Abstract The relationship of meal habits and alcohol/cigarette consumption to circadian typology and sleep health in Japanese female students was studied from an epidemiological point of view. Questionnaires on Morningness-Eveningness by Torsvall and Åkerstedt (1980), sleep habits, regularity of meal intake and meal amount, and style of alcohol and cigarette consumption were administered to 800 students aged 18–29 years, attending university or training schools for nutrition specialists (Aichi Prefecture, 35°N). Points from ten questions were totaled to provide estimates of sleep habits given as the Unhealthy Sleep Index (UHSI). The average and standard deviation of Morningness-Eveningness scores were 16.07 ± 3.53. Students who had breakfast at regular times showed significantly higher Morningness-Eveningness scores than those who ate at irregular times. Based on an integrated analysis (ANOVA) on the effect of regularity of breakfast intake on sleep health, regular breakfast intake may link to sleep health positively via the shifting to morning-type (i.e., the phase-advance of the circadian clock). However, a similar analysis promoted the hypothesis that alcohol consumption and cigarette smoking relate to sleep health negatively and directly, rather than via the shifting to evening-type (i.e., the phase-delaying of the circadian clock). In the case of young women, getting a good quality and quantity of sleep in normal life seems to be important for promoting their mental health, which may fluctuate throughout the menstruation cycle accompanied by mental symptoms as a part of premenstrual syndrome. J Physiol Anthropol 28(2): 83–90, 2009 http://www.jstage.jst.go.jp/browse/jpa2 [DOI: 10.2114/jpa2.28.83]

Keywords: Morningness-Eveningness, sleep health, breakfast, alcohol and cigarettes, female students

Introduction

In Japan, 24-hour society is rapidly advancing and environmental pressure on Japanese students is increasing. Environmental factors such as mobile phones (Harada et al., 2002), convenience stores open 24 hours (Harada and Takeuchi, 2003; Harada et al., 2006), and midnight broadcasting programs (Harada et al., 2004) seem to function as zeitgebers of circadian oscillators and increase the tendency for Japanese students to be evening-typed. Additionally, many employees all over Japan, including students with part-time jobs, work in places such as convenience stores and video-rental shops that stay open 24 hours. Such employees and their family members must often adopt unusual evening-typed lifestyles with irregular timing of meals. As a result, 24-hour society may reduce the amplitudes of environmental daily cycles of light, social activities, and food intake. Persistent lower amplitudes of several zeitgebers may promote an inner-desynchronized protocol between the main clock, which drives the autonomous nervous system, and the slave clock, which controls the sleep-wake cycle (Double-oscillations theory: Aschoff et al., 1967; Harada et al. 2007).

Some women suffer from sleep-disorders such as insomnia or hypersomnia as symptoms of Pre-Menstrual-Syndrome (PMS) (Kohsaka, 2004). Extremely evening-typed women have more severe physical symptoms (e.g., menstrual pain) and mental symptoms (e.g., depression or irritation) during their premenstrual and menstrual periods (Takeuchi et al., 2005). Consequently, in 24-hour society, sleep health and mental health in women may become worse than that of men from an anthropological and physiological point of view. Accordingly, one of the focuses of this study is on sleep health and mental health in women.

In Japan, smoking has recently become prohibited in most official places such as airports, airplanes, bullet trains, schools and universities, and municipal and prefectural administrative
offices. However, the number of female smokers in their 20s and 30s has been increasing in the last 20 years.

From physiological point of view, Morningness-Eveningness typology may possibly be based on several hormonal and homeostatic aspects. For example, Kudielka et al. (2006, 2007) showed data that supported the idea that morning chronotypes might show higher cortisol levels relative to evening chronotypes in the first hour after awakening. Griefahn (2002) reported that the minimal rectal temperature and heart rate as well as Morningness-Eveningness preference were significantly related to the subjective circadian phase as determined by a morningness-eveningness questionnaire. Moreover, Mongrain and Dumont (2007) showed that, based on EEG and Morningness-Eveningness questionnaire data, there was a postulated difference in homeostatic sleep regulation between morning types and evening types, with morning types showing indications of higher homeostatic responses to sleep disruption. Smoking and drinking may be related to such physiological parameters as cortisol, melatonin, and homeostasis which link to circadian typology.

In the period from 1987 to 1992 only around 10% of Japanese women in their 20s and 30s smoked, whereas this percentage increased to around 20% in 2005. On the other hand, the percentage of male smokers in their 20s decreased from around 60% to 50% during the 10-year period from 1995 (Japan Ministry of Health, Labor and Welfare, 2005). Japanese women who drink more than 650 ml of beer (5–5.5% alcohol) or more than 180 ml of Japanese sake (13–16% alcohol) habitually (more than 3 days per week) occupied 6.3% of all Japanese women in their 20s in 1989 and this percentage increased to 8.5% in 2002 (Japan Ministry of Health, Labor and Welfare, 2002; Tsukahara and Higuchi, 2004). Therefore, another focus of this study is on the smoking and drinking habits of Japanese women who are mainly around 20 years old and the effects of such habits on sleep health, circadian typology, and mental health.

Numerous studies on the risky effects of alcohol consumption on sleep health have been done thus far (Gillin et al., 2005). Alcohol consumption before night sleep is known to promote a reduced duration of slow wave sleep and frequent awakening during night sleep (Thorpy, 1990). In nonsmokers, nicotine has a sedating effect at low doses and alerting effects at high doses (Wetter et al., 1994; Salin-Pascual et al., 1995), and appears to reduce total sleep time and REM sleep time in healthy control participants. Additionally, a strong negative association was reported between smoking and sleep duration in male and female adults aged 16–67 yrs of some Oxfordshire villages in the UK (Palmer and Harrison, 1980). Smokers in the population aged 14–84 yrs living in Kentucky, USA, were more likely than nonsmokers to report problems going to sleep, problems staying asleep, daytime sleepiness, minor accidents, depression, and high daily caffeine intake (Phillips and Danner, 1995).

Heavy smoking can also be a risk factor for snoring and sleep-disordered breathing (Wetter et al., 1994). Heavy smokers showed increased sleep latency as well as increased arousal and difficulty staying asleep at night in comparison to nonsmokers (Palmer and Harrison, 1980). A similar association between sleep quality and smoking was recently found in Japanese civil servants (Hu et al., 2007). A newly found withdrawal symptom has been described recently in active smokers and labeled nocturnal sleep-disturbing nicotine craving (Wolter et al., 1996). Twenty percent of heavy smokers have this symptom, characterized by patients waking up one or more times in the middle of the night, unable to fall back to sleep without first smoking a cigarette. In the case of pregnant Japanese women, smoking and drinking were reported to be independently associated with increased sleep disturbance during pregnancy, in addition to their other well-known side-effects (Kaneita et al., 2005). However, there have been no studies on how habitual alcohol and nicotine consumption affects not only sleep health, but also circadian typology as an expression of the “phase of the circadian clock” in healthy pregnant women.

Earlier breakfast and supper consumption correlated positively with the tendency to be morning-typed in Japanese junior high school students aged 12–15 and university students aged 18–27 (Harada et al., 2000; Harada and Takeuchi, 2001). However, few studies have analyzed the role of eating behavior on the integrated physiological characteristics of circadian typology, sleep health, and mental health in adult women.

This study aims to answer the following two questions from the epidemiological point of view:

1. Does the regularity of breakfast intake and alcohol & cigarette consumption affect sleep health via the phase-delaying of the circadian clock?
2. What type of integrated relationship exists among circadian typology, sleep health, and mental health in Japanese female students?

Participants and Methods

This cross-sectional study was conducted in June and July of 2003 and used an integrated questionnaire which was administered to 880 female students aged 18–29 who attended a university or training school for nutritional specialists, both located in Aichi Prefecture in Japan (35°N). Responses from 862 students were received (with a response rate of 98%) and incomplete responses (i.e., age was not filled out or the ME section was incomplete) were discarded. Analysis for the current study was then limited to 800 responses from students aged 18–29, in order to focus on young Japanese women. Classes in the university and the training school start at 9:15 and 9:00, respectively. Saturdays and Sundays are off-days for both.

The integrated questionnaire consisted of three parts and asked participants to anonymously answer questions on the chronic state (subjective symptoms) of their life for the last one month. The first part was a Japanese version for students (Harada, 2004a) of the Morningness-Eveningness
questionnaire (MEQ) Torsvall and Åkerstedt (1980) originally constructed. The MEQ is used to measure an individual's diurnal preference. Three of the 7 questions included in the MEQ pertain to sleep onset timing in the evening, 3 to sleep offset timing in the morning, and 1 to peak timing of activity during the daytime. Each question allows for choice (scored from 1 to 4). The M-E score is the sum of the 7 answers. The minimum possible score is 7 (extreme evening-type), and the maximum possible score is 28 (extreme morning-type). The questionnaire currently used most widely was constructed by Horne and Östberg (1976) and was based on an original questionnaire by Östberg consisting of 14 items which was revised and lengthened to 19 items. Correlations have been examined in M-E scores in the two versions: one by Torsvall and Åkerstedt (1980), the other by Horne and Östberg (1976). High correlation values were seen in junior high students aged 12–15 years (Ishihara, communication, r=0.673–0.762; Pearson correlation test: p<0.001), and for 18- to 25-year-old students in occupational and physical therapy training school (Harada unpublished, r=0.736; Pearson correlation test: p<0.001). This provides validation of the Japanese version of the Torsvall and Åkerstedt questionnaire.

The second part of the integrated questionnaire used in this study was on sleep habits originally constructed by Harada et al. (1998) which has been used in several papers (Takeuchi et al., 2001a; Takeuchi et al., 2001b, Harada et al., 2002; Takeuchi et al., 2003; Harada et al., 2004; Shinomiya et al., 2004; Harada et al., 2007). Eleven questions were selected from the questionnaire on sleep habits detailing sleep quality, sleep hours, regularity of sleep-wake cycles, and sleep satisfaction. Each had four possible answers with points ranging from 1 to 4. The sum of the points was calculated and defined as the Unhealthy Sleep Index (UHSI). The UHSI scores range from 11 to 44 (lower scores translated to healthier sleep). This UHSI was made up to measure the degree of sleep health based on three studies on the estimation of sleep health (Monroe, 1967; Taub, 1978; Noda, 1999).

The last part of the questionnaire consisted of original questions on general life habits including consumption of alcohol and cigarettes and could be divided into two parts. The first part was an excerpt from a Questionnaire on Life Habits which was part of a Health Assessment Manual proposed and edited by the Health Assessment Review Committee (a Japanese advisory panel) in June 2000 (Part A: Health Assessment Explanatory Committee, 2002) and included questions on alcohol consumption and smoking. In particular, to determine participants’ status regarding alcohol consumption and smoking, they were asked the following two questions. (A) What is your current frequency of alcohol consumption? (1) drink (How many days do you drink alcohol each week?) (2) do not drink. (B) What is your current smoking status? (1) smoker, (2) ex-smoker, (3) nonsmoker. The second part consisted of items concerning life habits such as regularity of meal-timing, and was an excerpt from an Examination of Eating Habits which was part of Japan’s National Health and Nutrition Examination Survey (Part B: Japan Ministry of Health, Labor and Welfare, 2002). Only the data on drinking, smoking, and regularity of breakfast and supper out of Parts A and B were analyzed in this study.

In Japan, drinking and smoking by citizens aged 0–19 yrs is prohibited by law. However, some students aged 18 and 19 yrs in this study smoked and/or drank. Such data on women students were included to achieve a nondistorted analysis based on anonymous responses to questionnaires.

The questionnaire data (all independent variables) were analyzed using SPSS 12.0 statistical software. Part of the distributions of M-E scores and UHSI scores were not normal distribution (M-E: p=0.001, UHSI: p=0.001). Therefore the analysis on ME-scores and UHSI scores as dependent variables was standardized to nonparametric tests of the Mann-Whitney U-test and Kruskal-Wallis test. The other items for analysis were measured along an ordinal scale. For example, the relationship between the regularity of breakfast timing and each of 11 characteristics which made up UHSI scores was subject to chi-square tests and a Fisher’s test meta-analysis. Two-way ANOVA was used for the meta-analysis on integrated relationships among alcohol consumption, smoking (or breakfast intake), circadian typology (M-E scores), and UHSI. Throughout the statistical analysis, possibility, the p value, was regarded to be “significant” and was asterisked only when it was less than 0.05.

The concepts and purposes of this study were carefully explained in writing and orally and students were told that questionnaires would not be registered and answers would be used only for academic purposes. This study was permitted by the teachers’ committees of the university and training school which carried out ethical inspections on the contents of the questionnaire. After the above explanation, all students agreed completely with the proposal of the epidemiological work. Surveys were administered in class.

Results

Fundamental data on several parameters in general life

The mean age, ME score, and UHSI score of the participants was 19.26±1.33 yrs, 16.07±3.53, and 25.31±3.99, respectively. Both distributions of M-E and UHSI scores were almost normal (Figures 1, 2). 21.5% and 8.0% of the participants, respectively, consumed alcohol and smoked habitually (Table 1). “Drinker” and “smoker” were defined as those who drink more than one day per week and those who smoke habitually, respectively. 65.6% of the participants ate breakfast every morning and 2.1% never did (Table 2).

Relationship between meal habits and circadian typology or sleep health

The participants who had breakfast regularly and those who had breakfast earlier showed significantly higher M-E scores (more morning-typed) than those who ate irregularly or ate later, respectively (Table 3). Lower UHSI scores (more healthy
sleep) were shown by students who had breakfast or supper every day at regular times than those who did not (Kruskal-Wallis test: \( \chi^2 = 61.11, \text{df} = 3, p < 0.001^* \) for breakfast; \( \chi^2 = 15.49, \text{df} = 2, p < 0.001^* \) for supper). Participants who never had midnight snacks showed significantly lower UHSI scores (more healthy sleep) (Mann-Whitney U-test, \( z = 2.07, p = 0.039^* \)). Regular intake of breakfast had significant relationships to 7 of 11 characteristics which made up the UHSI scores.

### Relationship between alcohol consumption and cigarette smoking to circadian typology and sleep health

Students who habitually consumed alcohol and smoked showed significantly lower M-E scores (more evening-typed) and higher UHSI scores (unhealthy sleep) than those who did not. Women who exhibited “irritation” and “lack of concentration” showed lower M-E scores (more evening-typed) than those who did not. However, no significant relationship was shown between M-E scores and “anger” or “carelessness” (Table 5).

### Integrated analysis on sleep health

#### A. Integrated analysis among breakfast regularity, circadian typology, and sleep health

A significant relationship between regularity of breakfast timing (independent variable) and UHSI (dependent variable) was shown by one-way ANOVA (df=3, \( F = 25.24, p < 0.001^* \)), whereas this relationship disappeared when two-way ANOVA was done on the effects of the breakfast regularity (independent variable) and M-E scores (co-variable) on UHSI scores (dependent variable) (effect of the independent variable: df=3, \( F = 1.70, p = 0.167 \)).

#### B. Integrated analysis among alcohol consumption (or cigarette smoking), circadian typology, and sleep health

A significant relationship of alcohol consumption (or cigarette smoking) (independent variable) to UHSI (dependent variable) was shown by one-way ANOVA (alcohol: df=1, \( F = 11.19, p = 0.001^* \); cigarette: df=2, \( F = 23.8, p < 0.001^* \)), and this significant relationship still remained when two-way ANOVA was done on the effects of alcohol consumption (or
Table 3  The relationship between breakfast habit and Morningness-Eveningness score [Mean±SD (n)]
(A) Effect of regularity on M-E scores

<table>
<thead>
<tr>
<th>Frequency of breakfast consumption</th>
<th>always</th>
<th>usually</th>
<th>rarely</th>
<th>never</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME</td>
<td>16.78±3.36 (523)</td>
<td>15.15±3.32 (186)</td>
<td>14.21±3.23 (71)</td>
<td>11.88±3.57 (17)</td>
</tr>
</tbody>
</table>

Kruskal-Wallis test: χ² value=74.55, df=3, p<0.001*

(B) Effect of time on M-E scores

<table>
<thead>
<tr>
<th>Breakfast time</th>
<th>5:00–6:59</th>
<th>7:00–7:29</th>
<th>7:30–7:59</th>
<th>8:00–</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME</td>
<td>18.23±3.25 (166)</td>
<td>16.54±3.26 (178)</td>
<td>15.48±2.88 (157)</td>
<td>14.91±3.25 (18)</td>
</tr>
</tbody>
</table>

Kruskal-Wallis test: χ² value=88.94, df=3, p<0.001*

Table 4 Relationship of alcohol consumption and cigarette smoking to M-E scores and UHSI score [Mean±SD (n)]

<table>
<thead>
<tr>
<th>Do you consume alcohol?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you smoke?</td>
<td>Yes</td>
<td>No, but yes in the past</td>
</tr>
</tbody>
</table>

A. In total

<table>
<thead>
<tr>
<th>M-E scores</th>
<th>15.39±3.67 (172)</th>
<th>16.26±3.47 (628)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U-test: z = −2.27, p=0.023*</td>
<td>13.55±3.35 (64)</td>
<td>15.04±3.74 (27)</td>
</tr>
<tr>
<td>Kruskal-Wallis test: χ² value=35.22, df=2, p&lt;0.001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UHSI scores</th>
<th>25.93±3.81 (165)</th>
<th>25.15±4.03 (610)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U-test: z = 2.01, p=0.044*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kruskal-Wallis test: χ² value=44.84, df=2, p&lt;0.001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. 18–19 yrs group

<table>
<thead>
<tr>
<th>M-E scores</th>
<th>15.64±3.64 (88)</th>
<th>16.58±3.49 (453)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U-test: z = −1.953, p=0.051</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.87±2.71 (30)</td>
<td>16.65±3.46 (510)</td>
<td></td>
</tr>
<tr>
<td>Mann-Whitney U-test: z = −5.62, p&lt;0.001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UHSI scores</th>
<th>26.08±3.94 (83)</th>
<th>24.93±3.94 (437)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U-test: z = −2.161, p=0.031*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.53±3.53 (30)</td>
<td>24.90±3.88 (489)</td>
<td></td>
</tr>
<tr>
<td>Mann-Whitney U-test: z = −4.734, p&lt;0.001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. 20–29 yrs group

<table>
<thead>
<tr>
<th>M-E scores</th>
<th>15.13±3.70 (84)</th>
<th>15.41±3.28 (175)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U-test: z = 0.150, p=0.880</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.26±3.50 (31)</td>
<td>15.37±3.26 (214)</td>
<td></td>
</tr>
<tr>
<td>Mann-Whitney U-test: z = −1.72, p=0.090*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UHSI scores</th>
<th>25.77±3.70 (82)</th>
<th>25.71±4.20 (173)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U-test: z = 0.109, p=0.914</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.68±3.52 (28)</td>
<td>25.36±3.99 (214)</td>
<td></td>
</tr>
<tr>
<td>Mann-Whitney U-test: z = −4.550, p&lt;0.001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

The negative correlation between alcohol consumption (and cigarette smoking) and sleep health shown in this study, which was strongly shown in female students less than 20 years old, follows numerous previous studies (Thorp, 1990; Wetter et al., 1994; Salin-Pascual et al., 1995; Gillin et al., 2005). Based on the integrated analysis on the effect of regularity of breakfast intake on sleep health, regular breakfast intake seems to link to good sleep positively via the shifting to morning-type (i.e., good coupling or entrainment of main and slave clocks to 24-hr cycles occurring in the natural environment). For Japanese female students aged around 19 years old, breakfast

...
Table 5 Relationship of the four mental symptoms to M-E scores and UHSI scores [Mean±SD (n)]

<table>
<thead>
<tr>
<th></th>
<th>Irritation</th>
<th>Anger</th>
<th>Lack of concentration</th>
<th>Carelessness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Not</td>
<td>Yes</td>
<td>Not</td>
</tr>
<tr>
<td>M-E scores</td>
<td>15.64±3.64 (256)</td>
<td>16.27±3.48 (508)</td>
<td>15.72±3.65 (122)</td>
<td>16.12±3.52 (642)</td>
</tr>
<tr>
<td>z</td>
<td>2.06</td>
<td>-0.88</td>
<td>-3.65</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>p</td>
<td>0.040*</td>
<td>0.379</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>z</td>
<td>-4.17</td>
<td>-3.31</td>
<td>-4.63</td>
<td>-3.04</td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

at regular times might be a strong zeitgeber for their circadian clock, which regulates the diurnal rhythms of plasma melatonin and cortisol (Duffy et al., 1999; Bailey and Heitkemper, 2001). Regular breakfast intake can be speculated to cause an advance in the phase of such hormonal rhythms, accompanying the shifting to morning-type. A similar analysis shows that alcohol consumption and cigarette smoking seem to relate to sleep health negatively and directly, rather than via the shifting to evening-type (i.e., the phase-delaying of the circadian clock) based on the results of this study. Smoking could also lead to degradation in the central nervous center regulating sleep, and such a direct effect might be stronger than that caused by alcohol consumption based on the comparison of the results of one-way and two-way ANOVA. However, there are strict limits in the epidemiological study, and the causal relationship of the breakfast, alcohol, and cigarettes to sleep health remains to be studied with other methodologies, such as field and intervention experiments.

The relationship between Morningness-Eveningness and mental symptoms has previously been reported: thirty-nine healthy outpatients with current DSM-III-R depression, free of recent substance abuse or confounding medications reported greater “eveningness” than 39 age- and sex-matched controls (Harada et al., 1999). Also, in Japanese junior high school students and university students, evening-types more frequently showed mental symptoms such as irritation, unreasonable anger, and depression (Harada, 2004b). Even in infants, similar relationships were shown (Harada et al., 2007). One possible factor causing such degradation in mental health in evening-type women is hypothesized to be inner desynchronization of the main and slave clocks of women students (Harada, 2004b). However, linkage between sleep health and mental health could be stronger than that between circadian typeology and mental health based on the statistical analysis shown in Table 5 in this study. The relationship between sleep health and mental health seems to occur not via circadian typology in young Japanese women. In the case of women, premenstrual syndrome appears as several mental and physical symptoms, including sleep disorders and depression (Lee et al., 2007). Keeping quality and quantity of sleep in normal life seems to be important for promoting their mental health, which may fluctuate throughout their menstruation cycle.

Acknowledgments This study was financially supported by Research Grant of Kochi University (2006–2007, 2007–2008). Thanks are due to all participants of the university and training school for kind participation in this study.

References

Harada T, Takeuchi H (2001) Epidemiological study on

Harada T, Takeuchi H (2003) If they use convenience store and mobile phone in the evening or at night and watch late night TV, do Japanese children show the shortage of sleep duration? Jpn J Clinic Dent Child 8: 57–67 [In Japanese]


Received: September 1, 2008
Accepted: January 16, 2009
Correspondence to: Tetsuo Harada, Laboratory of Environmental Physiology, Faculty of Education, Kochi University, 2–5–1 Akebonocho, Kochi 780–8520, Japan
Phone: +81–088–844–8410
Fax: +81–088–844–8410
e-mail: haratets@kochi-u.ac.jp