An Epidemiological Study of Habu-bites in the Amami Islands

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INTRODUCTION

Habu (*Trimeresurus flavoviridis*) is a venomous snake whose geographical distribution is restricted to certain islands of the Amami and Ryukyu groups. Because of its aggressive nature, habu is greatly feared by those who live in infested areas. Although deaths from habu-bites are relatively rare, local injuries caused by the venom are always serious with extensive necrosis of the tissues.

Many cases of habu-bite have been reported in the infested areas in the past years and several epidemiological studies on these bites have been done¹⁻⁵. Few reports have dealt with the population risking habu-bite. We have investigated a possible underlying mechanism of the epidemiological features of habu-bites in the Amami Islands.

MATERIALS

The materials used were case reports of habu-bites collected from the Amami Islands by local health centers from 1972 to 1976. In the Amami Islands, habu-bites are inevitably reported to local health centers because anti-venom serum is supplied by the government to local communities, free of charge, in exchange for case reports. Thus, these case reports should be a reliable source of statistics. Records show: name, sex, date, time, residence, locality and body-part of the bite. However, information about the place where the habu-bite occurred and the occupation of the victim are either lacking or uncertain. Meteorological data were obtained from the Nase Meteorological Station.

RESULTS AND DISCUSSION

Over a period of 5 years (from 1972 to 1976) 1285 cases of habu-bite were reported in Tokunoshima and Amamioshima (Amamioshima proper, Yorojima, Kakeromajima, Ukejima and other small islands). Table 1 shows the annual case records of habu-bites by local community units (village, town and city). An average of 257 cases of habu-bite was reported in a year, the highest number being 301 cases in 1973 and the lowest 202 in 1976. Of the 1285 cases of habu-bite, 923 or 71.8% occurred on Tokunoshima alone. This indicates that the habu-bite problem is much more serious on Tokunoshima than on Amamioshima. Mori¹⁾ reported that the incidence of habu-bite on Tokunoshima was about twice that on Amamioshima. Among the 1285 cases were 11 deaths; a fatality rate of 0.86%. Of these 11 deaths, 2 were caused by a second habu-bite. Thus, the fatality rate for a second habu-bite is about 11% which is considerably higher than the former rate.

Although the number of deaths from habu-bites was very small, the data suggest that victims who were attacked a second time might have hesitated to receive another injection of anti-venom serum because of the possibility of serum sickness re-occurring. Sasa et al.²⁾ reported that the fatality rate recorded in the Amami Islands was relatively high before 1904 when no anti-venom serum was available and that it declined gradually, probably because

of the use of anti-venom serum and the general improvement in medical care. No death was reported in 1976.

Table 2 shows the incidence of habu-bites arranged by the localities at which the bites took place and the local community units. The localities are roughly divided into two

Table 1 Annual case records of habu-bites by local community units

Local community \ Year		1972	1973	1974	1975	1976	Total
Amamioshima	Kasari-town	19	17	16	19	7	78
	Tatsugo-town	5	12 (1)	7	9	15	48 (1)
	Nase-city	16	13	14	14 (1)	8	65 (1)
	Yamato-village	12 (1)	4	4 (1)	2	2	24 (2)
	Sumiyo-village	6	5	3	4	5	23
	Setouchi-town	25 (1)	21	14	25 (1)	12	97 (2)
	Uken-village	8	6	3	8	2	27
Subtotal		91 (2)	78 (1)	61 (1)	81 (2)	51	362 (6)
Tokunoshima	Tokunoshima-town	54 (1)	81 (1)	70 (1)	54	55	314 (3)
	Amagi-town	36	57	34	54 (1)	32	213 (1)
	Isen-town	76	85 (1)	90	81	64	396 (1)
	Subtotal	166 (1)	223 (2)	194 (1)	189 (1)	151	923 (5)
Total		257 (3)	301 (3)	255 (2)	270 (3)	202	1285 (11)

Note: Numbers in parentheses represent the number of deaths

Table 2 Incidence rate of habu-bite arranged by the locality where the bite occurred and by local community units

Local communities		Case records of habu-bites per 5 years by types of locality							Size of the local population		Farming land (hectare)	Incidence rate of habu-bite per unit per 5 years		
		Outdoor			Indoor			Total	Total population	Farming population		Incidence rate per 1000 of total popu- lation	Incidence rate per 1000 of farming population	Incidence rate per 100 hectare of farm- ing land
		Farm	Others	Subtotal	Room	Others	Subtotal							
Amami- oshima	Kasari-town	32	25	57	9	12	21	78	9281	3990	915	8.40	19.54	8.62
	Tatsugo-town	13	14	27	10	11	21	48	6233	2163	613	7.70	22.19	7.83
	Nase-city	8	27	35	19	11	30	65	46737	2797	721	1.39	23.23	9.02
	Yamato-village	6	14	20	3	1	4	24	2634	1049	357	9.11	22.87	6.72
	Sumiyo-village	4	14	18	3	2	5	23	2468	1431	216	9.31	16.07	10.64
	Setouchi-town	22	47	69	19	9	28	97	14992	4540	809	6.47	21.36	11.99
	Uken-village	5	14	19	4	4	8	27	2636	1221	307	10.24	22.11	8.79
Subtotal		90	155	245	67	50	117	362	84981	17191	3938	4.26	21.06	9.19
Tokuno- shima	Tokunoshima-town	208	41	249	35	30	65	314	15374	7680	2336	20.42	40.88	13.44
	Amagi-town	106	43	149	36	28	64	213	9169	7073	2152	23.23	30.11	9.89
	Isen-town	230	54	284	74	38	112	396	11053	8259	2187	35.83	47.95	18.10
	Subtotal	544	138	682	145	96	241	923	35596	23012	6675	25.93	40.11	13.82
Total		634	293	927	112	246	354	1285	120577	40203	10613	10.65	31.96	12.11

categories; indoors and outdoors. The former comprises rooms, beds, lavatories, kitchens and animal sheds or gardens and the latter farms, rice-fields, forests, tombs, roads or passes, swamps, seashores and river banks. Of the 1285 cases of habu-bite, 927 or 72.1% occurred outdoors. Those bites which took place on farms were 634 or 49.3% of the total. The incidence rate of habu-bites per thousand of the local population differs remarkably among the community units; the lowest 1.39 is for Nase city and the highest 35.83 is for Isen town. However, the incidence rate of habu-bites per thousand of the local farming population and per 100 hectares of farm land did not differ so widely among the community units. The lowest, 16.07, was in Sumiyo village and the highest, 47.95, was in Isen town for population, and the lowest, 6.72, was in Yamato village and the highest, 18.10, was in Isen town for land units. This indicates that the incidence of habu-bite is closely related to farming.

We have assumed here, that all members of a given population—"the population risking habu-bite"—are equally exposed to the risk. If habu-bite is unusual and occurs at random among a population risking habu-bite, we can expect a complete Poisson distribution of the frequency of habu-bites per head. The total number of victims in the 1285 cases of habu-bite was 1265, of which 1246 were attacked only once, 18 twice and 1 three times as shown in Column 1 of Table 3. Thus, we have information only on those who had at least one bite. Therefore, the distribution for the frequency of habu-bites per head must be a truncated Poisson as follows;

$$P(x) = \frac{m^x}{(e^m - 1)x!} \quad x=1, 2, 3, \dots$$

where m is the incidence rate of habu-bite and x is the frequency of habu-bites per head. The size of the total and farming populations combined for Tokunoshima and Amamioshima was 120577 and 40203, respectively, from the census of 1975. If the total cases of habu-bite are randomly derived from the total population, then the frequency distribution of habu-bite containing the class 0 can be shown as Column 2 of the table. The fitted values for the Poisson series were calculated in the usual way as shown in Column 3 of the table. Clearly the fit is unsatisfactory, and this is borne out by the high value of χ^2 , 22.615, on one degree of freedom, for which $P < 0.005$. However, when we turn to the analysis of the data based on the farming population, the frequency distribution of habu-bite containing the class 0 can be shown as Column 5 of the table. The fitted values for the Poisson series indicate good agree-

Table 3 Frequency distributions of habu-bites per head during a 5 year period: their fitness to the Poisson distribution

		Number of victims among the population risking habu-bite	Total population			Farming population		
			Number of victims attacked by habu		Deviation	Number of victims attacked by habu		Deviation
			Observed	Estimated		Observed	Estimated	
Column number		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Frequency of habu-bites per head over 5 year period	0		119312	119298.833	13.167	38938	38938.4276	0.4276
	1	1246	1246	1271.367	25.367	1246	1244.4721	1.5279
	2	18	18	6.774	12.232	18	19.8866	20.1001
	3	1	1	0.024		1	0.2118	
	4	0	0	0.000		0	0.0017	
Population size		41993	120577	120576.998		40203	40202.9998	
Parameter		0.0306	0.010657	$\chi^2=22.615$ D.f=1		0.03196	$\chi^2=0.062$ D.f=1	

ment and the well-fitting χ^2 is 0.062 on one degree of freedom, which is unexceptionable. Therefore, we assume that the total cases of habu-bite randomly occurred among a population of some 40000, "the population risking habu-bite", rather than the total population. The objective reality for the population risking habu-bite is unknown at present but it may be related to farming. Although we had no information on those who were not attacked by habu, the incidence rate of habu-bite for the risk-population could be readily estimated by the maximum likelihood method as the unknown parameter m of the equation given above⁶⁾. Thus, a value of 0.0306 was obtained, see Column 1 of the table. Accordingly, the size of the population risking habu-bite is $1285 \div 0.0306 = 41993.464$. This is approximately 35% of the total population and is roughly equal to the size of the farming population. This appears to be strong proof that the majority of the risk-population belongs to the farming group. The rest of the population may be free from the danger of habu-bite.

Table 4 Incidence of habu-bite arranged by localities and body parts

Body part Locality	Upper extremity	Lower extremity	Head	Trunk	Total
Outdoor	467 (50.4)	440 (47.5)	14 (1.5)	6 (0.6)	927 (100)
Indoor	139 (38.8)	179 (50.0)	16 (4.5)	24 (6.7)	358 (100)
Total	606 (47.2)	619 (48.2)	30 (2.3)	30 (2.3)	1285 (100)

Note: Numbers in parentheses represents percents of total cases

Table 4 shows the incidence of habu-bite arranged by localities and the body-parts of the bites. The body-parts most frequently attacked by habu are the upper and lower extremities. In the case of outdoor habu-bites, 98% of the total occurred on the upper and lower extremities. This suggests that almost all the habu-bites may be preventable if these body-parts are effectively protected by long leather boots or heavy gloves. In the case of indoor habu-bite, however, about 11% of the total cases occurred on other body-parts such as the head and trunk. In these cases, the prognosis may be serious because the venom spreads towards the proximal parts of the body. Sasa et al.²⁾ have indicated that a higher fatality rate was recorded for habu-bites on the trunk than for bites on the upper and lower extremities.

Fig. 1 shows the diurnal distribution of habu-bite by types of locality. The time of the habu-bite was arranged in 4 hour intervals. Outdoor habu-bites mainly occurred in the day-time with the highest incidence between 8 a.m. and 12 a.m. Indoor bites mainly took place at night with the highest incidence between 8 p.m. and 12 p.m. The habu is nocturnal while humans are mainly diurnal. Therefore, the diurnal pattern for habu-bites suggests that the outdoor bite is mainly a result of the activities of humans and indoor bites are a result of activities of habu.

Table 5 shows the annual case records for habu-bites by months. The table shows the incidence of habu-bites differs greatly according to the month. There is a peak in June, followed by a lesser one in May and July. The lowest incidence is in December. Tanaka⁷⁾ has reported that in the Amami

Fig. 1 Diurnal distribution of habu-bites by types (indoor and outdoor) of locality

Islands, the number of habu captured and taken to health centers was highest in June. In fact, of the 1285 cases of habu-bite, 584 or 45% occurred during three months, from May to July. The seasonal variation in habu-bite may be attributed to meteorological conditions, e.g. atmospheric temperature, humidity and precipitation on the activities of both humans and habu. Sasa et al.³⁾ reported in a previous paper that in the Amami Islands, the highest incidence of habu-bite was observed not in August—the hottest season—but in June which has the highest amount of precipitation.

Table 6 shows the distribution of the frequency of habu-bites per day. An average of 0.703338 cases of habu-bite occurred within a day, but the highest number was 7 cases. Fitted values for the Poisson distribution are given in Column 3 and for the negative binomial

Table 5 Annual case records of habu-bite by months

Month	Year	1972	1973	1974	1975	1976	Total (%)
January		6	4	3	3	2	18 (1.4)
February		7	14	12	8	14	55 (4.3)
March		15	25	16	9	21	86 (6.7)
April		23	26	24	18	20	111 (8.6)
May		32	53	26	37	30	178 (13.9)
June		57	46	54	50	44	251 (19.5)
July		33	32	24	37	29	155 (12.1)
August		25	24	20	40	9	118 (9.2)
September		22	38	29	27	17	133 (10.4)
October		17	27	37	27	9	117 (9.1)
November		12	9	9	11	5	46 (3.6)
December		8	3	1	3	2	17 (1.3)
Total		257	301	255	270	202	1285(100.0)

Table 6 Frequency distributions of habu-bites per day: their fitness to the Poisson distribution and to the negative binomial distribution

		Observed value	Estimated value for the Poisson distribution	Deviation	Estimated value for the negative binomial distribution	Deviation
Frequency of habu-bites per day	0	1021	904.238	116.762	1005.655	19.545
	1	476	635.985	159.983	514.022	38.022
	2	225	223.656	1.344	201.596	23.404
	3	75	52.435	22.565	71.073	3.927
	4	21	9.220		23.648	2.648
	5	6	1.297		7.587	
	6	1	0.152		2.374	
	7	2	0.015	10.68544	0.729	10.996
	8	0	0.00134	19.317	0.220	1.996
	9	0	0.00010		0.066	
	10	0	0.00000		0.020	
Total days (5 years)		1827	1826.99944		1826.990	
Total cases of habu-bite		1285	1284.99560		1284.861	
Parameter			$m=0.703338$ $\chi^2=99.969$ D.f=3		$k=1.871$ $p=0.376$ $\chi^2=6.639$ D.f=3

Fig. 2 Relationship between the incidence of habu-bites per day and the daily average temperature

distribution in Column 5.⁶⁾ The fit to the Poisson series is inadequate. In fact χ^2 is 99.969 on 3 degrees of freedom, which is significant at the 0.1% level. In contrast, the fitted values for the negative binomial distribution indicate good agreement and the goodness-of-fit for χ^2 is 6.639 on 3 degrees of freedom, which is unexceptionable. This suggests that the days when habu-bites occur tend to cluster.

Figures 2, 3 and 4 show the relationships between the incidence of habu-bites per day and meteorological conditions. Fig. 2 shows that the incidence of habu-bite increased with a rise in temperature and reached a peak at 26°C after which it tended to decrease. This indicates that the optimum temperature for habu activity is about 26°C. The incidence of habu-bite also increased steadily with an increase in humidity. Precipitation is also related to the incidence of habu-bite. As Fig. 4 shows, a high incidence of habu-bite was observed when the amount of precipitation (on the day of the bite or on the preceding day) exceeded 10 mm. These facts suggest the most probable explanation for the highest incidence of habu-bite being in June.

Fig. 3 Relationship between the incidence of habu-bites per day and the daily average humidity

Fig. 4 Relationship between the incidence of habu-bites per day and the amount of precipitation per day

We concluded that: The habu-bite in the Amami Islands is an unusual event; The size of the hypothetical population risking habu-bite is approximately 35% of the total population and is roughly equal to the size of the farming population; The rest of the population should be free from the danger of habu-bite; and the body-parts most frequently bitten are the upper and lower extremities. Therefore, most habu-bites appear to be preventable by wearing leather boots or heavy gloves. This is acceptable in theory but not always practicable in daily life. Thus, environmental improvements such as the paving of roads and agrarian reforms, may be useful in reducing the opportunities for humans to encounter habu.

SUMMARY

Epidemiological features of habu-bite in the Amami Islands were investigated. Over a period of 5 years (1972 to 1976) 1285 cases of habu-bite, including 11 deaths, were recorded on Tokunoshima and Amamioshima. The total number of victims was 1265, of which 1246 were attacked once, 18 twice and 1 three times during the 5 year period. Assuming that the frequency of habu-bite per head is a truncated Poisson distribution, the size of the hypothetical population risking habu-bite was estimated by the maximum likelihood method. We obtained the value of 41993, which was approximately 35% of the total population and roughly equal to the size of the farming population. The incidence rate of habu-bite per unit of local population differed greatly according to the community unit (village, town or city), but the rates for the farming population and farming land did not differ greatly among the local communities. Patterns for the seasonal and diurnal distribution of habu-bite clearly indicated that the incidence of bites reflects the activities of both humans and habu.

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奄美諸島における“はぶ”咬傷の疫学的研究

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奄美諸島における“はぶ”咬傷の疫学像についての調査を行った。1972年から1976年の5年間に、徳之島、奄美大島両島で、死亡11例を含む1285件の“はぶ”咬傷が記録されている。犠牲者の総数は、5年間を通して1265人で、そのうち、1246人は1回だけの咬傷をうけており、18人は2回、1人は3回の咬傷をうけていた。1人あたりの“はぶ”咬傷回数の頻度分布は、“切れたポアソン分布”であるという仮定の下に、最尤法によって、“はぶ”咬傷をうけるおそれのある仮設人口の大きさを推定し、41993という数値を得た。これは全人口の約35%で、農業人口のサイズにはほぼ匹敵するものであった。単位地域人口あたりの“はぶ”咬傷率は、地域（村、町、市）により大きなちがいがみられたが、単位農業人口あたり或いは単位農地面積あたりの“はぶ”咬傷率には、地域間でそれほどちがいはなかった。“はぶ”咬傷の季節的変動及び1日の時間変動のパターンは、“はぶ”咬傷の発生は、人と“はぶ”の双方の活動によって生じたものであることを明瞭に示していた。

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