広島大学総合博物館研究報告 Bulletin of the Hiroshima University Museum 8: 53−59, December 25, 2016

資料 Data

Field experiments on chironomid phototaxis at the shore of Lake Kojima, Japan

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Abstract: Phototaxis in response to a variety of lamps, including white and colored fluorescent and LED lamps, was compared by species and sex among the chironomids, from Lake Kojima, Okayama Prefecture, Japan. Males were usually much more attracted to lights than were females. Pantanal white attracted the highest number of species among six white lamps. Among five colored lamps, Blue attracted the highest number and Black the lowest number. Among 5 LED lamps, Blue again attracted the highest number and Amber the lowest number. In terms of the number of individuals attracted, Pantanal white was the highest among white lamps for the seven major species. Green and Blue were the highest for the six and seven major species, respectively, and Yellow and Red did not attract the highest number of individuals of any species among colored lamps. Green LED was the highest among LEDs for the seven major species while Amber and Red LEDs were not the highest for any species.

Keywords: chironomid, lake, LED, mass emergence, phototaxis

Ⅰ. Introduction

Chironomids are widely distributed in the world and some species are well known to emerge in an enormous mass and to be a nuisance (Ali, 1995). In Japan, mass emergence at a nuisance level sometimes becomes a problem on the sides of eutrophic lakes (Kondo et al., 2001). Lake Kojima, Okayama Pref., is one of such eutrophic lakes, and mass emergence has been reported for recent 30 years (Sasa, 1988). On the other hand, such a nuisance is considered to be a result of swarm formation for successful reproduction and successive attraction to strong lights emitted by town areas. Buzzing sound in chironomid swarm has been well studied by Ogawa (1992) and Hirabayashi et al. (1999). However, there are only a few studies on light spectrum of chironomid attraction or nuisance control by light attraction (Ali, 1995). Although insects are reported to distinguish yellow, blue green, blue and UV (Saito et al., 1998), it is not clear which color is the most attractive to chironomids. Besides, differences in attracted light spectrum between sexes or among species have not been clarified yet.

In this study, phototaxis to a variety of lamps comprising some white and colored fluorescent and LED lamps, were compared among chironomid sexes and species emerging from Lake Kojima.

Ⅱ. Materials and Methods

1. Research field

Research was conducted at Miishi on the shore of Lake Kojima, Hachi-hama Town, Tamano City, Okayama Pref., Japan, once in a month in 2008-2010 (Fig. 1)

2. Lights

Six types of white fluorescent lamps (20W): Pantanal white (Sudo, Nagoya), Full white (National, Osaka), Koen-shoku (National, Osaka), Bijutsukan (National, Osaka), Tei-yuchu (National, Osaka) and Shizen-shoku (National, Osaka); 5 types of colored fluorescent lamps (20W; Toshiba, Tokyo): Red (650nm of energy peak in wavelength), Yellow (600nm), Green (530nm), Blue (440nm) and Black (350nm); and five types of LED lamps (equivalent to 20W; Takagi Kogyo, Takamatsu): Red (620nm of energy peak in wavelength), Amber (590nm), Green (520nm), Blue (460nm) and Deep-blue (430nm), were used for comparison.

Lights for ornamental fishes equipped with different lamps were set on the transparent top of the ‘Abutora’ traps (Toyama Kasei, Toyama) (Fig. 2), arranged in a row with an interval of 5m and facing to the lake shore and with a distance of 7m from the lake shore. The arrangements of lights in a row were constant at all

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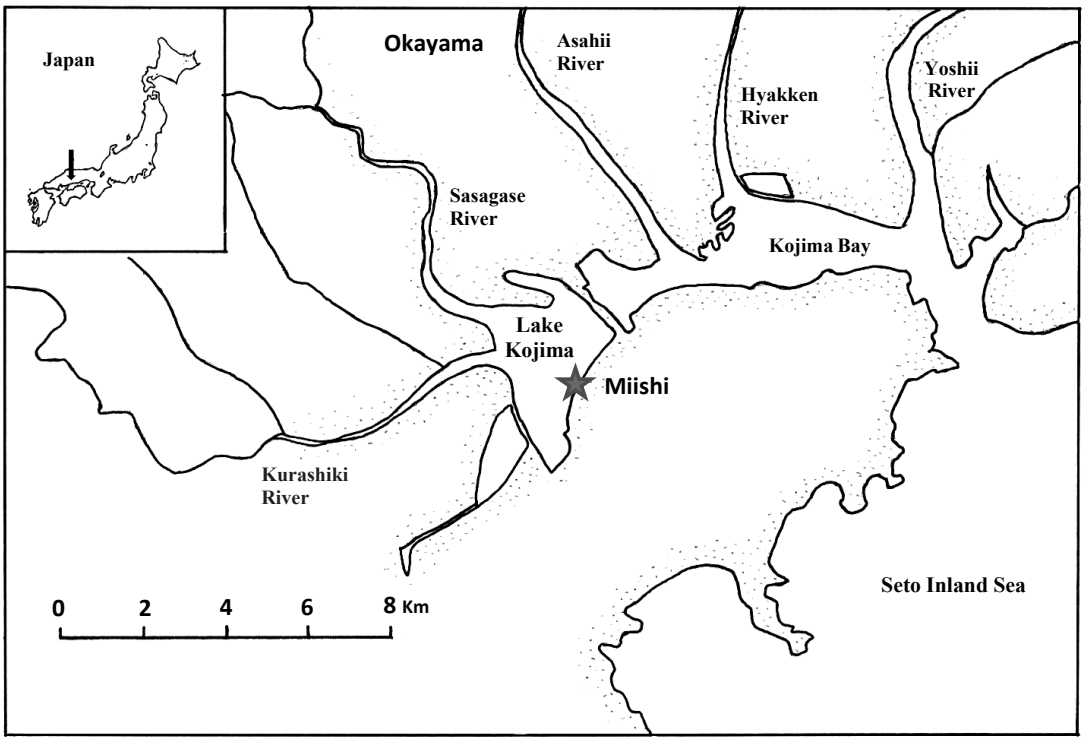

Fig. 1 Map of sampling site on the shore of Lake Kojima.

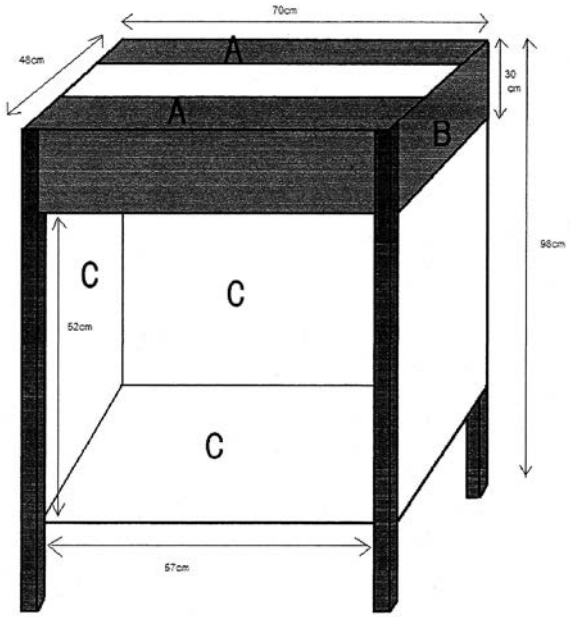

Fig. 2 Structure of a collection box 'Abutora'. Wood plate A is put on the transparent acryl ceiling. Plate B is covered by aluminum foil on the backside for light reflection. Plastic plate C is covered by a reflecting material on the inside.

samplings for each type of lamps.

3. Chironomid collection

Attracted midges in all 5 inner walls of the trap were collected with a sucking tube for 1 hour from a half hour after the sunset by one collector. Collection was performed in June, August, October and December in 2008, monthly from June to November in 2009, and in March in 2010. White fluorescent lamps were used in 2008, colored fluorescent lamps were used in 2008-2010, and LED lamps were used in 2009-2010.

4. Identification

Males were mounted onto the slides according to Sasa (1980), microscopically examined and identified based on Wiederholm (1989), Sasa and Kikuchi (1995) and Yusurika-kenkyukai (2010).

Ⅲ. Results

1. Sex ratio (Table 1)

Males were much more strongly attracted to lights than females for *Propsilocerus akamusi*, *Chironomus plumosus*, *Dicrotendipes pelochloris*, *Einfeldia dissidens*, *Endochironomus pekanus*, *Glyptotendipes tokunagai*, *Lipiniella moderata* and *Nilodorum tainanus*, whereas females were more attracted than males for *Microchirono-*

Table 1 Numbers of males and females collected by white and colored fluorescent, and LED lights. The total number of individuals collected by 4 samplings in 2008 was shown for white lamps, that by 11 samplings during 2008 and 2010 was shown for colored lamps, and that by 7 samplings in 2009 and 2010 was shown for LED lamps.

Species	White lamps		Colored lamps		LED lamps	
	male	female	male	female	male	female
Procladius spp.	0	0	10	7	5	0
Corynoneura cuspis	3	※ND	5	ND	0	0
Cricotopus bicinctus	2	0	0	0	0	0
C. sylvestris	1	0	0	1	0	1
Hydrobaenus kondoi	1	0	0	0	0	0
Limnophyes minimus (LmM)	47	ND	21	ND	0	0
Paralimnophyes sp.	1	ND	0	0	0	0
Propsilocerus akamusi (PpA)	1111	198	1164	1120	161	28
Smittia aterrima (SA)	30	ND	9	ND	0	0
S. pratora	11	ND	1	ND	0	0
Chironomus circumdatus	0	0	5	0	0	1
Chironomus kiiensis (CK)	5	3	19	16	18	9
C. nippodorsalis	0	0	0	6	0	0
C. plumosus (CP)	92	57	505	554	410	417
Dicrotendipes pelochloris (DP)	137	50	212	99	124	59
Einfeldia dissidens (EiD)	36	5	60	11	1	0
Endochironomus pekanus (EnP)	17	3	25	3	1	0
Glyptotendipes fujisecundus	1	0	0	0	0	0
G. tokunagai (GT)	46	9	198	85	206	82
Harnischia cultilamellata	0	0	1	0	0	0
Lipiniella moderata (LpM)	62	7	616	112	399	62
Microchironomus tener (MT)	22	85	23	210	27	135
M. tabarui	1	0	0	0	0	0
Nilodrum tainanus (NT)	387	197	2162	1781	1104	764
Pentapedilum tigrinum (PtT)	59	54	25	48	3	2
Polypedilum cultellatum	1	0	1	0	0	0
P. masudai (PoM)	11	20	39	21	55	24
P. nubifer (PoN)	7	8	29	2	9	3
Tanytarsus oyamai	2	7	2	8	0	0
T. unagiseptimus	1	0	0	0	0	0

※ Not determined.

mus tener and *Tanytarsus oyamai*, and there was no remarkable differences in attractiveness between sexes of *Pentapedilum tigrinum*.

2. Differences in species attracted to various white and colored fluorescent and LED lamps (Table 2)

Among white lamps, Pantanal white was the highest in the number of species and Shizen-shoku was the lowest. Tei-yuchu was the secondly highest in the number of species. Among colored lamps, Blue was the highest and Black was the lowest. *Chironomus circumdatus* was attracted only by Green and Blue lamps. Among LED lamps, Blue was the highest and Amber was the lowest. *C. circumdatus* was also attracted only by Blue lamp.

3. Differences in No. of attracted individuals to various white fluorescent lamps (Fig. 3)

In the number of attracted individuals for major 13 species, Pantanal white was the highest for LmM, PpA, SA, EnP, MT, PtT and PoM. Shizen-shoku was the highest for CP and GT, and Bijutsukan was the highest for DP. Tei-yuchu was usually not so effective in

Table 2 Differences in collected species among 16 different lights. The species collected during 2008 and 2010 were listed.

Species	White						Colored					LED				
	Pantanal	Full White	Koen-shoku	Bijutsukan	Teiyuchu	Shizen-shoku	Black	Blue	Green	Yellow	Red	Deep blue	Blue	Green	Amber	Red
Procladius spp.							○	○	○	○			○			
Corynoneura cuspis				○	○				○	○	○					
Cricotopus bicinctus					○	○										
C. sylvestris			○					○						○		
Hydrobaenus kondoi	○															
Limnophyes minimus	○	○	○	○	○	○	○	○	○	○	○					
Paralimnophyes sp.				○												
Propsilocerus akamusi	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Smittia aterrima	○	○	○	○	○	○		○	○	○	○					
S. pratora	○	○	○	○		○				○						
Chironomus circumdatus								○	○				○			
C. kiiensis	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○
C. nippodorsalis							○									
C. plumosus	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Dicrotendipes pelochloris	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Einfeldia dissidens	○	○	○	○	○	○		○	○	○	○					○
Endochironomus pekanus	○	○		○	○			○	○	○	○		○			
Glyptotendipes fujisecundus					○											
G. tokunagai	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Harnischia cultilamellata											○					
Lipiniella moderata	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Microchironomus tener	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○
M. tabarui	○															
Nilodrum tainanus	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Pentapedilum tigrinum	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
Polypedilum cultellatum			○					○								
P. masudai	○	○	○		○		○	○	○	○	○	○	○	○	○	○
P. nubifer	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
Tanytarsus oyamai		○	○	○			○	○	○							
T. unagiseptimus	○															
No. species	19	17	18	17	18	14	15	20	19	18	17	11	14	12	9	11

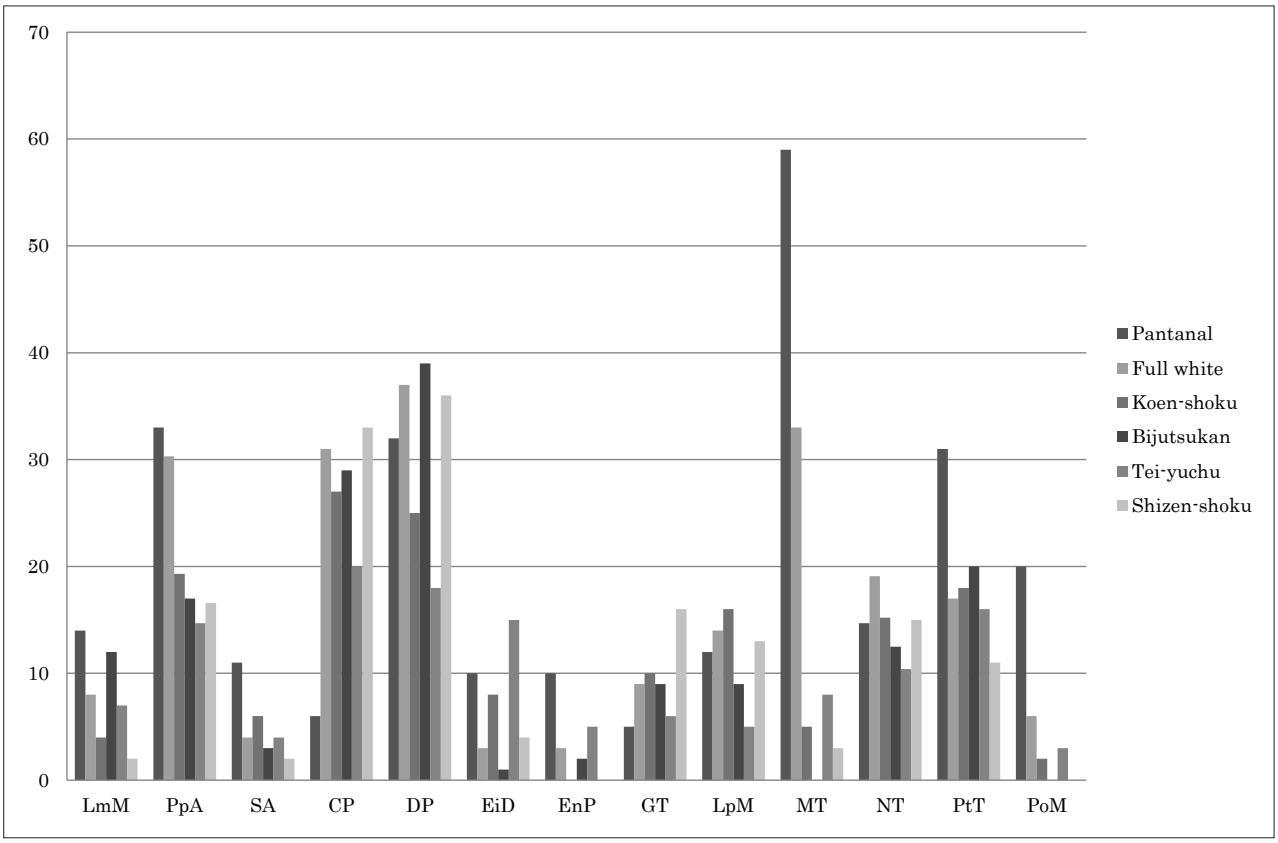

Fig. 3 Number of attracted individuals of major 13 species to various white fluorescent lamps. The total number of individuals collected by 4 samplings in 2008 was shown. The numbers of PpA and NT are to be ×10.

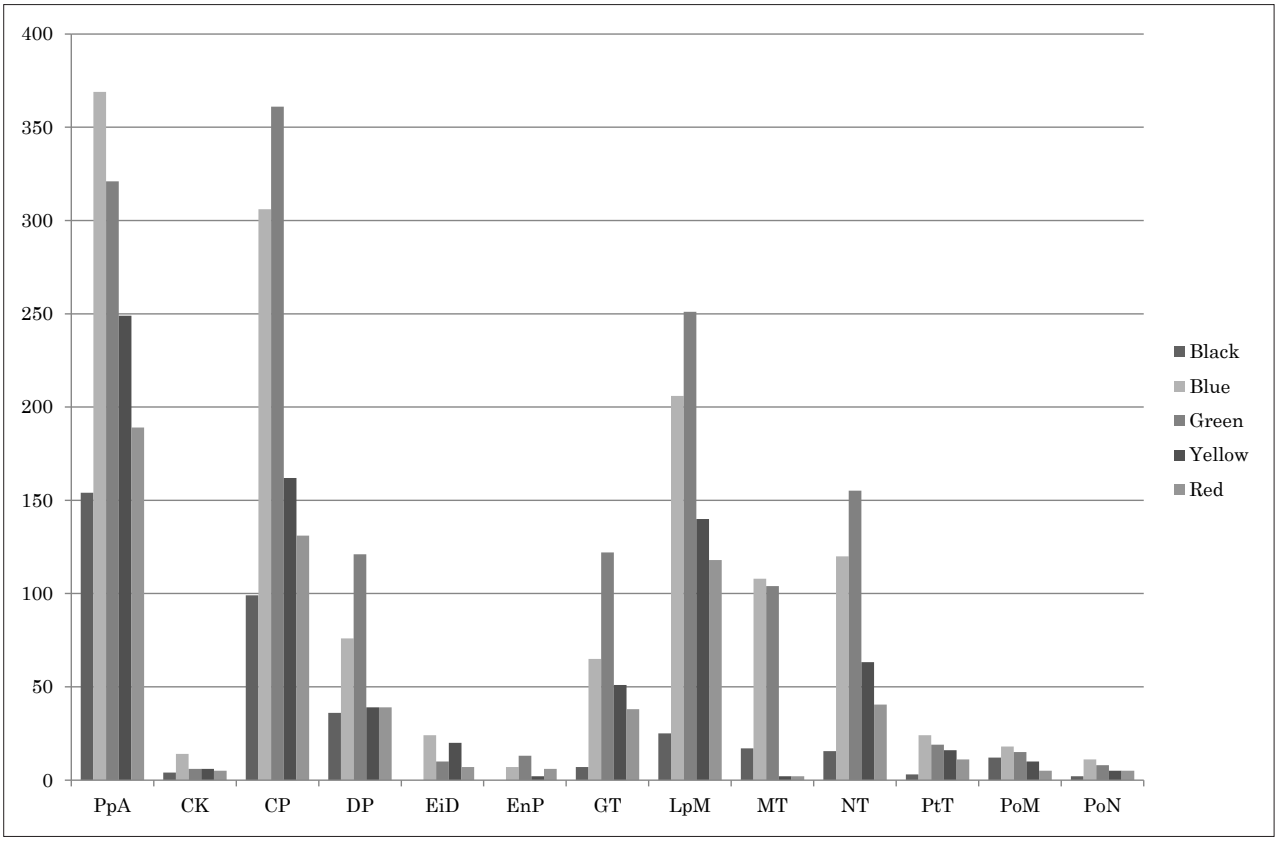

Fig. 4 Number of attracted individuals of major 13 species to various colored fluorescent lamps. The total number of individuals collected by 11 samplings during Jun. 2008 and Mar. 2010 was shown. The number of NT is to be ×10.

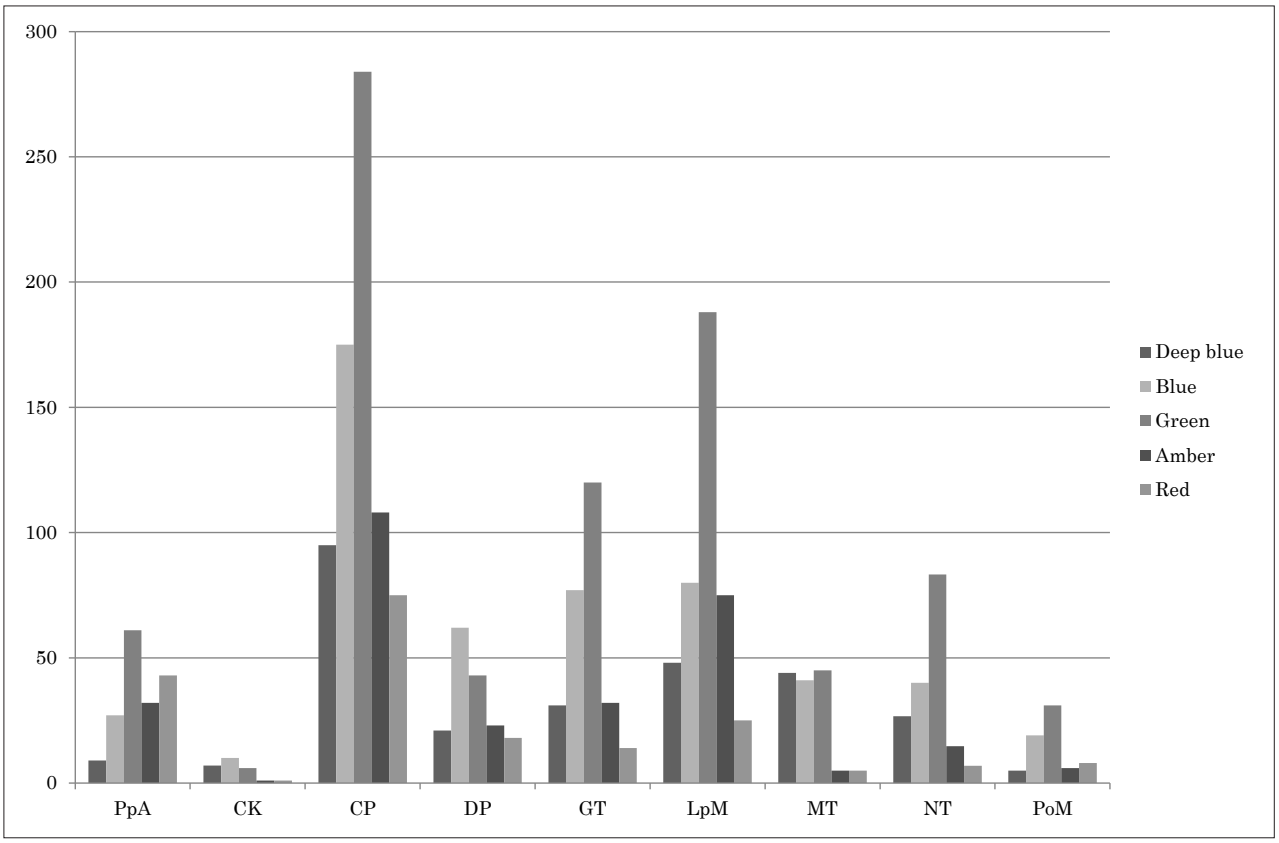

Fig. 5 Number of attracted individuals of major 9 species to various LED lamps. The total number of individuals collected by 7 samplings during Jun. 2009 and Mar. 2010 was shown. The number of NT is to be ×10.

attraction, although it was the most effective in attraction of EiD.

4. Differences in No. of individuals attracted to various colored fluorescent lamps (Fig. 4)

In the number of attracted individuals for major 13 species, Green lamp was by far the highest for CP, DP, EnP, GT, LpM and NT. Blue lamp was the highest for PpA, CK, EiD, MT, PtT, PoM and PoN. Yellow and Red lamps were not the highest for any species.

5. Differences in No. of individuals attracted to various LED lamps (Fig. 5)

In the number of attracted individuals for major 9 species, Green LED was the highest for many species, PpA, CP, GT, LpM, MT, NT and PoM. Blue LED was the highest only for DP. Deep blue, Amber and Red were not the highest for any species. Deep blue, blue and green LEDs were almost equally attractive to MT.

【Acknowledgements】

We are very grateful to our colleagues in the Laboratory of Aquatic Ecology, Hiroshima University, for their kind help, advices and continuous encouragements.

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（2016 年 8 月 31 日受付）
（2016 年 12 月 6 日受理）