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Original article

Periodic mass flights of *Apis laboriosa* in Nepal[1]

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Abstract – The investigations were conducted in the Himalayas in Nepal. Two cliff sites, one with 16 *A. laboriosa* nests and the other with 53 nests were observed. Together 120 periodic mass flights (PMF) performed by *A. laboriosa* worker bees during 8 days were recorded. Workers from 50–81% of colonies performed PMF, during days of adequate weather conditions. The flights were not performed during overcast days. Worker bees from different colonies perform PMF at different times of the day. Workers from the same colonies perform PMF at different times in subsequent days. While workers from some colonies did not perform any PMF during several days, others perform 2 or 3 PMF per day.

***Apis laboriosa* / periodic mass flights / Nepal / Himalayas**

1. INTRODUCTION

Apis laboriosa F. Smith lives in the Himalayas on hardly accessible rock cliff sites. Its biology is little known. In autumn, the colonies migrate from the subalpine (2800 m–3600 m) and cool temperate (2000 m–2800 m) zones to the warm temperate (1200 m–2000 m) zone (Underwood, 1990b). Woyke et al. (2001) showed that those colonies which already resided in the lower margin of the warm zone (1250 m) did not migrate, but reared brood throughout the winter. Underwood (1990a), who monitored *A. laboriosa* during 1.5 years, mentioned only one periodic mass flight (PMF) in that species (designated by him as an "orientation flight"). The purpose of our investigation was to find out whether PMF in *A. laboriosa* represent exceptional phenomena, or whether they occur regularly. We tried also to examine the character of those flights.

2. MATERIALS AND METHODS

Observations of *A. laboriosa* nests were made at two cliff sites in the Himalayas in Nepal in November and December 1999. One site with 16 nests was located on the Annapurna slope in Kyumi at the Modi Khola river near Landrung in Kaski district (lat. 28º22' N., long. 83º50' E., alt. 1250 m). All colonies occupied combs. This site was probably the Landrung cliff observed by Underwood (1990b). The cliff site was oriented West-South. The sun started to lighten one side of the cliff at 12:20 h, and the total cliff site was in sun at 13:00 h. The observations were conducted here from November 27th to December 2nd. The other rock cliff with 53 nests was situated in Chale, Sindhupalchok district (lat. 28º09' N., long. 85º48' E., alt. 1500 m) at the Bhote Koshi river near Kodari on the Tibetan border. The Chale cliff site was oriented East-South. The cliff was in sun by the beginning of each day of observation (08:00 h). Investigations were conducted here on the 5th and 6th December. Out of the 53 colonies, 6 were adhered flat to the cliff. We suppose that these were

[1] Two video-clips are available electronically at the following address: http://www.edpsciences.org/apido/

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in the form of comb-less clusters. Worker bees of the nests in both sites were active. We observed foragers collecting nectar and pollen on flowers and returning to the nests with pollen loads. The colonies at the Kyumi site were harvested by local honey hunters on the 20th December. We harvested two colonies from the Chale cliff on 24th December. Brood of all ages, pollen and honey were present in all combs. Evidently, the colonies were not making preparations to abandon the combs nor to migrate. In both places, the bees were observed with the aid of 12×50 power binoculars from the other side of the river, from a distance of approximately 28 m. Air temperature was recorded in Kyumi and Chale every hour from 0800 to 1600 h with the aid of electronic thermo hygrometer located in shade 1 m above the ground. Day or parts of day were defined as overcast when the sky was covered completely with clouds (no blue strip visible), and no shade was visible. For statistical calculations, the hours were converted into minutes. Significant differences between means were determined using Student *t*-tests. Correlation coefficients between different factors were calculated.

3. RESULTS

3.1. Periodic mass flights

Undisturbed *A. laboriosa* worker bees made periodic mass flights (PMF) during the day. At once, complete disorder of the curtain occurred and the workers flew out *en masse*. Perpendicular gaps could be seen in the curtain through which worker bees came up from the inside of the nest to the surface. The workers flew in circles up to about 30–40 m around the nests. Most of the flight activities lasted 3–5 min. However, a range of 2–7 min was recorded. During PMF, the workers excreted yellow faeces, some of which dropped on us on the other side of the river. Videos presenting periodic mass flights of *A. laboriosa* are available on the on-line version.

3.2. Percentage of colonies performing periodic mass flights

We recorded 44 PMF of 16 colonies during 6 days of observation at Annapurna slope in Kyumi, and 76 PMF of 53 colonies during 2 days at the Chale site. Workers from 50–81% of colonies performed PMF during the days when the sun was shining at least for part of the day (Tab. I). In Kyumi, during the 4 sunny days, workers from 25% (4), 25% (4), 31% (5) and 19% (3) of the colonies performed PMF during all 4, 3 successive, 2 or 1 day, respectively. When bees performed only two PMF during the 4 days, none occurred in two successive days.

In Chale, worker bees from 19% of the colonies did not perform any PMF during both days of observations. After dividing the colonies into normal and combless categories, there appeared that out of the 6 flat nests, workers from 3 (50%) did not perform PMF during both days. However, out of the remaining 47 normal nests, only 7 (15%) did not perform PMF during both days. Thus, worker bees from normal colonies performed relatively more PMF during both days than from the combless ones. The results suggest that worker bees from nests containing brood perform more PMF than from nests without brood.

Figure 1A shows, that during the sunny Kyumi day, 27 Nov., 14 PMF were made. During the other days, of which some were partly cloudy, 8 to 10 PMF were recorded. However, no *A. laboriosa* colonies performed PMF during the overcast day 28 Nov., nor during overcast parts of the other days. Nevertheless, we observed foraging activity during all the days.

During the unfavourable weather conditions of 2 Dec., only two PMF were made. One PMF was performed by workers which did not make PMF during the last four days. The second was made by bees which performed PMF during all the four days.

3.3. Time, beginning and end of periodic mass flight activity

PMF activity occurred in Kyumi between 11 h and 1600 h and in Chale between 0900 h and 1500 h (Figs. 1A and 1B). Thus, worker bees from different colonies performed PMF at times differing by several hours of the same day. PMF started in Chale (mean 1242 h, sd ± 1:04 h, n = 64) significantly earlier in the day than during the 4 sunny days in Kyumi (1334 h, sd ± 0:52 h, n = 41), ($t = 5.8$, $P < 0.01$) and the activity lasted longer.

Table I. Periodic mass flights performed by *A. laboriosa* worker bees.

16 colonies at Annapurna slop	27 Nov.	28. Nov.	29. Nov.	30. Nov.	1 Dec.	2 Dec.
No. colonies performing PMF	13	0	8	10	10	2
% colonies performing PMF	81	0	50	63	63	13
Total No. PMF	14	0	8	10	10	2
Mean No. PMF per all colonies	0.9	0	0.5	0.6	0.6	0.1
Mean No. PMF per colonies performing PMFs	1.1	0	1	1	1	1

53 colonies at Chale site	5 Dec.	6 Dec.
No. colonies performing PMF	27	37
% colonies performing PMF	51	70
Total No. PMF	32	44
Mean No. PMF per all colonies	0.6	0.8
Mean No. PMF per colonies performing PMF	1.2	1.2
% colonies not performing PMF during both days	19	19
No. colonies performing 2 PMF during 1 day	5	6
% colonies performing 2 PMF during 1 day	9	11
% 2nd PMF in relation to No. colonies performing PMF	19	16
Time lapse between 2 PMF of the same colony	52 min – 2 h 21 min	34 min – 2 h 09 min
Mean time lapse between 2 PMF	1 h 33 min	1 h 14 min
Mean start time (h) of 1st PMF	1156 h [a*]	1247 h [a]
Mean start time (h) of 2nd PMF	1206 h [a]	1326 h [a]
Mean start time (h) of 1st PMF of colonies performing 1 PMF	1215 h [a]	1253 h [a]
Mean start time (h) of 1st PMF of colonies performing 2 PMF	1033 h [b]	1213 h [b]
No colonies performing 3 PMF during 1 day	0	1

* Different letters after the means indicate significant differences $P < 0.05$. Vertical comparison.

The high number of flights performed 28 Nov, between 1200 and 1300 h in Kyumi was the result of an absence of PMF the previous day (Fig. 1A). The increased number of PMF on 30 Nov. between 1300 and 1400 h in Kyumi (Fig. 1A), and on 6 Dec. between 1200 and 13 in Chale (Fig. 1B) was the result of an aggregation of PMF that could not be made earlier due to cloudy sky, a condition in which PMF are not performed. Figures 1A and B show, that the first day of observations, PMF activity ended after 1600 h, and all the other sunny days after 1500 h.

3.4. Correlation between air temperature and number of periodic mass flights

No correlation was found between the air temperature at particular hours of the day and the number of PMF, neither for the 5 days in which PMF occurred in Kyumi ($r = -0.09$, $P = 0.77$) nor for both days in Chale ($r = 0.37$, $P = 0.26$). PMF in Kyumi did not take place at temperatures lower than 18 °C, while in Chale they were performed at 12 °C. Figure 1A and B show that the temperature at the end of PMF activity was the same or even higher then earlier.

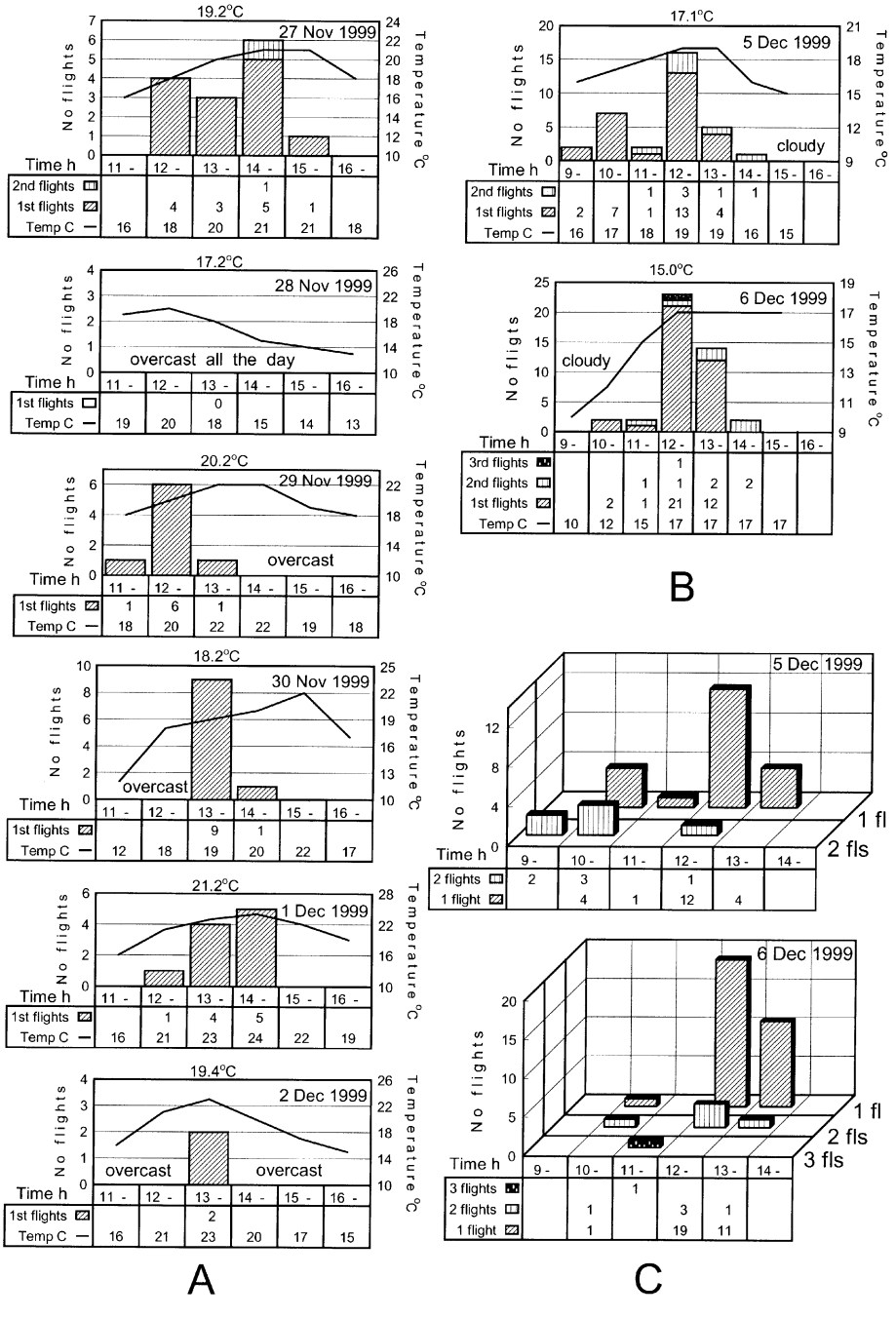

Figure 1. Number of periodic mass flights performed at different times of the day by *Apis laboriosa* bees. A – at Mt. Annapurna slope in Kyumi, B – in Chale site, C – start times of first periodic mass flights performed by *Apis laboriosa* making one, two or three flights per day.

3.5. Several periodic mass flights per day

Workers from only one colony performed two PMF during the same day in Kyumi. However, in Chale, two PMF per day were performed by worker bees from 16% or 19%, respectively, of colonies making PMF. Observations revealed that some colonies did not perform PMF during both days, while others performed 1, 2 or even 3 PMF per day, and one colony performed two PMF during both days.

Figure 1B shows, that most second PMF occurred at the same time, or even earlier than the first PMF performed by other colonies. Table I shows that the time lapse between two PMF performed by workers of the same colonies in the same day ranged up to more than 2 h and in one colony lasted over 4 hours. Worker bees from one colony performed also a third PMF on the same day. The time lapses between the 3 consecutive flights were 1 h and 07 min and 39 min, respectively.

The mean start time of the first PMF of colonies performing two flights per day (Tab. I) was significantly earlier in both days than in those making only one flight ($t = 3.2$, $P < 0.01$; $t = 2.2$, $P = 0.04$). However, workers from several colonies performing two PMF per day and the one colony performing three PMF started their first flights at the same time or later than those making only one PMF per day (Fig. 1C).

4. DISCUSSION

We describe here the daily frequency distribution of 120 periodic mass flights performed by *A. laboriosa* worker bees during 8 days and present data on PMF activity from individual colonies. The main characteristics of PMF include the fact that worker bees from different colonies perform PMF at different times of the day and workers from the same colony may perform PMF at different times on different days. While workers from some colonies performed two or three PMF per days, others did not perform any PMF during several days. The results show that PMF are not exceptional phenomena in *A. laboriosa.*

The absence of PMF activity during overcast days or part of the days, despite foraging activity, suggests that young worker bees need sun for orientation flights. The occurrence of two exceptional PMF performed during unfavourable conditions on 2 Dec. may be explained by individual colony demand. Workers from the one colony needed to perform a PMF, because they did not make any during 4 last days. Possibly the internal conditions of the other colony, including the presence of brood and many young bees, forced the bees to perform PMF every day, even during the unfavourable weather conditions.

We observed that *A. laboriosa* worker bees did not forage at temperatures lower than 10 °C, and we did not record PMF activity at temperatures lower than 12 °C. Thus, the air temperature is probably the factor determining the beginning of PMF activity. However, we did not find correlation between the air temperature during the day and PMF activity. Probably other factors were more important. The termination of PMF activity also was not related to the temperature. The PMF activity ceased about 2 hours before sunset (Kyumi 1728 h, Chale 1723 h). Thus, we hypothesize that the position of the sun determined the end of PMF activity.

One of the reasons PMF activity began earlier in Chale, than in Kyumi, could be the orientation of the cliff site toward ES in first place and toward WS in the second. As a result, the colonies were lighted by sun earlier in Chale than in Kyumi. Microclimate conditions on the surface of the nest must have been different from the air temperature measured 1 m above the ground. However, the microclimate conditions must have been similar for particular colonies in successive sunny days or sunny parts of days. Examination of the Kyumi records revealed, that the time difference between the earliest and the latest PMF performed by the same colonies was more than 1 h in 8 (57%) colonies performing at least 2 flights during the whole period. In Chale the difference was higher than 1 h in 7 (33%) colonies performing PMF in both days.

The sequence of the start of PMF of particular colonies in relation to other colonies was different in successive days. For example,

in Kyumi, colony No. 7 started PMF as the 3rd, 9th, 4th, and 1st in order during four successive days. This shows that the same colonies performed PMF at different time in successive days.

The time lapse between two PMF in the same day ranged up to more than 2 h. The microclimatic conditions on the surface of the curtain must have differed during both flights. This suggests that microclimatic conditions at the surface of the nest curtain were not the most important factors determining the initiation of PMF.

Probably, the internal conditions of the colonies are the prevailing factors determining the initiation of PMF. Among others, one can imagine the amount of open brood to be fed, the number of emerging workers, the amount of stored nectar and pollen may be important. Our observations suggest that the main purposes of PMF are cleansing and orientation flights of young bees. Dislodging the position of worker bees in the curtain also may play some role. We suggest that the short period of PMF activity acts to minimize the negative consequences of disturbing the protective curtain of bees on the open nest of *A. laboriosa*.

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Résumé – Vols en masse périodiques chez *Apis laboriosa* au Népal. La biologie d'*Apis laboriosa* F. Smith est peu connue ; un seul vol en masse périodique (VMP) a été mentionné pour ces abeilles. Nous avons donc recherché si ces VMP étaient des phénomènes exceptionnels ou s'ils se produisaient régulièrement chez *A. laboriosa*. Les recherches ont été menées au Népal dans la chaîne de l'Himalaya. Le premier site, une falaise comportant 16 nids d'*Apis laboriosa,* était situé sur les pentes de l'Annapurna et le second, avec 53 nids, était près de Kodari sur un col de la frontière tibétaine. On a enregistré au total 120 VMP effectués par les ouvrières d'*Apis laboriosa* sur une période de huit jours. L'activité de VMP durait de trois à cinq minutes, entre 10:00 h et 15:00 h. Pendant les conditions météorologiques convenables les ouvrières de 50 à 81 % des colonies ont effectué des VMP. Les ouvrières de différents nids accomplissaient leur VMP à des périodes de la même journée séparées de plusieurs heures. Les ouvrières de la même colonie les accomplissaient à une heure variable au cours de jours successifs. Alors que les ouvrières de certaines colonies n'ont effectué aucun VMP durant plusieurs jours, d'autres en ont effectué deux à trois par jour. Les ouvrières accomplissant deux VMP par jour démarraient leur premier vol à la même heure, ou même plus tard, que celles qui n'en effectuaient qu'un seul. On n'a pas trouvé de corrélation entre la température de l'air à des heures données de la journée et le nombre de VMP. L'observation suggère que les conditions microclimatiques à la surface du rideau d'abeilles qui protège le nid ne sont pas les facteurs qui déterminent l'heure des VMP. Nous pensons que les conditions internes de la colonie, comme la quantité de couvain ou le nombre de jeunes abeilles, sont des facteurs qui déterminent l'activité de VMP. Les résultats montrent que chez *A. laboriosa* les VMP ne sont pas exceptionnels mais des phénomènes normaux qui se produisent par jours ensoleillés.

***Apis laboriosa* / vol en masse périodique / Népal / Himalaya**

Zusammenfassung – Periodischer Massenflug von *Apis laboriosa*. Von der Biologie von *A. laboriosa* ist wenig bekannt. Nur ein regelmäßiger Massenflug (PMF) dieser Bienen wurde erwähnt. Deshalb untersuchten wir, ob PMFs bei *A. laboriosa* durch besondere Anlässe hervorgerufen werden oder ob sie regelmäßig auftreten. Die Beobachtungen wurden im Himalaya in Nepal durchgeführt. Ein Felsen mit 16 *A. laboriosa* Völkern lag am Annapurna Hang und der andere mit 53 Völkern in der Nähe von Kodari an einem Tibetanischen Grenzpass. Über einen Zeitraum von 8 Tagen wurden insgesamt 120 PMFs der *A. laboriosa* Arbeitsbienen beobachtet. Die PMF Aktivität zwischen 10:00 h und 15:00 Uhr dauerte zwischen 3 und 5 Minuten. Arbeiterinnen von 50–81 % der Völker unternahmen bei passenden Wetterbedingungen PMFs. An Tagen mit bedecktem Himmel wurden keine Flüge durchgeführt. Arbeiterinnen von verschiedenen Völkern unternahmen PMFs, die sich zeitlich am gleichen Tag um mehrere Stunden unterschieden.

Arbeiterinnen eines Volkes flogen an aufeinanderfolgenden Tagen zu unterschiedlichen Zeiten. Einige Völker führten während mehrerer Tagen gar keine PMFs durch, während andere 2 oder 3 PMFs täglich unternahmen. Arbeiterinnen, die an 2PMFs pro Tag beteiligt waren, begannen mit ihren ersten Flügen zur gleichen Zeit oder sogar später als solche, die am Tag nur einen PMF machten. Es ergab sich keine Korrelation zwischen der Lufttemperatur zu bestimmten Tageszeiten und der Anzahl der PMFs. Diese Beobachtungen sprechen dafür, dass die Bedingungen des Mikroklimas an der äußeren Bienenhülle kein Faktor war, der die Zeit für eine PMF Aktivität bestimmt. Wir vermuten, dass interne Bedingungen des Volkes wie die Brutmenge, die Zahl von Jungbienen und andere Faktoren die PMF Aktivitäten bestimmen. Die Ergebnisse zeigen, dass PMFs bei *A. laboriosa* kein Zeichen für ungewöhnliche Situationen sind, sondern ein normales Verhalten an sonnigen Tagen ist.

***Apis laboriosa* / periodischer Massenflug / Nepal / Himalaya**

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