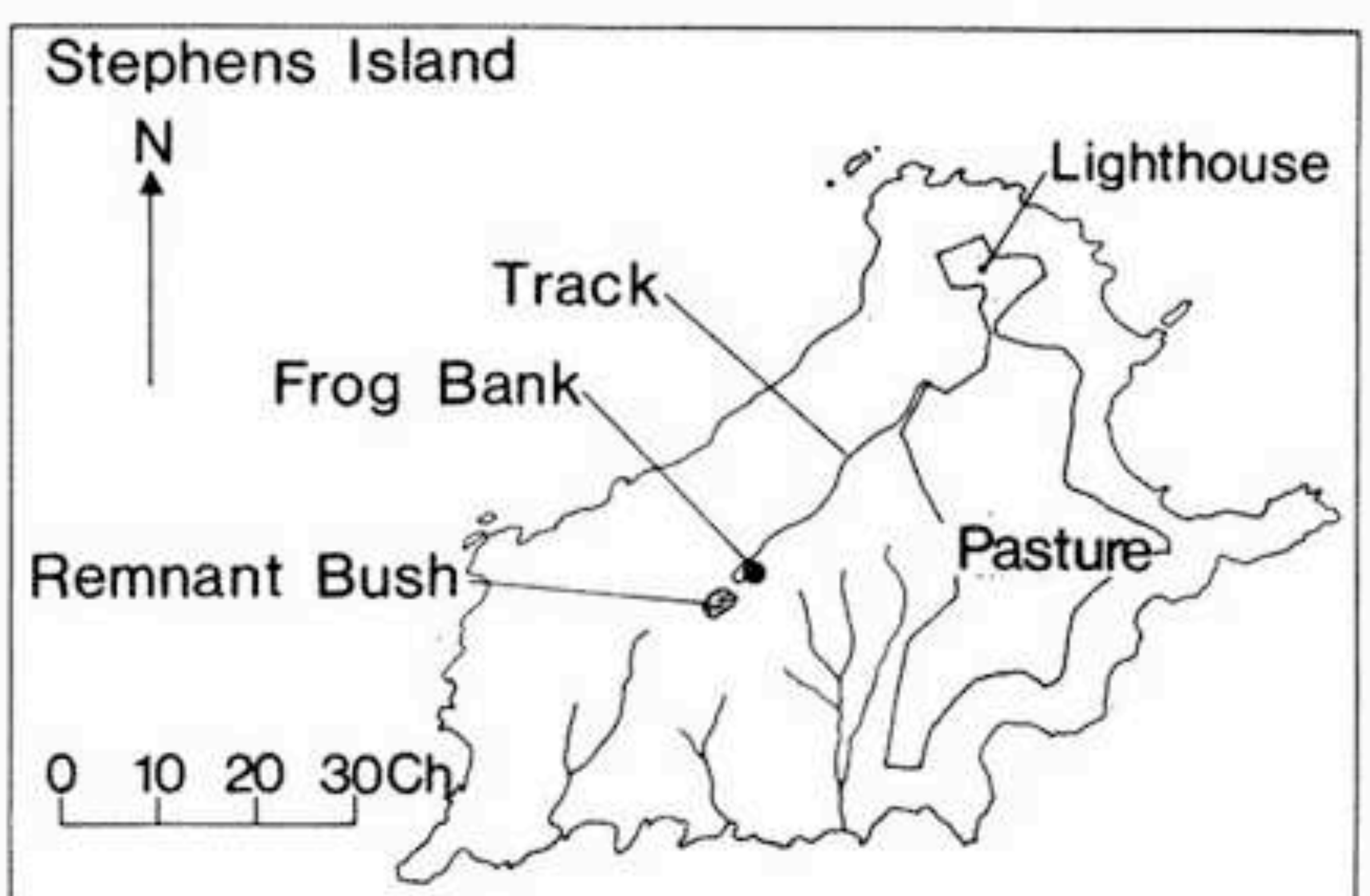

FIGURE 4. *Map of Stephens Island.*

2. Activity patterns.

That a possible difference in the activity patterns of the two species existed was initially suggested by the observation that in summer, when frogs were very difficult to find, large numbers of tuataras were about, and in winter, while many frogs could be seen on suitable nights, generally relatively few tuataras were located. To quantify this possible relationship, the number of frogs found within a specified period one metre on either side of specially constructed search paths on the "frog bank" was taken as an index of "frog activity" and the number of tuataras found on the track from the Stephens Island lighthouse station to the "frog bank" was taken as an index of "tuatara activity" (Fig. 4).

Results verified the observation that the activity patterns of the two species differed during summer and winter. However, no clear cut differences appeared during spring (Stephens Island experienced unusually dry conditions during the month of September 1975), while during autumn the recorded activity of both animals reached a peak (Fig. 5). To attempt to explain this situation correlation coefficient values were calculated between frog and tuatara activity values and various physical factor measurements recorded at the "frog bank" on the nights when searches were made (Table 1).

CORRELATION COEFFICIENTS (r)

	FROGS	TUATARAS
Rain	0·414***	−0·081
Wind	0·036	0·086
Temperature	0·035	0·855***
Relative Humidity	0·324**	0·393**
Light	−0·330*	−0·268•

•$p<0·1$ *$p<0·05$ **$p<0·01$ ***$p<0·001$

TABLE 1. *Correlation coefficient values (r) calculated between Hamilton's frog and tuatara activity values and the various physical factor measurements taken on the nights of searches.*

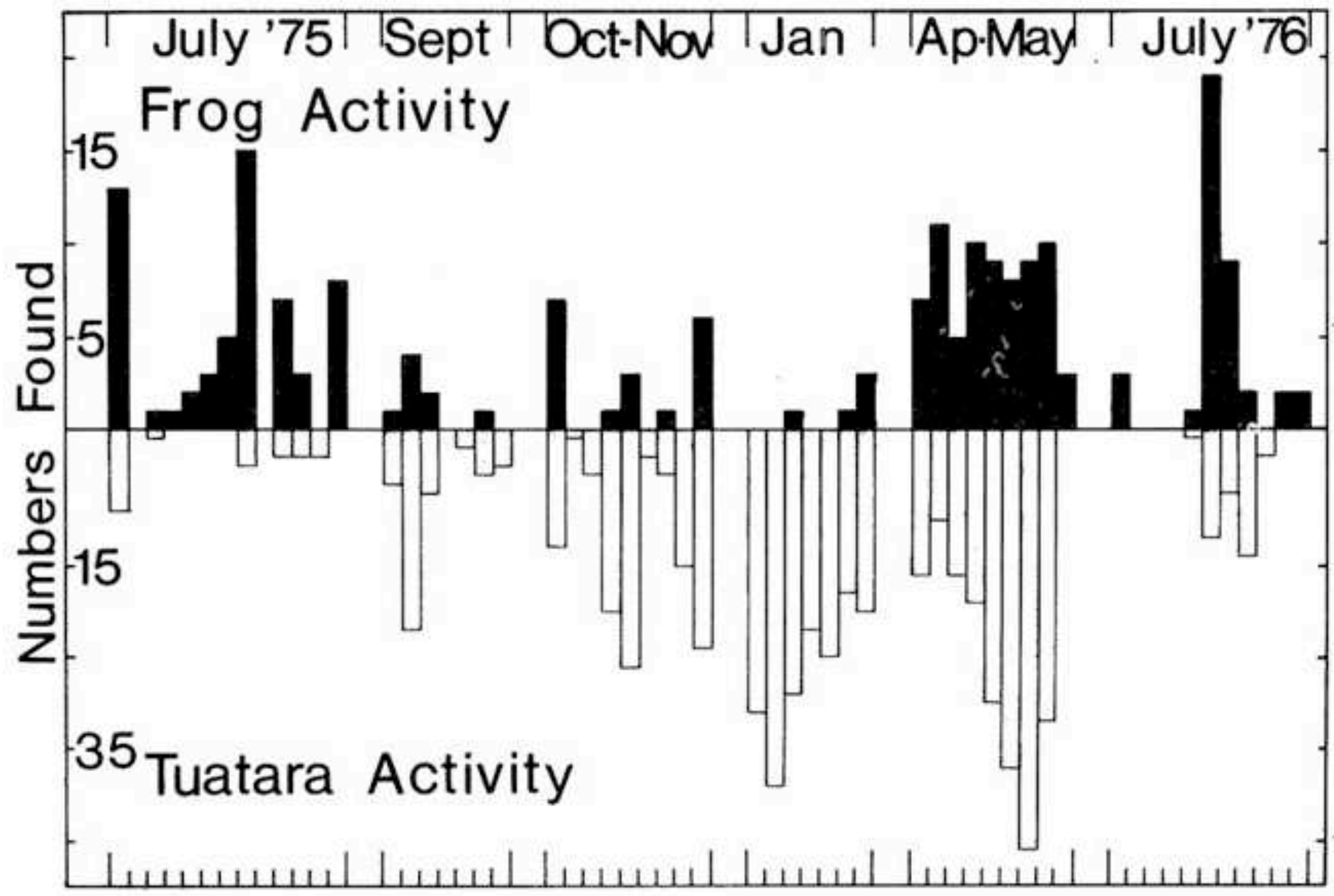

FIGURE 5. *The number of Hamilton's frogs found on each search night in relation to the number of tuataras located on the "frog bank" track.*

These values suggest that differences recorded in the activity patterns of the two species during summer and winter can best be explained by their differing response to ambient temperatures. Whereas tuataras showed a significantly positive response to rising temperatures, frogs appeared to avoid warm conditions, presumably because such conditions promote a greater risk of dehydration. Thus, while tuatara activity was inhibited by winter minimums, frog activity was inhibited by summer maximums. During spring and autumn such extremes of temperature would be unlikely so that the activity of neither frog nor tuatara would probably be adversely affected.

The activity of both species reached a peak during autumn 1976 and it was in May 1975 (no figures for tuatara activity available) that the frog bones were found in the tuatara dropping.

3. Behaviour patterns.

When both tuataras and frogs are active on the same evening, behaviour patterns of the two species may help reduce the extent of predation. As indicated earlier, tuataras seldom react to an object until some movement occurs. Frogs found on the surface at night have almost invariably been sitting motionless apart from the slight raising and lowering of the floor of their mouths associated with respiration. The usual reaction of frogs when "spotted" by a search light is to drop their heads which in effect disguises any breathing movements and puts on display a maximum area of their cryptically coloured dorsal surface (Fig. 6). As hunting tuataras are apparently only sensitive to movement, a frog, sitting quite still in such a manner, could be overlooked. In fact, a tuatara has been actually found standing, quite still, on a live motionless frog! This tuatara appeared to be quite oblivious of the fact that it was standing on a potential meal.

FIGURE 6. *Hamilton's frog sitting on* Muehlenbeckia *sp. (snout—vent length of frog ca 37 mm). Note the cryptically coloured dorsal surface.*

CONCLUSION

Although there is now some evidence that tuataras may eat Hamilton's frogs, the protection offered to frogs by rock crevices in their habitat, the differences in surface activity in response to temperature of the two species and their behaviour patterns all tend to reduce the incidence of predation. The interaction between the two species may, however, play a role in limiting the frogs' present distribution on Stephens Island.

Because the frogs' Stephens Island habitat is so severely restricted and has "deteriorated" through the loss of its original vegetative cover as a result of previous grazing coupled with salt storms (Crook *et al.*, 1971), it could well be a useful exercise to create an artificial boulder bank in the nearby remnant forest in an effort to expand the frogs' range. As the absence of frogs from the forest appears to be due, in large measure, to tuatara activity, such an action could constitute wise management of this endangered species.

ACKNOWLEDGEMENTS

I would like to thank Messrs I. G. Crook and L. R. Moran for making many helpful suggestions throughout the course of this work. Dr G. R. Williams and Mr T. A. Caithness kindly commented on a draft of the paper. Messrs L. R. Moran, I. McFadden and R. Blackwell assisted with field work.

REFERENCES

ATKINSON, I. A. E.; BELL, B. D. 1973. Offshore and outlying islands. In WILLIAMS, G. R. (Ed.), *The natural history of New Zealand*, 372-392. A. H. and A. W. Reed, Wellington.

BULL, P. C.; WHITAKER, A. H. 1975. The amphibians, reptiles, birds and mammals. In KUSCHEL, G. (Ed.), *Biogeography and ecology in New Zealand*, 231-276. Junk, The Hague.

CROOK, I. G.; ATKINSON, I. A. E.; BELL, B. D. 1971. Habitats of the frog *Leiopelma hamiltoni* McCulloch on Stephens and Maud Islands, Cook Strait. *New Zealand Journal of Science*, 14:1082-1093.

DAWBIN, W. H. 1962. The tuatara in its natural habitat. *Endeavour*, 21: 16-24.

FLEMING, C. A. 1975. The geological history of New Zealand and its biota. In KUSCHEL, G. (Ed.), *Biogeography and ecology in New Zealand*, 1-86. Junk, The Hague.

STEPHENSON, E. M. 1961. New Zealand native frogs. *Tuatara*, 8: 99-106.

STEPHENSON, E. M.; STEPHENSON, N. G. 1957. Field observations on the New Zealand frog, *Leiopelma* Fitzinger. *Transactions of the Royal Society of New Zealand*, 84: 867-882.

WETTSTEIN, O. VON. 1931. Rhychocephalia, *Kukenthal und Krumback's Handbuch der Zoologie*, 7: 1-128, 215-235.