

***Ephemera separigata*, a New Species of Ephemeridae
(Insecta: Ephemeroptera) from Korea**

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ABSTRACT

Mature larva and male and female adults of an ephemerid mayfly (Ephemeroptera: Ephemeridae), *Ephemera separigata* n. sp., were described from Korea. Larvae and adults of the species were distinguished from other *Ephemera* spp. by a pair of narrow and laterally oriented longitudinal stripes on the abdominal terga 7-9. Larvae of the species adapted to cold water high mountain torrents (altitude 500-700 m) where substrates were sand, gravel, and a large portion of pebbles and cobbles. Altitudinal adaptations between Korean *Ephemera* spp. were briefly discussed.

Key words: *Ephemera separigata*. Ephemeroptera. description. habitat adaptation. Korea

The burrowing mayfly Ephemeridae (Ephemerinae) are widespread in the Holarctic, Oriental, and Afrotropical regions (McCafferty, 1991) inhabiting sand or gravel substrates in streams or rivers. Because of their large body size, common occurrence, and ecological importance in stream ecosystems as well, members of Ephemeridae have been relatively well known.

Comprehensive systematic studies were worked out for Palearctic *Ephemera* (Tshernova, 1973) and Nearctic Ephemeridae (McCafferty, 1975). In East Asia, *Ephemera orientalis* McLachlan (1875) and *E. strigata* Eaton (1892) were described from Japan, and fifteen species of Ephemeridae were subsequently described from China (Hsu, 1931-32, 1936-37, 1937-38). More recently, revisionary studies and identification keys of Ephemeridae were prepared from Japan (Gose, 1981) and from far eastern Russia (Tshernova *et al.*, 1986). In Korea, larvae of two ephemerid mayflies, *E. strigata* and *E. orientalis*, were reported by Imanishi (1940) for the first time, and larvae and adults of those two species were redescribed by Yoon and Bae (1985) based on a good series of *Ephemera* materials from Korea.

When I examined materials of *Ephemera* collected from more than 120 localities in South Korea since 1960's (see map and locality table in Bae, 1985, ms), I found certain populations of the larvae possessed distinct color pattern on the abdominal terga (see Yoon and Bae, 1985, p. 99). I recently obtained and examined reared materials, and concluded that the populations could be separated as a new species. I herein describe larva and male and female adults of the species with supplementary information on habitat adaptations.

Larval and adult materials of *Ephemera* were taken from many localities in South Korea as indicated above, and some adults were reared in the field. For comparisons, larval and adult materials of *E. strigata* from Japan (1 ♂ imago and 1 ♀ imago, Kanagawa Pref., Hakone, Sengokubara, 9 May 1985, S. Ishiwata; 1 larva, Yamaguchi Pref., Yoshiki-gun, Ogouri-machi, Shijuhasse R., 20 Mar. 1989, S. Ishiwata) and from far eastern Russia (1 ♂ imago, Primorsky Territory, Big Ussurka R., 20 June 1980, N. Yu. Kluge; 4 larvae, Primorsky Territory, Tigrovaya R., 15 June 1980, N. Yu. Kluge), and *E. japonica* from Japan (2 ♂♂ imagos, 1 ♀ imago, and 3 ♂♂ subimagos, Kanagawa Pref., Fuzine-machi, Magino, Kawakami R., Sagami R., 9 June 1988, S. Ishiwata; 1 ♂ imago, 1 ♀ imago, 1 ♂ subimago, and 1 ♀ subimago, Yamanashi Pref., Otsuki City, Nanahomachi, Hukashiro, 24 Aug. 1992, H. Moriya & H. Hasegawa; 3 larvae, Kanagawa Pref., Fujino-Machi, Magino, 26 June 1989, S. Ishiwata) were also examined.

A larval habitus was prepared by half-tone drawings. All materials examined in this study were deposited at Seoul Women's University (SWU).

***Ephemera separigata* n. sp.** 가는무늬하루살이(신칭) (Figs. 1 and 2)

Ephemera strigata Eaton: Yoon and Bae, 1985, p. 98 (in part), p. 108, fig. 31.

Type Material. *Holotype*. ♂ imago (in alcohol), Korea, Kangwon-do, Wonju, Chiak Mt., Sangwongol, alt. 600 m, 5 June 1992, H. J. Lee (SWU). *Paratypes*. 1 ♂ imago, same data as holotype (SWU); 5 mature larvae, Korea, Kangwon-do, Hongchon, Kyebang Mt., Undu-gol, alt. 700 m, 6 June 1983, Y.J. Bae (SWU); 16 ♂♂ imagos (1 ♂ imago wings on slide), 1 ♀ imago, Korea, Chollanam-do, Namwon, Chiri Mt., Talgung, alt. 600 m, 25 June 1986, Y.J. Bae (SWU).

Other Material Examined. 2 ♂♂ subimagos, 3 ♀♀ subimagos, and 2 mature larvae (subimagos reared, with exuviae), same locality and date as holotype, Y.J. Bae; 12 immature larvae, Korea, Kangwon-do, Hongchon, Kyebang Mt., Undu-gol, alt. 700 m, 6 June 1983, Y.J. Bae; 4 ♂♂ imagos (wings damaged), 1 ♂ subimago, 1 ♀ subimago, and 1 mid-grown larva, Korea, Chollanam-do, Namwon, Chiri Mt., Talgung, alt. 600 m, 25 June 1986, Y. J. Bae; 3 mid-grown larvae and 5 early instar larvae, Korea, Chollabuk-do, Muju, Minjuji Mt., Naebok-dong, alt. 500 m, 2 Oct. 1984.

Mature Larva. Body length 17.5-18.6 mm; caudal filaments 7.5-8.5 mm. Body color white to light yellow, with reddish brown or dark brown markings. General body shape as in Fig. 1. *Head*. Dorsal head with large purplish brown markings on vertex and with rectangular dark brown marking between ocelli. Compound eyes black; dorsal cross diameter of male 0.65 mm (female 0.38 mm); dorsal longitudinal diameter of male 0.92 mm; distance between compound eyes of male 0.95 mm (female 1.40 mm). Anterior ocellus black, with dark brown medial stripe extended posteriorly; pair of posterior ocelli white, with C-shaped black circumferential band. Antennae 3.8 mm; flagella with well developed whorls of hairlike setae; 1st basal segment 0.25 mm; 2nd basal segment 0.30 mm, with well developed setal field dorsally; distance between inner bases 0.80 mm (outer bases 1.50 mm).

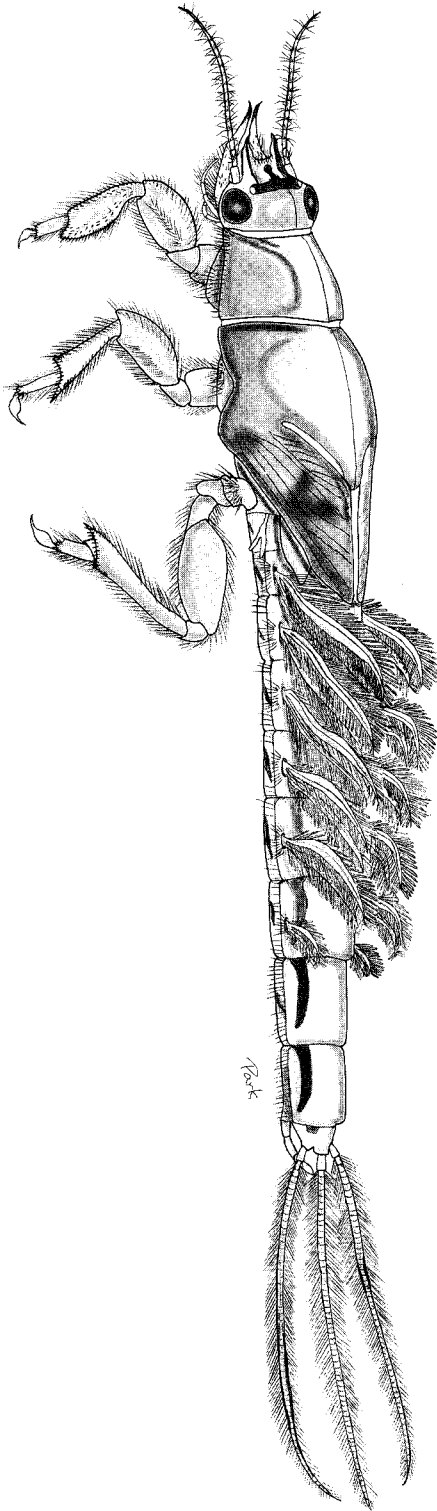


Fig. 1. *Ephemera separigata*, larval habitus.

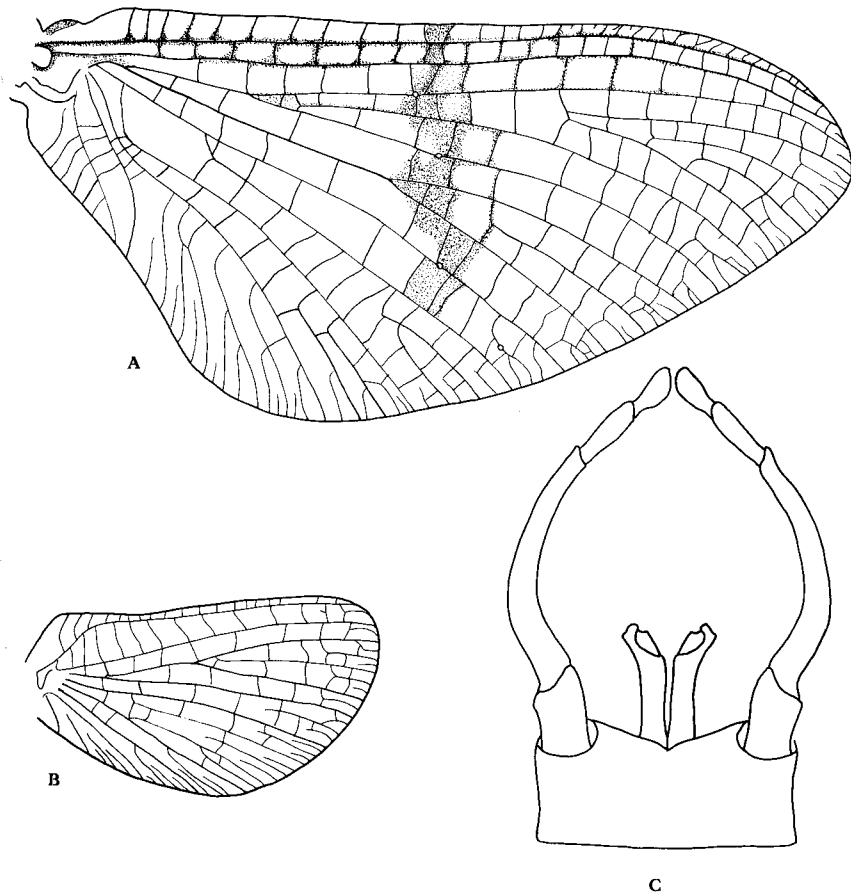


Fig. 2. *Ephemera separigata*, male adult: A, right forewing; B, right hindwing; C, genitalia.

Frontal process well developed (length 1.03 mm), with strongly concave anterior margin (vertical height of forks 0.30 mm) appearing biforked frontal process; forks slightly upcurved apically and convex laterally (basal width of frontal process 0.80 mm, apical width 0.78 mm, longest width at midlength 0.93 mm). Mandibular tusks well developed (length 1.50 mm), upcurved and outcurved distally, with 20-30 hairlike setae mixed with 15-20 stout setae along dorsolateral margin, and with dense hairlike setal field basally. Maxillary palpi 3-segmented (1st segment 0.50 mm; 2nd 0.38 mm; 3rd 0.58 mm); segments 2 and 3 with dense hairlike setae. Labial palpi 3-segmented (1st segment 0.50 mm; 2nd 0.20 mm; 3rd 0.38 mm); terminal segment strongly falcate and setaceous. *Thorax*. Pronotum 1.3 mm in length, 2.5 mm in width, purplish yellow, with dense setal field on anterolateral and lateral margins. Meso and metanotum white to light yellow, with purplish yellow markings; forewingpads with dark veins, and with dark brown markings basally, at midlength, and along lateral margins. Pleura and sternum white; meso and metapleura with dense hairlike setal fields. Forelegs purplish brown dorsally, white to light yellow ventrally; femur 1.5 mm, tibia 1.0 mm, tarsus 0.8 mm, and claw 0.3 mm in length. Forefemora with rows of hairlike setae along anterior and posterior margins, and with longitudinal hairlike setal field on dorsal surface. Foretibiae with dense hairlike setae and rows of dense stout setae along anterior margin, and with mixed hairlike and stout setae on posterior half of dorsal surface; apical margin moderately produced posteriorly, not produced

anteriorly. Foretarsus with sparse hairlike setae anteriorly, with mixed stout and hairlike setae along posterior margin, and with tuft of hairlike setae apically; claws moderately tapered. Midlegs white to light yellow, femur 1.4 mm, tibia 1.2 mm, tarsus 0.7 mm, and claw 0.5 mm in length; midfemora setation as in forefemora; midtibiae with hairlike setae along anterior and posterior margins, and with row of stout setae apically; midtarsal claws greatly tapered. Hindlegs white to light yellow, femur 2.1 mm, tibia 1.5 mm, tarsus 0.7 mm, and claw 0.6 mm in length; hindfemora with rows of hairlike setae along anterior and posterior margins, without setal fields dorsally; hindtibiae as in midtibiae; hindtarsal claws greatly tapered. *Abdomen.* Abdomen white to light yellow, with dark brown markings. Abdominal tergum 1-10 with pair of longitudinal stripes; stripes on tergum 7-9 narrow, separated, laterally oriented, and slightly divergent posteriorly; tergum 2-6 with dense hairlike setal field at base of gills; tergum 7-9 with row of sparse hairlike setae along lateral margins. Abdominal sternum 1-9 with pair of longitudinal stripes; stripes on sternum 1-8 narrow and divergent posteriorly; stripes on sternum 9 broad. Gills on abdominal tergum 1-7 raised at midlength; gills 1 simple, bifurcate, without setae; gills 2-7 bilamellate and fringed; gills 7 relatively small, with 25-35 fringes on outer lamella, and with 15-20 fringes on inner lamella. Caudal filaments ca. $0.43 \times$ length of body, with row of lateral hairlike setae.

Male Adult. Body length 13.6-16.6 mm; caudal filaments 32.0-41.0 mm. Body color white, with dark purplish brown markings. *Head.* Compound eyes dark grey in alcohol, moderately large (dorsal diameter 0.83 mm), ventrally hemispheric and dorsally raised, and dorsally separated more than diameter of compound eyes (distance between compound eyes 1.05 mm). Anterior ocellus dark brown; pair of posterior ocelli white apically and dark brown basally. Antennae 1.6 mm; basal segment light brown; flagellum white. *Thorax.* Thorax color shiny purplish brown; non-sclerotised region white; color of notum slightly darker than pleura and sternum; pronotum with pair of dark longitudinal stripes. Forelegs purplish brown, femur 2.3 mm, tibia 6.1 mm, and tarsus 6.4 mm (each segment 0.2, 2.3, 2.0, 1.2, and 0.7 mm) in length; claws similar. Midlegs white, femur 1.8 mm, tibia 2.1 mm, and tarsus 1.0 mm in length; claws dissimilar. Hindlegs white, femur 2.5 mm, tibia 2.5 mm, and tarsus 1.0 mm in length; claws dissimilar. Forewings (Fig. 2A) 13.7-17.0 mm in length, 6.5-8.0 mm in width, entirely stained light purplish brown, with slightly darker marginal area, and with dark purplish brown transverse stripe at midlength; veins of forewing brown to dark brown (basally darker); basal half of Sc black; crossveins darker and slightly infuscated; crossveins of stigmatic area well developed; crossveins between Sc and R1 31; 2-3 crossveins at transverse stripe crowded; bullae on Sc, R2, R4+5, and MP1; MA forked at midlength; base of MP2 greatly arched to CuA, sometimes connected to CuA; CuA arched to CuP; A1 not forked, with 6-7 veinlets. Hindwings (Fig. 2B) 5.6-7.9 mm in length, 2.9-4.1 mm in width, stained purplish brown except anal margin; costal margin rounded; Rs ca. $0.5 \times$ length of R2; MP forked at ca. $1/4$ length basally; crossveins between C and Sc 22-23; crossveins between Sc and R1 15-16. *Abdomen.* Abdominal terga white; tergum 1-9 with pair of dark brown longitudinal stripes; stripes on tergum 7-9 narrow, separated, laterally oriented, and slightly divergent posteriorly as in larva; Abdominal sternum 1-9 with pair of longitudinal stripes; stripes on sternum 2-8 narrow and divergent posteriorly; stripes on sternum 9 broad. Genitalia as in Fig. 2C; genital forceps 4-segmented, light brown to brown, sometimes basal segments and basal half of 2nd segments white; each segment 0.05, 0.11, 0.04, and 0.02 mm in length; 2nd segments strongly arched; subgenital plate slightly notched; penis paired, slender, Y-

shaped, and light yellow basally and light brown apically. Caudal filaments light brown, and dark brown at joints; cerci ca. $2.5 \times$ length of body; terminal filament ca. $0.9 \times$ length of cerci.

Female Adult. Body length 21.2 mm; caudal filaments 25.0 mm. *Head.* Color similar to male. Compound eyes dark grey in alcohol; dorsal diameter of compound eyes 0.50 mm; distance between compound eyes 1.35 mm. *Thorax.* Color as in male. Forefemora light purplish brown, and 2.4 mm in length; foretibiae dark purplish brown, and 2.8 mm in length; foretarsal segments 1-4 dark purplish brown; foretarsal segments 5 light purplish brown; each tarsal segment 0.15, 0.63, 0.45, 0.30, and 0.58 mm in length; claws similar. Midlegs white, femur 2.0 mm, tibia 2.5 mm, and tarsus 1.0 mm in length; claws dissimilar. Hindlegs white, femur 2.8 mm, tibia 2.8 mm, and tarsus 1.0 mm in length; claws dissimilar. Forewings 19.0 mm in length, 8.0 mm in width; color and venation as in male. Hindwings 6.6 mm in length, 3.5 mm in width, color and venation as in male. *Abdomen.* Abdomen white (yellowish brown in egg contained individuals); color and markings as in male. Posterior margin of subanal plate V-shaped, with pair of small capitate processes. Caudal filaments as in male; cerci ca. $1.2 \times$ length of body; terminal filament ca. $0.9 \times$ length of cerci.

Etymology. The trivial name *separigata* is a combination of *separata* (Latin: separate) and *strigata* (Latin: having narrow, transverse lines) alluding "separate narrow stripes" on the abdominal terga.

Remarks. *Ephemera separigata* n. sp. is morphologically very similar to *E. strigata*, but distinguished by a pair of relatively narrow, separated, and laterally oriented longitudinal stripes on the abdominal terga 7-9 in larval, subimaginal, and adult stages of both sexes. In many individuals of adults, contrastive body markings and heavily stained wings may also distinguish this species from *E. strigata*.

Ecological notes. An ecological study of altitudinal distribution of *Ephemera* spp. conducted recently in a Korean stream (Lee *et al.*, 1995) indicated that *E. strigata* inhabited the upper part of stream (range of altitude 140-350 m, mean altitude 279 m) comparing with *E. orientalis* (range 40-200 m, mean 160 m) when those two mayflies occurred in the same stream area.

Distribution of *E. separigata*, moreover, indicated very clear habitat partitions among Korean *Ephemera* spp. as seen in a stream of Chiak Mt. (see Material Examined). In that stream, *E. separigata* inhabited the uppermost part of the stream (altitude 600 m), above the limits of *E. strigata* or *E. orientalis*, where water temperature was relatively low. Lee *et al.* (1995) suggested that water temperature was the major factor determining altitudinal distribution of *Ephemera* spp.

Similar distributional discontinuity along gradient between closely related burrowing mayflies were known in Japanese *Ephemera* spp. (Kuroda *et al.*, 1984; Watanabe, 1985), in North American *Ephemera* spp. (McCafferty, 1975), and even in North American *Anthopotamus* spp. (Potamanthidae) (Bae and McCafferty, 1991).

Microhabitat of *E. separigata* was somewhat different from that of *E. strigata* or *E. orientalis*. *E. separigata* inhabited relatively coarse substrates, i.e., mixed sand, gravel, and large portion of pebble or cobble substrates. *E. separigata* were also found at slow to moderately fast current areas where the above type of substrates were predominant.

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REFERENCES

- Bae, Y.J., 1985. Taxonomic study of Korean Ephemeroptera. Master's Thesis. Dept. of Biology, Korea Univ., Seoul (in Korean).
- Bae Y.J. and W.P. McCafferty, 1991. Phylogenetic systematics of the Potamanthidae (Ephemeroptera). *Trans. Am. Entomol. Soc.* **117**: 1-143.
- Eaton, A.E., 1892. On two new and some other Japanese species of Ephemeridae. *Entomol. Mon. Mag.* **38**: 302-303.
- Gose, K., 1981. A revision of the genus *Ephemera* in Japan. *Biol. Intl. Wat. (Japan)* **2**: 11-14 (in Japanese).
- Hsu, Y.C., 1931-32. Two new species of mayflies from China (Order Ephemerida). *Peking Nat. Hist. Bull.* **6**: 39-42.
- Hsu, Y.C., 1936-37. The mayflies of China (Order Ephemeroptera). *Peking Nat. Hist. Bull.* **11**: 287-296, 433-440.
- Hsu, Y.C., 1937-38. The mayflies of China (Order Ephemeroptera). *Peking Nat. Hist. Bull.* **12**: 53-56.
- Imanishi, K., 1940. Ephemeroptera of Manchoukuo, Inner Mongolia, and Chosen. *Rep. Limnol. Sur. Kwant. Manch.* pp. 169-263 (in Japanese).
- Kuroda, T., T. Fujimoto, and N.C. Watanabe, 1984. Longitudinal distribution and life cycle of the three species of *Ephemera* in the Kazuradani River, Kagawa Prefecture. *Kagawa Seibutsu* **12**: 15-21 (in Japanese).
- Lee, S.J., I.B. Yoon, and Y.J. Bae, 1995. Altitudinal distribution of *Ephemera strigata* and *E. orientalis* in Sudong Cr., Kyonggi-do. *Korean J. Entomol.* (in Korean). (in press).
- McCafferty, W.P., 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. *Trans. Am. Entomol. Soc.* **101**: 447-504.
- McCafferty, W.P., 1991. Toward a phylogenetic classification of the Ephemeroptera (Insecta): A commentary on systematics. *Ann. Entomol. Soc. Am.* **84**: 343-360.
- McLachlan, R., 1875. A sketch of our present knowledge of the neuropterous fauna of Japan. *Trans. Entomol. Soc. London*, pp. 167-190.
- Tshernova, O.A., 1973. On Palearctic species of mayflies of the genus *Ephemera* L. (Ephemeroptera, Ephemeridae). *Entomol. Obozr.* **52**: 324-339 (in Russian).
- Tshernova, O.A., N. Yu. Kluge, N.D. Sinitshenkova, and V.V. Belov, 1986. 5. Order Ephemeroptera. *In: Identification of Insects of Far East USSR* (ed. P. A. Lera). **1**: 99-142 (in Russian).
- Watanabe, N.C. 1985. Distribution of *Ephemera* nymphs in Kagawa Prefecture, Japan, in relation to altitude and

gradient. Kagawa Seibutsu 13: 1-7 (in Japanese).

Yoon, I.B. and Y.J. Bae, 1985. The classification of Ephemeroidea in Korea. Entomol. Res. Bull. (Korea) 11: 93-109.

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한국산 하루살이과(곤충강: 하루살이목)의 1신종 가는무늬하루살이의 보고

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요 약

한국산 하루살이과(곤충강: 하루살이목)의 신종인 가는무늬하루살이(*Ephemerella separigata* n. sp.)의 성숙유충과 암·수성충을 기재하였다. 본 신종은 7-9 배마디등판에 한쌍의 세로줄무늬가 매우 가늘고, 각자 옆쪽 가장자리로 치우쳐 있어서 하루살이속의 다른 종들과 구별된다. 본 종의 유충은 수온이 상대적으로 낮은 산간 계류(고도 500-700 m)의 모래, 왕모래 및 다량의 자갈이 섞인 하천바닥을 파고 서식한다. 한국산 하루살이 유충의 고도에 따른 서식처 적응에 관하여 간략히 논하였다.