

**Coqui 1**

**HAWAII RESIDENTS' ATTITUDES TOWARDS THE MANAGEMENT OF AN  
INVASIVE FROG SPECIES (*ELEUTHERODACTYLUS COQUI*)**

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## Coqui 2

### HAWAII RESIDENTS' ATTITUDES TOWARDS THE MANAGEMENT OF AN INVASIVE FROG SPECIES (*ELEUTHERODACTYLUS COQUI*)

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#### **Abstract**

The coqui frog *Eleutherodactylus coqui* was unintentionally introduced to Hawaii in the late 1980's. Since its introduction, the frog has been discovered in four islands: Oahu, Maui, Kauai, and Island of Hawaii. Much research has been done regarding the management of the coqui frog, including evaluation of control options involving the use citric acid, hydrated lime and chytrid fungus; however, little research has been done to address the societal impacts of the coqui frogs or the attitudes of Hawaii residents and their support for various management options. A self-administered mail questionnaire was used to evaluate Hawaii residents' perceptions toward the frog and its management. (32.4% response rate, n=653). A majority (72.4%) of respondents do not enjoy the presence of the coqui frog and consider it a nuisance while others (20.1%) simply do not care about it. Residents of the Island of Hawaii and those who had been born in Hawaii State are more likely to consider the frog a nuisance and to favor the different management options compared to residents of other islands and those not born in Hawaii. Although most respondents considered it very important for the government to manage the coqui frog, support for management decreased when respondents were asked about their support for specific management methods, most of which are lethal to the frog. Using the New Ecological Paradigm (NEP) Scale, it was revealed that most respondents tended to have a proenvironmental orientation. Respondents' knowledge and proenvironmental orientation were associated with the degree of management that they would support. However, a proenvironmental orientation was not always associated with support for the management of the coqui frog. Managers may be able to use communication strategies to increase public understanding about the ecological impacts of the coqui and the implications of specific management options, appealing to Hawaii residents' proenvironmental orientation.

## Coqui 3

### Introduction

*Eleutherodactylus coqui* (coqui frog), a frog native to Puerto Rico, was introduced via nursery plants into Hawaii in the late 1980's (Beard and Pitt 2005; Woolbright et al. 2006). Hawaii has no native herpeto-fauna, and thus there is debate about the extent to which introduced reptiles and amphibians may pose ecological threats (Kraus et al. 1999; Kraus et al. 2002). Most research has been devoted to the management of the coqui frog instead of assessing its ecological and social impacts as an invasive species (Beard and Pitt 2005). This study aims to improve understanding of public attitudes towards the frog and its perceived impacts, as well as provide insight about support for various management options.

Reasons cited by authorities for the eradication and management of the coqui frog include: 1) its high-pitched mating call could deprive people from sleep; 2) the coqui frog could lower real estate values and hurt local tourism; 3) it could predate on native Hawaiian insects; and, 4) it could compete with native birds for food or attract predators (CTAHR 2006; Ciesla 2002; HEAR 2006; Kraus et al. 1999; Kraus et al. 2002). Yet, studies have shown that some of the ecological concerns are unfounded; for example, the concern over the coqui frog competing with native birds for prey may not be necessary because the frog has mostly invaded sites below 500m of elevation whereas endemic birds are typically found above 500m (Beard and Pitt 2006). The argument that coqui frogs may attract and sustain potential bird predators, such as rats and mongooses may be erroneous, because studies suggest that coqui frogs are unlikely to bolster rat or mongoose populations (Beard et al. 2003; Beard and Pitt 2005; Beard and Pitt 2006).

## Coqui 4

Several management options have been proposed and studied, including chemical and biological control (CTAHR 2006; Kraus et al. 2002). One of the proposed methods for management has been the establishment of capture programs to exterminate or relocate frogs (Kraus et al. 2002). Spraying plants where the Coqui frog inhabits with hot water, killing the frogs, has also been promoted and seems to be effective (Beard and Pitt 2005; CTAHR 2006). In addition, citric acid and hydrated lime have been approved by authorities to stimulate frog mortality, yet both seem to have phytotoxic effects and could potentially harm native vegetation and other fauna (Beard and O'Neill 2005; CTAHR 2006). Authorities are evaluating the use of the chytrid fungus, *Batrachochytrium dendrobatidis*, as a method of biological control to reduce coqui numbers (CTAHR 2006; Beard and O'Neill 2005). The chytrid fungus has been identified as a causal agent of amphibian declines in the Americas, Europe, and Australia, however, it might not be able to completely control the coqui frog and the fungus' effects on other species have not been studied (Beard and O'Neill 2005).

Regardless of its impacts, the spread of the coqui frog throughout Hawaii has been rapid and strong, and at some sites the frog has achieved population densities higher than in its native Puerto Rico (Woolbright et al. 2006). The frog has now been found in the Hawaiian Islands of Oahu, Maui, Kauai, and the Island of Hawaii (Beard and Pitt 2005; Woolbright et al. 2006). Because several journalistic reports as well as citations from authorities have claimed that the coqui frog has lowered the quality of life of Hawaiian residents, this study aims to determine the attitudes of Hawaiian residents towards the coqui frog and the management options that have been proposed to control its population and spread. Research regarding attitudes of people towards wildlife

## **Coqui 5**

management has shown that communication regarding specific management techniques can influence the public's attitudes towards them and that communication addressing the concerns of the public tend to be the most effective (Lauber and Knuth 2004). The study could serve as a step towards identifying more comprehensively the impacts of the frog and the social context in which management must occur, to help establish more effective management practices.

### **Theoretical background**

#### ***New Ecological Paradigm***

In 1978, Dunlap and Van Liere developed the New Environmental Paradigm (NEP) Scale to measure individuals' proenvironmental orientation. Even though attitude theory cautions against the use of particular individual items as precise (clear-cut) indicators of attitudes, it can be argued that the NEP Scale items tap into so called "primitive beliefs" about the nature of the relationship between humans and the earth (Dunlap et al. 2000). Social psychologists see primitive beliefs as influencing a wide range of beliefs and attitudes concerning more specific environmental issues (Dunlap et al. 2000). In addition, researchers have found that young, well-educated, and politically liberal adults tend to be more proenvironmental than their counterparts (Jones and Dunlap 1992) and that differences occur based on rural vs. urban residence (Dunlap et al. 2000).

#### ***NEP and the attitudes of Hawaii residents towards the coqui frog***

This study incorporates the NEP 15-item scale and assesses the attitudes of Hawaii residents towards the coqui frog and its management while comparing these attitudes to the proenvironmental orientation measured by the NEP scale. The objectives for this study were to:

## **Coqui 6**

*Objective 1:* Characterize Hawaii residents' knowledge, perceptions, and information sources related to the coqui;

*Objective 2:* Identify the degree of support among Hawaii residents for potential coqui management options;

*Objective 3:* Identify differences in perceptions and attitudes toward the coqui and its management, based on island of residence, and on whether individuals are born in Hawaii or not;

*Objective 4:* Compare the attitudes of Hawaii residents towards the coqui frog and the environment as measured by the NEP scale.

## **Methods**

### ***Study area***

The literature review revealed that four islands of the Hawaiian archipelago had been invaded by the coqui frog (Hawaii, Kauai, Maui and Oahu) (Beard et al., 2005; Woolbright et al., 2006). Oahu is the most populous island of the Hawaiian archipelago, while Hawaii, the largest island in the archipelago, was the first to be invaded (1988) and contains much higher densities of the coqui frog than the other islands and even the frog's native Puerto Rico, particularly in the Hilo district (Woolbright et al., 2006).

### ***Survey Design***

The self-administered mail questionnaire was designed consisting mostly of Likert-type questions and some multiple choice and true-or-false questions. We followed the survey implementation methods recommended by Dillman (2000). The survey questions were grouped into four different categories that measured the attitudes of Hawaii residents towards: (1) the coqui frog; (2) its management; and (3) the environment; as well as (4)

## **Coqui 7**

demographic characteristics. A set of true-or-false statements was introduced to measure the knowledge of respondents regarding the coqui frog.

Specialists in Cornell's Human Dimensions Research Unit (HDRU) reviewed the questionnaire, as well as researchers familiar with the coqui frog, and staff from the Invasive Species Councils of Hawaii, Oahu, and Maui. The questionnaire was later submitted for approval to Cornell University's University Committee on Human Subjects (UCHS) and received institutional approval.

### ***Survey Implementation***

After the survey was reviewed, updated, and approved, it was mailed to 2,500 Hawaii residents (625 per island) for which the addresses were purchased from GENESYS. Based on previous experience within the HDRU in the Department of Natural Resources at Cornell, I anticipated a 10% unusable rate for addresses, and a 40% response rate, resulting in a final, useable respondent pool of about 900. The first wave of questionnaires was mailed in January 2007 along with a cover letter, and was followed by three additional waves including a reminder letter, a letter with another copy of the questionnaire, and a final letter.

### ***Analyses***

Data from the survey were recorded using SPSS Data Entry. Results are presented by island and overall. For overall results pooling responses from all islands, weighting of responses was used to correct for sampling bias. Because the original sample had an equal number of addresses drawn from each island and was not in proportion to the number of households on each island, I used the number of households on each island and calculated a weight factor for each island to apply during data analysis (Table 1)

## Coqui 8

when using pooled, overall data. The analyses were performed using SPSS 14.0 for Windows XP (George and Mallery 2001). Pearson's chi-square analyses, ANOVA, frequencies, means, standard deviations, and cross-tabulations were calculated depending on the questionnaire item. A non-response bias test, usually done by a telephone follow-up of non-respondents, could not be performed due to financial constraints.

Knowledge scores were calculated for respondents based on the amount of correct answers to seven factual statements. The scores ranged from 1 to 7, the higher score representing the most knowledge. Finally, NEP scores were calculated based on the level of agreement given by respondents to the fifteen statements in the NEP Scale. Recoding was done for those statements that reflected a non-proenvironmental view and means were calculated using the scale as a single factor. The NEP scores ranged from 1 to 5 with 1 representing a very pro-environmental orientation and 5 representing a not at all proenvironmental orientation.

<b>Island</b>	<b>Number of Households</b>	<b>Proportion of Population</b>	<b>Number of Respondents</b>	<b>Adjusted Number of Respondents According to Proportion of Population</b>	<b>Weight Factor</b>
Oahu	173,352	0.64	155	415	2.68
Hawaii	46,911	0.17	216	112	0.52
Kauai	16,591	0.06	135	40	0.29
Maui	35,899	0.13	147	86	0.58
<b>Total</b>	<b>272,753</b>	<b>1</b>	<b>653</b>	<b>653</b>	<b>1</b>

## Results

### *Response*

There was an unexpectedly high number of undeliverable addresses, 19.5% (n=487). Removing these from the sample, an overall adjusted response rate of 32.4% (n=653) was



## **Coqui 9**

achieved with a 95% confidence interval of 3.83. The adjusted response rate was highest for the Island of Hawaii at 34.7% (n=216) and lowest for Kauai at 21.4% (n=135). The adjusted response rates for Maui and Oahu were 23.5% (n=147) and 24.8% (n=155), respectively. It was determined the response rate was sufficient to address the study objectives.

### ***Respondent Characteristics***

The average age of respondents was 58.24 years. Of the respondents who answered the question about their sex, 59.2% (n=372) were male and 40.8% (n=256) female. This contrasts with the 49.8% male 50.2% female distribution of Hawaii's adult population (US Census 2007). Half of the respondents (48.6%, n=318) had obtained a bachelor's degree or graduate degree, while only 26.2% of Hawaii's population possesses a bachelor's degree or higher (US Census 2007).

Of the respondents, 20.6% identified themselves as urban residents while 40.1% identified their residences as suburban and 39.3% as rural. However, the frequencies of urban, suburban and rural residents varied per island. For example, 32.9% of the respondents from Oahu identified their residences as urban, 51.4% as suburban and 15.7% as rural while the respondents from Kauai, Maui and the Island of Hawaii showed similar numbers to those of the overall population of Hawaii (9.4% urban, 36.7% suburban, and 53.9% rural).

In terms of identifying those respondents born in Hawaii, 43.8% of respondents had been born in Hawaii and 46.5% had spent the majority of their youth in Hawaii. It is important to note that 98.8% of those born in Hawaii State had spent the majority of their

## Coqui 10

youth there while 91.3% of those born outside of Hawaii State had spent the majority of their youth outside the State ( $X^2=513.06$ ,  $df=1$ ,  $sig=0.000$ ).

### *Attitudes towards the coqui frog*

The vast majority of respondents (96.4%) had read or heard about the coqui frog prior to receiving the questionnaire. These results varied by island. While 99.1% of respondents from the Island of Hawaii had heard or read about the frog, only 87.7% of residents from Oahu had done the same. ( $X^2=66.81$ ,  $df=3$ ,  $sig=0.000$ ). The type of residence also affected whether an individual had read or heard about the coqui frog since 8.7% of urban residents had never read or heard about it but only 2.5% of rural residents had not done so ( $X^2=12.29$ ,  $df=2$ ,  $sig=0.002$ ). The main sources that respondents identified as having used to read or hear about the coqui frog were newspapers, TV/Radio, friends and family, and other. Over 74.4% of residents who had heard or read about the coqui frog did not identify the government as a source of that information.

Having heard a coqui frog differed among islands. When asked whether they had ever heard a coqui frog, 54.6% of respondents from the Island of Hawaii answered affirmatively, while only 13.1% and 11.7% from Oahu and Kauai, respectively, answered the same. For Maui, 20.6% of respondents reported also having heard the coqui frog's call ( $X^2=162.113$ ,  $df=3$ ,  $sig=0.000$ ). For those respondents who reported having heard the frog, the frequencies for which they heard the coqui differed per island; most of those responding affirmatively for the Island of Hawaii heard it daily as opposed to those residents from other islands who mostly heard it less than monthly (Table 2). When asked the places where they heard the coqui frog, 69.9% of respondents from the Island of Hawaii had heard it at their homes, while only 27.7%, 24.3%, and 19.5% of residents

## Coqui 11

from Oahu, Maui, and Kauai only heard it at their home, respectively. Over 20% of Oahu residents who had heard the frog reported listening to it at a hotel (listed under “Other”). A majority of respondents from each island who reported hearing the frog marked the location as other, yet many respondents wrote down Hilo or Island of Hawaii under that category. A majority of respondents from Oahu, Maui, and Kauai reported never having seen the frog (17.8%, 25.0%, and 11.7% respectively) while the opposite was true for the Island of Hawaii where 66.5% percent of respondents had seen it ( $X^2=147.547$ ,  $df=3$ ,  $sig=0.000$ ). Most respondents who reported having seen the frog indicated that it was less than monthly and at the same locations they had heard it.

	Daily		Weekly		Monthly		Less than monthly	
Island	n	%	n	%	n	%	n	%
Oahu	4	9.5	2	4.8	4	9.5	32	76.2
Maui	7	10	8	8.4	8	8.4	47	67.1
Kauai	3	7.7	4	10.3	2	5.1	30	76.9
Hawaii	120	61.9	12	6.2	20	10.3	42	21.6
$X^2=224.07$ , $df=6$ , $sig=0.000$								

A majority of respondents from all four islands indicated no interest in seeing or hearing the coqui frog, the respondents who showed more interest were those from Oahu where 33.8% of respondents showed some level of interest in seeing the frog and 28.1% in hearing it. When asked how they felt personally about the frog, responses varied somewhat by island with a majority of respondents noting that they “do not enjoy the presence of the coqui frog and regard them as nuisances” followed by those noting that they “have no particular feelings about coqui frogs in Hawaii” (Table 3). There were small differences between Hawaii residents born in Hawaii vs. those not born in Hawaii

## Coqui 12

regarding their attitudes towards the frog. Over 80% of respondents born in Hawaii responded “do not enjoy the presence of the coqui frog and regard them as nuisances” whereas only 65.6% of respondents not born in Hawaii responded in this way. A greater proportion of respondents not born in Hawaii (23.5%) noted that they had “no particular feelings about the frog” compared with a smaller proportion (16.1%) of those born in Hawaii who noted the same response.

	<b>Oahu</b>		<b>Maui</b>		<b>Kauai</b>		<b>Hawaii</b>		<b>Total</b>	
	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>
I enjoy the presence of the coqui frog, and I do not worry about problems it may cause.	6	4.1	0	0.0	4	3.3	1	0.5	11	<b>1.8</b>
I enjoy the presence of the coqui frog, and I worry about problems it may cause.	12	8.2	7	5.2	7	5.7	8	8.1	34	<b>5.6</b>
I do not enjoy the presence of the coqui frog and regard them as nuisances.	87	59.2	96	71.1	82	66.7	171	86.8	436	<b>72.4</b>
I have no particular feelings about coqui frogs in Hawaii.	48	28.6	32	23.7	30	24.4	17	8.6	121	<b>20.1</b>
$X^2=79.80, df=9, sig=0.000$										

When presented with the true or false statements in Table 4, many respondents did not know the answer or a majority marked the wrong one in three instances. Interestingly, a majority of the respondents of Hawaii State do not know that it has no native amphibians or land reptiles (Table 4). There were no significant differences in the knowledge score of respondents by island, but overall knowledge scores demonstrated rather low levels of knowledge about the coqui frog and the Hawaiian ecosystem (Table 5).

**Table 4. Overall responses of Hawaii residents to the true-or-false statements presented regarding coqui and Hawaii ecology.**

	True		False		Do not know	
	n	%	n	%	n	%
The coqui frog is an introduced species. <b>T</b>	519	85.1	18	3.0	73	12.0
Coqui frogs control insect populations. <b>T</b>	136	22.7	183	30.6	280	46.7
The coqui frog is an endangered species. <b>F</b>	14	2.4	417	69.8	157	27.8
Coqui frogs compete with native birds for food. <b>F</b>	283	48.7	47	8.1	251	43.2
Coqui frogs have no natural predators in Hawaii. <b>T</b>	316	52.2	55	9.1	234	38.7
Hawaii has no native amphibians or reptiles. <b>T</b>	189	31.4	218	36.2	195	32.4
Coqui frogs serve as food source to mongooses. <b>F</b>	33	5.5	200	33.2	369	61.3
Coqui frogs serve as food source to birds. <b>U</b>	46	7.6	209	34.7	348	57.7

**Table 5. ANOVA showing mean knowledge score of respondents regarding coqui and Hawaii ecology based on the statements in Table 4, by island.**

	Mean	Standard Deviation
<b>Oahu</b>	3.21	1.12
<b>Hawaii</b>	3.24	1.03
<b>Kauai</b>	3.15	1.11
<b>Maui</b>	3.18	1.15
F=0.085, Sig=0.968; 0= no knowledge, 7=high knowledge		

Overall, Hawaii residents differed in the extent they believed they had been properly informed by government authorities about the coqui frog, its impacts and its management; 7.6% felt they had been informed to a great extent, 30.7% to a moderate extent, 35.0% to a slight extent, and 17.6% indicated they had not been informed at all. Respondents from the Island of Hawaii felt they had been better informed compared to respondents from the other three islands, while respondents from Oahu felt they had been the least informed ( $X^2=29.298$ ,  $df=12$ ,  $sig=0.004$ ).

***Attitudes towards the management of the coqui frog***

Nearly 65% of respondents felt that the government should manage the coqui frog to a great extent and 58.5% found it to be very important for the state of Hawaii to sponsor research on the ecological, economic, and social impacts of the coqui frog.

## Coqui 14

However, there was some variation between the islands; more respondents from the Island of Hawaii (76.1%) supported management to a great extent than those from Oahu (50.8%), Maui (65.9%), and Kauai (58.4%) ( $X^2=69.022$ ,  $df=12$ ,  $sig=0.000$ ).

When asked about the management options for the coqui frog, a majority of respondents found it acceptable to “capture and kill” the frogs (Table 6). However, support decreased when presented with specific management options such as the use of cytric acid, hydrated lime, and spraying with hot water. A majority of respondents did not find acceptable the capture and relocation of coqui frogs or the application of chytrid fungus. The support for most management options was higher for the respondents of the

Island	Management options	Not at all acceptable		Slightly acceptable		Moderately acceptable		Very acceptable		Do not know	
		n	%	n	%	n	%	n	%	n	%
Oahu	Capture & Relocate	60	40.8	15	10.2	12	8.2	32	28.6	18	12.2
	Capture & Kill	25	16.8	11	7.4	21	14.1	74	49.7	18	12.1
	Cytric acid	35	23.5	20	13.4	28	18.8	42	28.2	24	16.1
	Hydrated lime	40	26.8	19	12.8	23	16.4	38	25.5	29	19.5
	Spray hot water	32	21.6	9	6.1	15	10.1	66	44.6	26	17.6
	Chytrid fungus	76	51.4	9	6.1	7	4.7	16	10.8	40	27.0
Maui	Capture & Relocate	66	48.5	9	6.6	9	6.6	33	24.3	19	14.0
	Capture & Kill	19	13.7	10	7.2	16	11.5	78	56.1	16	11.5
	Cytric acid	28	20.3	9	6.5	21	15.2	54	39.1	26	18.8
	Hydrated lime	31	22.8	10	7.4	20	14.7	50	36.8	25	18.4
	Spray hot water	29	21.3	8	5.9	10	7.4	65	47.8	24	17.6
	Chytrid fungus	57	41.9	14	10.3	3	2.2	23	16.9	39	28.7
Kauai	Capture & Relocate	54	45.4	11	9.2	12	12.1	34	28.6	8	6.7
	Capture & Kill	18	14.3	8	6.3	18	14.3	74	58.7	8	6.3
	Cytric acid	27	21.6	8	6.4	26	20.8	47	37.6	17	13.6
	Hydrated lime	27	21.6	8	6.4	27	21.6	44	35.2	19	15.2
	Spray hot water	27	22.0	10	8.1	11	8.9	57	46.3	18	14.6
	Chytrid fungus	61	48.8	4	3.2	10	8.0	19	15.2	31	24.8
Hawaii	Capture & Relocate	140	68.6	14	6.9	8	3.9	34	16.7	8	3.9
	Capture & Kill	21	10.2	11	5.4	19	9.3	145	70.7	9	4.4
	Cytric acid	21	10.0	25	11.9	23	11.0	128	61.0	13	6.2
	Hydrated lime	25	12.1	19	9.2	24	11.7	123	59.7	15	7.3
	Spray hot water	36	17.5	20	9.7	18	8.7	103	50.0	29	14.1
	Chytrid fungus	81	38.9	20	9.6	6	2.9	43	20.7	58	9.4
Chi-Squares per management option, with comparisons among islands.	Capture & Relocate	$X^2=41.200$ , $df=12$ , $sig=0.000$									
	Capture & Kill	$X^2=21.655$ , $df=12$ , $sig=0.042$									
	Cytric acid	$X^2=59.836$ , $df=12$ , $sig=0.000$									
	Hydrated lime	$X^2=58.843$ , $df=12$ , $sig=0.000$									
	Spray hot water	$X^2=5.655$ , $df=12$ , $sig=0.932$									
	Chytrid fungus	$X^2=21.958$ , $df=12$ , $sig=0.038$									

## Coqui 15

Island of Hawaii than those of Oahu, Maui, and Kauai Islands (Table 6). Respondents from Oahu and Maui held similar views towards the different management options, whereas respondents from the Island of Hawaii diverged the most (Table 7).

**Table 7. ANOVA for attitudes of respondents per island towards the different management options.** A and B identify values significantly different from each other, while AB indicates that the value was not significantly different from the other values.

Management options	Island				
	Oahu	Hawaii	Maui	Kauai	
Capture & Relocate	A	B	AB	A	F=7.694, sig.=0.000
Capture & Kill	A	A	A	A	F=3.159, sig.=0.024
Cytric acid	A	B	AB	A	F=9.781, sig.=0.000
Hydrated lime	A	B	A	A	F=11.541, sig.=0.000
Spray hot water	A	A	A	A	F=0.314, sig.=0.816
Chytrid fungus	A	A	A	A	F=1.372, sig.=0.070

Most respondents considered the factors in Table 8 to be very important to a coqui frog management effort, except for the minimization of suffering to the frog. Although only 40.8% of respondents considered public support to be very important to a coqui frog management method, 68.7% considered it to be at least moderately important.

**Table 8. Importance to Hawaii resident respondents regarding characteristics of coqui management methods.**

How important is it to you that a coqui frog management method:	Very important		Moderately important		Slightly important		Not at all important		Do not know	
	N	%	N	%	n	%	n	%	N	%
Maintains the diversity of plant and animal species.	347	57.0	119	19.5	38	6.2	32	5.3	73	12.0
Minimizes health and safety risks to people.	500	80.3	55	8.8	14	2.2	7	1.1	47	7.5
Minimizes the suffering of the coqui frog.	124	20.2	75	12.2	97	15.8	266	43.3	53	8.6
Minimizes health and safety risks to other wild animals.	387	62.5	134	21.6	37	6.0	15	2.4	46	7.4
Minimizes economic costs to society.	294	47.6	157	25.4	92	14.9	30	4.9	44	7.1
Maximizes economic benefits to society.	310	53.2	138	22.3	74	12.0	33	5.3	63	10.2
Is effective at reducing coqui related problems.	436	70.3	97	15.6	20	3.2	10	1.6	57	9.2
Produces quick results.	314	50.6	160	25.8	65	10.5	27	4.4	54	8.7
Is supported by the public.	249	40.8	170	27.9	89	14.6	47	7.7	55	9.0
Minimizes the potential for harm to pets.	426	58.6	103	16.6	39	6.3	9	1.4	44	7.1

## Coqui 16

### *Attitudes towards the environment*

Based on the New Ecological Paradigm as revised by Dunlap et al. (2000), a majority of Hawaii resident respondents have strong to mild proenvironmental orientations (Tables 9 and 10). The one item that showed no clear majority was “Human ingenuity will ensure we do NOT make the Earth unlivable.” For that item, 35.5% of respondents agreed strongly or mildly, while 26.5% were unsure and 32% disagreed strongly or mildly. For all other items there were clear majorities for agreement or disagreement with a given statement.

How important is it to you that a coqui frog management method:	Strongly Agree		Mildly Agree		Unsure		Mildly Disagree		Strongly Disagree	
	N	%	N	%	n	%	n	%	N	%
We are approaching of the number of people the Earth can support.	236	36.0	155	23.7	117	17.9	75	11.5	53	8.1
Humans have the right to modify the natural environment to suit their needs.	60	9.2	184	28.2	79	12.1	151	23.1	138	21.1
When humans interfere with nature it often produces disastrous consequences.	252	38.6	221	33.8	59	9.0	66	10.1	18	2.8
Human ingenuity will ensure we do NOT make the Earth unlivable.	79	12.1	153	23.4	173	26.5	122	18.7	87	13.3
Humans are severely abusing the environment.	293	44.9	204	31.2	44	6.7	46	7.0	28	4.3
The Earth has plenty of natural resources, if we just learn how to develop them.	212	32.5	178	27.3	70	10.7	92	14.1	60	9.2
Plants and animals have as much right as humans to exist.	285	43.6	190	29.1	49	7.5	57	8.7	35	5.4
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	35	5.4	73	11.2	119	18.2	174	26.6	209	32.0
Despite our special abilities, humans are still subject to the laws of nature.	368	56.4	180	27.6	44	6.7	14	2.1	10	1.5
The so-called “ecological crisis” facing human-kind has been greatly exaggerated.	40	6.1	104	15.9	114	17.5	158	24.2	196	30.0
The Earth is like a spaceship with very limited room and resources.	196	30.0	203	31.1	91	13.9	86	13.2	38	5.8
Humans were meant to rule over the rest of nature.	51	7.8	123	18.8	95	14.5	127	19.4	217	33.2
The balance of nature is very delicate and easily upset.	272	41.7	203	31.1	70	10.7	54	8.3	16	2.5
Humans will eventually learn enough about how nature works to be able to control it.	41	6.3	121	18.5	155	23.7	159	24.3	133	20.4
If things continue on their present course, we will soon experience a major ecological catastrophe.	229	35.1	183	28.0	110	16.8	65	10.0	28	4.3



## Coqui 17

In addition, respondents' proenvironmental orientation influenced the degree to which they supported management of the coqui frog as measured by their NEP scores. Respondents who did not support any degree of management had a higher proenvironmental orientation (low NEP score) whereas respondents who were not sure had the lowest proenvironmental orientation (higher NEP score) (Table 11). Respondents who supported some degree of management had moderate proenvironmental orientations, with NEP scores that ranged from 1.90 to 2.00. The extent to which respondents thought the government should manage the coqui frog was influenced by the knowledge respondents had about the frog; the higher the knowledge score the less support respondents exhibited towards management of the coqui frog (Table 11).

<b>Table 10. ANOVA showing the degree of proenvironmental orientation of respondents, by island, as measured by NEP score.</b>		
	<b>Mean</b>	<b>Standard Deviation</b>
<b>Oahu</b>	1.97	0.51
<b>Hawaii</b>	1.93	0.53
<b>Kauai</b>	1.88	0.53
<b>Maui</b>	1.86	0.52
F=1.318, Sig=0.267; 1= very proenvironmental, 5= not at all proenvironmental		

<b>Table 11. Degree of support towards management of the coqui frog by the government based on respondents' knowledge score and proenvironmental orientation (NEP score) using ANOVA.</b>						
	<b>Great Extent</b>	<b>Moderate Extent</b>	<b>Slight Extent</b>	<b>Not at all</b>	<b>Not sure</b>	
<b>Knowledge Score</b>	3.22	3.29	3.70	4.14	2.82	F=7.287, sig.=0.000
<b>NEP Score</b>	1.90	2.00	1.92	1.48	2.16	F=8.784, sig.=0.000
For Knowledge Score, 0= no knowledge, 7=high knowledge; for NEP Score, 1= very proenvironmental, 5= not at all proenvironmental.						

## Coqui 18

### Discussion

#### *Hawaii residents' attitudes and perceptions towards the coqui frog*

Respondents to the survey mostly regarded the coqui frog as a nuisance or had no particular feelings about it; however, the majority of them had never heard or seen the frog with the exception of those respondents who are residents of the Island of Hawaii. Respondents born in Hawaii State were also more likely to consider the coqui frog a nuisance. When asked about factual statements regarding the frog or Hawaii ecology, respondents were unaware about the coqui frog's potential to control insect populations and were unclear if it competes for food with native birds. Research has suggested that the coqui does not compete directly with native birds (Beard and Pitt 2005).

Respondents to the survey identified the newspaper, TV/Radio, and family and friends as the major sources of what they had heard regarding the coqui frog. Yet, 73.3% of respondents indicated that they had been informed to some extent by government authorities. Of those who had been informed by government authorities, only 7.6% felt that they had been informed to a great extent.

It is important to note that both respondents born in Hawaii State and those respondents from the Island of Hawaii were more likely to have negative feelings towards the frog compared to those not born in Hawaii and respondents from other islands. Those respondents born in Hawaii might be more inclined to regard the frog as a nuisance because of cultural reasons, while respondents from the Island of Hawaii, which was the first island to be invaded by the frog and the one with the highest frog density populations, may have been more likely to regard them as nuisances because of their constant exposure. Many residents of other islands who had heard the frog indicated that

## **Coqui 19**

they had heard it in the Hilo District of Hawaii Island. It seems that the length of time that respondents are exposed to the coqui frog leads to an accumulation of negative perceptions, thus influencing the attitudes of respondents towards the frog and its management. Such observation would explain why respondents from the Island of Hawaii tended to have more negative views of the coqui frog and were more likely to endorse the different management options that have been suggested.

### ***Hawaii residents' attitudes towards the management of the coqui frog***

When asked about the management of the coqui frog, 64.6% of respondents felt that the government should manage the coqui frog to a great extent and 58.5% found it to be very important for the state of Hawaii to sponsor research on the ecological, economic, and social impacts of the coqui frog. Most respondents favored the killing of the coqui frog but when presented with specific management methods such as citric acid, hydrated lime, and spraying with hot water the support for such practices decreased. Respondents did not endorse the potential use of chytrid fungus as a management tool and were not in favor of the capture and relocation of the frogs. It is interesting that respondents favor the elimination of the frogs but their support towards specific management methods was lower than their overall support for the general concept of coqui management. Although, communication regarding the specific management techniques could influence the public's attitudes towards them, particularly if their concerns are addressed (Lauber and Knuth 2004).

When addressing management methods, respondents considered the health and safety to people to be the most important (80.3% considering it very important) while only 20.2% of respondents considered the suffering of the frog to be very important.

## **Coqui 20**

Respondents' answers about the importance of public support for a particular management method revealed that only 40.8% of respondents considered public support to be very important but 68.7% of respondents considered it to be very or moderately important. Such results show that respondents consider public support to be relevant to successful management, but not necessarily essential.

The degree of support towards management of the coqui frog was influenced by the knowledge score of respondents, as seen in Table 11. Yet, it seems that the more knowledge a respondent had the less likely they were to support management of the frog. In addition, it seems that knowledge is not necessarily influenced by the length of exposure or experience of respondents with the frog.

### ***Hawaii residents' attitudes towards the environment using the New Ecological Paradigm (NEP)***

The use of the NEP Scale as a single factor within the questionnaire revealed that respondents tended to have a proenvironmental orientation and that they were divided regarding whether "human ingenuity will ensure we do NOT make the Earth unlivable." Yet, if one compares Hawaii residents' proenvironmental orientation with their attitudes towards the coqui frog, it is hard to distinguish if they consider the frog to be nuisances because of anthropocentric reasons or because of the frog's capacity to change Hawaii's ecological landscape. comments included by respondents within the returned questionnaires appear to indicate that the frogs are mostly regarded as nuisances because of their traditional "co-kee" call as opposed to respondents' interest in protecting Hawaii's ecological balance and/or other species.

## **Coqui 21**

Yet, 57.0% percent of respondents considered that “maintenance of plant and animal diversity” is very important when considering a management method. The relative importance given by respondents to biodiversity in any management method is in accordance with the proenvironmental orientation of Hawaii resident respondents, as revealed by the NEP Scale. It is possible that the NEP scale does reveal “primitive beliefs” about nature (Dunlap et al. 2000), yet does not predict whether those “primitive beliefs” will take precedence over immediate anthropocentric concerns. The degree of support towards management of the coqui frog actually decreased with higher proenvironmental orientations (low NEP score). It seems that Hawaii residents may care more about their quality of life to be uninterrupted by the calls of an invasive frog species than about the ecological effects that such species may have.

### **Conclusions**

This study revealed how some Hawaii residents perceive the coqui frog. Respondents from the Island of Hawaii have mostly formed those perceptions out of first-hand experience, because they are the ones most exposed to the coqui frogs. However, respondents from Oahu, Maui, and Kauai appeared to have similar perceptions and attitudes even though they had never seen or heard the frog on many occasions. Such attitudes could be attributed to mass media coverage of the “coqui frog problem.”

Answers by respondents also revealed useful information for managers regarding the factors respondents consider important for any management option, as well as the public’s decrease in support for management when specific methods are presented. It is quite possible that more communication from managers with the public would increase public awareness not only of the problem but also of many other aspects surrounding the

## Coqui 22

coqui frog that seem to be misunderstood. It is interesting that many respondents did not know coqui frogs could control insect populations or that there were no native amphibians or land reptiles in the Hawaiian archipelago.

It might also be very useful to managers and researchers to further explore how the proenvironmental orientation of Hawaii residents can be utilized in the creation of effective management tools and outreach efforts. The NEP Scale revealed an underlying proenvironmental orientation of respondents. Yet, such orientation did not necessarily translate into their attitudes regarding the coqui frog but appeared to have an influence in the degree of management that respondents might support.

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