

## BATS OVER BANGKOK\*

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We had only recently moved into our new home at 4 Soi 15 Sukumvit Road, Bangkok. It had a veranda shaded by Bouganvillia and palms and we had already established the routine of a quiet moment in the late afternoon before supper on the veranda, where we could watch the activities in a small garden before us. As dusk descended bats would appear in the gold and blue sky, traveling toward the sunset. These intrigued me and on 12 Nov., 1966, I made the first tally, followed by 2303 tallies and 86,000 bats to 3 July 1975. This is an unscientific introduction to a study reported here that will become belaboured with lengthy tables and graphs.

As the months passed numerous questions developed concerning this bat flight. How many species were involved? This was never really satisfactorily resolved. Following the path of the approaching bats, it was found that the flight originated as a vast assemblage of Hairless Bats (*Cheiromeles torquatus*) from old buildings in the Imperial Palace grounds as well as from the eaves of other buildings in the heart of the city. But these did not constitute the entire population, for those that regularly passed low over the garden appeared to be a large eared species such as *Hipposideros*. Fruit bats were not in the assemblage, since they roosted in gardens in the city and did not fly in thin undulating lines out to the surrounding country side as did the insectivores. I could not stand in my garden with a shot gun and shoot the passing bats. This was hardly a relevant approach in the confines of a city of three million, even if I had had official sanction. So the initial question of what species of bats were involved in this study was never clarified.

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If they were only local species roosting in the centre of the city, what factors conditioned the vast differences in the numbers seen passing over the city from evening to evening? Further, did the addition of migrants to the total population account for the cyclic increase in numbers? Observing flight patterns, direction of movement, and heights of flight suggested that the majority of animals in the sky were of one species. Only occasionally when there was a conspicuous difference in altitude of flight did I feel that other species were involved. Most of the activity was below two hundred metres most of the evenings, and individual bats appeared to follow regular routes of flight to feeding grounds evening after evening.

The evening flight out was *en masse*, was the dawn return equally massive? It was not. The bats dribbled back across the roofs at dawn, dwindling in numbers to none by sunrise. I suspect that many returned in darkness after having satisfied their hunger.

What were the criteria, the stimuli, which induced the evening flights and controlled their densities and direction? Most obvious of these would be the movement of the sun north and south of the equator. A second controlling factor could be the light intensity as related to the amount and density of cloud cover; which would also involve the bats in rain. A third, the intangible of hunger. Does every bat feed every evening? This would seem to be answered by a "yes", but if they did not, this might account for the wide daily fluctuations in numbers seen. In a study done in the sixties of animal life at Batu Cave near Kuala Lumpur (McCLURE 1961, 1965, 1967) some observations were made at night and it was noted that not all of the bats left the cave at sundown. During the breeding season the majority of these were non-flying juveniles, but at other times some bats were still present after sundown. Were the sources of food consistent, in the same directions from the roosts, and of equal nutritional value? Many years before (McCLURE 1938, 1942, 1943) I had made a study of aero-plankton densities in the

lower air levels in Kentucky and Illinois (USA), but temperate zone data have little relevancy to those of the tropics. No equivalent study of aeroplankton movements had been made in Thailand.

So all that I can do here is to present summaries of the tallies with inferences and conclusions tentatively stated relating cause and effect.

### The Time Factor

The time factor was relatively simple to determine. The moment of the first bat sighting and that of the last were recorded. The appearance of the bats in the evening sky almost exactly coincided with sunset, and the last seen were usually just at dusk after which they were no longer visible. Since they were hurrying toward feeding grounds outside of the city or at the outskirts and rarely tarried to feed on termite flights, it was assumed that none followed after darkness. But what happened when heavy rain struck at sundown and no flying bats were seen? Did they not go out to feed at all or did they wait until the storm passed? The only clue to an answer for this was that at dawn on mornings following an evening storm bats were hurrying back to midtown. This intimated that they had dispersed in the dark, but in what directions and densities could not be determined.

Figure 1 illustrates the range of starting and stopping times by monthly averages for the nine years. Connecting the nine year average moments of arrival and of closing creates a figure that straddles the moment of sunset. Variations in the time result from the amount of cloudiness for that year and from normal errors in the efficiency of the observer and his clocks. The maximum average variation through the years was from 1755 to 1847, less than one hour, and from 1813 to 1903 for the closing, also less than one hour. The average duration of the flight was 16 minutes, two minutes less during the dry months (December-May) with clear skies and  $2\frac{1}{2}$  minutes longer during the rainy season (June-November) with overcast skies.

### The Cloud Cover Factor

The above statement suggests that the presence of an overcast sky during the rainy season, or at any other time, would induce the bats to leave their roosts earlier. This did indeed seem true, for over the nine year period there was an average difference of nearly five minutes between the initiation of the flights during dry and hence clear months and during rainy or cloudy months. Thus the flights lasted only a couple of minutes longer, but began nearly 33% earlier during cloudy months.

But when we consider the effect of overcast skies upon the bat movements, the data become less conclusive. Tables 1 through 8 list the observational data by months for each of the years when a complete year's information had accrued. Table 9 summarizes these further by giving the yearly averages. The categories of cloud cover were defined as follows: clear, with no shadow casting clouds. This included no clouds at all, haziness, high cirrus, cirro-stratus, broken stratus, or velum stratus. Partly cloudy, included those cloud formations which cast shadows and obscured part of the sky. These would be cumulus, broken strato-cumulus, alto-cumulus, and a few others. Cloudy included unbroken strato-cumulus, cumulus, and cumulo-nimbus where little or no sky could be seen, that is, almost complete to complete heavy cloud cover, but without rain. The category of rain is obvious and included light to heavy rains.

Fig. 2 presents the weather conditions at sundown for the nine years (105 months) based upon the percentages of the observations during the above cloud cover categories. From this it can be seen that clear to partly cloudy weather predominated from October into April, and that cloudy weather predominated during the remaining months with rain occurring at sundown as much as 20% of the time during June, July, August and September.

In Table 10 are summarized the nine year average flight data by month. These are presented in Fig. 3. In Fig. 4 we see that the average density of bats by months formed a relatively simple curve with peak

density and activity during the months of June, July and August. Bats flying in June were five times as abundant as those in February. Back to Fig. 3 we see that the density was similar to the overall average regardless of the weather conditions. In further analysis, Table 11, the data from which are presented in Figs. 5 and 6, it now becomes evident that the presence of bats over Bangkok is unrelated to cloud cover. The percentage of bats flying shows no significant variations from the percentage of the observations when a given cloud cover was present. Only rain held them back. But if we consider the average number of bats seen flying, the numbers during clear weather were up to twice those during cloudy, except in August when they were less and in November and December when they were nearly equal.

Figure. 7 compares the data for clear and cloudy weather as three dimensional graphs superimposed one upon the other. The rear figure is that for clear weather the fore figure that for cloudy conditions. During the months of May through September these figures invade each other (or overlap) indicating not only the change in weather but a change in the habits of the bats. They must perforce fly in cloudy weather because it is present at the time that they are moving to their feeding grounds.

#### Number of Bats in Flight

The number of bats in the air changed rapidly from day to day. For a long time I thought that they were operating on a three day rhythm: one day of abundance followed by two of reducing numbers. Exploratory summaries proved that this was not the case. Since the months did not readily break up into seven day periods I chose five and averaged the numbers in groups of five, the last five of the month becoming six for 31 day months and 3 or 4 for February. These averages are given in Table 12. Blank squares indicate that no tallies were made. The five day periods which are underlined are those during which the moon was full.

These data are further condensed into monthly averages and presented in Table 13. Table 13 in turn is presented as a graph, Fig. 8. The flights were large in 1967 and decreased in 1968 and 1969. They increased again in 1970 and decreased in 1971 and 1972. Now I thought I had a three year cycle, only the numbers failed to increase in 1973 or 1974. Before I left Bangkok in 1975 the numbers had been steadily increasing so possibly this was to be a peak year. I attributed the decrease in numbers to the destruction of old buildings in downtown Bangkok, replaced by new ones, but the major source of the flight, the Palace structures were not disturbed during the study. Again we have reached an impasse with no ready explanation for the reduction of numbers during some years and not during others.

#### The Moon Factor

In the previous discussion we related the bat movements to our own division of the year into twelfths. This is, of course, irrelevant. Since these are nocturnal animals, their physiological clocks should be attuned to phenomena that they can experience such as moonlight or weather. Abundance could be related to these or to other phenomena for which we have no data. We have already seen that the abundance follows closely the length of the day, being greatest when the days were longest. And that the abundance was in some way related to or coincident with the rainy season, being greatest during those months of greatest precipitation. Whether either of these is a direct relationship or an artifact has not been clarified. The bats come from someplace and increase their numbers by more than two fold during June, July, August and September; and this coincides with increased cloudiness and rain and with the lengthened day.

But what about that other factor of the night, the moon? Since we are aware that the bats would know nothing about months, we could assume that they are aware of the cycle of the moon. Possibly these are imprinted upon their movements. Moon effect could be considered upon the basis of its light intensity, full or absent; it could be considered

on the basis of waxing or waning; it could be related to the presence and intensity of moonlight at dusk or its presence and intensity at dawn; or the moonlight effect could be modified by the amount of cloud cover at night. Since we do not have names for lunar months and since they move through our year, I elected to summarize the data by totaling the tallies from the date of full moon to full moon and dividing it into the phases or quarters of the moon. Although the position of the moon varied with relationship to the new year as well as to the soltices, for the period from the second through the sixth moon (i.e. about February through June) there were 29.7% more bats in motion when the moon was waning as compared with those when it was waxing. For the rest of the year the numbers present were 22.8% less while waning: the figures a complete reversal: Second through Sixth Moon, Waxing, Average 33.6 bats, Waning, Average 43.6 bats. Seventh through First Moon, Waxing, Average 43.8 bats, Waning, Average 33.8 bats.

These data are further illustrated in Fig. 9 in which the average number of bats at sundown are arranged by lunar months. To relate to the calendar year the quarters based upon the soltices are shown. This graph is very similar to that of Fig. 8, and it becomes evident that the bat numbers were not related to the moon or its phases anymore than to other factors that we have been examining. They show the same increase during the rainy season and the same decreases during the years following 1967. In spite of these declines and increases the annual density of bats remained fairly uniform (Table 9) between 35 and 40 animals.

#### Another Approach

The figures given in Table 12 demonstrate the rapidity with which the bat numbers changed; for which the foregoing discussions offer no valid explanations. The seasonal change is evident here as in other tables and graphs. I remain convinced that such fluctuations, as were seen from day to day, were related to the presence or absence of food; and that this changed randomly in the environs surrounding Bangkok.

Bird nesting studies (McCLURE, 1974; McCLURE & CHAIYAPHUN, 1971) indicated that many species reached peak activity just prior to the rainy season; so that juveniles were entering the population at the time of wet weather, suggesting an abundant food availability then. If the bats followed this pattern, then the increased numbers seen in May, June and July could relate to the appearance of young in the population rather than the infiltration of migrants.

#### S U M M A R Y

Questions were asked about the causes of the variations in the numbers of bats seen at sundown over a fixed point in Bangkok. Nine years of observations have given us the following: 1. Bats (of one or several species) leave their roosts in the central city and fly a few moments before dusk to outlying areas around the city to feed. 2. The time of departure follows the time of sunset. 3. The presence of heavy overcast induces the bats to leave a few minutes earlier than under clear weather conditions. 4. The annual cycle of bat abundance reaches its peak during May, June, July, August, and September which coincides with the rainy and cloudy season. 5. There appeared to be little or no relationship between the number of bats flying and the weather, except that they did not fly during rain. 6. There appeared to be little or no relationship to the presence or absence of moonlight. 7. There appeared to be no ready explanation of the rapid fluctuations in bat numbers unless they were caused by an influx of migrants or other species, or unless the bats shifted their flights toward alternate feeding sources. No data were available concerning the breeding season or its affect upon these flights. 8. There may be a three year cycle in abundance among these bats, but the annual differences in numbers may have been related to other causes.

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Table 1. Summary of the Observations of Bat Flights During 1967.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	Bats Tallied			Clear	% of Observations		
							P. Cl.	Cloudy	Rain		P. Cl.	Cloudy	Rain
Jan.	1825	1835	17	134	8	100		34		70.5		29.5	
Feb.	1846	1847	12	7	.6	7				100			
Mar.	1843	1850	25	599	21	596	3		0	93.1	3.4		3.4
Apr.	1845	1857	28	608	22	454	122	32		64.3	17.8	17.9	
May	1849	1901	30	1378	46	448	492	438	5	50.0	23.3	20.0	6.7
June	1851	1906	10	975	98	457	156	362		40.0	20.0	40.0	
July	1850	1903	15	1916	128	749	308	844	15	20.0	13.3	60.0	6.7
Aug.	1835	1854	28	2407	86	142	545	1544	176	7.1	21.4	53.6	17.8
Sept.	1817	1839	30	2908	97	1453	84	1194	178	36.7	6.7	46.7	10.0
Oct.	1810	1828	21	858	41	588		270	0	57.0		38.1	4.8
Nov.	1755	1815	14	499	36	333	119	47	0	54.3	21.4	7.1	7.1
Dec.	1804	1819	19	402	21	347	55			84.2	15.8		
Totals	1831	1845	253	12691	50	5674	1884	4765	374	141	31	67	14
Percent						44.7	14.8	37.5	2.9	55.7	12.3	26.4	5.5

Table 2. Summary of the Observations of Bat Flights During 1968.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	P. Cl.	Bats Tallied			Clear	% of Observations		
								Cloudy	Rain			P. Cl.	Cloudy	Rain
Jan.	1823	1835	26	810	31	720	90				84.6	15.3		
Feb.	1843	1852	18	312	17	243	59	10			66.6	22.2	11.1	
Mar.	1845	1858	24	728	30	723		5			95.8		4.2	
Apr.	1844	1859	26	699	27	401	77	221	0		38.4	15.3	38.2	7.6
May	1845	1900	27	1892	73	1595	66	313	7		48.1	7.4	29.6	14.8
June	1846	1905	15	685	46	299		386	0		46.6		46.7	6.7
July	1843	1903	27	1491	55	435	92	894	70		22.2	11.1	55.5	11.1
Aug.	1833	1852	26	1733	53	315	491	492	71		19.2	26.9	23.0	30.8
Sept.	1818	1837	24	2045	85	971	263	784	27		41.7	12.5	41.7	4.2
Oct.	1802	1818	28	552	20	218	160	156	18		39.3	25.0	21.4	14.2
Nov.	1756	1812	28	295	11	263	20	12			82.1	7.1	10.7	
Dec.	1803	1816	27	273	10	181	81	11			70.3	25.9	3.7	
Total	1828	1844	296	11075	40	6364	1399	3284	193		161	43	69	23
Percent							54.3	11.9	28.0	1.6	54.4	14.5	23.3	7.8

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Table 3. Summary of the Observations of Bat Flights During 1969.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	Bats Talled		Rain	Clear	% of Observations		
							P. Cl.	Cloudy			P. Cl.	Cloudy	Rain
Jan.	1826	1834	14	68	5	68				100.0			
Feb.	1846	1849	5	10	2	5	5			50.0	50.0		
Mar.	1848	1857	27	245	9	188		57		81.5		18.5	
Apr.	1839	1856	26	1437	55	1090	252	95		69.2	15.4	15.4	
May	1847	1858	23	1028	45	254	154	620		39.1	21.7	39.1	
June	1849	1902	12	546	45	39	113	394	0	8.3	8.3	66.7	16.6
July	1847	1904	20	1228	61	21	210	925	72	5.0	20.0	55.0	20.0
Aug.	1834	1853	29	1206	42	88	220	882	16	6.9	13.8	65.5	13.8
Sept.	1819	1837	27	1033	38	407	85	540	1	37.0	7.4	81.1	7.4
Oct.	1804	1821	31	1077	36	673	209	225	0	45.1	19.4	29.1	6.5
Nov.	1755	1816	13	374	29	92	111	171		23.1	30.5	46.2	
Dec.	1809	1822	18	318	18	207	73	38		66.7	22.2	11.1	
Totals	1830	1844	245	8600	35	3132	1432	3947	89	109	36	86	14
Percent						36.4	16.6	45.8	1.0	44.4	14.6	35.1	5.7

Table 4. Summary of the Observations of Bat Flights During 1970.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	Bats Tallied			Clear	% of Observations		
							P. Cl.	Cloudy	Rain		P. Cl.	Cloudy	Rain
Jan.	1823	1835	19	244	13	201	18	25		79.0	10.5	10.5	
Feb.	1841	1849	17	104	6	55	40	4		70.6	17.6	11.8	
Mar.	1848	1858	20	55	3	52	3	0		90.0	5.0	5.0	
Apr.	1848	1858	23	357	16	326	16	15	0	65.2	13.0	13.0	8.7
May	1843	1857	23	2066	90	1067	232	759	8	39.1	17.4	34.8	8.7
June	1841	1900	22	2256	103	1032	273	633	218	31.8	9.1	22.7	36.4
July	1838	1900	24	1257	52	364	37	856	0	25.0	4.2	58.3	12.5
Aug.	1826	1853	17	883	52	52	173	658	0	5.9	29.4	58.9	5.9
Sept.	1812	1828	13	509	39	166	112	231	0	30.8	15.4	46.2	7.7
Oct.	1805	1817	21	335	16	174	55	104	2	33.3	19.1	33.3	14.3
Nov.	1754	1810	26	314	12	128	137	48	13	38.4	30.8	26.9	3.8
Dec.	1800	1813	23	417	18	269	15	110	23	69.6	4.3	13.0	13.0
Totals	1827	1842	248	8797	35	3886	1111	3544	264	120	36	68	24
Percent						44.1	12.6	40.3	3.0	48.4	14.5	27.4	9.7

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Table 5. Summary of the Observations of Bat Flights During 1971.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	Bats Tallied			Clear	% of Observations		
							P. Cl.	Cloudy	Rain		P. Cl.	Cloudy	Rain
Jan.	1821	1835	30	1020	35	891	159			90.0	10.0		
Feb.	1836	1846	20	306	15	277	25	4		80.0	15.0	5.0	
Mar.	1843	1854	23	348	15	206	111	31		52.1	34.8	13.0	
Apr.	1843	1900	25	462	18	361	28	71	0	64.0	20.0	12.0	4.0
May	1849	1904	14	285	20	101	60	95	29	35.7	14.3	35.7	14.3
June	1847	1904	20	950	48	311	427	183	29	15.0	30.0	30.0	25.0
July	1845	1905	23	1126	49	376	385	325	40	21.7	34.8	30.4	13.0
Aug.	1842	1900	10	426	43	83	226	31	86	20.6	60.0	10.0	10.0
Sept.	1815	1834	18	706	39	203	105	323	75	22.2	22.2	22.2	33.3
Oct.	1800	1821	23	860	37	489	170	201	0	39.1	21.7	26.1	13.0
Nov.	1784	1815	30	1095	37	581	272	242		63.3	26.7	10.0	
Dec.	1805	1822	25	880	35	744	88	57		76.0	12.0	12.0	
Totals	1828	1845	261	8464	32	4623	2047	1563	259	137	61	42	21
Percent						54.6	24.2	18.4	3.0	52.4	23.4	16.1	8.0

Table 6. Summary of the Observations of Bat Flights During 1972.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	P. Cl.	Bats Talled Cloudy	Rain	Clear	P. Cl.	% of Observations Cloudy	Rain
Jan.	1821	1836	27	913	34	911		2		96.3		3.7	
Feb.	1831	1848	21	524	25	502	5		17	90.5	4.8		4.8
Mar.	1839	1857	18	684	38	601	32	51	0	77.8	5.5	11.1	5.5
Apr.	1842	1859	23	807	35	369	399	39		47.8	43.5	8.7	
May	1840	1859	25	1285	51	910	210	165		64.0	20.0	16.0	
June	1847	1901	21	529	25	136	131	237	25	14.3	19.0	47.6	19.0
July	1848	1858	27	826	31	12	185	536	93	18.5	14.8	40.7	25.9
Aug.	1844	1859	21	665	32	160	236	258	11	23.8	23.8	38.1	14.3
Sept.	1823	1839	28	829	30	392	166	267	4	32.1	21.4	21.4	25.0
Oct.	1808	1825	23	538	23	331	137	70	0	52.1	26.1	17.4	4.3
Nov.	1756	1814	28	528	19	279	183	55	11	39.3	28.6	14.3	17.8
Dec.	1801	1818	23	537	23	334	87	116	0	43.3	21.7	30.4	4.3
Totals	1828	1844	289	8665	30	4937	1771	1796	161	141	55	59	30
Percent						56.9	20.4	20.7	1.8	49.5	19.3	20.7	10.5

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Table 7. Summary of the Observations of Bat Flights During 1972.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	P. Cl.	Bats Talled Cloudy	Rain	Clear	% of Observations		
											P. Cl.	Cloudy	Rain
Jan.	1823	1834	25	531	25	504	27			84.0	16.0		
Feb.	1838	1842	23	52	2	49	3			87.0	13.0		
Mar.	1843	1852	18	89	5	55	15	19	0	55.6	27.8	11.1	5.6
Apr.	1834	1854	27	1876	69	1712	164			88.9	11.1		
May	1843	1853	19	392	21	124	0	268	0	31.6	5.3	52.6	10.5
June	1847	1901	18	828	46	243	0	45	0	16.7	55.6	22.3	5.6
July	1846	1902	20	900	45	394	101	367	38	10.0	25.0	55.0	10.0
Aug.	1835	1857	20	933	47	503	225	177	28	35.0	20.0	35.0	10.0
Sept.	1824	1843	28	1246	45	461	291	475	19	21.4	17.8	50.0	10.7
Oct.	1809	1826	25	998	40	517	264	217		44.0	24.0	32.0	
Nov.	1759	1817	29	919	32	507	219	176	17	58.6	17.2	20.6	3.4
Dec.	1759	1817	24	832	35	554	183	95		75.0	12.5	12.5	
Toals	1828	1843	276	9596	35	5623	2032	1839	102	145	54	65	12
Percent						58.5	21.2	19.2	1.0	52.5	19.6	23.6	4.3

Table 8. Summary of the Observations of Bat Flights During 1974.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	Bats Tallied		Rain	Clear	% of Observations		
							P. Cl.	Cloudy			P. Cl.	Cloudy	Rain
Jan.	1825	1832	30	1475	49	1368	107			92.7	7.2		
Feb.	1833	1847	21	360	17	331	14	17		90.5	4.8		
Mar.	1842	1854	26	894	34	701	193		0	80.7	15.4		3.8
Apr.	1841	1855	23	775	34	386	128	164	97	52.2	13.0	21.7	13.0
May	1841	1858	25	862	34	289	323	234	16	24.0	28.0	36.0	12.0
June	1847	1901	25	1353	54	366	320	635	32	24.0	12.0	52.0	12.0
July	1846	1905	24	989	41	315	127	327	20	41.7	20.8	25.0	12.5
Aug.													
Sept.													
Oct.	1802	1820	20	1075	54	384	316	375	0	45.0	25.0	25.0	5.0
Nov.	1750	1807	23	868	38	456	146	263	2	47.9	17.4	30.4	4.3
Dec.	1755	1810	23	784	34	410	263	102		52.2	34.8	13.0	
Totals	1826	1841	240	9467	39	5206	1937	2150	167	134	42	50	15
Percent						55.0	20.4	22.7	1.8	55.8	17.5	20.8	6.2

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Table 9. A comparison of bat flights by yearly averages 1966-1975. 1966 and 1975 were only partial years, two and seven months respectively. Final line summarizes only 1967-1974.

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Yaer	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	No. Bats Tallied			Clear	No. Observations		
							P. Cl.	Cloudy	Rain		P. Cl.	Cloudy	Rain
1966			42	1379	33	1071	169	202	0	29	6	6	1
1967	1831	1845	253	12691	50	5674	1884	4765	374	141	31	67	14
1968	1828	1844	296	11705	40	6364	1399	3284	193	161	43	69	23
1969	1830	1844	245	8600	35	3132	1432	3947	89	109	36	86	14
1970	1827	1842	248	8787	35	3886	1111	3544	264	120	38	68	24
1971	1828	1845	261	8464	32	4623	2047	1563	259	137	61	42	21
1972	1828	1844	285	8665	30	4937	1771	1796	161	141	55	59	30
1973	1828	1843	276	9599	35	5623	2032	1839	102	145	54	65	12
1974	1826	1841	240	9467	39	5206	1937	2150	167	134	42	50	15
1975			157	6878	44	3531	1395	1829	73	81	29	40	7
Total	1828	1844	2303	85825	37.4	44047	15177	24919	1682	1198	393	552	161
						Percent of Bats Tallied				% of Observations			
1966						77.7	12.1	14.6		69.0	14.3	14.3	2.3
1967						44.7	14.8	37.5	2.8	55.7	12.3	26.4	5.5
1968						54.3	11.9	28.0	1.6	54.4	14.5	23.3	7.8
1969						36.4	16.6	45.8	1.0	44.4	14.6	35.1	5.7
1970						44.1	12.6	40.3	3.0	48.4	14.5	27.4	9.7
1971						54.6	24.2	18.4	3.0	52.4	23.4	16.1	8.0
1972						56.9	20.4	20.7	1.8	49.5	19.3	20.7	10.5
1973						58.5	21.2	19.2	1.0	52.5	19.6	23.6	4.3
1974						55.0	20.4	22.7	1.8	55.8	17.5	20.8	6.2
1975						51.3	20.3	26.6	1.0	51.6	18.5	25.4	4.5
Percent						51.3	17.7	29.0	2.0	52.0	17.0	24.0	7.0
8 Yr. Percent						50.5	17.8	29.1	2.0	51.6	16.9	24.2	7.2
1967 Thru 1974													

McCLURE

Table 10. Comparison of the Nine Year Average Monthly Bat Flights, 1966-1975.

Month	Time Start	Time Stop	Total Obs.	Total Bats	Ave. Bats	Clear	P. Cl.	Bats Tallied			Clear	No. Observations		
								Cloudy	Rain			P. Cl.	Cloudy	Rain
Jan.	1822	1834	219	5695	26	5048	497	224	16	178	22	19	1	
Feb.	1839	1848	156	1959	13	1515	217	34	17	128	21	6	1	
Mar.	1844	1855	214	4550	21	3800	463	287	0	168	24	18	4	
Apr.	1842	1857	227	8399	37	6057	1392	851	97	138	41	40	8	
May	1844	1859	213	10504	49	5299	1825	3313	71	88	39	68	18	
June	1847	1902	165	10261	62	3691	2300	3915	355	40	32	66	27	
July	1846	1903	184	10209	56	3049	1738	5074	348	39	34	84	26	
Aug.	1836	1855	151	8353	55	1343	2116	4042	388	24	37	66	24	
Sept.	1818	1837	168	9276	55	4053	1106	3814	304	54	24	67	23	
Oct.	1805	1822	192	6326	33	3374	1311	1618	20	85	39	53	15	
Nov.	1755	1813	209	5545	27	3241	1207	1130	43	118	42	40	9	
Dec.	1802	1817	206	5167	25	3515	1005	616	23	136	30	25	5	
Totals	1825	1850	2303	86245	37.4	43985	15177	24918	1682	1196	394	552	161	
Ave.					37.4	36.8	38.5	45.1	10.4					
Percent						51.0	17.6	28.9	1.9	51.9	17.2	24.0	7.0	

Table 11. Comparison of the density of bat flights and the amount of cloud cover at Bangkok.  
Percentages based Upon nine year totals for each month.

Month	% of Bat Flight				% of Observations				Ave. No. Bats		Ratio Clear to Cloudy
	Clear	P. Cl.	Cloudy	Rain	Clear	P. Cl.	Cloudy	Rain	Clear	Cloudy	
Jan.	88.6	8.7	3.9	.02	81.3	10.0	8.7	.4	28	12	2.3
Feb.	77.3	11.1	1.7	.8	82.0	13.4	3.8	.6	12	6	2.0
Mar.	83.5	10.2	6.3		78.5	11.2	8.4	1.9	23	16	1.4
Apr.	72.1	16.6	10.1	1.1	60.7	18.1	17.6	3.5	44	21	2.1
May	50.4	17.3	31.5	.6	41.3	18.3	31.7	8.4	60	49	1.2
June	36.0	22.4	38.2	3.4	24.2	19.4	40.0	16.4	92	59	1.6
July	29.9	17.0	49.7	3.4	21.3	18.5	45.9	14.2	78	60	1.3
Aug.	16.1	25.3	48.4	4.6	15.9	24.5	43.7	15.8	56	61	.9
Sept.	43.7	11.9	41.1	3.2	32.1	14.2	40.0	13.6	75	57	1.3
Oct.	53.3	20.7	25.6	.3	44.3	20.3	27.6	7.8	40	30	1.3
Nov.	58.4	21.7	20.4	.8	56.4	20.0	19.1	4.3	27	28	1.0
Dec.	68.0	19.4	11.9	.4	66.0	18.9	12.1	2.4	26	25	1.0
Ave.	51.0	17.6	28.9	1.9	51.9	17.1	23.9	7.0	46	35	1.4

Table 12. The average number of bats above the observation point in Bangkok, based upon five day tallies.

Underlined figures indicate the five days during which the moon was full.

	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	January						February						March					
1966	11.0	21.5	11.8	9.3	14.5	8.7	1.7	2.0	6.2	12.5	5.3	—	3.8	3.5	5.0	5.0	3.5	4.7
1967	8.5	16.2	3.6	1.0	—	—	—	—	—	1.7	.6	—	2.2	3.7	6.5	23.8	40.0	45.1
1968	8.6	33.0	42.4	46.6	28.2	19.0	—	6.0	9.2	23.6	15.6	24.3	8.0	15.0	33.0	10.0	25.0	64.6
1969	6.0	4.7	8.0	6.5	2.0	1.3	5.0	—	—	—	—	2.0	5.8	3.0	3.8	8.3	6.2	23.5
1970	11.0	21.5	11.8	9.3	14.5	8.7	1.7	2.0	6.2	12.5	5.3	—	3.8	3.5	5.0	5.0	3.5	4.7
1971	16.6	103.0	25.4	32.0	19.2	15.6	7.2	10.6	22.8	17.3	21.0	16.0	24.0	20.0	12.0	13.0	11.0	17.0
1972	19.2	18.0	33.0	39.4	77.0	43.7	33.5	18.2	29.0	14.3	28.3	35.5	16.3	78.7	70.8	28.2	14.0	36.6
1973	30.5	28.2	17.5	30.2	20.0	5.0	1.4	.7	1.2	3.7	4.0	4.0	3.5	2.4	3.5	—	13.0	6.0
1974	83.3	78.8	50.5	56.8	25.4	8.2	10.5	4.2	46.2	13.0	18.5	6.6	13.2	41.0	25.0	53.8	37.4	40.0
1975	16.2	23.2	13.4	16.4	20.4	10.0	24.0	17.2	12.0	11.0	5.0	11.5	11.8	9.5	27.0	43.9	38.1	58.6
Total	22.2	36.3	22.8	26.4	26.1	13.6	11.5	8.4	18.0	12.0	12.2	12.0	9.8	19.5	20.5	22.9	20.7	32.7
	April						May						June					
1966	47.0	24.2	30.0	11.2	12.5	21.3	37.8	54.8	8.2	9.0	80.8	84.6	65.0	—	130.0	107.5	—	—
1967	54.8	20.6	7.2	16.4	51.2	11.5	13.3	32.2	34.3	132.0	145.0	86.8	60.5	57.7	—	—	42.5	39.4
1969	24.0	19.2	42.0	76.2	102.8	50.9	23.2	16.7	52.8	51.4	23.5	83.0	58.2	68.0	57.0	—	—	—
1970	4.3	2.5	5.0	41.0	43.0	8.3	40.0	110.8	83.2	39.3	118.2	181.7	216.0	90.8	74.7	69.0	184.3	35.8
1971	28.2	22.2	13.7	18.0	10.0	26.2	—	—	—	18.8	17.2	23.5	30.2	15.0	59.9	54.2	62.2	67.0
1972	26.0	21.8	27.0	35.8	61.8	34.6	56.2	70.8	73.0	33.5	8.0	65.0	18.5	45.0	23.8	9.0	75.0	10.8
1973	26.0	49.8	81.4	66.0	101.6	86.0	1.5	12.0	15.0	—	52.0	28.6	48.5	47.5	15.7	38.0	37.7	104.5
1974	47.3	32.4	39.5	29.4	41.0	15.7	26.6	61.0	29.6	5.5	24.2	54.0	61.0	28.2	57.0	58.3	40.7	73.0
1975	13.8	26.0	54.5	90.4	57.0	76.7	25.2	35.0	54.0	67.2	63.4	58.2	17.0	112.2	108.0	103.7	132.3	94.5
Total	30.0	24.2	33.3	41.7	53.4	36.4	28.0	49.1	43.7	68.6	59.1	73.9	63.9	58.0	65.6	62.8	82.1	60.7

	1	2	3	4	5	6
	July					
1966						
1967	128.4	103.2	149.6	—	—	—
1968	57.0	<u>44.8</u>	20.8	103.4	<u>64.2</u>	52.2
1969	—	—	43.8	46.8	48.8	<u>95.8</u>
1970	62.2	54.5	37.0	<u>77.4</u>	54.3	<u>50.0</u>
1971	65.1	<u>57.6</u>	54.0	53.3	24.0	37.5
1972	13.6	1.6	61.7	101.5	46.0	<u>36.0</u>
1973	22.5	51.0	<u>65.2</u>	53.0	16.6	<u>79.3</u>
1974	29.0	38.2	30.2	61.5	67.0	58.0
1975	158.7					
Total	67.1	50.1	57.8	71.6	45.8	58.4

	1	2	3	4	5	6
	August					
1966						
1967	67.0	94.0	58.4	<u>7.22</u>	152.4	65.3
1968	41.5	<u>89.8</u>	43.8	<u>49.0</u>	75.7	40.8
1969	45.0	<u>51.7</u>	40.2	27.6	37.2	<u>62.5</u>
1970	93.8	36.0	39.0	<u>52.0</u>	13.0	—
1971	25.4	<u>69.0</u>	47.0	—	—	—
1972	6.5	47.2	34.2	43.4	<u>22.8</u>	41.0
1973	52.8	77.0	<u>52.3</u>	13.0	<u>50.7</u>	64.3
1974	—	—	—	—	—	—
1975						
Total	47.4	66.4	45.0	42.0	58.6	54.8

	1	2	3	4	5	6
	September					
1966						
1967	71.4	148.8	142.2	108.0	80.4	52.8
1968	70.8	98.0	152.4	93.3	40.5	29.0
1969	48.2	55.4	17.3	40.4	32.0	50.0
1970	—	—	<u>59.5</u>	43.2	38.5	10.5
1971	—	57.0	<u>27.0</u>	62.5	63.6	60.0
1972	13.8	32.5	19.4	76.6	<u>65.5</u>	40.0
1973	58.3	48.6	<u>63.4</u>	40.2	28.8	49.3
1974	—	—	—	—	—	—
1975						
Total	52.5	73.4	68.4	65.3	49.9	41.6

	1	2	3	4	5	6
	October					
1966						
1967	29.2	57.4	58.4	<u>11.0</u>	35.0	—
1968	34.2	<u>40.0</u>	13.6	9.2	18.5	12.8
1969	32.5	15.8	51.0	63.0	<u>37.7</u>	28.1
1970	19.8	29.6	<u>10.6</u>	6.3	—	18.0
1971	<u>74.4</u>	45.4	24.0	20.2	25.2	15.0
1972	27.3	21.4	22.5	42.0	<u>21.0</u>	30.8
1973	40.7	21.0	<u>68.0</u>	31.8	42.8	52.6
1974	—	100.0	76.0	36.4	48.0	<u>62.0</u>
1975						
Total	36.6	41.3	40.5	27.4	32.6	31.3

	1	2	3	4	5	6
	November					
1966			37.3	42.2	36.8	<u>42.0</u>
1967	—	—	—	<u>39.0</u>	36.0	40.8
1968	<u>11.8</u>	11.4	15.5	9.6	6.2	8.6
1969	<u>37.6</u>	22.2	24.2	—	—	—
1970	17.0	9.0	<u>12.6</u>	9.0	16.5	6.2
1971	<u>38.2</u>	26.8	16.8	10.8	75.8	50.6
1972	14.6	27.7	18.0	<u>11.8</u>	14.6	30.2
1973	43.2	<u>31.8</u>	37.5	<u>34.4</u>	22.0	22.4
1974	25.2	<u>63.7</u>	34.8	31.0	38.2	<u>11.0</u>
1975						
Total	26.8	27.5	24.6	23.4	26.7	26.4

	1	2	3	4	5	6
	December					
1966						
1967	27.8	45.2	29.0	39.4	25.0	<u>16.8</u>
1968	23.4	26.0	7.2	—	—	25.2
1969	<u>10.6</u>	12.0	10.2	8.2	9.0	9.8
1970	—	15.0	16.0	19.8	<u>2.0</u>	25.3
1971	30.2	15.5	<u>18.4</u>	14.2	19.0	16.2
1972	<u>36.4</u>	30.2	22.0	19.5	50.8	<u>43.2</u>
1973	7.0	14.0	34.7	<u>23.5</u>	37.3	33.8
1974	23.8	<u>39.4</u>	37.4	<u>15.2</u>	42.0	127.0
1975	54.6	41.4	33.7	<u>21.2</u>	12.6	16.0
Total	26.7	26.5	23.1	20.1	24.7	34.8

Table 13. The Monthly Average Numbers of Bats Tallied Over Bangkok.

Year	Month												Ave.
	J	F	M	A	M	J	J	A	S	O	N	D	
1976											36	30	33
1967	8	1	21	22	46	98	128	86	97	41	36	21	50
1968	31	17	30	27	73	46	55	53	85	20	11	10	40
1969	5	2	9	55	45	45	61	42	38	36	29	18	35
1970	13	6	3	16	90	103	52	52	39	16	12	18	35
1971	35	15	15	18	20	48	49	43	39	37	37	35	32
1972	34	25	38	35	51	25	31	32	30	23	19	23	30
1973	21	2	5	69	21	46	45	47	45	40	32	35	35
1974	49	17	34	34	34	54	41			54	38	34	39
1975	15	15	31	53	45	97	159						44
Ave.	26	13	21	37	49	62	56	39	55	33	27	25	37
Total	5662	1959	4550	8398	10504	10261	10209	5946	9276	6323	5545	5168	86242
Bats													
Total	219	156	214	227	213	165	183	151	168	193	209	206	2303

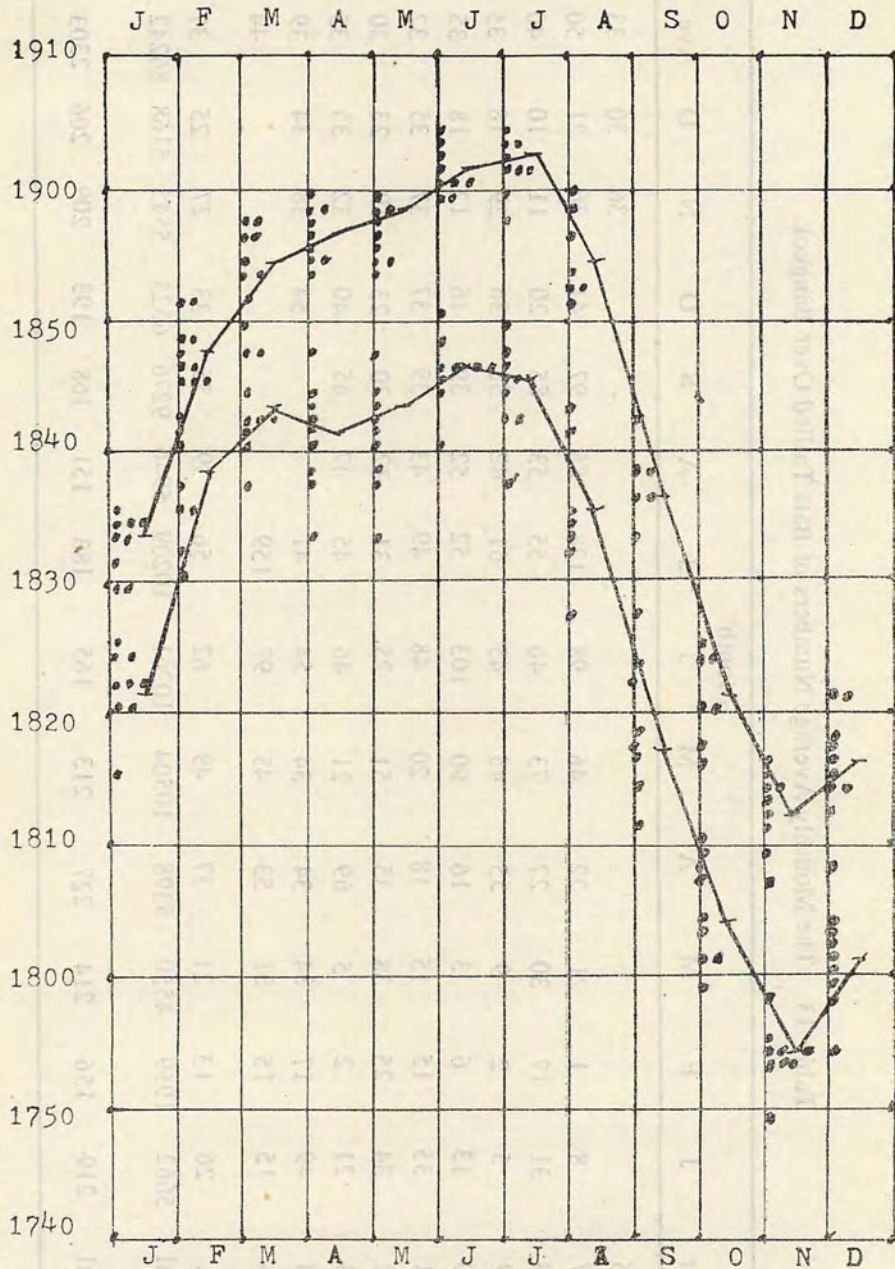


Fig. 1. Nine year summation of the starting and stopping times of bat flights over Bangkok, Thailand. Dots indicate the monthly averages for each year, 1966-1975. The figure parallels the time of sunset.

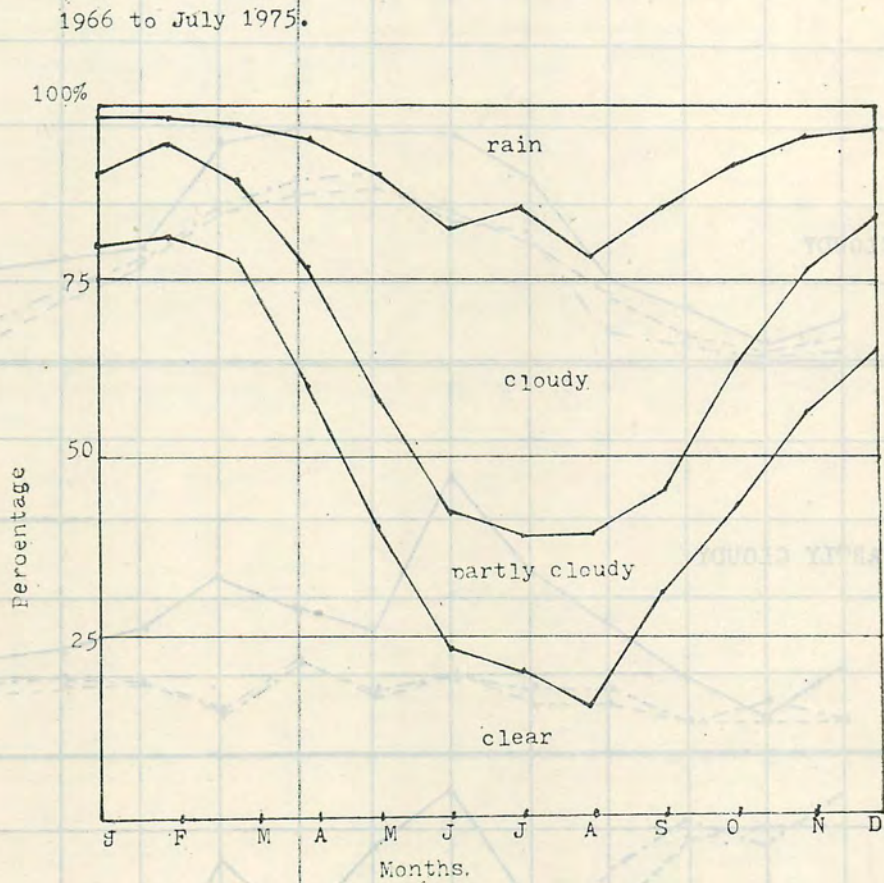


Fig. 2. The cloud cover at sundown over Bangkok, summarized by percentage of the number of observations from November 1966 to July 1975.

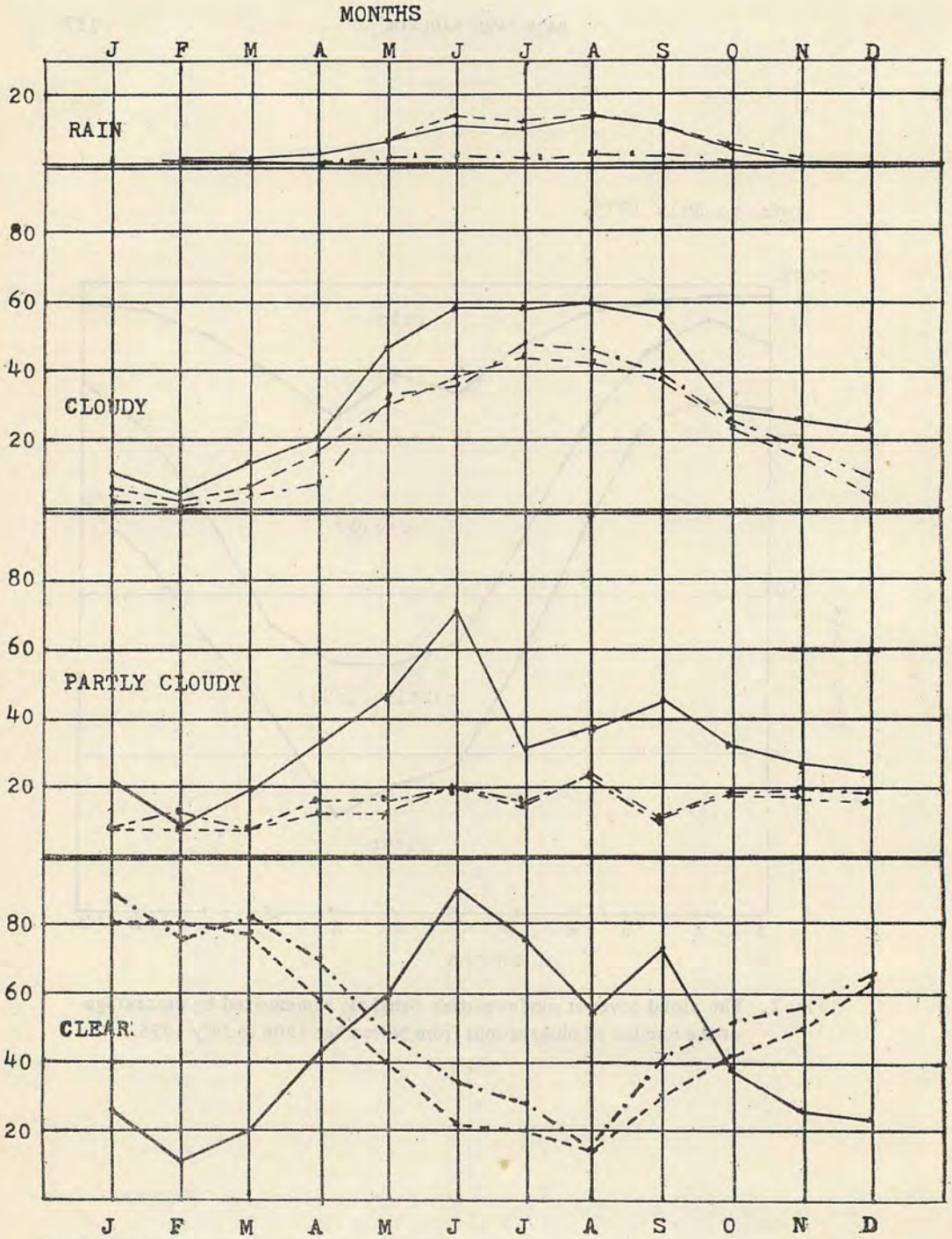


Fig. 3. The relationships between bat movements and cloud cover. Average number of bats per observation  
 Percent of total bats seen that month - - - -  
 Percent of observations with that weather - - - - -

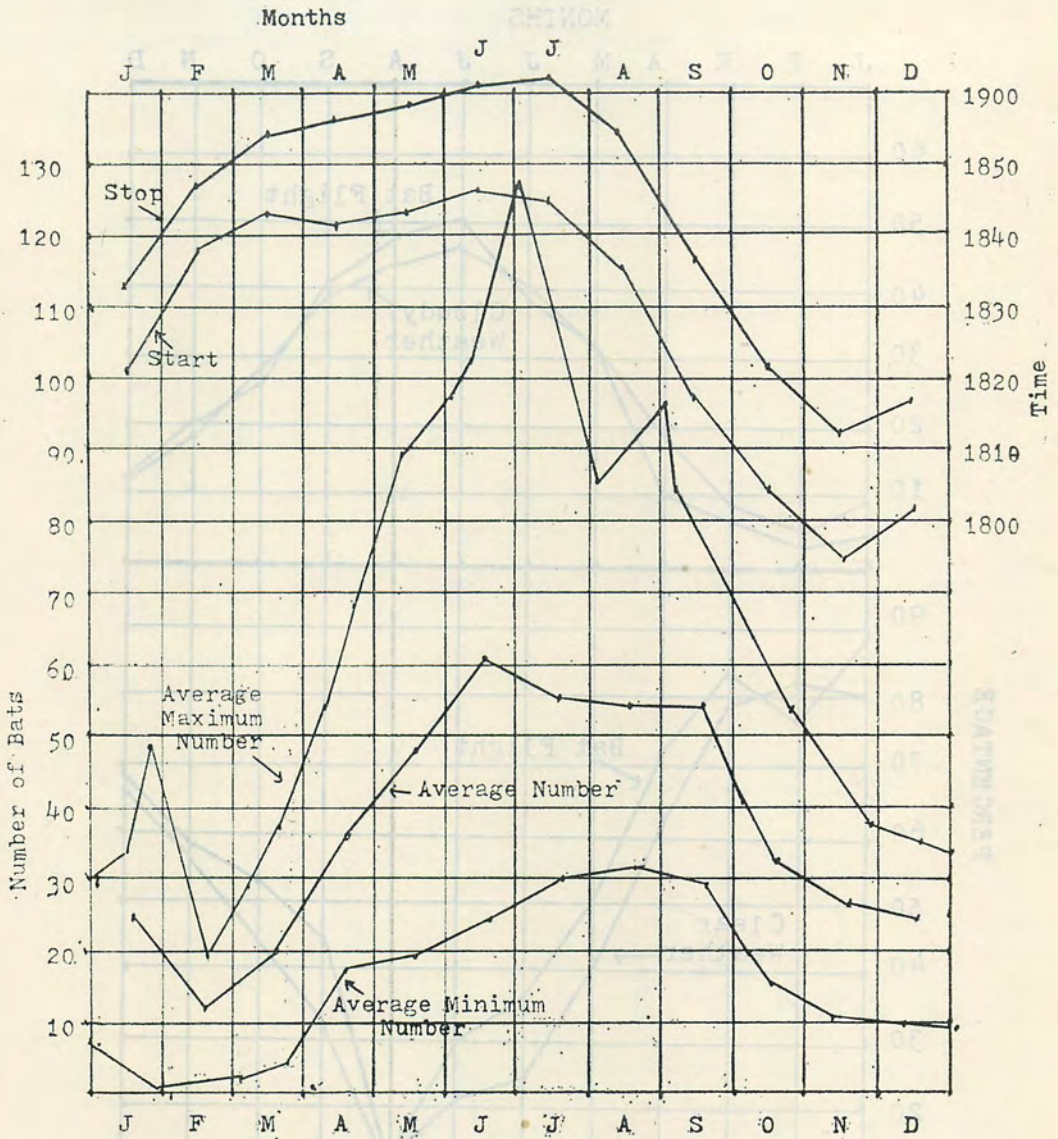


Fig 4. A nine year summation of the flight time and the number of bats in the air above Bangkok.

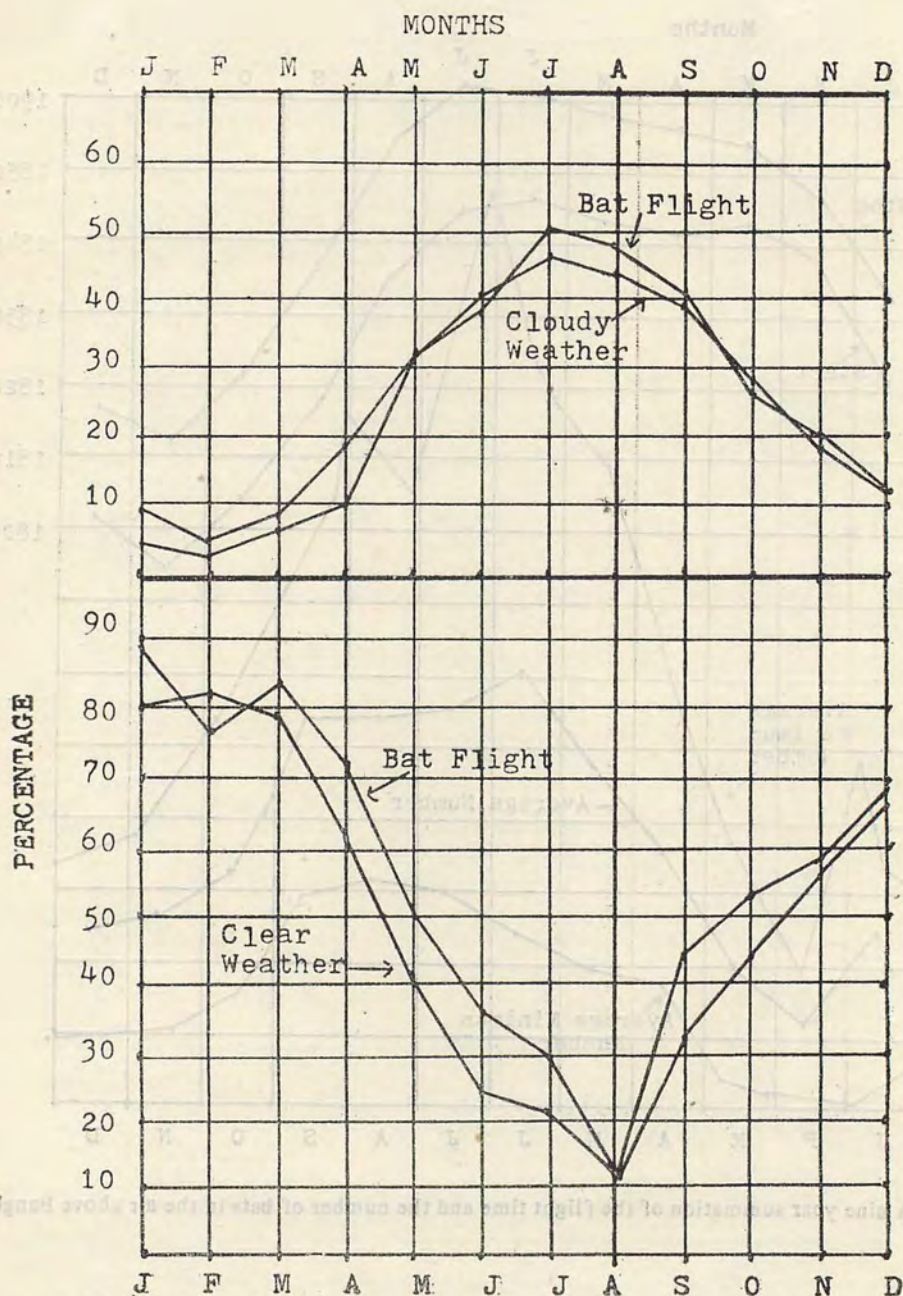


Fig. 5. The percentage of bats in flight compared to the percentage to cloudy weather by month.

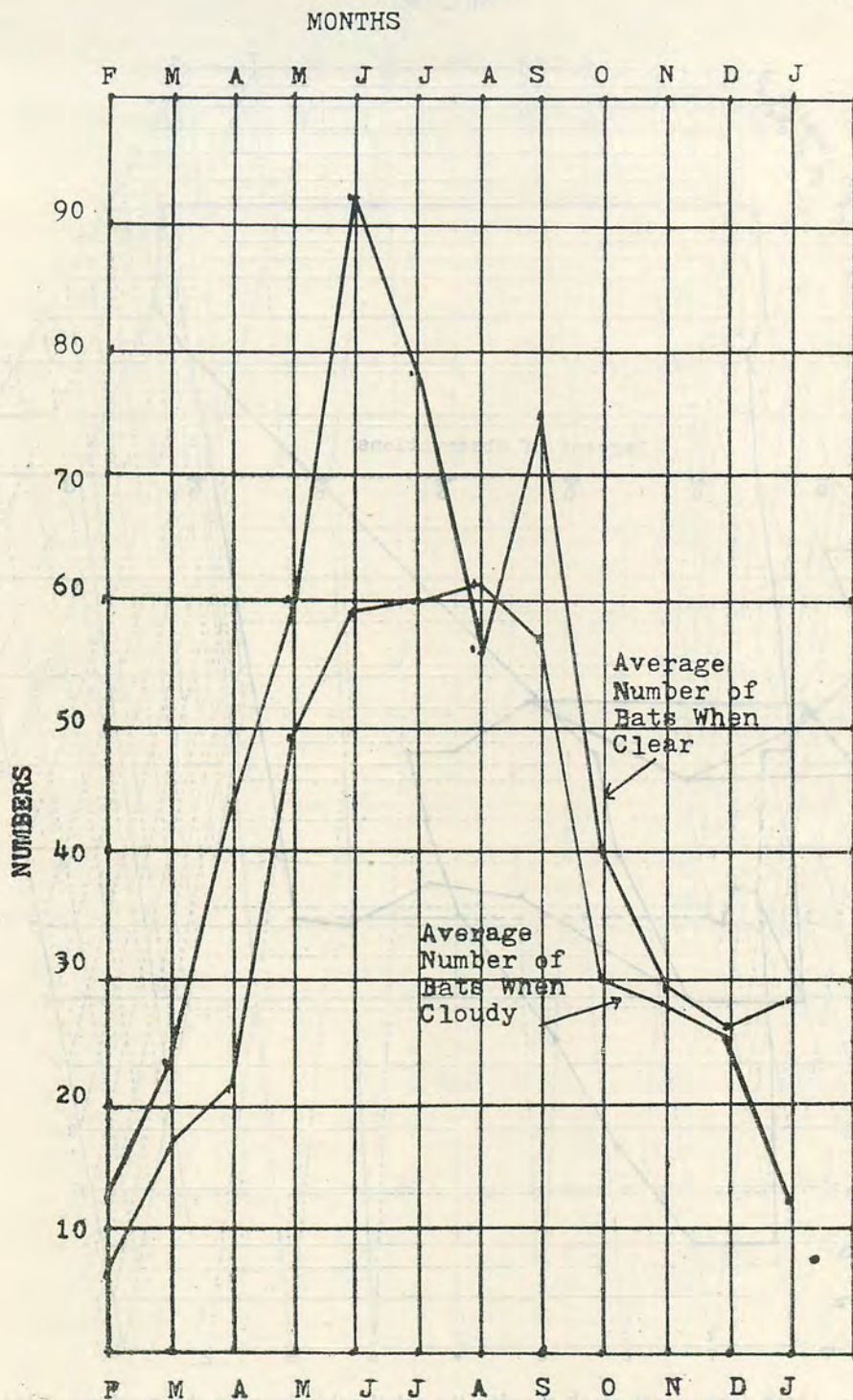


Fig. 6 Comparison by month of the number of bats in the air in clear or cloudy weather.

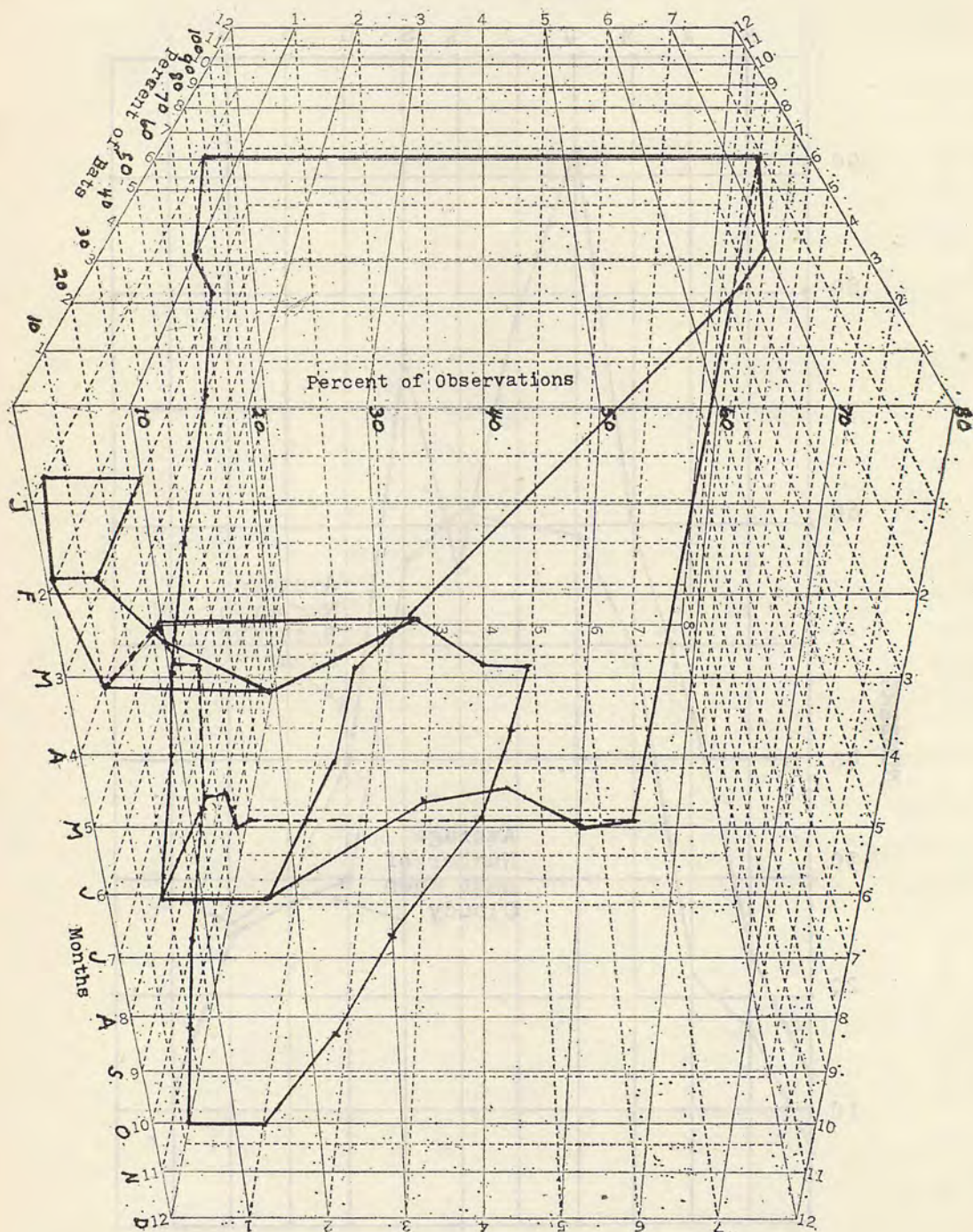


Fig. 7. Three dimensional graph showing the relationship between the numbers of bats flying during clear and cloudy evenings and the months of the year.

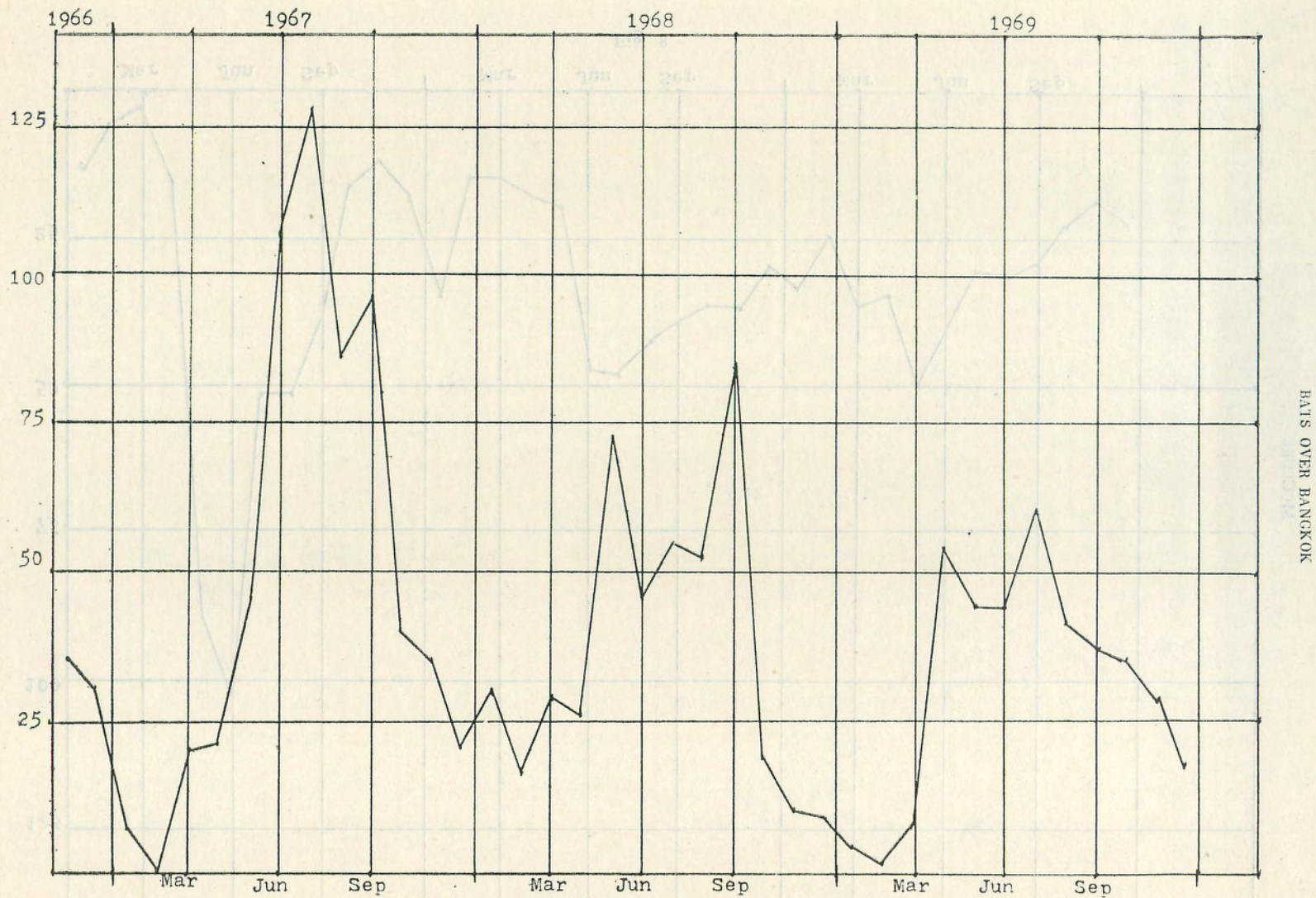


Fig. 8. The average number of bats per month.

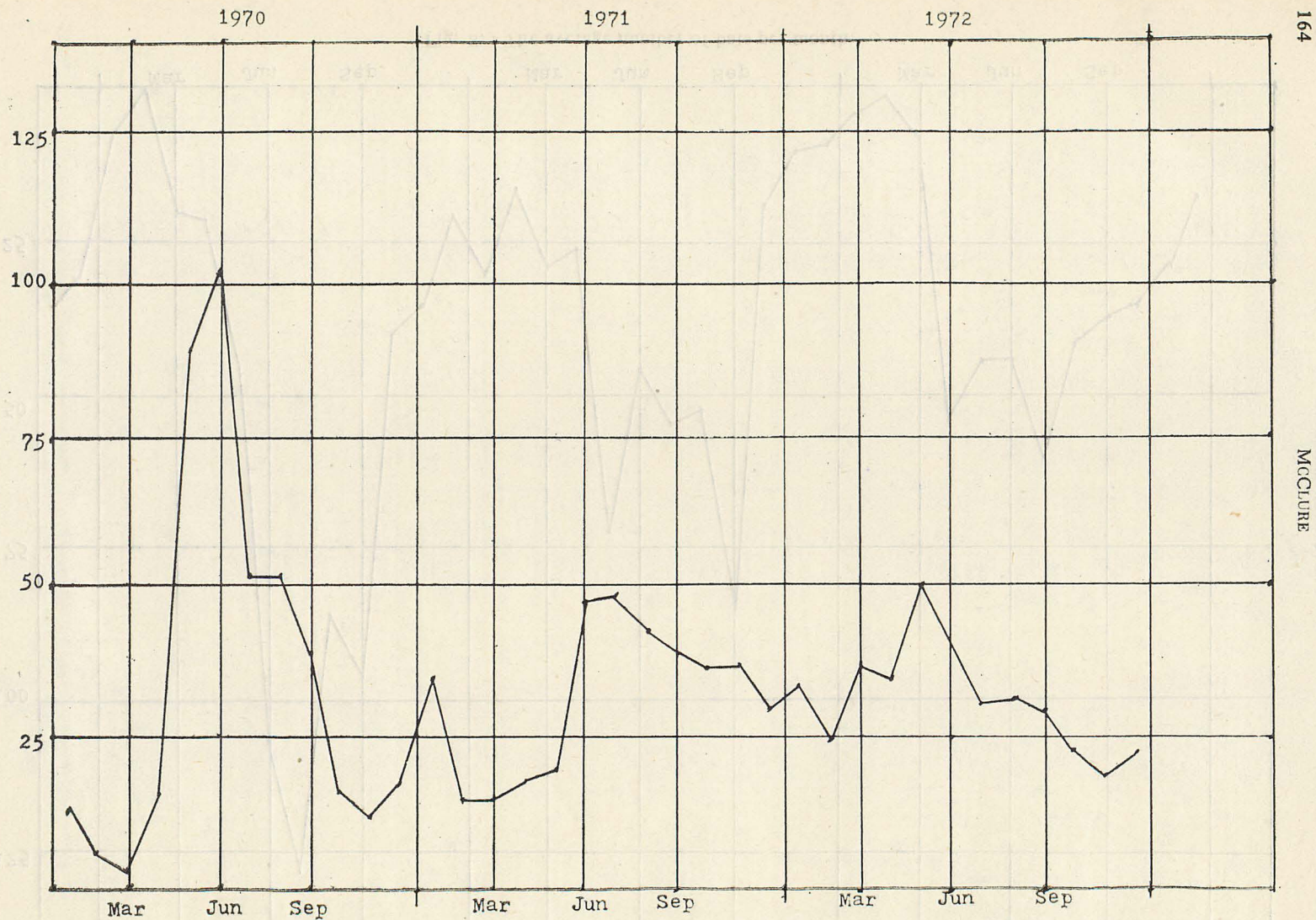
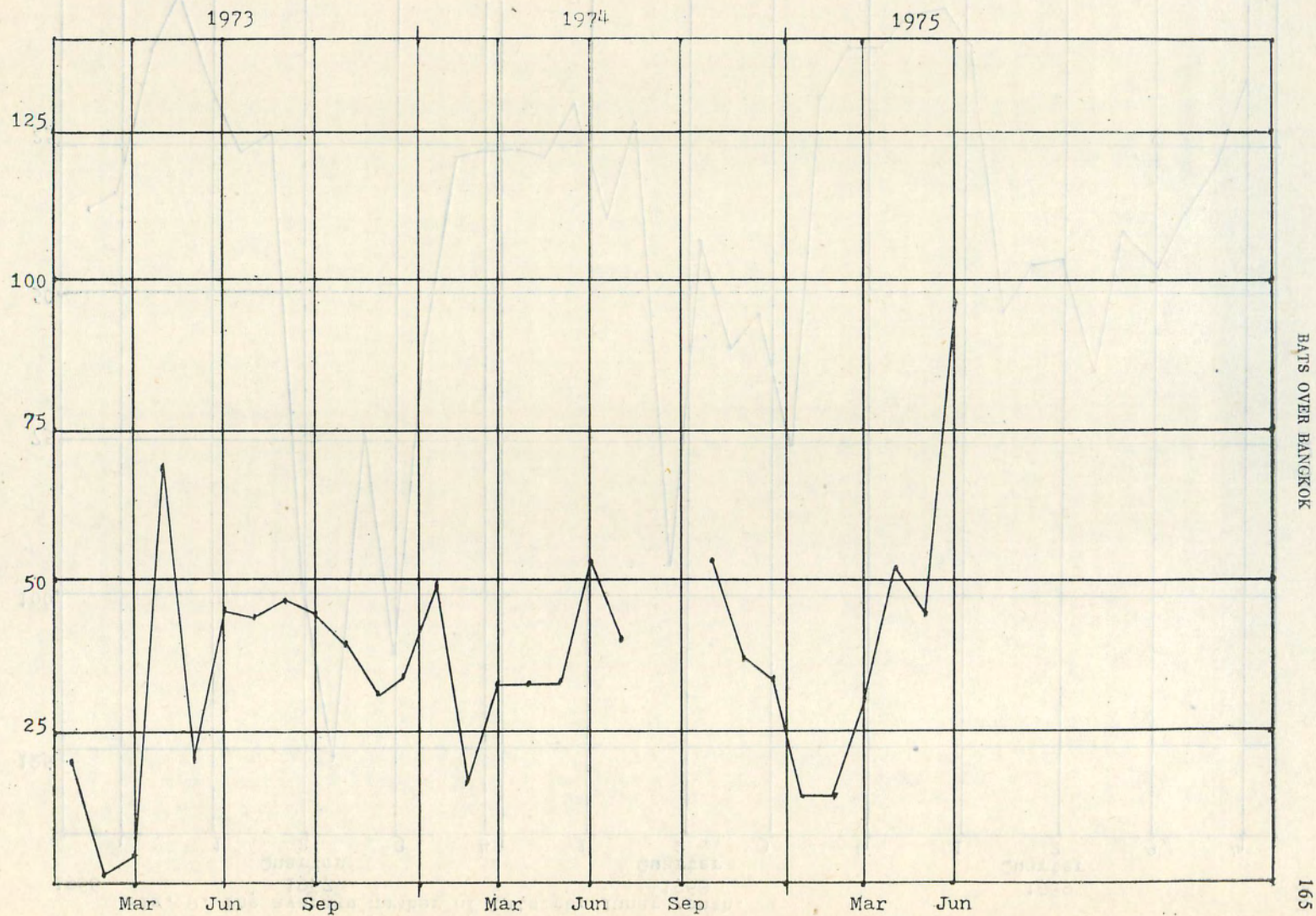


Fig. 8.

Fig. 8. Continued.



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Fig. 9. The average number of bats per lunar month.

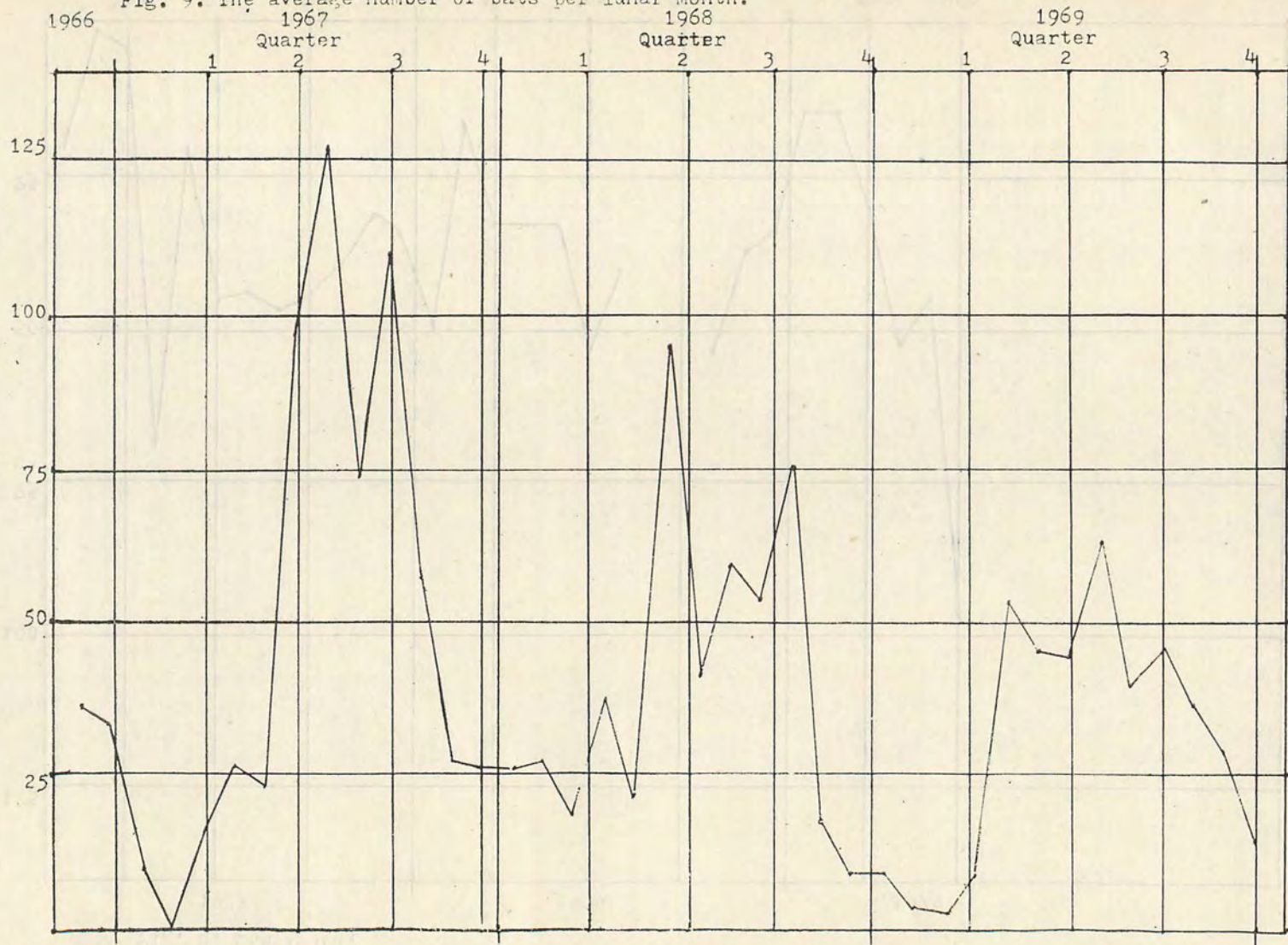
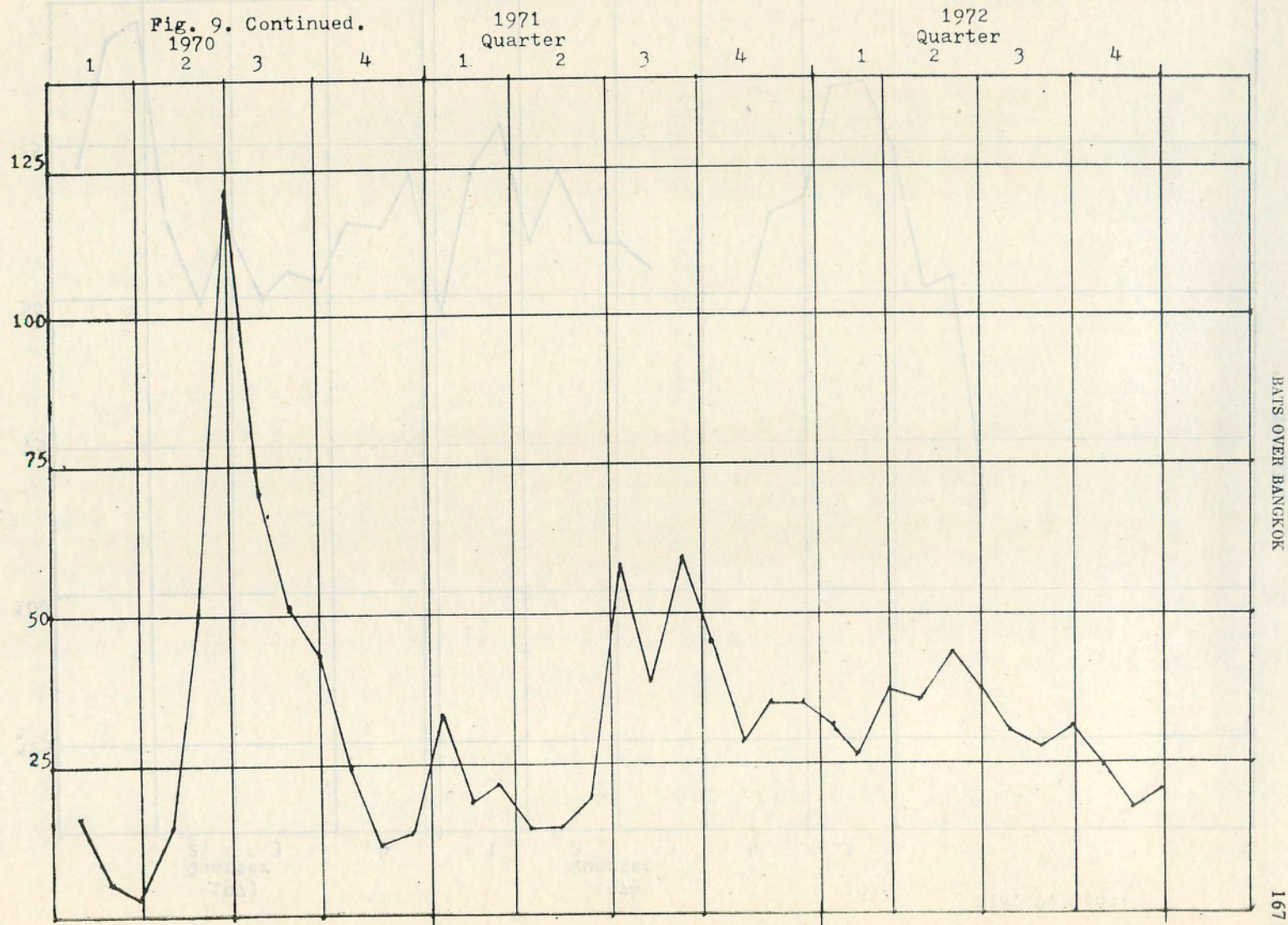


Fig. 9. Continued.



BAIS OVER BANGKOK

Fig. 9. Cont.

