101217 稲田昼ゼミ

Nighttime exposure to ozone reduces whole-plant production in *Betula pendula*

Rainer Matyssek
Tree Physiology(1995)

Contents

1. Introduction

…の前に・・・

0. Basic knowledge about O_3

- Tropospheric O_3 increases in the Northern Hemisphere recently
- O_3 causes adverse effect on plants

  (visible leaf injury, growth decline, changing allocation…)
- O_3 may be one of the cause of forest decline
- Researches have been started from 1970s in Europe


ミシガン工科大学


バイエルン州環境健康研究所


ドイツ･ミュンヘン工科大学


北大OTC(16基）

1. Introduction

- O_3 can limit tree development in controlled experiments with young plants (Reich 1987)
- Critical level of O_3 exposure (CL) is required

  CL: No adverse effect are assumed to occur in plants

  (UNECE 1988)

- CL needs to be defined for the time period

1. Introduction

- Forest can experience high O_3 concentration in the evening and early morning.
- It has not been determined whether O_3 sensitive periods are restricted to daylight time for trees

To determine whether trees are sensitive to O_3 during the night

analyzed the influence of nighttime exposure

1. Introduction

- The capacity of stomata to open without light stimulation may favored…
  1. under warm and humid condition
  2. depend on leaf age
  3. be caused by sluggishness in stomatal regulation under O_3 stress

To distinguish among these possibilities with

⇨ an examination of leaf gas exchange

2. Materials and Methods

- *Betula pendura* clone
- 1990 4/17~9/27
- Each grew in field fumigation chambers (5/17~)
- O_3 concentration

  (5 plants/ treatment, 1 plant/ chamber)

  O_3 free-air (Control) : about 0ppb

  nighttime regime : 75ppb 19:00~7:00

  daylight regime : 75ppb 7:00~19:00

  24h regime : 75ppb all day

① Macroscopic leaf injury

- Visible symptoms of O_3-induced leaf injury
- Classified "Class1" or "Class 4"

Class 1 : Early symptoms

(light-green dots spread over the leaf lamina)

Class 4 : Premature leaf loss

(Gunthardt-Goerg et al. 1993)

These were examined in early and late June, early August and mid-September

② Biomass analysis

- 1990 9/27 5 trees in each treatment were harvested
- Leaves, branches, stem, root, initially planted cutting ... after dry, were weight

③ Measurement of leaf gas exchange (another experiment)

- In 1992 measurements were conducted with the same birch clone
- O_3 regime (7:00~21:00 90ppb, the rest 40ppb)
- O_3 uptake rate was calculated according to the water vapor surrogate method (Laisk et al. 1989)
- Subject leaves

① 4-week-old leaf, August, control

② 7-week-old leaf, September, O_3 exposure

Continued

- Stomatal conductance for O_3 (g_{O_3})

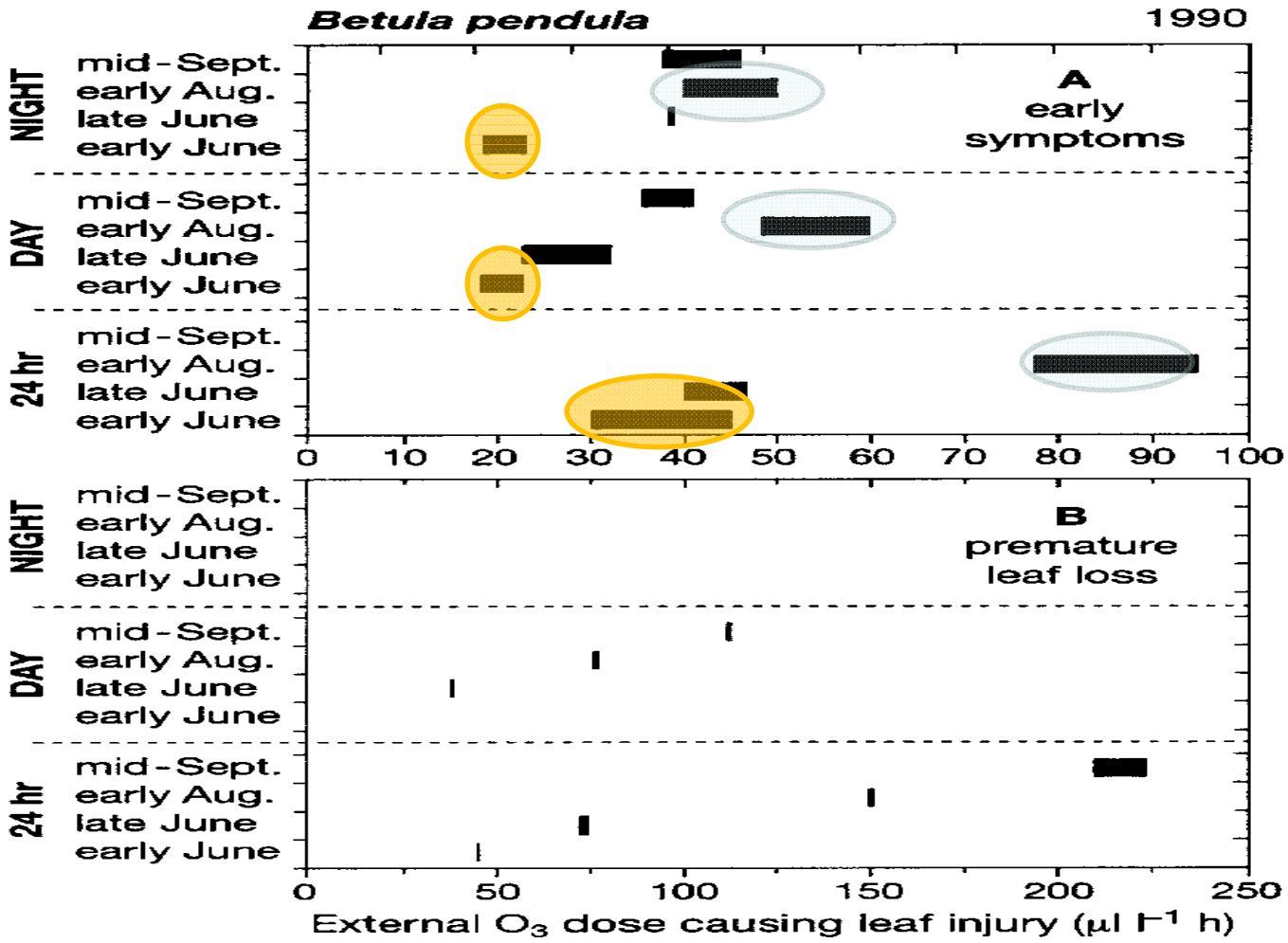
$$D_{H_2O} / D_{O_3} = 1.68$$

(The ratio of the diffusion coefficients)

- External O_3 dose (μ l l^{-1} h): concentration of the ambient air multiplied by the duration of exposure

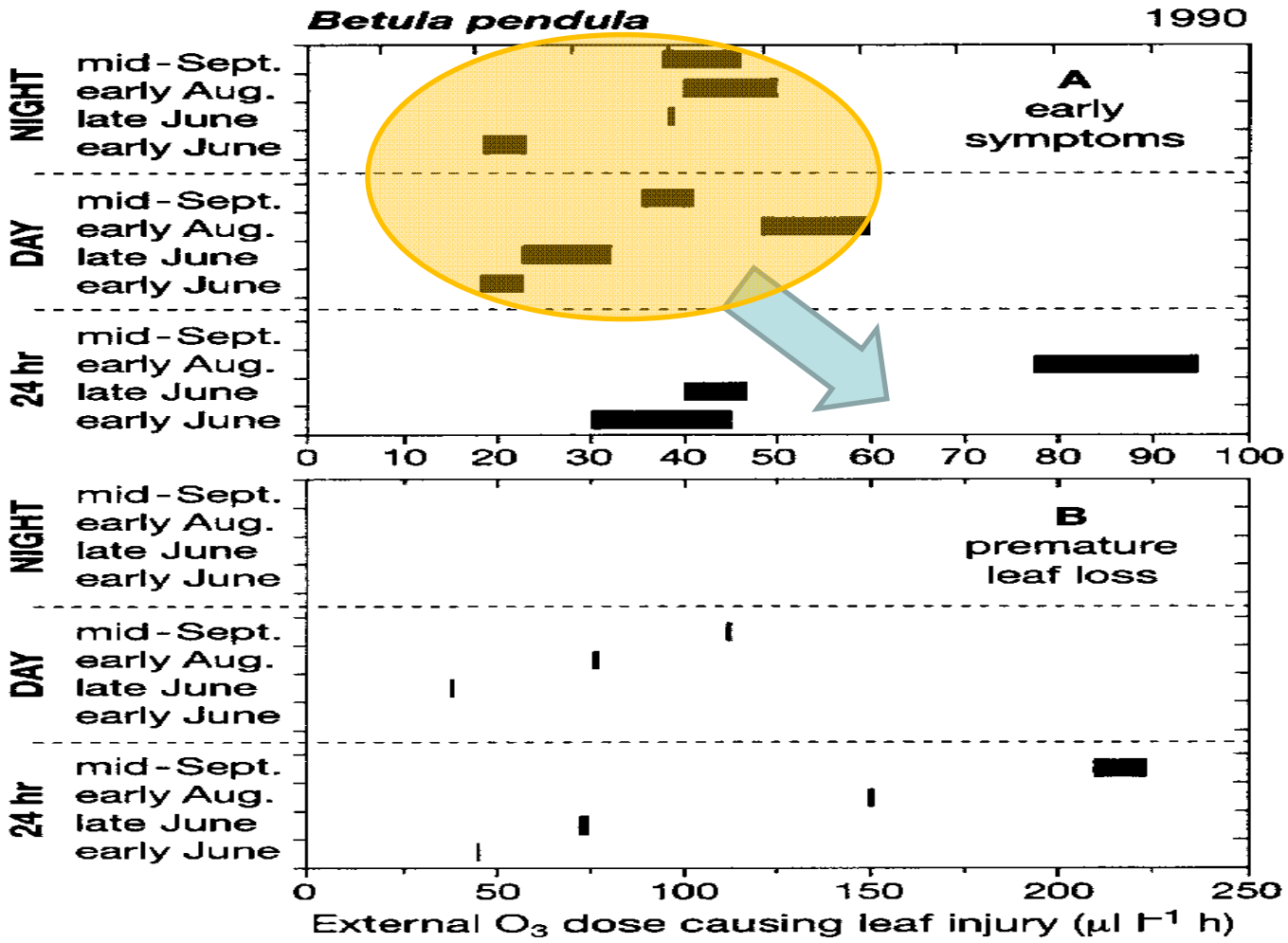
3. Result ~① leaf injury~

Leaves developing in summer have higher tolerance than leaves developing in spring to higher O_3 dose



3. Result ~① leaf injury~

Tolerance to O_3: daylight & nighttime < 24h regime

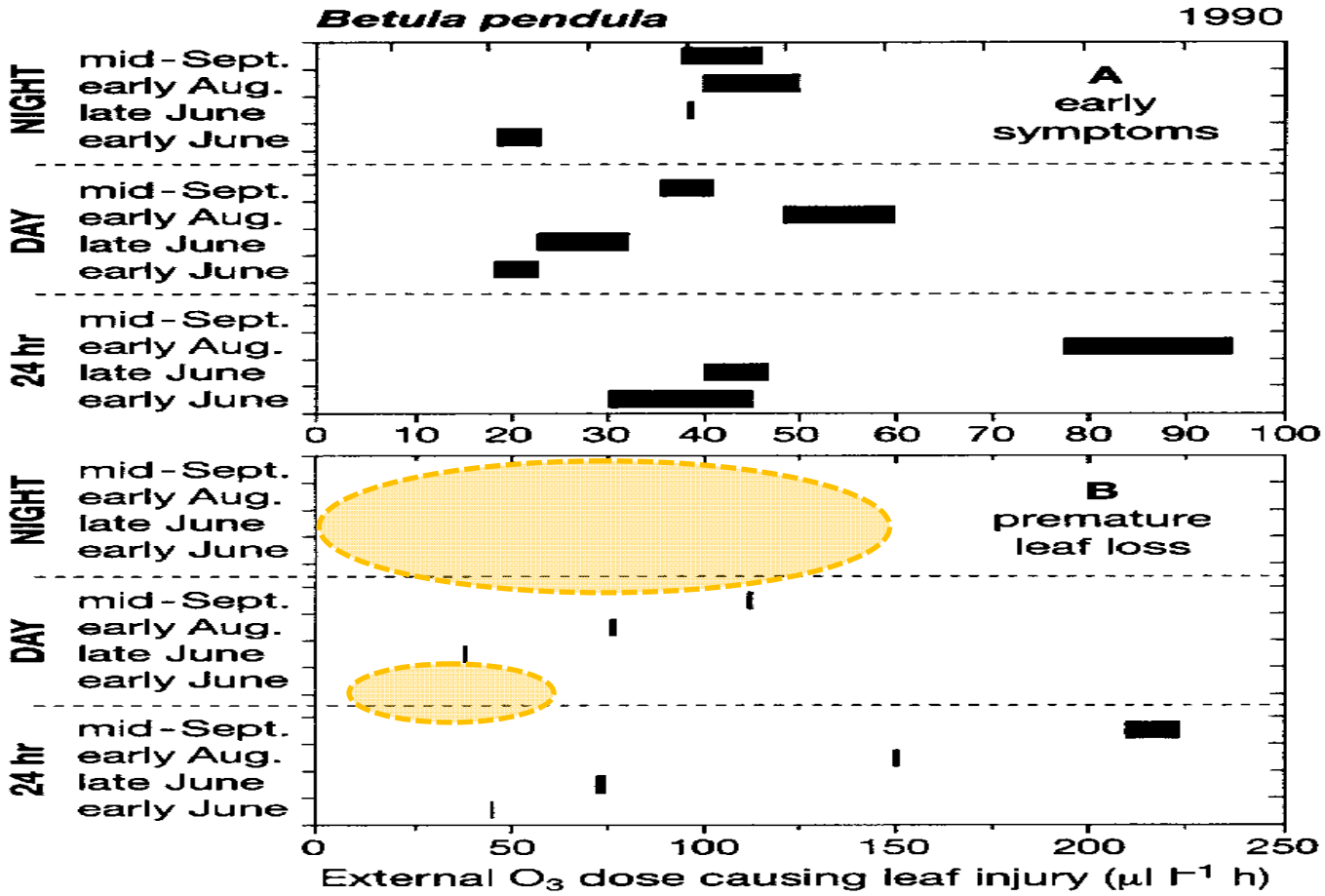


3. Result ~① leaf injury~

Daylight O_3 regime : didn't lose by early June

Nighttime O_3 regime : didn't lose

O3 dose range :
A > B
(early symptom > premature leaf loss)



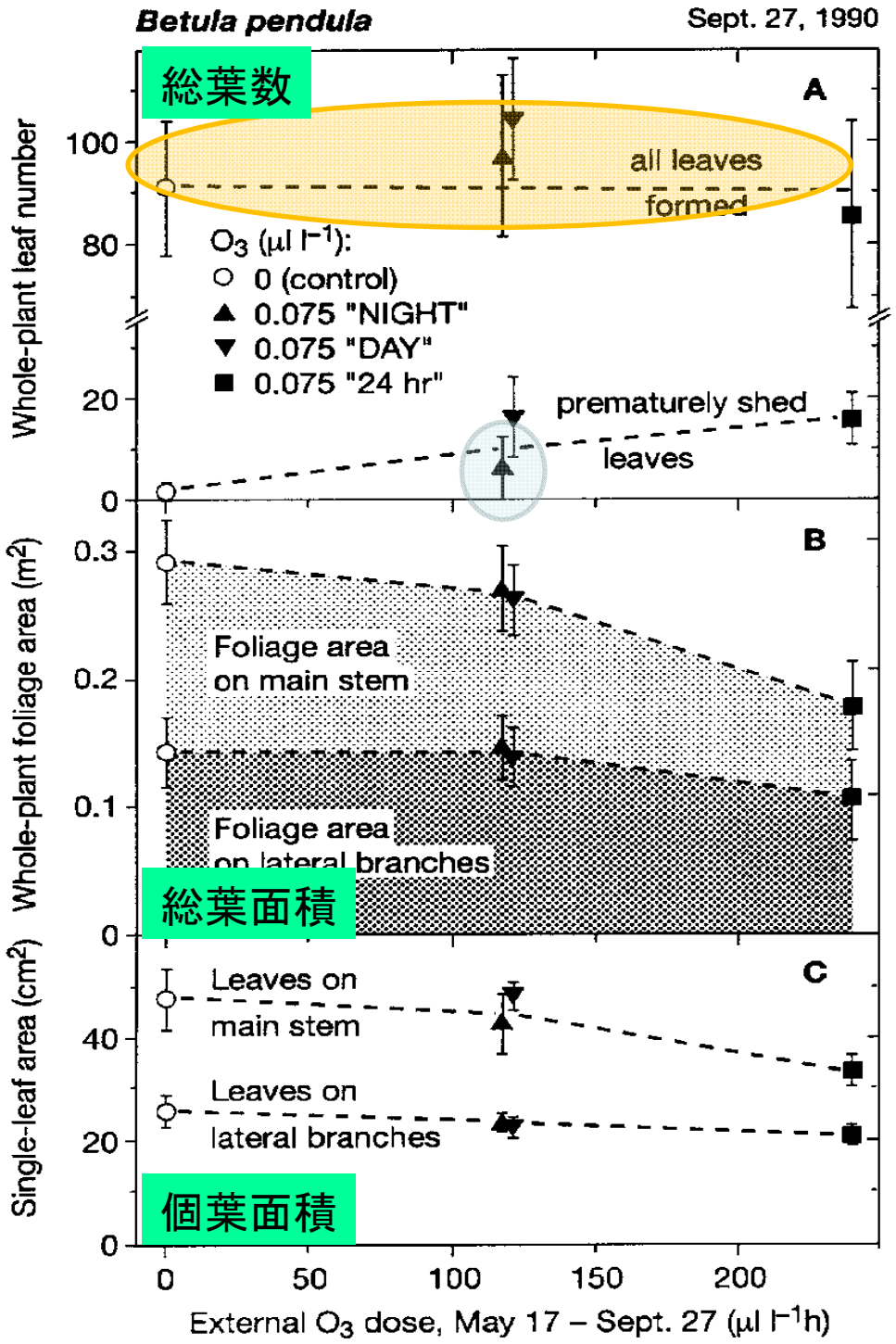
3. Result
~② Biomass analysis~

- Total leaf number didn't change

- Nighttime regime

⇩

reduction of premature shed leaves



3. Result
~② Biomass analysis~

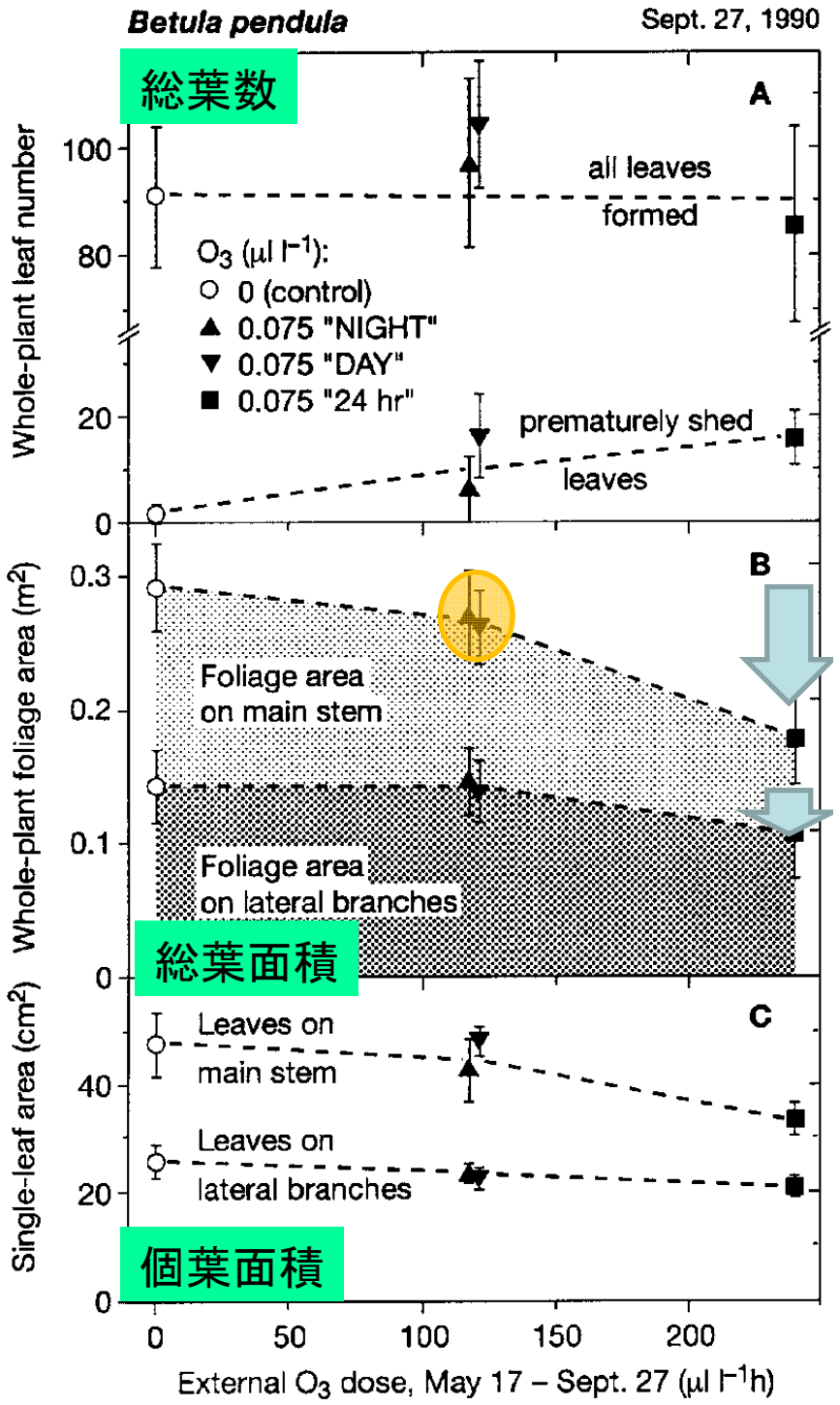
- Nighttime and Daylight :

Whole-plant foliage area didn't change

- Mainly foliage area of stem decrease

⇩

Whole-plant foliage area decrease



3. Result ~② Biomass analysis~

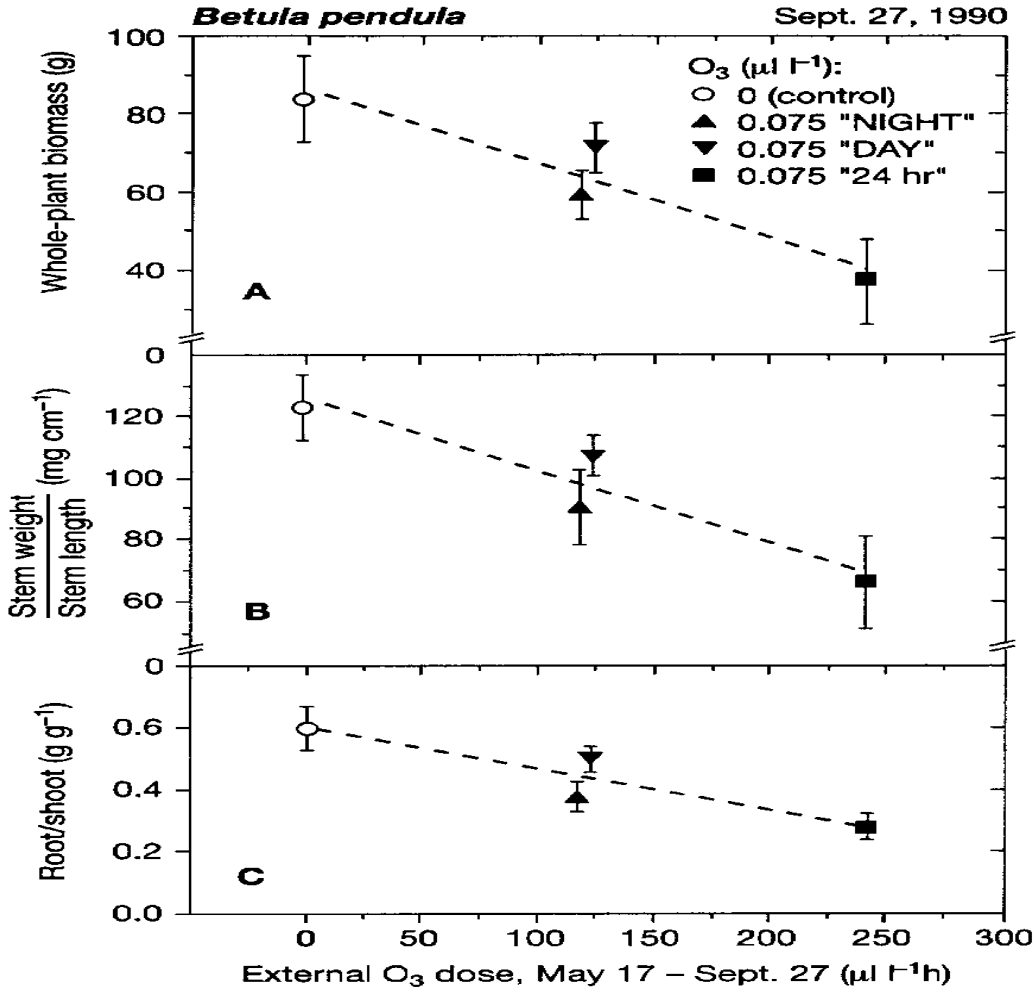
O_3 effect : whole-plant biomass production > foliage area

Stem production was reduced (with increasing external O_3 dose

個体乾重量

幹間重量/幹の長さ

Root/shoot



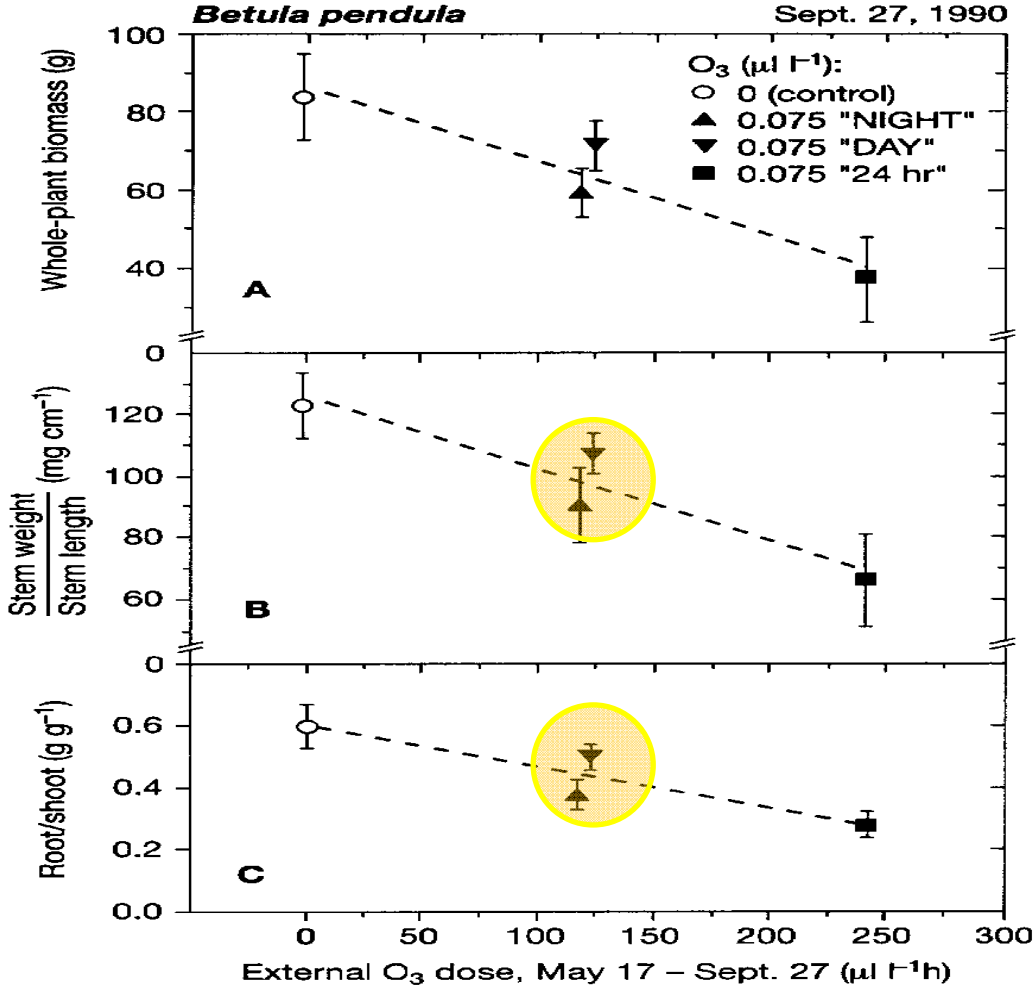
3. Result ~② Biomass analysis~

O3 sensitivity (biomass production and carbon allocation) : nighttime > daylight

個体乾重量

幹間重量/幹の長さ

Root/shoot

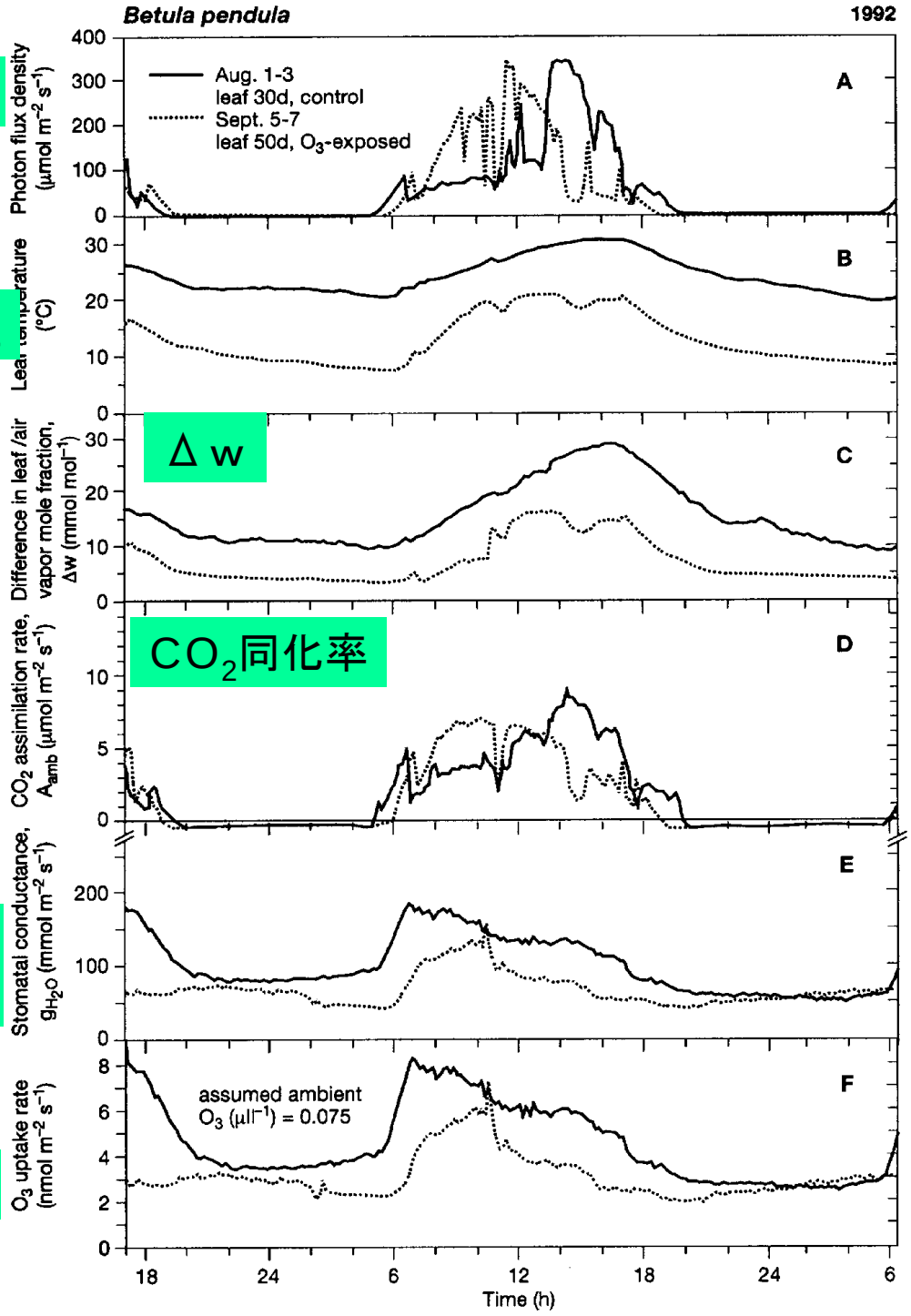


3. Result
~③Gas exchange

光量子密度

葉温

O_3 uptake parallels the time of g_{H_2O} , could have reached 3-4nmol m^{-2} s^{-1} at night



気孔コンダクタンス（g_{H_2O}）

O_3取り込み率

4. Discussion

- Nighttime exposure to O_3

  ⇨ leaf injury, limited biomass production,

  decreased root/shoot rate (R/S)

impeded assimilate translotation?

(Gunthardt-Goerg et al. 1993)

同化産物の転流の遅期化

may cause acclimation to O_3

O_3の順化

repair and detoxification > allocated to roots

修復と解毒

4. Discussion

- Birch stomata remained open at night
- It has also been observed in

  spruce (Wieser and Havranek 1993), and herbaceous plants (Aben et al. 1989)

The 24h information may be basis for defining critical O_3 exposure

4. Discussion

- O_3 sensitivity : nighttime > 24h
- the absence of light may render plants susceptible to O_3 stress

光の欠如がO_3ストレスに敏感にしやすい?

The enhance sensitivity at night didn't reflect the reduction of leaf area and leaf injure

夜間にO_3に敏感になるのは葉面積の減少と傷害の出現には関係ない

The amount and appearance of foliage were not coupled with a decline in photosynthesis capacity

葉の量や出現は光合成能力と一緒には起こらない

4. Discussion

Tropospheric O_3 concentration can remain enhanced during night or continuously elevated...

(NAPAP 1991)

For defining critical exposure for O_3 in trees, a daily time of 24h is justified