



**Activity/Rest Patterns of Instructor and Rated  
Student Pilots During Rapid Transitions  
From Daytime to Nighttime Duty Hours  
at the Eastern Army Aviation  
Training Site**

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**February 1993**

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**United States Army Aeromedical Research Laboratory  
Fort Rucker, Alabama 36362-5292**

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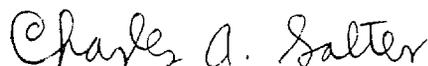
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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188		
1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS			
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release, distribution unlimited			
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE			5. MONITORING ORGANIZATION REPORT NUMBER(S)			
4. PERFORMING ORGANIZATION REPORT NUMBER(S) USAARL Report No. 93-16			7a. NAME OF MONITORING ORGANIZATION U.S. Army Medical Research and Development Command			
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Aeromedical Research Laboratory		6b. OFFICE SYMBOL (if applicable) SGRD-UAB-CS	7b. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, MD 21702-5012			
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 620577 Fort Rucker, AL 36362-0577			9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER			
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (if applicable)	10. SOURCE OF FUNDING NUMBERS			
8c. ADDRESS (City, State, and ZIP Code)			PROGRAM ELEMENT NO. 0602787A	PROJECT NO. 3M1627 87A879	TASK NO. OB	WORK UNIT ACCESSION NO. 173
11. TITLE (Include Security Classification) (U) Activity/Rest Patterns of Instructors and Rated Student Pilots During Rapid Transitions from Daytime to Nighttime Duty Hours at the Eastern Army Aviation Training Site						
12. PERSONAL AUTHOR(S) C.A. Comperatore, J.A. Chiamonte, J.Y. Pearson, L.W. Stone, G. Hess, K. Boley						
13a. TYPE OF REPORT		13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) 1993 February		15. PAGE COUNT 51	
16. SUPPLEMENTARY NOTATION						
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)			
FIELD	GROUP	SUB-GROUP	shiftwork; sleep; flight performance; night operations			
05	08	00				
01	02	00				
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Rapid shifts in work schedules demand that pilots and aircrew quickly adapt to new sleep schedules. Transitions to nighttime duty hours lacking planned work/rest schedules can result in the delay of physiological and cognitive adaptation, fatigue, and performance degradation (shift lag). The objective of this study was to determine the effects of a night shift coping strategy in the adaptation of helicopter pilots (UH-1) to nighttime (2100 to 0100) flying schedules. Daily activity/rest rhythms of instructor and rated student pilots (IPs/RSPs) were monitored 24 h per day for a total of 21 to 28 days using individual wrist activity monitors. RSPs (n=6) lived in dormitories with complete blocking of daylight (below 10 lux) and reduced environmental noise until 1000. Meals and academic activities were scheduled to allow RSPs the opportunity to sleep until 1000 after night flights. IPs lived in private homes and were expected to meet administrative, academic, and flight instruction demands. Throughout the NVG course, RSPs elected to retire between 0040 and 0200, (continued on back)						
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED			
22a. NAME OF RESPONSIBLE INDIVIDUAL C; Scientific Information Center			22b. TELEPHONE (Include Area Code) (205) 255-6907		22c. OFFICE SYMBOL SGRD-UAX-SI	

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## Military significance

In the Army Aviation community, night operations are a significant component of combat and training missions. Mission objectives often require an initial shift from daytime to nighttime duty hours within 24 to 48 hours. Complete physiological adaptation to such abrupt changes in the work schedule may take several days or weeks (for a review see Comperatore and Krueger, 1990; Winget et al., 1984; Scott and Ladou, 1990).

Experimental and clinical evidence indicates that rapid shifts to nocturnal work schedules have a detrimental impact on an individual's health, performance, and psychological well being (Scott and Ladou, 1990; Smolensky and Reinberg, 1990). In general, shiftwork is often associated with disruption of the sleep-wake rhythm, fatigue elevation, deterioration of performance, and discomfort associated with gastrointestinal disorders (Comperatore and Krueger, 1990).

This report contains a summation of the results and conclusions obtained from the collaborative research effort between the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL and the Eastern Army Aviation Training Site (Eastern AATS), Indiantown Gap, PA, conducted in August and September 1991 at Fort Indiantown Gap. The operational objectives of this research project were twofold: (1) to assess the impact of rapid transitions from daytime to nighttime duty hours on crew rest during night vision goggle (NVG) training, and (2) to provide COL Boley, Commander, Eastern AATS, with recommendations that would prevent shift lag and refine the AATS crew work/rest schedules during NVG training.

## General approach

The evaluation protocol was designed to: (1) assess the timing and duration of rest that instructor pilots (IPs) and rated student pilots (RSPs) obtained during NVG training; and (2) identify environmental factors affecting the quality of rest of RSPs during transitions to nocturnal duty hours. These two objectives required the study of activity/rest rhythms during consecutive days of work involving transitions from daytime to nighttime duty hours. Daily activity/rest data were obtained from wrist activity monitors (WAMs) worn by IPs and RSPs 24 hours a day throughout the instructor pilot course conducted at the Eastern AATS in August and September 1991.

The following dependent variables were assessed throughout the training period : (1) bedtimes and rise times; (2) duration and timing of daily bed rest; (3) total time of immobility during the bed rest periods; and (4) the amount of daylight illuminance present at the installation dormitories during the early morning hours.

## Methods

### Participants

A total of 16 male Army pilots (10 IPs and 6 RSPs) served as participants during NVG training in August and September 1991. There were 6 IPs and 6 RSPs who participated in all phases of the NVG training course. Four more IPs carried out administrative and academic duties and were studied separately. This group of 4 participants will be referred to as administrative IPs (ADM).

Participation was voluntary and withdrawal from the study was allowed at any time without penalty. Only one subject (IP) ended participation prematurely due to a prescheduled 2-week assignment which began in the last week of the study. Each subject was informed of the project objectives and of the procedures to be implemented throughout the study. Details of the objectives, procedures, and methods of this study were presented in the subject's informed consent form.

### Apparatus

#### Wrist activity monitor (WAM)

The WAM is a water-resistant metal box approximately 66 mm x 43 mm x 15 mm containing a piezoelectric motion sensor, an 8-bit microprocessor powered by a lithium battery, 32 Kb of nonvolatile RAM, and a real-time clock. It was worn on the nondominant arm. WAMs were set up to detect accelerations exceeding 0.1 g. The WAMs were used in the threshold crossing mode. In this mode, single counts were registered for each signal that crossed through a predetermined voltage baseline reference. These counts were accumulated over 1-minute intervals. When the integrating period expired, the total number of crossings during the epoch interval was stored in memory. Each crossing indicated a movement count, thus yielding frequency of body movements per minute or activity level per minute. Normal movement of an awake individual was empirically observed, always resulting in an average of at least 50 counts per 30 minutes or greater than approximately 2 counts per minute in a 30-minute period.

## Log books

Participants also maintained a log of their activities in a small (4.0 x 5.5-inch loose-leaf) notebook. The log book could be easily carried in flight suit pockets. Table 1 illustrates a page of the notebook.

## Procedure

Participants were asked to carry out their activities without attempting to change their normal and customary approach to NVG training. Throughout the entire period of data collection, participants were asked to log the timing of significant daily activities. Significant entries included bedtimes, wake-up times, mealtimes, exercise periods, and WAM off-wrist times. Log pages were collected daily. At the end of the study, daylight illuminance within sleeping quarters was measured with window blinds down and closed on a sunny day at 1000 hours using a Minolta illuminance meter with a range of .01 to 100,000 lux.

## Schedule evaluation strategy

The operational objectives of this study were to describe the work-rest schedule experienced by IPs and RSPs during the transition from diurnal to nocturnal duty hours. These objectives required the daily documentation of bedtimes, rise times, total bed rest duration, and immobility time during total bed rest duration. WAM activity data were analyzed by plotting activity counts per minute over time for each day of the participants. The examination of activity plots allowed the determination of the above variables as follows:

### Bedtimes

Clock times associated with the beginning of a time period exceeding 2 consecutive hours of less than 50 activity counts per 30 minutes were designated as bedtimes. Although zero threshold movement frequency is desirable for the determination of sleep related immobility, minor body movements can be detected as low level counts. The criterion of less than 50 activity counts per 30 minutes allows for normal body movements that occur during sleep without erroneously assuming wakefulness time.

### Rise times

Clock times associated with the beginning of a time period exceeding 2 consecutive hours of 50 activity counts per 30 minutes and followed by persistently high activity levels were designated as periods of continuous wakefulness.

Sleep and wake-up times recorded from personal log entries were used instead of bedtimes and rise times in cases of WAM malfunction. This procedure was necessary in only 2 cases and for no more than 2 days.

### Daily bed rest duration

Daily bed rest duration was determined by continuously recording average activity counts below 50 per 30 minutes between bedtimes and rise times. Periods of wakefulness during bed rest were indicated by momentary increments in activity counts above 50 which did not persist for more than 2 consecutive 30-minute periods.

### Immobility time

In the period determined by activity data marking the beginning and end of bed rest, activity counts equal to 0 per minute were summed and reported as the total immobility time for that rest period. Immobility time represents periods of time in which the subject is resting during the estimated sleep period and does not move. Restful sleep is generally devoid of frequent movement, thus long immobility durations suggest restful sleep while short immobility periods suggests less restful sleep.

### Data analysis

Participants were expected to use individual strategies to cope with the rapid transition from daytime to nighttime duty hours. In the case of IPs, social and family situations were expected to influence bedtimes, rise times, and total bed rest duration. These variables could not be experimentally controlled. However, RSPs lived in dormitories provided by the Eastern AATS. Individual living quarters provided reasonable comfort to the participants. The Eastern AATS management had taken a number of precautions which allowed RSPs to sleep until approximately 1000 hours and eat a late breakfast or early lunch. Three important conditions characterized RSPs' dormitories:

- 1) The window blinds in dormitory rooms blocked daylight efficiently (see Table 2).

2) During NVG training, day shift personnel respected quiet hours in the morning.

3) Meal schedules were adjusted so that RSPs could choose to eat either a late breakfast or an early lunch.

Due to the differences in living conditions between RSPs and IPs, data analysis concentrated on within-subjects comparisons. Between-subjects comparisons were of less interest because IPs were expected to experience different family conditions, possibly helping night shift adaptations in some cases and not in others. Comparing the effects of shiftwork schedule on estimated sleep duration was central in the evaluation of the routines used by IPs and RSPs during NVG training. We expected consistent reductions in estimated sleep durations as a result of maladaptation to night shift.

IPs worked under three different work shift conditions:

1) Daytime duty hours following or preceding nighttime duty hours during NVG training (referred to as Day 1).

2) Nighttime duty hours interspersed with daytime duty hours during the NVG training period (referred to as Night 1).

3) Five consecutive days of daytime duty hours beginning 3 days after the end of NVG training (referred to as Day 2). RSPs worked under either Day 1 or Night 1 conditions since their participation in the study ended at the time of completion of the IP training course.

For both IPs and RSPs, bedtimes, rise times, total bed rest duration, and immobility duration were recorded during 10 days of Day 1 conditions and 10 days of Night 1 conditions. Analysis of IP data also included Day 2 conditions. In this case, within-subject averages were carried across only 5 working days, but not all IPs worked during this period. Since some IPs did not work during this period and did not complete 5 days of data recording, Day 2 data will be excluded from statistical analysis. For all dependent variables (bedtimes, rise times, bed rest time, and immobility time), analysis of variance (ANOVA) with repeated measures was applied to determine main effects and interactions of two factors, shiftwork schedule (Night 1 and Day 1) and group membership (IPs and RSPs). Averaged data for Day 1 versus Night 1 conditions for RSPs and IPs constituted the within-subject analysis for each group. When appropriate, within-subject comparisons were carried out using paired t-tests. Descriptive statistics are reported for the sake of completeness.

As the shape of the population distributions of variables derived from activity measures (bed rest, bedtimes, rise times, and immobility) are unknown and the number of participants was

restricted to six in the IP and the RSP groups (four participants comprised the Administration group (ADM)), skewness and kurtosis were examined prior to analysis. No evidence of nonnormality was observed.

## Results

### Activity/rest patterns

Examination of activity plots indicated that RSPs exhibited a gradual scalloping pattern of consecutive rise times. This pattern was characterized by a gradual delay of rise times (e.g., Figure 1, 13-14 Aug through 15-16 Aug) exhibited over several days reaching a maximum (Figure 1, 15-16 Aug) which was immediately followed by several days of gradual advances of rise times (Figure 1, 14-16 Aug through 17-18 Aug). The rise time scalloping pattern could be repeated several times throughout the NVG training period (Figure 1, 17-18 Aug through 24-25 Aug, 24-25 Aug through 29-30 Aug). All RSPs exhibited clear scalloping in their activity records (Figures 1 through 6).

In this set of data, the gradual delays in rise times observed at the beginning of the scalloping patterns occurred as RSPs attempted to make up for sleep lost after night flights. Since duty hours during NVG training did not begin until approximately 1000 to 1300 hours, RSPs consistently delayed rise time as much as possible.

Examination of bedtime data revealed a stable phase position with less frequent periods of delays and advances (Figures 1-6). When present (e.g., Figure 1, 18-19 Aug through 24-25 Aug), the bedtime pattern appears as a reversal of the rise time pattern. This scalloping begins with a gradual delay of bedtimes (Figure 1, 18-19 Aug through 20-21 Aug) and transitions to a sequence of gradually earlier bedtimes (Figure 1, 21-22 Aug through 24-25 Aug). The lack of consistent scalloping of bedtimes suggested that RSPs maintained relatively consistent bedtimes regardless of work schedules (Day 1 or Night 1 conditions).

The gradual delay of rise times in the scalloping pattern indicated that RSPs tended to delay rise times as much as the biological clock permitted. The gradual advances in the same pattern suggested the tendency of the activity-rest rhythm to return to an earlier phase position previously established by a daytime duty schedule. In fact, RSPs had been exposed to several weeks (at least 4) of daytime duty hours just prior to NVG training. Reporting time during that schedule was 0730 hours.

In the case of instructor pilots participating in the 2 weeks of NVG training, gradual delays in rise times were not systematically observed during NVG training (Figures 7 through 12). Evidence of scalloping was observed infrequently in five of the six IPs. Only one participant exhibited scalloping patterns of both rise times and bedtimes similar to those of RSPs (Figure 7, 13-14 Aug through 20-21 Aug rise times, 26-27 Aug through 30-31 Aug bedtimes). In most cases, gradual delays of bedtimes were frequently discerned, but the gradual advance of bedtimes characteristic of scalloping patterns was usually replaced by a large advance (e.g., Figure 11, 20-21 Aug through 24-25 Aug; Figure 12, 20-21 Aug through 24-25 Aug). In general, these observations indicated that IPs retired progressively later after night flights and earlier after the transition to daytime duty hours. The lack of consistent scalloping of rise times suggested that IPs were less likely to sleep during morning hours (0600 to 0900 hours) to compensate for loss of sleep after night flights.

Statistical analysis of bedtimes, rise times, estimated sleep durations, and immobility during sleep obtained under Day 1 and Night 1 schedules were carried out to determine the validity of the observations revealed by the examination of activity/rest rhythms.

#### Bedtimes

A two-way analysis of variance on bedtimes revealed a significant interaction of group membership and shiftwork schedule ( $F(1,10) = 116.56, p < .0133$ ). Results of t-tests revealed that IPs and RSPs retired later under Night 1 conditions. Group data are discussed below independently.

#### Instructor pilots

During NVG training after daytime duty hours (Day 1), IPs retired at an average clock time of 2349 hours (SD = 30 min, n = 6) with a range from 2317 to 0041 hours. After night flights (Night 1), bedtimes were delayed to a mean of 0116 hours (SD = 17 minutes, n = 6) with a range from 0056 to 0141 hours. Results of a t-test between Day 1 and Night 1 conditions confirmed a significant delay of bedtimes after night shift ( $p = .0009$ ).

#### Rated student pilots

Under Day 1 conditions, RSPs retired at a mean time of 0043 hours (SD = 26 minutes, n = 6) with a range from 2348 hours to 0114 hours. After Night 1 work shifts, RSPs retired

significantly later at a mean time of 0132 hours (SD = 25 minutes, n = 6) with a range from 0048 to 0203 hours (p < .00001)

### Rise times

A two-way analysis of variance on rise times revealed significant main effects of group membership ( $F(1,10) = 18.26$ ,  $p = .0016$ ) and shiftwork schedule ( $F(1,10) = 6.82$ ,  $p < .0260$ ). Results of t-tests revealed that RSPs, but not IPs, consistently delayed wake-up time after nighttime duty hours. Group data are discussed below.

#### Instructor pilots

Under Day 1 conditions, IPs arose at an average clock time of 0749 hours (SD = 56 minutes, n = 6) with a range from 0711 to 0825 hours. After night flights, IPs arose at a similar mean time of 0757 hours (SD = 1 hour 21 minutes, n = 6) with a range between 0721 to 0834 hours. After a shift to 5 consecutive day shifts (Day 2), IPs arose a few minutes earlier than during Day 1 and Night 1 work schedules at a mean time of 0727 hours (SD = 51 minutes, n = 6) with a range from 0645 to 0754 hours. A paired t-test confirmed that differences in average rise times between daytime and nighttime duty hours were not significant (Day 1 vs. Night 1,  $p = .6552$ ).

#### Rated student pilots

Under Day 1 conditions, the group mean rise time of 0825 hours (SD = 1 hour 15 minutes, n = 6) exhibited considerable variability (range from 0741 to 0915 hours). Under Night 1 conditions, rise times were consistently delayed to a group mean of 0908 hours (SD = 52 minutes, n = 6; range from 0840 to 0952 hours). A paired t-test confirmed a significant difference between Day 1 and Night 1 rise times ( $p = .0089$ ).

Taking into account both bedtimes and rise times, these results indicate that IPs were not able to sleep after night flights to compensate for the significant delay in bedtimes. Analysis of bedtimes suggests that IPs retired early after daytime duty hours between NVG nights to compensate for lost sleep after night flights.

## Daily bed rest duration

A two-way analysis of variance on bed rest duration revealed a significant interaction between group membership and shiftwork schedule ( $F(1,10) = 8.16, p = .0171$ ). Results of paired t-tests indicated that RSPs, but not IPs, maintained consistent bed rest durations both after daytime and nighttime duty hours. Group data are discussed independently below.

### Instructor pilots

In general, IPs lost sleep after night shifts and attempted to compensate by sleeping longer after day shifts. Under Day 1 conditions, IPs rested an average of 7.98 hours (SD = 1.3 hours,  $n = 6$ ) with a range from 5.5 to 11 hours. After night flights, IPs rested an average of 6.52 hours (SD = 1.29 hours,  $n = 6$ ) with a range from 2 to 9 hours. A paired t-test applied to Day 1 and Night 1 bed rest averages indicated a significant reduction under Night 1 conditions ( $p = .0194$ ).

In contrast, after a shift to 5 consecutive days of daytime duty hours, IPs total rest time mean values reflected more consistent bedtimes and rise times throughout this period. During these conditions, IPs rested an average of 7.61 hours (SD = 1.27 hours,  $n = 6$ ) with a range from 5.5 hours to 10 hours.

### Rated student pilots

Group means of Day 1, 7.54 hours (SD = 1.24 hours,  $n = 6$ ; range from 4 to 10 hours), and Night 1 conditions, 7.55 (SD = .99 hours,  $n = 6$ ; range from 5 to 9.5 hours), were strikingly similar. Paired t-test analysis confirmed ( $p = .9125$ ) that RSPs did not significantly change bed rest duration throughout the entire NVG training period. This was suggested previously by the systematic delay in rise time found in the comparison of Day 1 and Night 1 rise time data. The preservation of total rest time further indicates that the delay in rise time sufficiently compensated for the predictable delays in bedtimes after night flights.

## Immobility time

Analysis of variance of immobility data revealed a significant interaction of group membership and shiftwork schedule ( $F(1,10) = 7.36, p = .0218$ ). Results of paired t-tests supported the notion that IPs consistently lost sleep time after night shifts and did not recover throughout the entire duration of the NVG training course.

### Instructor pilots

Analysis of mean values of immobility time showed a significant reduction from Day 1 (398.83 minutes,  $SD = 31.40$ ) to Night 1 (344.33 minutes,  $SD = 27.28$ ) conditions (paired t-test,  $p = .0362$ ). An increase of immobility time was observed under Day 2 conditions (404.67 minutes,  $SD = 31.01$ ).

### Rated student pilots

Analysis of mean values of immobility time revealed no significant differences from Day 1 (381.83 minutes,  $SD = 8.59$  minutes) to Night 1 (384.17 minutes,  $SD = 18.17$  minutes) conditions (paired t-test,  $p = .7929$ ). These results supported the notion that RSPs consistently preserved sleep throughout NVG training.

## Schedule of Meals

### Instructor pilots

Log book entries revealed that IPs exhibited individual patterns in the timing of three daily meals: breakfast, lunch, and dinner. IP 4 reported late morning times from 0730 to 0900 hours throughout the NVG training period (Day 1 and Night 1) and earlier morning times from 0600 to 0620 hours during the transition to continuous day shift (Day 2). In contrast, IPs 11 and 19 exhibited more variable times and did not consistently delay breakfast after nighttime duty hours. IP 11 exhibited a variety of breakfast times between 0650 and 0955 hours with 44 percent beginning between 0600 and 0800 hours and 66 percent beginning between 0800 and 1000 hours. On the transition to the Day 2 work schedule (daytime), IP 11 exhibited 4 consecutive days of early morning breakfast times between 0700 and 0730 hours. IP 19 reported 65 percent of breakfast times between 0900 and 1000 hours and 35 percent between 0700 and 0900 hours. IP 19 did not

show a consistent pattern of early breakfast times during the transition to the Day 2 work schedule. Data sets for breakfast times are not complete for IPs numbers 5, 6, and 17.

Lunch and dinner times were reported with more stability. All six IPs preferred to eat lunch between 1100 and 1300 hours (see Table 5). Five IPs reported dinner times more frequently between 1700 and 1900 hours (see Table 6). One IP (19) consistently preferred late dinners after daytime duty hours between 2100 and 2300 hours (49 percent).

In general, IPs maintained consistent schedules for lunch and dinner but not for breakfast times. This agrees with the indication observed in the analysis of rise time data showing irregular rise times from day to day. The severity of this irregular pattern of meal timing is not considered sufficient to result in adverse effects on health and performance.

### Rated student pilots

In general, RSPs reported their first meal of the day to occur between 1100 and 1300 hours (see Table 7). On the mornings following NVG training, breakfast was usually replaced by lunch, but the timing of the meal remained the same. The second meal of the day occurred at dinner time from 1500 to 2100 hours. Unlike breakfast and lunch, individual differences in timing preference can be noticed for dinner times. RSP 1 preferred to schedule dinners between 1500 and 1900 hours (62 percent), and in fewer instances between 1900 and 2200 hours (38 percent). RSP 3 distributed dinners almost equally between late afternoon, early evening, late evening, and night (see Table 8). RSP 7 preferred evenings and night times, RSP 9 early evenings, and RSP 16 late afternoons and early evenings (Table 8).

## Physical exercise

### Instructor pilots

Log entries on physical exercise were complete for five of six participants. Fifty percent of the reported times included afternoon start times (1200 to 1600 hours), 24 percent morning start times (0800 to 1100 hours), and 22 percent evening start times (1700 to 2100 hours). Exercise consisted mostly of activities such as running, walking, bicycle riding, swimming, and in fewer instances, golfing.

### Rated student pilots

Five of the six participants exercised regularly. Exercise periods lasted approximately 1 hour and consisted of running, walking, or playing basketball. In general, RSPs (3, 7, and 9) preferred to exercise between 0900 to 1100 hours, while RSPs 1 and 8 preferred to exercise between 1100 and 1600 hours (see percentages on Table 9).

### Environmental conditions

#### Instructor pilots

Since IPs slept at their private homes, the study of the individual environmental conditions experienced during sleep was not possible during this initial evaluation.

#### Rated student pilots

In general, RSPs lived together in the facilities provided by the Eastern AATS and maintained very similar schedules of sleep, meals, exercise, flight, and classroom work. Only one out of the six RSPs lived in a local hotel and maintained a more individual schedule of activities.

Five of the six RSP participants resided at the dormitory throughout the entire IP course. These accommodations were comfortable and provided adequate control of temperature and noise level. Dormitory rooms faced either northward or southward.

#### Lighting

Northward rooms were found to be exposed to considerably lower sunlight levels than southward rooms. In Table 2, illuminance measurements were obtained in one room for each orientation in order to approximate the amount of sunlight participants experienced prior to awakening. Measurements were carried out with curtains opened and closed on the center of pillows located at the head of each bed. In general, sunlight illuminance was reduced sufficiently in both room orientations. However, northward rooms are considerably darker than southward rooms and should be preferred during NVG training.

## Noise

Although dormitory noise levels were not recorded, there were no indications that RSPs were awakened by daytime students on mornings following NVG training nights. Housekeeping personnel usually delayed servicing these rooms until approximately 1000 hours.

## Administration instructor pilots

### Characteristics

Four IP's, numbers 10, 12, 15, and 20, carried out administrative duties throughout the duration of the IP course. Hereafter, the acronym ADM will be used to identify IPs with administrative duties. These duties included classroom instruction, NVG flying instruction, and control tower activities. Most of the activities carried out by these participants were conducted on a daytime work schedule. The sequence of nighttime and daytime duty hours for each of these participants are described in Table 3. Notice that ADM 10 and 20 worked only one night, ADM 12 worked 2 nights, and ADM 15 worked 4 nights. Throughout the study, ADM participants experienced different workloads relative to IPs and RSPs. IP and RSP participants shared nighttime flights using NVGs as well as the challenge of adaptation to frequent shiftwork transitions. In contrast, ADM members followed individual schedules driven by the requirements of the course and their individual function within the Eastern AATS organization. For instance, participant numbers 10 and 15 both supported the IP course and also carried out normal everyday duties: one served as the Eastern AATS safety officer and the other served as Chief of the Utility Rotary Wing Branch. ADMs could not be compared to IP and RSP participants due to the lack of schedule uniformity and the individual variability in workload. Consequently, ADM data will be presented in a descriptive format, avoiding the tendency to carry out group statistical contrasts. For all ADM participants, means and standard deviations for bedtime, rise time, bed rest duration, and immobility duration data are described under the sections titled Day 1 condition, Night 1 condition, and Day 2 condition. Special recommendations for each participant are described in "Individual evaluation."

### ADM 10

Participant number 10 worked 19 daytime duty days (Day 1 condition), one nighttime duty day during the IP course (Night 1 condition), and 3 daytime duty days after the completion of the

IP course (Day 2 condition). In general, this participant maintained consistent bedtimes and rise times throughout Day 1 and Day 2 conditions. However, after the transition to nighttime duty, ADM 10 experienced a marked reduction in bed rest and immobility time durations because he did not delay rise time.

#### Day 1 condition

Under Day 1, ADM 10 retired at an average clock time of 2338 hours (SD = 50 min). Average rise time during this period was 0641 hours (SD = 60 minutes). Average bed rest and immobility durations were calculated at 6.9 hours (SD = 1.13 hours) and 5.52 hours (SD = 65.13 minutes) respectively.

#### Night 1 condition

After the single night flight, bedtime was delayed to 0030 hours, rise time to 0730 hours, bed rest reduced to 5 hours, and immobility time to 4.13 hours.

#### Day 2 condition

Under Day 2, average clock bedtime (2324 hours, SD = 13 minutes) and rise time (0654 hours, SD = 1 hour and 23 minutes) returned to values similar to those observed under Day 1 (see above). Bed rest and immobility durations were also similar to those observed under Day 1, 6.3 hours (SD = .58 hours) and 6.68 hours (SD = 38.2 minutes) respectively.

#### Schedule of meals and physical exercise

ADM 10 preferred breakfast between 0700 and 0900 hours (67 percent), lunch between 1100 and 1300 hours (64 percent), and dinner between 1700 and 1900 hours (67 percent). See Tables 10, 11, and 12 for details. Physical exercise was more frequently reported during afternoon hours (1100 to 1500 hours). Some exercise periods ended at approximately 1600 hours but never began that late (Table 13).

#### Individual evaluation

Although ADM 10 transitioned once from daytime to nighttime duty hours, descriptive statistics revealed that he did not properly delay rise time after a delay of bedtime. The major consequence of this transition is the reduction of bed rest and immobility time. Immobility time is the one variable which

yields an indication of the total amount of deep sleep experienced by each participant. More frequent transitions to nighttime duty hours may have resulted in a consistent loss of sleep. Consequently, ADM 10 may also benefit from the general recommendations offered in "Conclusions and recommendations."

#### ADM 12

ADM 12 worked 22 daytime duty days and 2 nighttime duty days during the IP course. Upon completion of the IP course, ADM 12 worked 4 consecutive daytime duty days completing the Day 2 data set. Exercise and meal times were consistent from day to day. This participant preferred late meal times and late bedtimes even during Day 1 and Day 2 conditions. Physical exercise often consisted of long range bicycling approximately three times per week. ADM 12 maintained consistently late bedtimes and rise times during Day 1. Transitioning to nighttime duty hours was not particularly difficult for this participant and did not result in loss of sleep.

#### Day 1 condition

During Day 1, ADM 12 retired at an average clock time of 0208 hours (SD = 1 hour, 7 minutes). Average rise time during this period was 0907 hours (SD = 1 hour, 49 minutes). Average bed rest and immobility durations were calculated at 6.9 hours (SD = 2.16 hours) and 5.78 hours (SD = 1.96 hours) respectively.

#### Night 1 condition

During the two night flights, ADM 12 delayed bedtime until 0230 hours (SD = 0.0 hours) and rise time until 1000 hours (SD = 1 hour and 15 minutes). The average bed rest duration was 7.5 hours (SD = 1.4 hours) and the corresponding immobility duration was 6.36 hours (SD = 1.46 hours).

#### Day 2 condition

Under Day 2, average clock bedtime (0140 hours, SD = 2 hours, 20 minutes) and rise time (0755 hours, SD = 2 hours, 59 minutes) were more variable than under Day 1 and Night 1 conditions due to changes in the administrative requirements for this subject. The beginning of a subsequent course required early morning coordination as well as preparation of academic lessons. Bed rest and immobility durations were reduced relative to those observed under Day 1 conditions, 5.8 hours (SD = 1.8 hours) and 5.68 hours (SD = 1.98 hours) respectively.

## Schedule of meals and physical exercise

ADM 12 preferred breakfast between 0700 and 0900 hours (100 percent), and lunch between 1100 and 1300 hours (78 percent). Dinner was distributed over two time periods--1700 to 1900 hours (55 percent) and 1900 to 2100 hours (28 percent), (see Tables 10, 11, and 12). Physical exercise was more frequently reported between 1300 and 1600 hours (43 percent). See Table 13 for details.

## Individual evaluation

ADM 12 sleep schedule under Day 1 conditions (late bedtimes and rest times) provides a natural adjustment to Night 1 conditions. In contrast to the flawless adaptation to nighttime duty hours, ADM 12 lost sleep time during Day 2 conditions due to new work schedule demands. Under Day 2, ADM 12 carried out several administrative duties related to a new IP course. These added duties demanded an early morning reporting time to the Eastern AATS (approximately from 0800 to 0900 h). Activity data suggests that ADM 12 naturally prefers late rise times and does not adjust well to early rise times. This idiosyncratic characteristic should not be discouraged since it simply reflects the natural preference of the individual's biological timing system. In order to better adapt to early morning reporting times, ADM 12 may need several days to fully transition to schedules requiring early morning reporting times. Three to four days of gradually shifting bedtimes and rise times to earlier onsets coupled with early morning exercise under normal daylight will facilitate this transition.

## ADM 15

ADM 15 worked 20 daytime duty days and 4 nighttime duty days during the IP course. Participation was interrupted on 24 Aug 91 due to duty related travel. In his case, Day 2 data are missing.

## Day 1 condition

During Day 1, ADM 15 retired at an average clock time of 0006 hours (SD = .49 hours). Average rise time during this period was 0725 hours (SD = 1 hour, 1 minute). Average bed rest and immobility durations were calculated at 7.47 hours (SD = .92 hours) and 6.29 hours (SD = 1.05 hours) respectively.

## Night 1 condition

During the 4 nighttime duty hour work days, ADM 15 maintained an average clock bedtime of 0015 hours (SD = 21 minutes) and an average rise time of 0800 hours (SD = 1 hour and 15 minutes). The average bed rest duration was 7.37 hours (SD = 1.54 hours), and the corresponding immobility duration was 6.26 hours (SD = 1.31 hours).

## Schedule of meals and physical exercise

ADM 15 preferred breakfast between 0700 and 0900 hours (52 percent), but also had breakfast at later times, between 0900 and 1100 hours (33 percent). Lunch times were frequently reported between 1100 and 1300 hours (77 percent) and dinners between 1700 and 1900 hours (53 percent), (see Tables 10, 11, and 12). Physical exercise was distributed throughout three time periods comprising early mornings, afternoons, or evenings (see Table 13).

## Individual evaluation

During transition to nighttime duty hours, ADM 15 was able to maintain bed rest and immobility durations to levels characteristic of Day 1 conditions. His personal strategy appeared to be associated with the maintenance of consistent bedtimes and rise times regardless of the work schedule. His exercise and meal times were also consistent throughout the study. This strategy is considered to be similar to that exhibited by RSPs and contains most of the features necessary for the successful adaptation to nocturnal work schedules.

## ADM 20

Participant number 20 worked 18 daytime duty days (Day 1 condition), 1 nighttime duty work day during the IP course (Night 1 condition), and 5 daytime duty days after the completion of the IP course (Day 2 condition).

## Day 1 condition

During the Day 1 condition, ADM 20 retired at an average clock time of 0000 hours (SD= 1 hour, 6 minutes) and rose at an average clock time of 0648 hours (SD = 50 minutes). The corresponding average bed rest and immobility time durations during Day 1 were 6.8 hours (SD = 1.01 hours) and 5.86 hours (SD = 1.10 hours) respectively.

## Night 1 condition

After the single night flight, ADM 20 delayed bedtime to 0300 hours and rise time to 0600 hours, thus reducing bed rest and immobility durations to 3 hours and 2.73 hours.

## Day 2 condition

Under Day 2, average bedtime (2340 hours, SD = 45 minutes), rise time (0645 h, SD = 46 min), bed rest duration (7.1 hours, SD = .96 hours), and immobility duration (6.23 hours, SD = .76 hours) returned to values similar to Day 1.

## Schedule of meals and physical exercise

ADM 20 preferred morning breakfast between 0500 and 0700 hours (52 percent), (Table 10). Lunch times were distributed throughout two time periods: 1100 to 1300 hours (55 percent) and 1300 to 1500 hours (45 percent), (Table 11). Dinners were also distributed over two time periods: 1700 to 1900 hours (48 percent) and 1900 to 2100 hours (47 percent), (Table 12). Physical exercise was reported more frequently in the afternoon between 1100 and 1600 hours (50 percent), (see Table 13).

## Individual evaluation

ADM 20 exhibited a considerable loss of sleep time during the transition to nighttime duty hours. In his case, all the recommendations offered to IPs (below) apply.

## Conclusions and recommendations

This initial evaluation revealed two patterns of bedtimes and rise times during the NVG training period. One pattern which was exhibited mainly by IP participants was a consistent delay in bedtimes after night flights (Night 1 condition) without a consistent delay in rise time on the following morning. Late bedtimes and early rise times resulted in the reduction of total rest time when compared to the pattern observed during daytime duty days occurring during the NVG training month (Day 1 condition) or after the end of the IP training course (Day 2 condition). Figure 13 illustrates the absolute difference in total rest time for IPs under Night 1 and Day 1 conditions. Figure 14 illustrates daily total rest time of IPs under Day 1 and Day 2 conditions.

The second pattern was exhibited by RSPs and involved consistently late bedtimes in both Day 1 and Night 1 conditions and a delay of rise times after night flights (Night 1 conditions). This approach to the frequent transitions from day to night shift observed during NVG training (see Tables 3 and 4) resulted in the preservation of the duration of daily sleep (see Figure 15) as indicated by total rest duration data, and possibly, the maintenance of sleep quality as suggested by immobility data (see results section). In addition, RSPs also exhibited consistent meal times and exercise times from day to day while the time range for IPs on both of these variables were considerably longer under both Day 1 (1100 to 1500 hours) and Night 1 (1100 to 1530 hours) conditions.

One explanation for these two distinct approaches to coping with shift transitions involves the following:

- 1) Most RSPs (five out of six) lived apart from families in individual rooms with controlled environmental conditions.

- 2) The Eastern AATS management enforced quiet time at the dormitories until approximately 1000 hours, thus day shift personnel seldom disrupted slumbering RSPs.

- 3) The daily schedule of classes and meals offered by the Eastern AATS management was conducive to the maintenance of a consistent daily routine.

In contrast, four of the six IPs were married and all lived at home during NVG training. Rise time may be directly influenced by normal daily family routine particularly during weekend days. In addition, the normal duty day for IPs may include activities that required early morning awakening.

Although the schedule maintained by IPs cannot be considered the most appropriate for shiftwork transitions, it is important to recognize that only two subjects slept less than 5 hours in 2 nights. Consequently, the general approach to NVG training currently used by IPs may be adequate to preserve safety during the actual flights. However, considering the information available in this report, a number of practical countermeasures may be useful to IPs in preventing sleep loss and fatigue during frequent transitions from daytime to nighttime duty hours. The following shift lag coping strategy takes into account both the eastern AATS mission objectives for NVG training and the adjustment needs of student and instructor pilots:

- 1) In days where daytime duty and nighttime flying are required, the duty cycle for IPs may be adjusted to begin on late morning, late afternoon, or early evening reporting times. IPs should be encouraged to nap during the late afternoon and early

evening to minimize the performance effects of sleep loss during night flights.

2) Work days durations may be adjusted to permit late reporting times. Work periods of less than 8 hours (e.g., 5 or 6 hours) may be used during the first 2 to 3 days of the transition to nighttime duty hours. One possible schedule including naps, late reporting times, and shortened work periods may consist of a late afternoon nap (1400 to 1600 hours), dinner between 1700 and 1800 hours, reporting for duty at 1930 hours, preflight aircraft and aircrew briefing until 2030 hours, departure at 2100 hours and flight debriefing between 0000 to 0100 hours. Another theoretical schedule may consist of dinner between 1600 and 1800 hours, a nap just prior to reporting for duty (between 1800 and 1900 hours), and arrival at the Eastern AATS facility at approximately 2000 hours. Preflight briefing and aircraft preparation may begin at 2030 hours and departure at 2130 hours. NVG training flights could take place from 2100 to 0100 hours allowing approximately 2 hours per student if IPs fly with two students. Late afternoon and early evening naps will be very helpful in facilitating the adaptation to late bedtimes occurring between 0100 and 0300 hours.

3) Night shifts extending beyond 2 weeks should be avoided if possible. Some individuals will experience more difficulty in adapting to nighttime duty hours for long periods of time, others will prefer long duration night shifts. Since age and state of health will affect individual choices, scheduling 2 week-night shift periods may suit both preferences.

4) When possible, IPs' bedrooms at home should maintain the same environmental characteristics as those found in the Eastern AATS dormitories, specifically low light and low environmental noise levels. Commercially available sound masking devices can be used to promote sleep throughout the night and in the morning hours when normal family activities may disrupt a night shifter's deep sleep. Blinds capable of reducing daylight illuminance below 10 lux are necessary to maintain a sufficiently darkened environment after sunrise.

5) IPs could preserve total sleep time by consistently maintaining late bedtimes (e.g., 0000 to 0100 hours) and rise times (e.g., 0900 to 1000 hours) throughout the entire NVG training period, including weekend and nonduty days.

6) Avoid staying indoors during off-duty hours. Outdoor activities, such as scheduled physical exercise periods, are recommended upon awakening and during the afternoon to ensure a consistent schedule of sunlight exposure. Daily sunlight exposure will facilitate the adaptation to the new work/rest schedule by resetting the body's biological timing system.

7) A late breakfast or early lunch occurring between 1000 and 1400 hours and early dinners scheduled between 1600 and 1900 hours will facilitate adjustment to the sleep/activity schedule prescribed in 1 and 5 above. Snacks scheduled prior to bedtime may minimize the tendency to wake up at usual breakfast times (0600 to 0800 hours). Coffee consumption approximately 2 hours prior to bedtime is discouraged while consumption is encouraged at the beginning of the night shift.

## References

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- Winget, C.M., DeRoshia, C.W., Markley, C.L., and Holley, D.C. 1984. A review of human physiological and performance changes associated with desynchronosis of biological rhythms. Aviation, Space, and Environmental Medicine. 55(12): 1085-1093.

Appendix A

Tables

Table 1.

Contents of notebook

```

=====
Daily log

Date _____
Subj # _____ WAM # _____

                start/stop
WAM _____/_____
   _____/_____
   _____/_____
Sleep _____/_____
Nap  _____/_____
   _____/_____
Meals _____/_____
   _____/_____
   _____/_____
Exercise _____/_____
Flight _____/_____
   _____/_____
   _____/_____
=====
    
```

Table 2.

Illuminance (lux)

	Southward rooms		Northward rooms	
Window	Open	Closed	Open	Closed
	109.64	11.39	83.37	10.54

All measurements recorded at center of pillow.

Table 3.

Shiftwork transitions for instructor pilots  
and administration instructor pilots

=====

IP

4 D D N D D N N D N N D D D D N N N D N N N D D D D D D D D  
5 D N D D D N N D N N D D D D D N N D N N N N D D D D D D  
6 D N D D D N N D N D D D D D D N N D N N N D D D D D D D D  
11 D D D D D N N D N D D D D D D N N D D N N N D D D D D D D  
17 D D D D D D N D D D D D D D N N N D D N D N D D D D D N D  
19 D D D D D D N N D D D D D D N N N D D N N N D D D D D D D

ADM

10 D  
12 D D D D D D D D D N D D D D D D D D D N D D D D D D D D  
15 N N D D D D D N D D D D D D N D D D D D D D D  
20 D D D D D D D D D D D D D D N D D D D D D D D D D D D D

-----  
LEGEND: N = Night, D = Day

Table 4.

Shiftwork transitions for rated student pilots

```

=====
RSP  1  D D N D D N N D N N D D D D N N N D N N N N
RSP  3  D D N D N N D D N D D D D D N N N D N N N
RSP  7  D D N D D N N D N N D D D D N N N D N N N N
RSP  8  D D N D D N N D N N D D D D N N N D N N N N
RSP  9  D D N D D N D D D D N D D D N N N N N N N D
RSP 16  D D N D D N N D N N D D D D N N N D N N N N
=====

```

LEGEND: N = Night, D = Day

Table 5.

IP lunch schedule

```

=====
IP numbers      4    5    6    11   17   19
1100-1300 h    88   76  100  85   100  85
1300-1500 h    12   24  ---  15   ---  15
=====

```

All numbers are percentages.

Table 6.

IP dinner schedule

IP numbers	4	5	6	11	17	19
1500-1700 h	20	5	5	15	36	4
1700-1900 h	73	80	55	52	64	39
1900-2100 h	7	15	35	33	--	9
2100-2300 h	--	--	--	--	--	48
2300-0000 h	--	--	5	--	--	--

All numbers are percentages.

Table 7.

RSP schedule of first meal of the day

RSP numbers	1	3	7	8	9	16
1100-1300 h	88	86	86	71	75	85
1300-1500 h	12	14	14	29	25	15

All numbers are percentages of total meals reported throughout NVG training.

Table 8.

RSP schedule of second meal of the day

RSP numbers	1	3	7	8	9	16
1500-1700 h	31	20	6	29	12	47
1700-1900 h	31	20	38	43	53	35
1900-2100 h	23	37	21	28	12	18
2100-2300 h	15	23	35	--	24	--

All numbers are percentages of total meals reported throughout NVG training.

Table 9.

RSP exercise schedule

RSP numbers	1	3	7	8	9	16
0600-0900 h	--	--	--	--	9	--
0900-1100 h	16	65	50	5	73	--
1100-1600 h	32	18	38	71	9	--
1600-2100 h	--	17	12	24	9	--

All numbers are percentages of total exercise reported throughout NVG training.

Table 10.

ADM breakfast schedule

ADM numbers	10	12	15	20
0500-0700 h	---	---	---	52
0700-0900 h	67	100	52	26
0900-1100 h	33	---	33	22
1100-1200 h	---	---	15	---

All numbers are percentages of total meals reported throughout NVG training.

Table 11.

ADM lunch schedule

ADM numbers	10	12	15	20
1100-1300h	64	78	77	55
1300-1500h	36	22	23	45

All numbers are percentages of total meals reported throughout NVG training.

Table 12.

ADM dinner schedule

ADM numbers	10	12	15	20
1500-1700h	8	10	16	5
1700-1900h	67	55	53	48
1900-2100h	25	28	26	47
2100-2300h	--	7	5	--

All numbers are percentages of total meals reported throughout NVG training.

Table 13.

ADM exercise schedule

ADM numbers	10	12	15	20
0600-0900h	--	29	29	25
0900-1100h	7	7	7	--
1100-1600h	67	43	36	50
1600-2100h	26	21	28	25

All numbers are percentages of total exercise reported throughout NVG training.

Appendix B

Figures

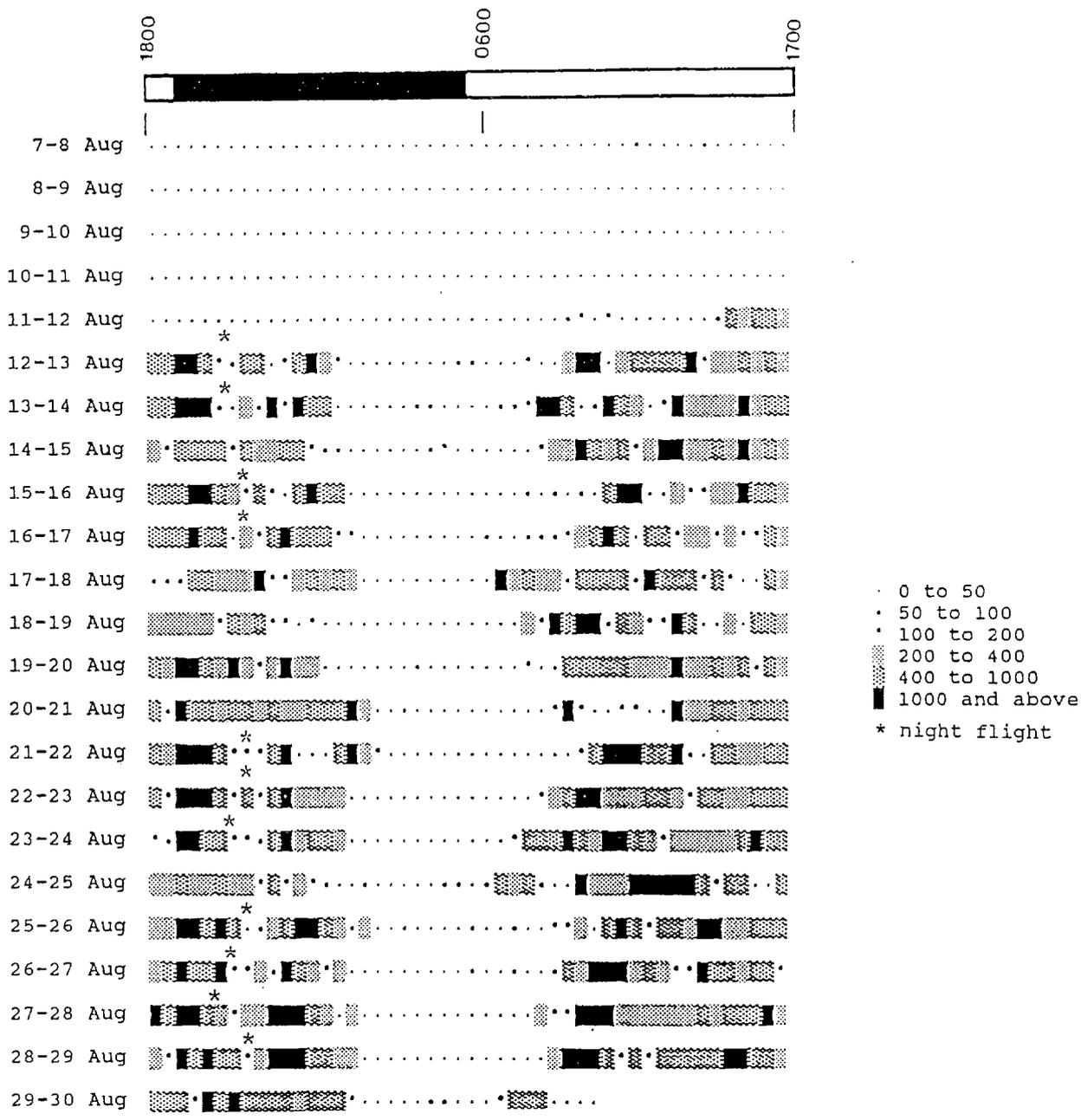


Figure 1. RSP 1 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.



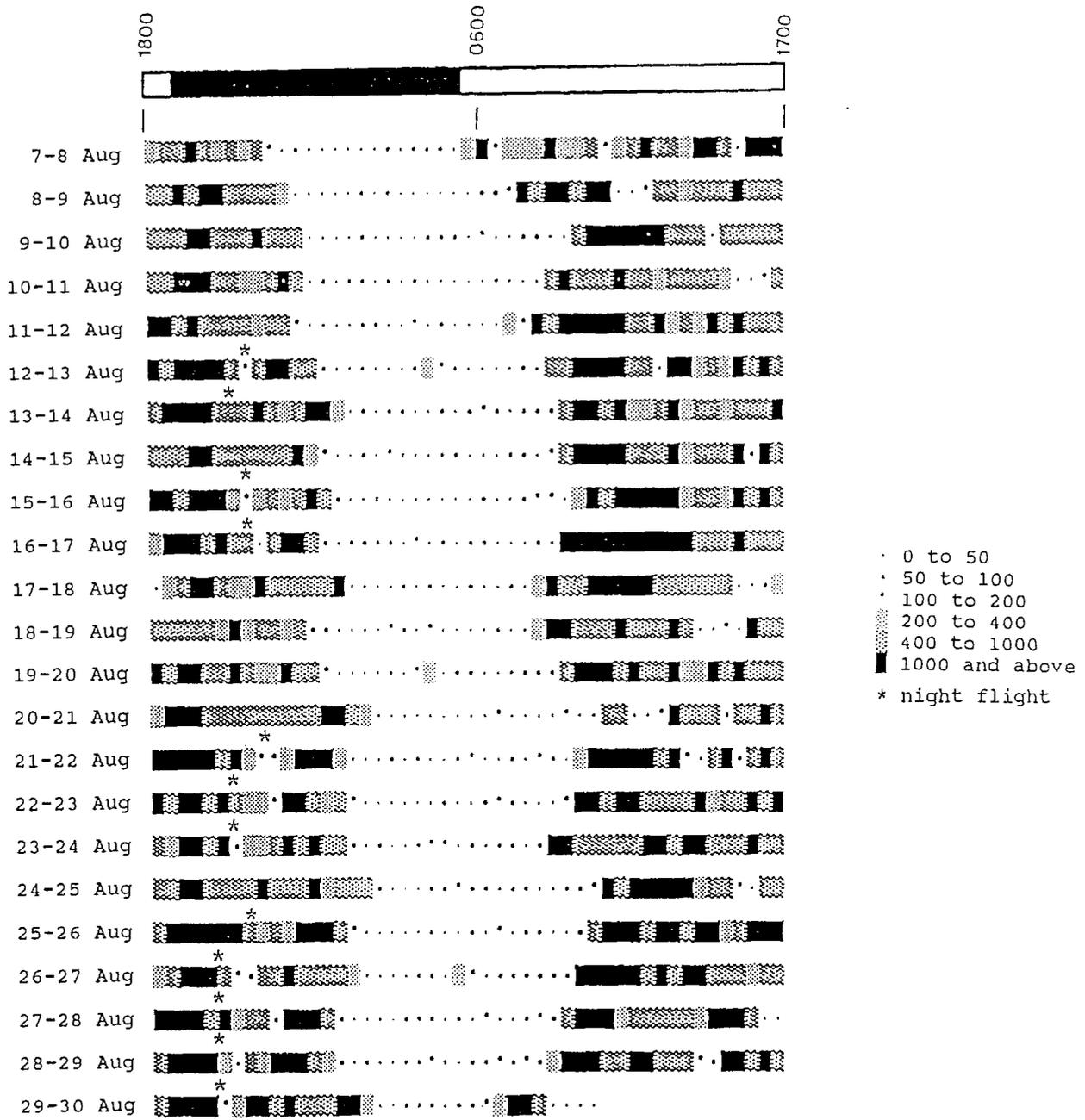


Figure 3. RSP 7 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

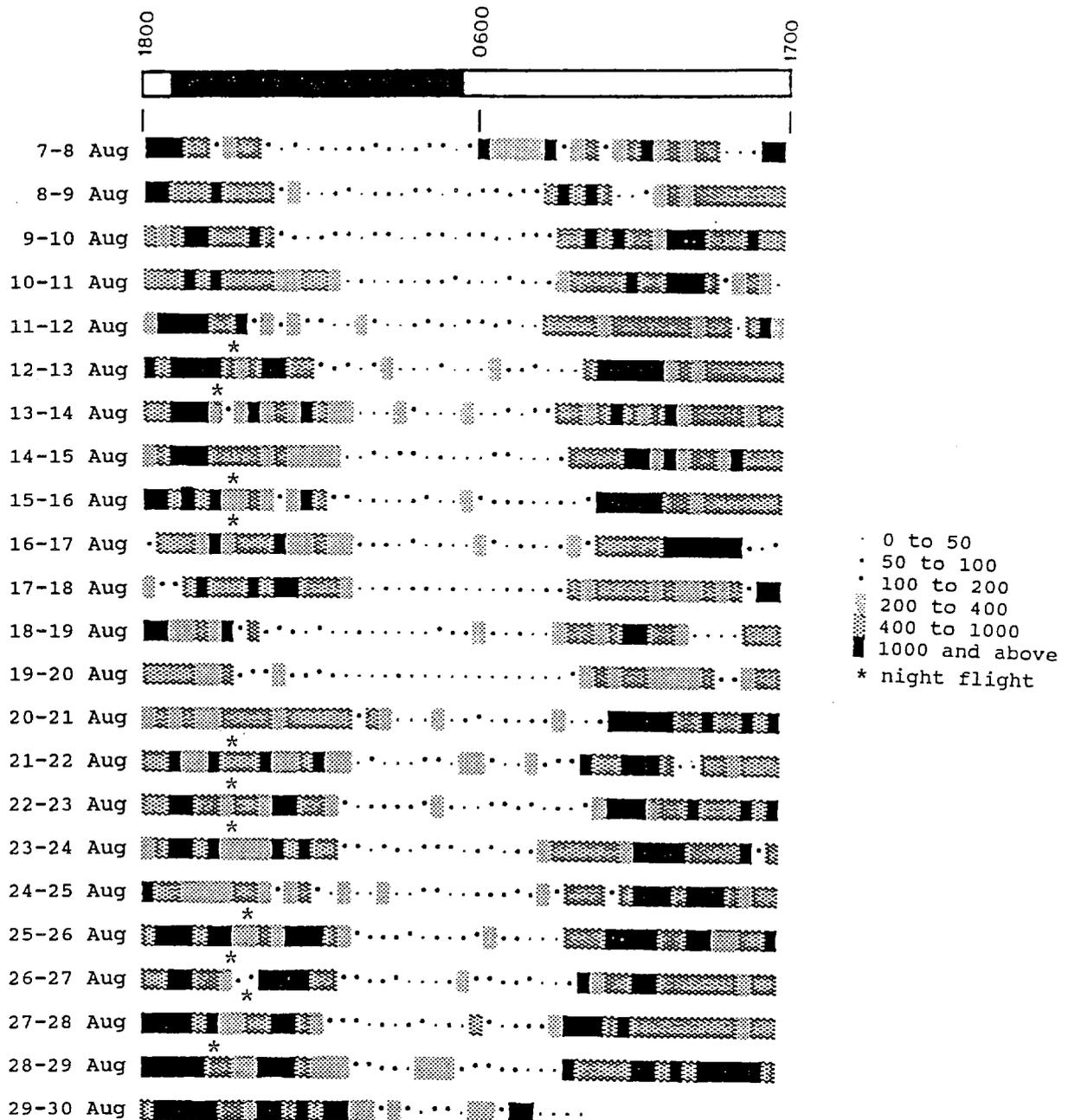


Figure 4. RSP 8 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.



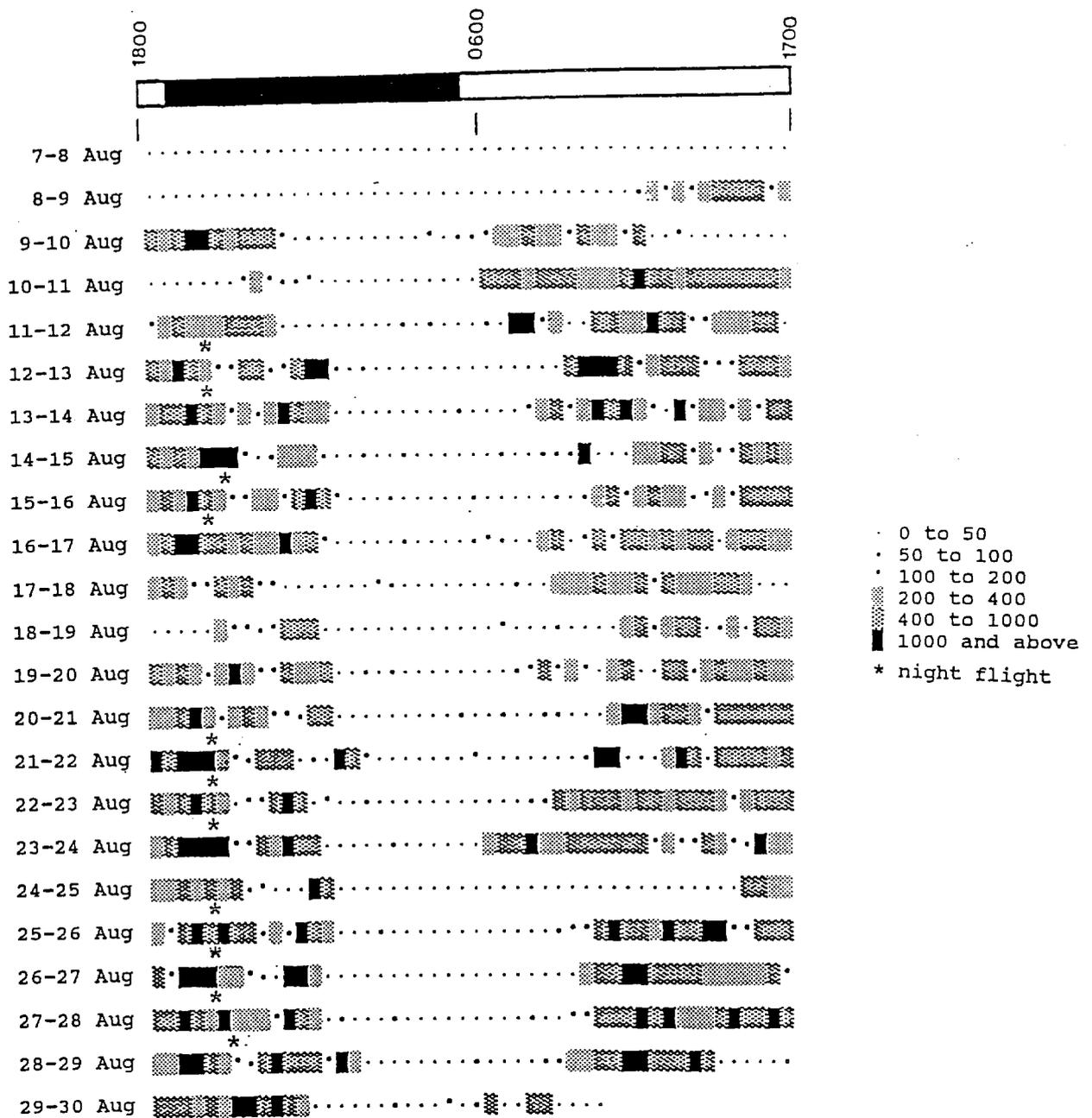


Figure 6. RSP 16 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

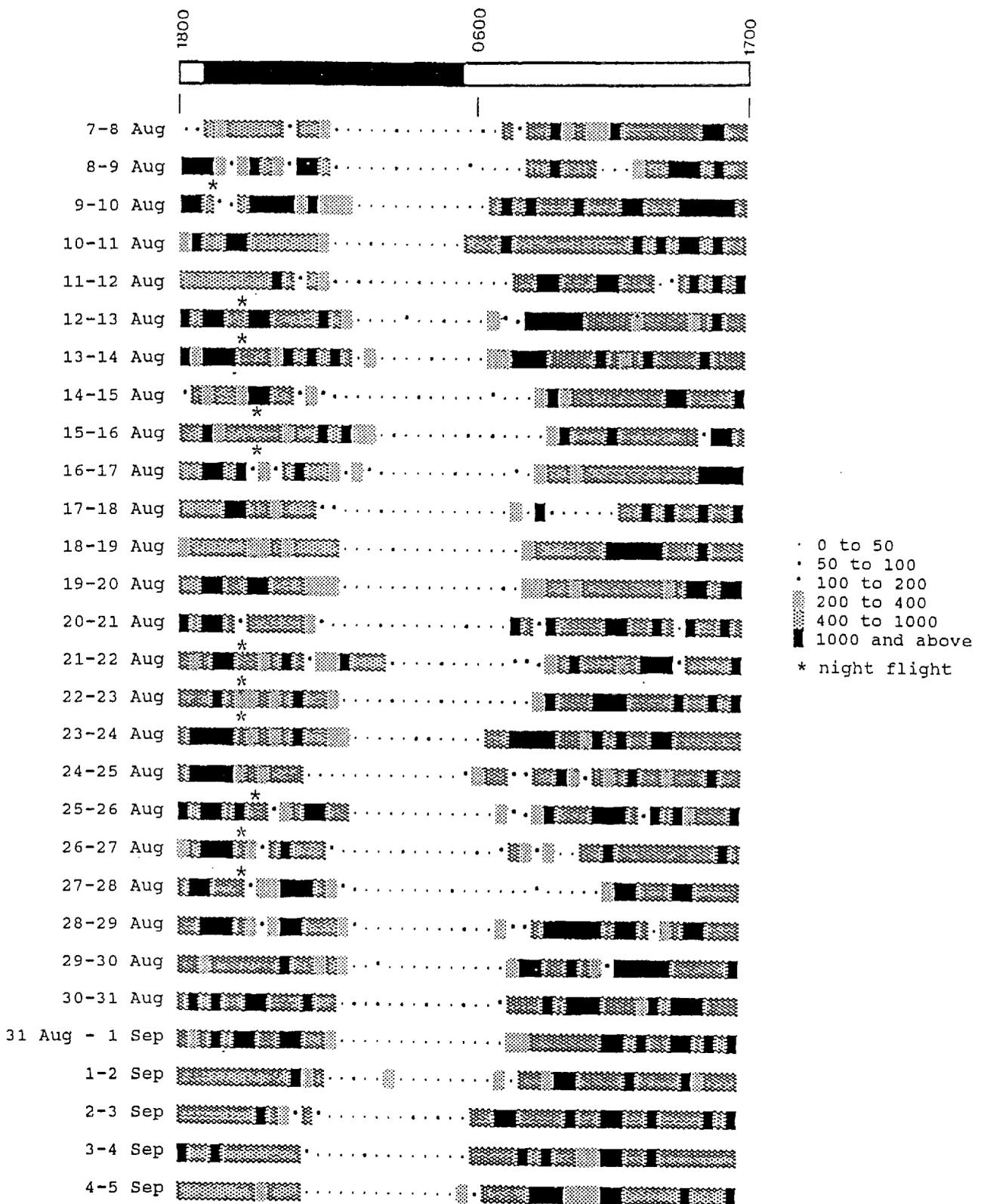


Figure 7. IP 4 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

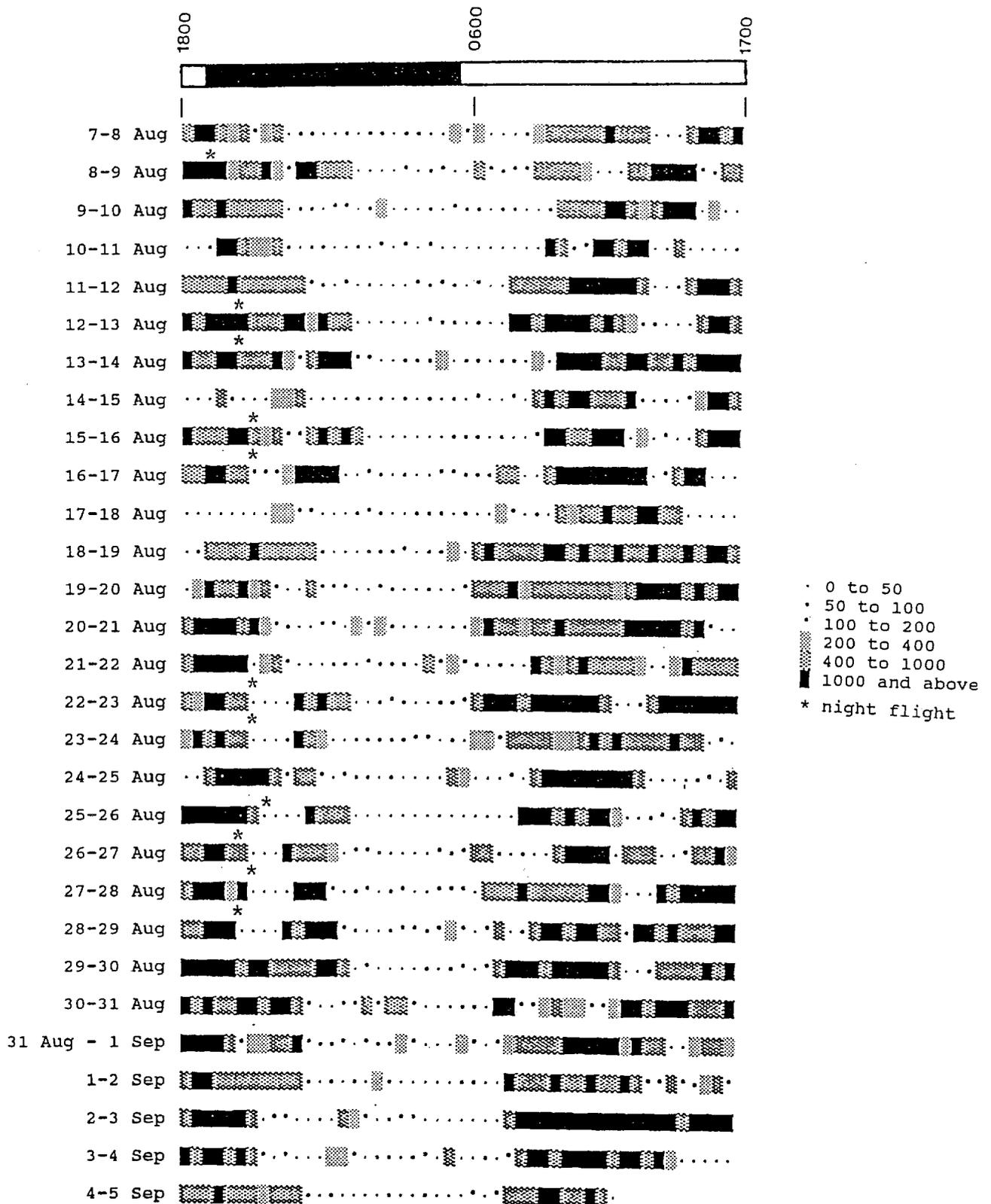


Figure 8. IP 5 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

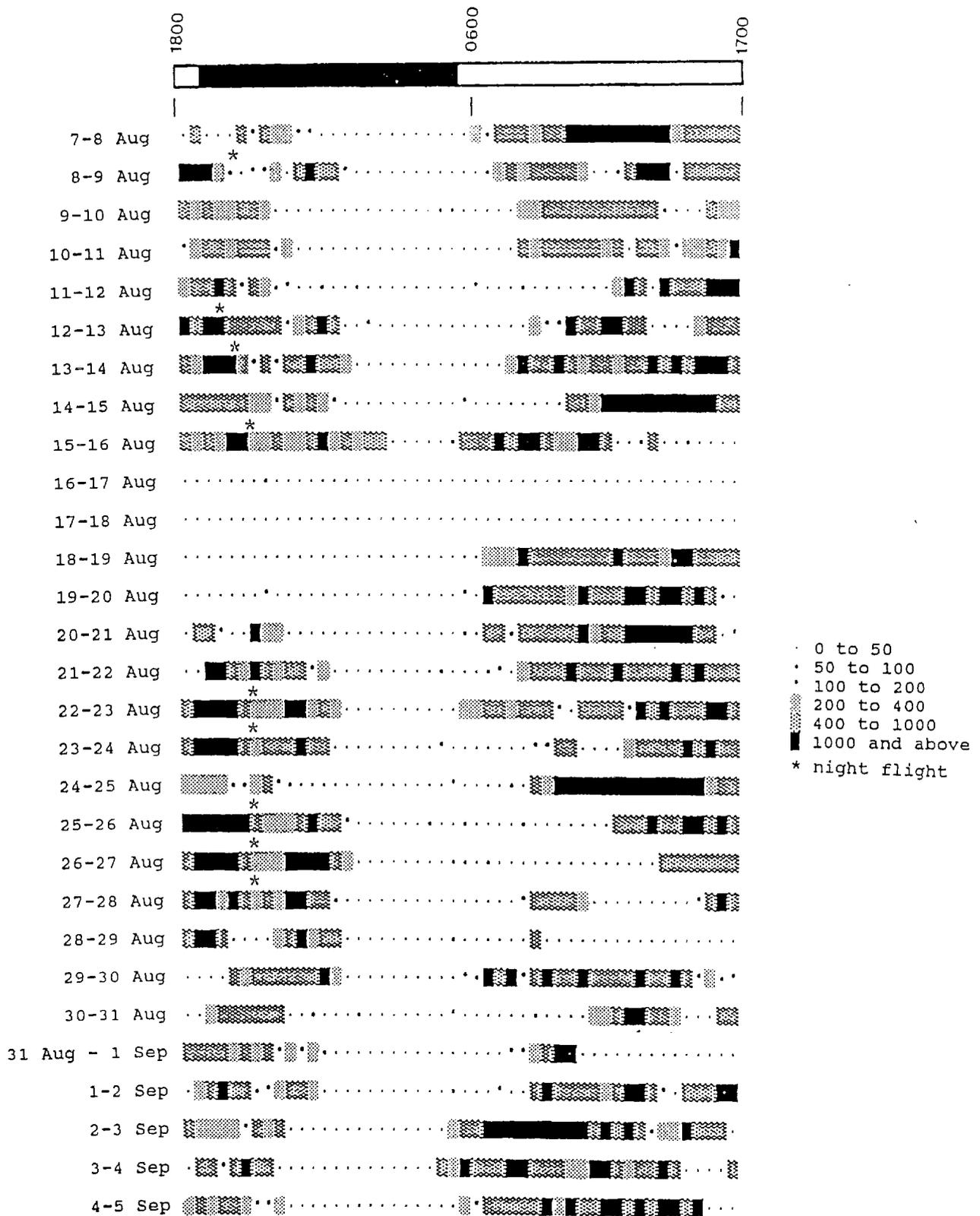


Figure 9. IP 6 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

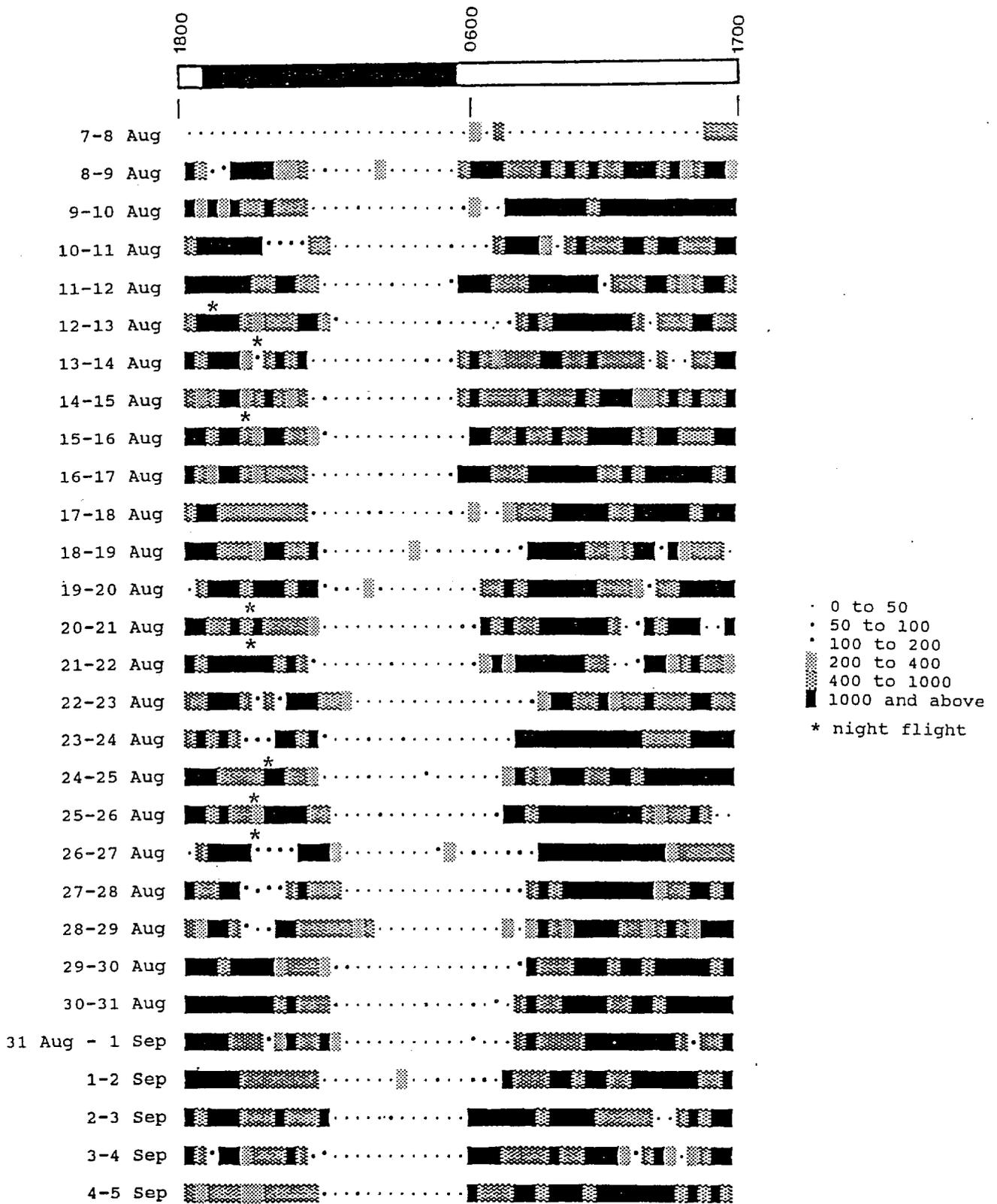


Figure 10. IP 11 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

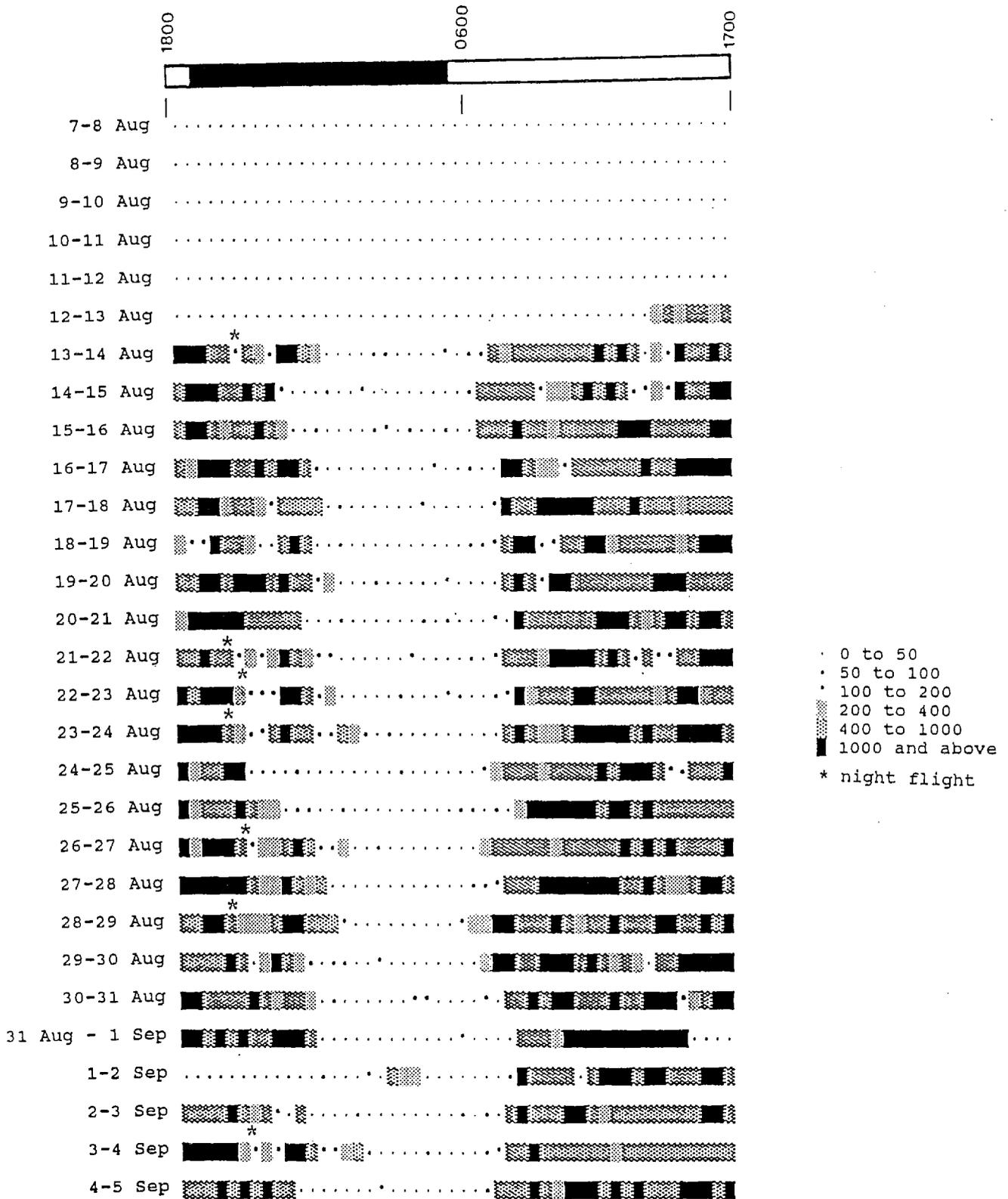


Figure 11. IP 17 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

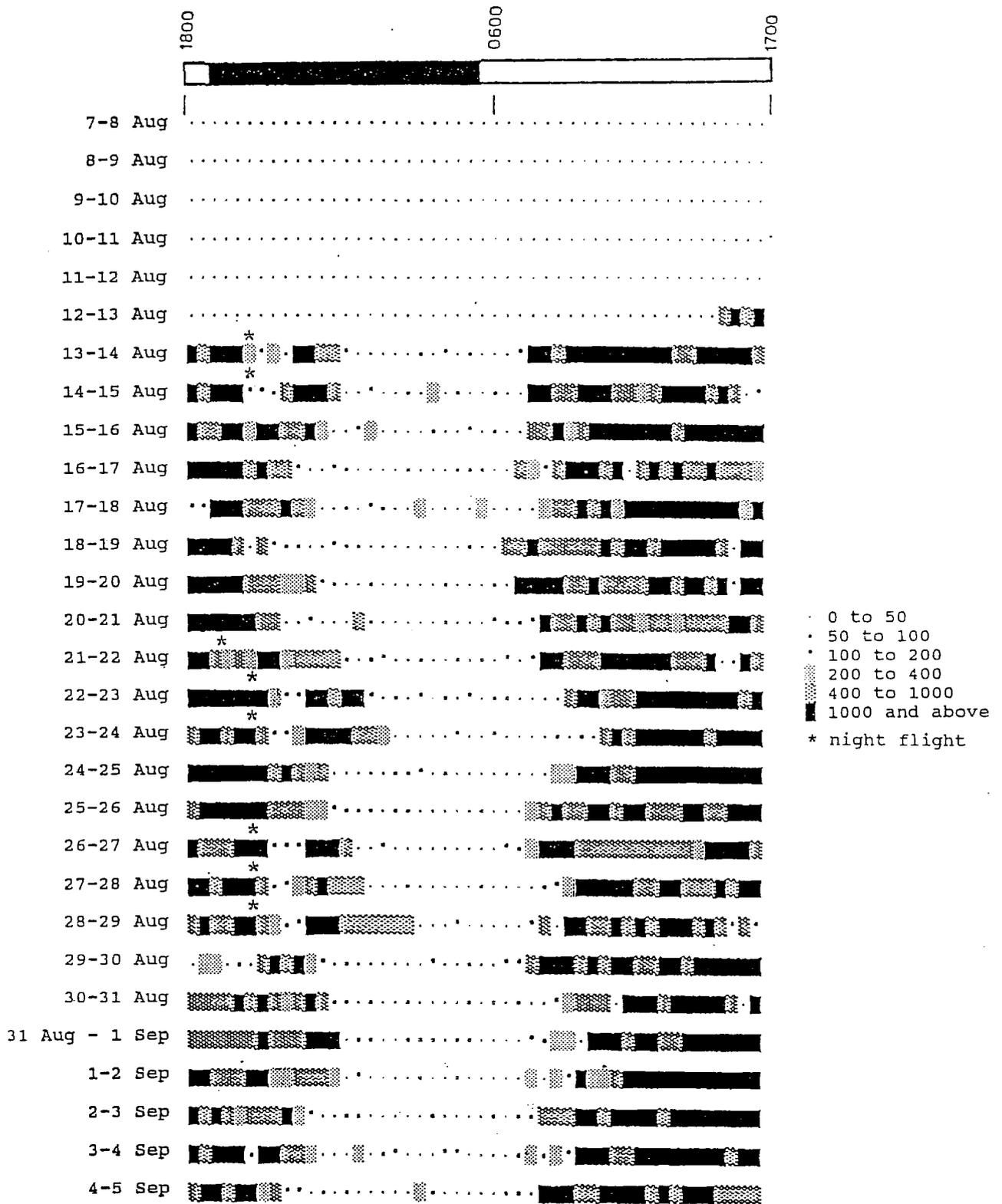


Figure 12. IP 19 activity data plotted over 24 hours. Each data point indicates frequency of movement per 30 minutes. The light-dark cycle is indicated at the top of the illustration.

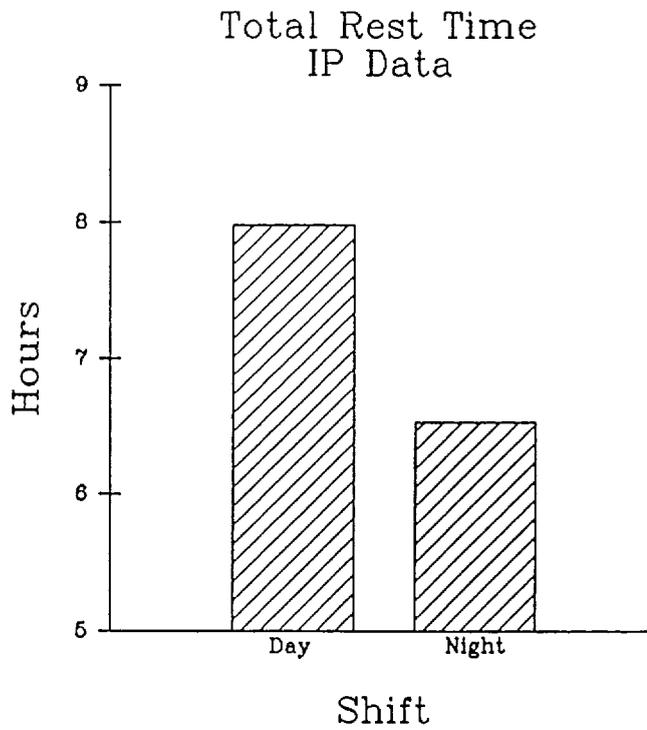


Figure 13. Average estimated sleep time or bedrest time for IPs under daytime and nighttime duty hours.

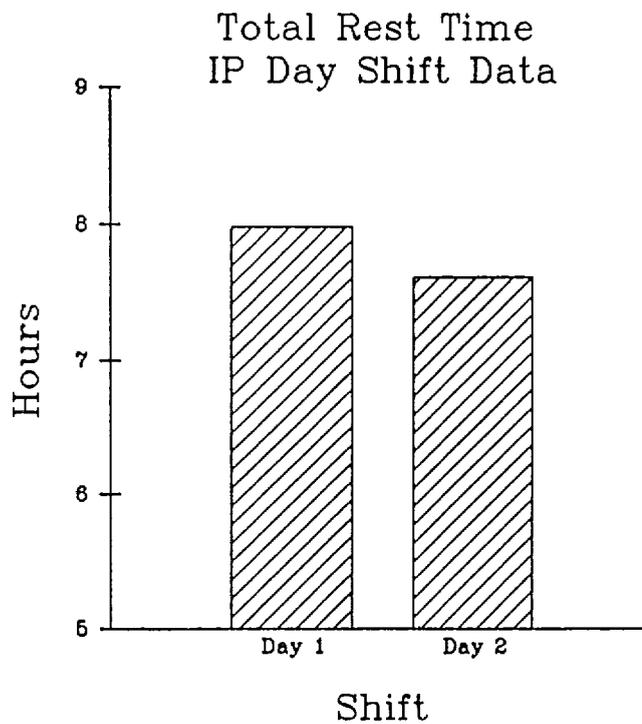


Figure 14. Average estimated sleep time or bedrest time for IPs under daytime duty hours during (Day 1) and after the end of the NVG training period (Day 2).

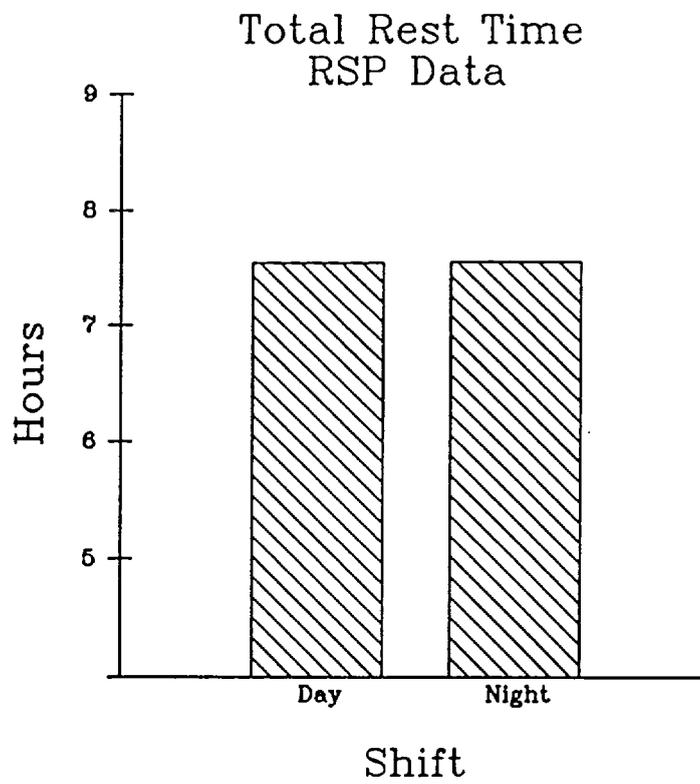


Figure 15. Average estimated sleep time or bedrest time for RSPs under daytime and nighttime duty hours.