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Diet of the Nonnative Southeast Asian Treefrog *Polypedates leucomystax* on Okinawajima, Ryukyu Archipelago, Japan

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Abstract: We investigated the food composition of the Southeast Asian Rhacophorid frog species *Polypedates leucomystax*, an invasive species introduced to Okinawajima in the Ryukyu Archipelago, during their breeding activities and the month immediately after that. We examined the stomach contents of 190 males and 54 females, uncovering 215 prey items (including at least 56 species) from 113 males and 21 females. The rate of empty stomachs was relatively high, 45.1% for all frogs (40.5% for males and 61.1% for females). Most prey were arboreal, with a minority being obligately terrestrial or aquatic. Insects constituted the majority of the diet (61.4%), followed by other arthropods, gastropods, and a vertebrate (an agamid lizard neonate). Orthopterans were the dominant prey group in terms of number (29.8%), frequency of occurrence (43.3%), and volume (51.6%). This species is considered an opportunistic feeder, a conclusion corroborated by comparisons with locally varied dietary data from populations of conspecific or closely related species in Southeast Asia. The average prey length was approximately one-third of the body length, but instances of the consumption of larger prey were observed. Similarly, males are able to swallow prey up to two-thirds of their gape width and females up to one-third. The data obtained in this study cover most of the active season of this species on the island, and thus provide a basis for elucidating the ecological impact of this species.

Key words: Invasive species; Prey size; Saurophagy; Stomach contents

Introduction

The Rhacophorid treefrog, *Polypedates leucomystax* (Gravenhorst, 1829), is a medium-to-large arboreal species indigenous to Southeast Asia. It was unintentionally introduced to the Ryukyu Archipelago in southwestern Japan from the Philippines (Kuraishi et al., 2009). Since its first confirmation in Okinawajima in 1964 (Kuramoto, 1965), this species has demonstrated significant invasive capabilities (as a frequent stowaway) and rapid range expansion in this archipelago. As of 2023, this species has been recorded on 36 islands in the archipelago extending south of Tokunoshima, plus Kitadaitojima of the Daito Islands (Ota et

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al., 2004, 2008; Maenosono and Toda, 2007; Taba et al., 2013; Takao et al., 2013; Aoyagi et al., 2022; Okinawa Amami Nature Conservation Office, Ministry of the Environment, 2023).

The presence of this species poses a potential ecological risk to the highly endemic terrestrial faunas in this archipelago (Ota, 2002; Sengoku and Toda, 2019), prompting a few eradication attempts based primarily on the precautionary principle (Toda, 2019). The potential negative impacts of this species on native faunas in the archipelago include (1) competition for food resources or breeding habitats with native anurans (Ota, 2002), (2) disruption of native anuran breeding activities (Ota, 2002), (3) introduction of novel parasites to local faunas, including co-occurring amphibians (Hasegawa, 1993, 1994; Hasegawa and Ota, 2017; Hasegawa et al., 2018) and predators feeding on this frog (Kadota and Maenosono, 2007), and (4) predation on insects in high-density frog areas (Sengoku and Toda, 2019).

However, apart from parasite issues (e.g., Hasegawa et al., 2018), few attempts have been made to scientifically validate these concerns. For instance, there is only limited published data on the diet of the Japanese populations of this species, which is essential for evaluating the degree of feeding niche overlap between this species and indigenous animals. We investigate its diet in Okinawa-jima and report the results here. Our data will form the basis for assessing the severity of concerns mentioned above, and could aid in prioritizing measures against this well-established, resilient frog species and other invasive alien species in this region.

Materials and Methods

Study site and collection

The frogs investigated in this study were collected from seven localities in Ogimi Village, located in the northern part of Okinawa-jima. This area is a critical biodiversity conservation site and is registered on UNESCO's World Heritage List (UNESCO, 2021). Three of these localities were artificial ponds, two were water tanks, one was a roadside ditch, and one was a paddy field. The mating call of this species was heard from late April to late October in these localities. Co-occurring anurans that were considered to be potentially suffer from competitive pressure from this species were *Hyla hallowellii* (Hylidae), *Fejervarya kawamurai* (Dicroglossidae), *Microhyla okinavensis* (Microhylidae), *Buergeria japonica*, and *Zhangixalus viridis* (Rhacophoridae).

The frogs were collected between July and November in 2019, September and November in 2020, and May and June in 2021. Surveys commenced an hour after sunset. We captured the frogs by hand, kept them in plastic bags, and then euthanized them with a 10% water solution of Acetonechloroform Hemihydrate. The euthanasia was performed at the collection site because national law prohibits the transportation of live animals of this highly invasive species.

Laboratory processing

In the laboratory, we measured the snout-vent length (SVL) and gape width (GW) of the frogs. Afterward, we dissected the frogs to extract their stomach contents. The sexes and maturity stages were determined by the developmental degrees of the testes in males or the gonads in females. We examined the extracted stomach contents under a binocular microscope and identified each animal item to the lowest taxonomic category. Stomachs containing only well-digested amorphous material or non-animal remains (e.g., sand grains or plant fragments) were considered empty, aligning with the results of previous studies that used stomach flushing or forced regurgitation methods to obtain stomach contents from live frogs (e.g., Yap, 2015).

Diet analysis and prey dimension

For each prey taxon, we calculated the following three values: the numeric percentage (%N), the volumetric percentage (%V), and the occurrence percentage (%F). The maximum length and width of each food item were measured using a digital caliper. The volume of each food item was calculated using the formula for an ellipsoid:

$$V=4/3\times pi\times L/2\times(W/2)^2,$$

where V is the volume, L is the length, and W is the width (Magnusson et al., 2003).

Depending on the prey type, we made certain modifications in calculating the volume of food items. For gastropods, we replaced length with the maximum shell height. For lizards, we did not include the long, thin tail in the body length.

We estimated the original body proportions of partial or fragmentary prey items from measurements of conspecific samples found in the prey items or museum specimens based on the assumption that the length of these body parts is linearly proportional to the maximum length and width of their body. For prey items that we could not infer the original body proportions from the remaining parts, we used the average volume of the same prey taxon in the food items (e.g., the volume of an unmeasurable "unidentified Orthoptera" item was the average volume of other orthopteran prey).

Statistical methods and calculations

The Chi-square test was used to investigate the intersexual differences in the vacuity index (the rate of empty stomachs). The Fisher's exact test was used to examine the difference in the males' monthly vacuity indexes. The normality of the variables was confirmed by the Shapiro–Wilk test. The statistical significance of several intersexual differences in specific values (prey item numbers and dimensions, total stomach content volume, and taxonomic variety of prey) was tested using Wilcoxon's rank sum tests.

RESULTS

Frogs and body size

Our study involved 244 individual frogs, with 190 males and 54 females. The frogs were found mostly on shrubs or grasses, but some were also found on the ground. Males' SVL ranged from 41.3 to 65.9 mm (median: 49.2; $\bar{x}\pm SD=49.9\pm3.76$), while females' SVL ranged from 56.9 to 83.1 mm (median: 73.0, $\bar{x}\pm SD=72.8\pm5.3$). All males were mature, and apart from one young female (SVL of 56.9 mm), all females were considered adults. The smallest mature female recorded an SVL of 64.1 mm. Due to the significant sexual size dimorphism of this species, males and females were analyzed separately in the following size-related comparisons.

Vacuity index and number of food items

Out of the 244 individuals, 134 (54.9%) had food items in their stomachs. The vacuity index for males was 40.5% (77/190), and for females, it was 61.1% (33/54). This intersexual difference was statistically significant (Chi-square test, $\chi^2=7.20$, $P<0.01$). Meanwhile, no statistically significant difference was observed in males' monthly vacuity index from May to November (Fisher's exact test, $P=0.07$). It was high in May (65%), August (50%), and October (38%) and low in June (28%), September (31%), and November (20%). The small sample size of females precluded a meaningful analysis of the monthly vacuity index variation.

A total of 215 prey items (186 items from 113 males and 29 items from 21 females) were found. The median number of prey among individuals with food in their stomachs was one ($\bar{x}=1.65$) for males and one ($\bar{x}=1.38$) for females, with no statistically significant intersexual difference (Wilcoxon's rank sum test, $W=1288$, $P=0.47$). The maximum number of prey found in a single stomach was seven for males and three for females.

Prey dimension

The median measurements of 139 prey items from male stomachs were as follows: length 9.7 mm (range: 0.4–66.0 mm), maximum width 3.1 mm (range: 0.3–9.3 mm), and volume 40.4 mm^3 (range: 0.02–1248.6 mm^3). The measurements for the 21 items from female stomachs were as follows: length

19.7 mm (range: 0.6–81.5 mm), maximum width 6.0 mm (range: 0.4–7.4 mm), and volume 413.3 mm^3 (range: 0.05–826.2 mm^3). These median values were significantly larger in females than in males (Wilcoxon's rank sum test; length: W=726, P<0.01; width: W=763, P<0.01; volume: W=636.5, P<0.01). The median total stomach content volume was 128.7 mm^3 (range: 0.02–1248.6 mm^3) in males (n=84) and 476.5 mm^3 (range: 1.14–1316.5 mm^3) in females (n=16), with a statistically significant intersexual difference (Wilcoxon's rank sum test, W=335, P<0.01).

The median and mean ratios of the length of the longest prey item to the frog's SVL were 24–33% in both sexes, reaching up to 140% in males and 126% in females. When compared to the frog's GW, the median and mean ratios were 76–101%, with the ratio reaching 446% in males and 369% in females. Regarding the width of the widest prey item found in each stomach, the median and mean ratios to the frog's SVL were approximately 8–9% in both sexes. These ratios reached 20% in males and 10% in females. When compared to the frog's GW, the median and mean ratios were 24–27% in both sexes, with the ratio peaking at 64% in males and 33% in females.

Prey taxa

We identified 56 species from these food items (Appendix), the bulk (85.6%N, 94.8%F, and 86.6%V) of which consisted of arthropods (predominantly insects: 61.4%N, 73.9%F, and 74.0%V), followed by gastropods (14.0%N, 20.2%F, and 12.0%V) and vertebrates (0.5%N, 0.8%F, and 1.4%V) (Table 1, Appendix). Orthopterans were the most important prey group of this frog. They represented the largest proportion of food items by number (29.8%N), followed by arachnids (20.0%N) and gastropods (14.0%N) (Table 1). Similarly, orthopterans were the most frequently consumed taxonomic group (43.3%F), followed by arachnids (28.4%F) and gastropods (20.2%F). In terms of volume, orthopterans accounted for more than half of all prey items (51.6%V), followed by gastropods (12.0%V) and Phasmatodea (7.0%V) (Table 1). The Eneopterid cricket *Cardiodactylus guttulus* was identified as the principal prey species, accounting for 17.2%N (37 individuals), 25.4%F, and 38.7%V of the diet (Appendix). This and several other prey species are arboreal and typically found in lower vegetation, such as bushes or grasses. However, we noted some ground-dwelling species, such as the field cricket *Teleogryllus occipitalis* and spiders *Pardosa* spp., and even some aquatic species, such as the diving beetle *Copelatus oblitus* and freshwater snail *Austropeplea ollula*.

The median, mean, and SD of the prey variety at the species level (i.e., that of Appendix) for all frogs with food in their stomachs were 1.0 and 1.49±0.81 taxa. These values were 1.0, 1.51±0.85 (maximum=6) for males and 1.0, 1.33±0.58 (maximum=3) for females, respectively, and there was no significant intersexual difference in the medians (Wilcoxon's rank sum test, W=1292.5, P=0.44). Similarly, the prey varieties at the order level (i.e., the taxonomic level shown in Table 1) were 1.0, 1.51±0.85 (range: 1–3) for males and 1.0, 1.33±0.58 (range: 1–3) for females, respectively, and there was no significant intersexual difference in the medians (Wilcoxon's rank sum test, W=1271.5, P=0.53).

The prey taxa consumed by males and females were similar. For instance, the most frequently foraged prey was the cricket *Cardiodactylus guttulus* in both sexes (male: 14.5%N, 23.0%F; female: 41.4%N, 57.1%F). Several other prey species (the stick insect *Sipyloidea sipylus*, beetle *Phaeochrous emarginatus*, and spider *Neoscona scylla*) were also common to both sexes. However, gastropod consumption by females was infrequent, unlike males (Table 1).

The majority of prey items for both males and females were less than 25 mm in length. Prey exceeding this length consisted exclusively of wholly or partially soft-bodied species, such as the stick insect *Sipyloidea sipylus*, a lepidopteran larva, Acridid or Tettigoniid orthopterans (*Euconocephalus* sp. and *Psyrana ryukyuensis*), the great house centipede

TABLE 1. Summary of %N, %F, and %V for prey classified according to higher taxonomic categories. Boldface fonts and underlined text represent the top three and maximum values, respectively.

Taxonomic group	%N			%F			%V		
	All frog	Male	Female	All frog	Male	Female	All frog	Male	Female
Mantodea	0.47	0.54	0	0.75	0.88	0	0.18	0.26	0
Dermaptera	2.79	2.69	3.45	4.48	4.39	4.76	0.65	0.59	0.80
Phasmatodea	2.33	1.61	**6.90**	3.73	2.63	**9.52**	**6.98**	4.30	**13.81**
Blattodea	2.79	3.23	0	2.99	5.26	0	1.82	2.54	0
Lepidoptera	3.72	4.30	0	4.48	7.02	0	4.23	5.90	0
Hemiptera	4.19	4.84	0	5.97	7.02	0	0.83	1.16	0
Orthoptera	**29.77**	**26.34**	**51.72**	**43.28**	**38.60**	**66.67**	**51.63**	**43.92**	**71.25**
Coleoptera	6.05	5.91	**6.90**	5.97	5.26	**9.52**	3.01	2.22	5.00
Hymenoptera	2.79	2.15	**6.90**	3.73	2.63	**9.52**	0.01	0.01	0.02
Diptera	2.33	2.69	0	2.24	2.63	0	0.12	0.17	0
Unidentified Insecta	4.19	4.84	3.45	6.72	7.89	4.76	4.53	5.53	2.00
Chiropoda	0.47	0.54	0	0.75	0.88	0	3.02	4.21	0
Isopoda	0.47	0.54	0	0.75	0.88	0	0.08	0.12	0
Arachnida	**20.00**	**20.43**	**17.24**	**28.36**	**30.69**	**23.81**	6.27	**6.41**	**5.94**
Unidentified Arthropoda	3.26	3.76	0	5.22	6.14	0	3.20	4.46	0
Gastropoda	**13.95**	**15.05**	3.45	**20.15**	**22.81**	4.76	**12.01**	**16.26**	1.17
Chordata	0.47	0.54	0	0.75	0.88	0	1.41	1.96	0

Thereuopoda clunifera, and the agamid lizard *Diploderma polygonatum polygonatum*.

The prey item with the largest relative width (20.3% of the frog's SVL and 63.9% of the frog's GW) was an unidentified land snail with a maximum shell width of 9.4 mm. This prey was consumed by a male with a SVL of 46.2 mm and a GW of 14.7 mm. In terms of volume, the largest items were a lepidopteran larva (1248.6 mm^3) and *Thereuopoda clunifera* (1154.5 mm^3). Both items had a total length of 46.0 and 45.0 mm, respectively, and were found in multi-folded states in the stomachs of males with SVLs of 53.4 and 49.2 mm, respectively.

Most prey animals were common species that were not regarded as either declining or threatened. The exception was the lizard *Diploderma polygonatum polygonatum*, an endangered species listed on national or prefectural red lists (Ota, 2014; Tanaka and Chigira, 2017). The reconstructed SVL was 30.6 mm, suggesting that it might have been a slightly grown neonate.

DISCUSSION

Prey and its composition

The diet of this species primarily consists of arthropods, especially orthopteran insects, with the majority of them being arboreal species. On average, the prey's length is approximately 30% of the frog's body length in both sexes, although they may occasionally consume prey larger than their body length. Similarly, males capable of swallowing up to two-thirds of their gape width and females up to one-third.

This species has often been considered a non-selective feeder in Southeast Asian studies, especially when compared to sympatric ant-specialist feeders, such as several microhylid frogs (Berry, 1965; Yap, 2015; Le et al., 2018). Prey compositions vary locally according to the composition of local prey guilds, as Berry (1965) predicted. For instance, while orthopterans emerged as the most numerous and frequently consumed prey category in Okinawajima and Vietnam (as "*Polypedates* cf. *leucomystax*": Le et al., 2018), they were overtaken by hymenopterans (mostly Formicid ants) in the Philippines, Malaysia, and Singapore (Berry, 1965; Almeria and Nuñeza, 2013; Yap, 2015; Gersava et al., 2020). As Katsube and Ota (2007) proposed, the prevalence of these prey types could reflect their high abundance in the primary habitats of this frog in Okinawajima (secondary forests, shrubs, and harvested areas). The dominance of the arboreal cricket, *Cardiodactylus guttulus*, could also be attributed to its abundance in Okinawajima's forest-edge lower vegetation. In addition, unlike males, females rarely consume gastropods, which might be due to differences in reproductive activity. Females may occupy places with fewer gastropods and temporarily visit wetlands for breeding.

Implications for the ecological impacts of P. leucomystax

Regarding the predation pressure from this frog on native animals, particular caution may be necessary for threatened arboreal species with body dimensions small enough to be preyed upon by *P. leucomystax*, typically those less than 25 mm in body length. Additionally, the species' predation on an arboreal lizard confirmed in this study may not be an isolated case. Hasegawa (1984) reported some endoparasites typically found in lizards in the rectum of an Okinawajima *P. leucomystax*, suggesting that the consumption of a gecko could potentially explain the frog's infection.

Concerning potential ecological conflicts with indigenous anurans (Ota, 2002; Sengoku and Toda, 2019), the lack of dietary data for these native species hinders the evaluation of the existence or extent of competition for food resources between *P. leucomystax* and these native species. It is expected that *P. leucomystax* and the co-occurring indigenous Rhacophorine species (*Zhangixalus owstoni* on Ishigakijima Island and *Z. viridis* on Okinawajima Island and adjacent islands) have similar feeding habits and prey components. This assumption is supported by the dietary data of the closely related *Z. arboreus* (see Toda and Kusano, 2013), which mirrors that of the *P. leucomystax* presented in this study.

It should also be noted that our nutritional data for Okinawan *P. leucomystax* represent only their dietary habits during their breeding activities and the month immediately after that. However, this period corresponds the most of expected active seasons for this tropical species on the island. Therefore, the data presented here provide a foundation for elucidating the ecological impacts from this introduced species upon indigenous faunas.

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Literature Cited

Almeria, M. L. and Nuñeza, O. M. 2013. Diet of seven anuran species (Amphibia: Anura) in Agusan Marsh, Mindanao, Philippines. *ABAH Bioflux* 5: 116–126.

Aoyagi, M., Nishimura, Y., Kubo, M., Higa, R., and Arai, R. 2022. The first record of *Polypedates leucomystax* from Gerumajima Island of the Kerama Islands. *Akamata* 31: 28–29.

Berry, P. Y. 1965. The diet of some Singapore Anura (Amphibia). *Proceedings of the Zoological Society of London* 144: 163–167.

Gersava, J. R. D., Abad, R. G., Camìno, F. A., Responte, M. A., Achondo, M. A. M. M., and Gamalo, L. E. D. 2020. Native and invasive alien anuran species in urbanized areas in Davao City, Philippines, with preliminary study of feeding biology. *Biyolojik Çeşitlilik ve Koruma* 13: 1–8.

Hasegawa, H. 1984. *Skrjabinodon* sp. collected from a frog, *Polypedates leucomystax* in Naha City, Okinawa, Japan (Nematoda: Oxyuroidea: Pharyngodonidae). *Akamata* 2: 9–11.

Hasegawa, H. 1993. *Raillietnema rhacophori* Yuen, 1965 (Nematoda: Cosmocercidae) collected from a frog, *Polypedates leucomystax*, on Okinawa-jima, Japan. *Biological Magazine Okinawa* 31: 15–19.

Hasegawa, H. 1994. Prevalence of helminth parasites in sympatric frogs, *Rana limnocharis* and *Polypedates leucomystax*, in Haneji, Nago, Okinawa Island, Japan. *Akamata* 10: 13–16.

Hasegawa, H., Kadota, Y., Ikeda, Y., Sato, A., and Matsuura, K. 2018. Helminth parasites of *Polypedates leucomystax* (Amphibia: Rhacophoridae) in Yaeyama Islands, Southern Ryukyu, Okinawa, Japan. *Current Herpetology* 37: 1–10.

Hasegawa, H. and Ota, H. 2017. Parasitic helminths found from *Polypedates leucomystax* (Amphibia: Rhacophoridae) on Miyakojima Island, Ryukyu Archipelago, Japan. *Current Herpetology* 36: 1–10.

Kadota, Y. and Maenosono, T. 2007. New records of the white-lipped tree frog, *Polypedates leucomystax*, from several islands of the Okinawa Group, Japan. *Akamata* 18: 23–27.

Katsube, I. and Ota, H. 2007. Breeding and dietary habits of the introduced tree frog, *Polypedates leucomystax* (Anura, Rhacophoridae), in the Ryukyu Archipelago, Japan. *Bulletin of the Herpetological Society of Japan* 2007: 73–74.

Kuraishi, N., Matsui, M., and Ota, H. 2009. Estimation of the origin of *Polypedates leucomystax* (Amphibia: Anura: Rhacophoridae) introduced to the Ryukyu Archipelago, Japan. *Pacific Science* 63: 317–325.

Kuramoto, M. 1965. A record of *Rhacophorus leucomystax* from the Ryukyu Islands. *Bulletin of Fukuoka Gakugei University, Part III, Natural Sciences* 15: 59–61.

Le, D. T. T., Rowley, J. J. L., Tran, D. T. A., Vo, T. N., and Hoang, H. D. 2018. Diet composition and overlap in a montane frog community in Vietnam. *Herpetological Conservation and Biology* 13: 205–215.

Maenosono, T. and Toda, M. 2007. Distributions of amphibians and terrestrial reptiles in the Ryukyu Archipelago: a review of published records. *Akamata* 18: 28–46.

Magnusson, W. E., Lima, A. P., Da Silva, W. A., and Araújo, M. C. 2003. Use of geometric forms to estimate volume of invertebrates in ecological studies of dietary overlap. *Copeia* 2003: 1–9.

Okinawa Amami Nature Conservation Office, Ministry of the Environment. 2023. *Confirmation of the Specific Alien Species, the White-lipped Tree Frog, on Tokunoshima.* https://kyushu.env.go.jp/okinawa/press_00049.html (accessed 22 May 2023)

Ota, H. 2002. *Polypedates leocomystax*. p. 107. *In*: The Ecological Society of Japan (ed.), *Handbook of Alien Species in Japan*. Chijin Shokan, Tokyo.

Ota, H. 2014. *Japalura polygonata polygonata* (Hallowell, 1861). p. 42–43. *In*: Ministry of the Environment (ed.), *Threatened Wildlife of Japan. Red Data Book 2014. Reptilia/Amphibia*. Gyosei, Tokyo.

Ota, H., Toda, M., Masunaga, G., Kikukawa, A., and Toda, M. 2004. Feral populations of amphibians and reptiles in the Ryukyu Archipelago, Japan. *Global Environmental Research* 8: 133–143.

Ota, H., Tsunoda, M., Nakaza, H., and Nakayama, A. 2008. Records of the exotic frog, *Polypedates leucomystax*, from Ishigakijima Island of the Yaeyama Group and Kitadaitojima Island of the Daito Group, Ryukyu Archipelago, Japan. *Akamata* 19: 44–48.

Sengoku, S. and Toda, M. 2019. *Polypedates leucomystax*. p. 134–135. *In*: Japan Wildlife Research Center (ed.), *A Photographic Guide to the Invasive Alien Species in Japan*. Heibonsha, Tokyo.

Taba, M., Shimoji, N., Yamazato, S., Shirahata, H., and Tominaga, A. 2013. Invasion of *Polypedates leucomystax* on Yoron Island, Kagoshima Prefecture. *Bulletin of the Herpetological Society of Japan* 2013: 96–97.

Takao, A., Take, M., and Take, M. 2013. A new record of *Polypedates leucomystax* from Yoron Island of the Amami Islands. *Akamata* 24: 19–20.

Tanaka, S. and Chigira, Y. 2017. *Japalura polygonata polygonata* (Hallowell, 1861). p. 193–194. *In*: Nature Conservation Division, Department of

Environmental Affairs, Okinawa Prefectural Government (ed.), *Threatened Wildlife in Okinawa, Third Edition (Animals)*. Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefectural Government, Naha.

Toda, M. 2019. Controlling the sugarcane toad and white-lipped tree frog in Yaeyama area, Okinawa Prefecture. p. 138. *In*: Japan Wildlife Research Center (ed.), *A Photographic Guide to the Invasive Alien Species in Japan*. Heibonsha, Tokyo.

Toda, M. and Kusano, T. 2013. Feeding habits of the Japanese treefrog, *Rhacophorus arboreus*, clarified by palpation and forced-regurgitation methods. *Journal of the Japanese Wildlife Research Society* 83: 13–20.

Toyama, M. 1984. A new record of *Polypedates leucomystax* (Rhacophoridae) from Okinawa-jima, the Okinawa Islands. *Akamata* 2: 1.

UNESCO. 2021. *Amami-Oshima Island, Tokunoshima Island, Northern part of Okinawa Island, and Iriomote Island*. http://whc.unesco.org/en/list/1574 (accessed 20 December 2023)

Yap, C. H. 2015. Diet of Five Common Anurans Found in Disturbed Areas in Northern Peninsular Malaysia. *Unpublished master's thesis*. Universiti Sains Malaysia, Penang.

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Appendix

Summary of %N, %F, and %V for prey taxa found from stomachs of *Polypedates leucomystax* examined in this study.

Higher taxonomic category			Species or the lowest taxonomic category	%N	%F	%V
Phylum	Class	Order				
Arthropoda			**Phylum Arthropoda all taxa**	**85.58**	**94.78**	**86.59**
	Insecta		**Class Insecta all taxa**	**61.40**	**73.88**	**74.01**
		Mantodea	*Amantis nawai* (Shiraki, 1908)	**0.47**	**0.75**	**0.18**
		Dermaptera	**Order Dermaptera all taxa**	**2.79**	**4.48**	**0.65**
			Proreus simulans (Stål, 1860)	2.33	3.73	0.59
			Unidentified Dermaptera	0.47	0.75	0.06
		Phasmatodea	**Order Phasmatodea all taxa**	**2.33**	**3.73**	**6.98**
			Sipyloidea sipylus (Westwood, 1859)	1.40	2.24	5.21
			Unidentified Phasmatodea	0.93	1.49	1.77
		Blattodea	**Order Blattodea all taxa**	**2.79**	**2.99**	**1.82**
			Episymploce sundaica (Hebard, 1929)	0.93	0.75	0.88
			Unidentified Blattodea	1.86	2.24	0.95
		Lepidoptera	**Order Lepidoptera all taxa**	**3.72**	**4.48**	**4.23**
			Unidentified moss (adult)	0.93	1.49	0.23
			Unidentified catarpillars	2.79	2.99	4.00
		Hemiptera	**Order Hemiptera all taxa**	**4.19**	**5.97**	**0.83**
			Mindura sundana Kirkaldy, 1909	0.47	0.75	0.11
			Ugyops vittatus (Matsumura, 1906)	0.47	0.75	0.06
			Nisia nervosa (Motschulsky, 1863)	0.47	0.75	0.01
			Unidentified Delphacidae	0.47	0.75	0.02
			Leptocorisa chinensis Dallas, 1852	0.47	0.75	0.10
			Metochus uniguttatus (Thunberg, 1822)	0.93	0.75	0.28
			Polytoxus fuscovittatus (Stål, 1860)	0.47	0.75	0.02
			Unidentified Reduviidae	0.47	0.75	0.24
		Orthoptera	**Order Orthoptera all taxa**	**29.77**	**43.28**	**51.63**
			Nippancistroger testaceus (Matsumura and Shiraki, 1908)	0.47	0.75	0.21
			Conocephalus exemptus (Walker, 1869)	0.47	0.75	0.61
			Euconocephalus sp. either *E. varius* (Walker, 1869) or *E. nasutus* (Thunberg, 1815)	0.47	0.75	1.08
			Hexacentrus unicolor Audinet-Serville, 1831	0.47	0.75	0.45
			Psyrana ryukyuensis Ichikawa, 2001	0.47	0.75	1.25
			Aphonoides rufescens Ichikawa, 2001	0.47	0.75	0.19

Appendix

(continued)

Higher taxonomic category			Species or the lowest taxonomic category	%N	%F	%V
Phylum	Class	Order				
			Teleogryllus occipitalis (Audinet-Serville, 1839)	0.47	0.75	1.13
			Cardiodactylus guttulus (Matsumura, 1913)	17.21	25.37	38.69
			Duolandrevus ivani (Gorochov, 1988)	1.40	2.24	3.01
			Natula pravdini (Gorochov, 1985)	1.40	2.24	0.08
			Natula sp.	0.93	1.49	0.04
			Trigonidium pallipes Stål, 1861	0.47	0.75	0.01
			Homoeoxipha lycoides (Walker, 1869)	0.47	0.75	0.04
			Ornebius kanetataki (Matsumura, 1904)	0.47	0.75	0.05
			Unidentified Mogoplistidae	0.93	1.49	0.08
			Tonkinacris ruficerus Ito, 1999	0.47	0.75	0.69
			Oxya podisma Karny, 1915	0.47	0.75	0.77
			Unidentified Orthoptera	2.33	3.73	3.27
		Coleoptera	**Order Coleoptera all taxa**	**6.05**	**5.97**	**3.01**
			Phaeochrous emarginatus Castelnau, 1840	0.93	1.49	0.90
			Copelatus oblitus Sharp, 1882	0.47	0.75	0.07
			Sybra ordinata loochooana Breuning, 1939	0.47	0.75	0.09
			Bumetopia japonica okinawana Hayashi, 1963	1.40	2.24	0.84
			Unidentified Cerambycidae	0.47	0.75	0.08
			Notomyllocerus neglectus (Voss, 1971)	0.47	0.75	0.05
			Unidentified Curculionidae	0.93	1.49	0.98
			Unidentified Scolytidae	0.47	0.75	0.00
			Unidentified Coleoptera	0.47	0.75	0.01
		Hymenoptera	**Order Hymenoptera all taxa**	**2.79**	**3.73**	**0.01**
			Pristomyrmex punctatus (F. Smith, 1860)	0.47	0.75	<0.01
			Monomorium floricola (Jerdon, 1851)	0.47	0.75	<0.01
			Tetramorium bicarinatum (Nylander, 1846)	0.93	0.75	0.01
			Brachyponera chinensis (Emery, 1894)	0.47	0.75	<0.01
			Unidentified Hymenoptera	0.47	0.75	<0.01
		Diptera	Unidentified Diptera	**2.33**	**2.24**	**0.12**
		Insecta order indet.	Unidentified Insecta	4.19	6.72	4.53
	Chiropoda	Scutigeromorpha	*Thereuopoda clunifera* (Wood, 1862)	**0.47**	**0.75**	**3.02**
	Malacostraca	Isopoda	Unidentified Armadillidae	**0.47**	**0.75**	**0.08**
	Arachnida		**Class Arachnida all taxa**	**20.00**	**28.36**	**6.27**

Appendix

(continued)

Higher taxonomic category			Species or the lowest taxonomic category	%N	%F	%V
Phylum	Class	Order				
		Acari	**Order Acari all taxa**	**2.33**	**2.24**	**0.01**
			Unidentified Oribatida	1.40	2.24	0.01
			Unidentified Acari	0.93	0.75	<0.01
		Araneae	**Order Araneae all taxa**	**16.74**	**24.63**	**5.91**
			Neoscona scylla (Karsch, 1879)	0.93	1.49	1.71
			Chiracanthium submordax Zhang, Zhu et Hu, 1993	0.47	0.75	0.11
			Unidentified Theridiidae	0.47	0.75	0.01
			Dolomedes horishanus Kishida, 1936	0.47	0.75	0.20
			Pisauridae sp. cf. *Dolomedes horishanus* Kishida, 1936	0.47	0.75	0.05
			Pardosa pseudoannulata (Bösenberg et Strand, 1906)	1.40	2.24	0.35
			Pardosa sp.	0.93	0.75	0.28
			Tetragnatha javana Thorell, 1890	0.93	1.49	0.16
			Tetragnatha mandibulata Walckenaer, 1841	0.47	0.75	0.08
			Unidentified Tetragnathidae	0.93	1.49	0.06
			Unidentified Salticidae	1.40	2.24	0.14
			Unidentified Araneae	7.91	11.94	2.76
		Opiliones	*Pseudogagrella amamiana* (Nakatsudi, 1942)	**0.93**	**1.49**	**0.36**
	Arthropoda class et order indet.		Unidentified Arthropoda	3.26	5.22	3.20
Mollusca	Gastropoda		**Class Gastropoda all taxa**	**13.95**	**20.15**	**12.01**
		Neritimorpha	*Aphanoconia verecundum* (Gould, 1859)	0.47	0.75	0.04
		Architaenioglossa	*Cyclophorus* sp.	0.47	0.75	0.06
		Pulmonata	*Austropeplea ollula* (Gould, 1859)	0.47	0.75	0.02
		Sorbeoconcha	*Paludinassiminea debilis* (Gould, 1859)	0.47	0.75	0.07
			Succinea sp.	5.12	6.72	5.00
			Bradybaena circulus (Pfeiffer, 1846)	1.40	2.24	1.80
			Bradybaena similaris (Férussac, 1822)	0.47	0.75	0.60
			Unidentified Gastropoda	5.12	8.21	4.42
Chordata	Reptilia	Squamata	*Diploderma polygonatum polygonatum* Hallowell, 1861	**0.47**	**0.75**	**1.41**