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Seasonal Abundance of Biting Midges, *Culicoides* spp. (Diptera: Ceratopogonidae), Collected at Cowsheds in the Southern Part of the Republic of Korea

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Abstract: Black light traps were used to measure the seasonal and geographical distribution of *Culicoides* spp. (biting midges or no-see-ums) at 9 cowsheds in the southern half of the Republic of Korea (ROK) from June through October 2010. A total of 25,242 *Culicoides* females (24,852; 98.5%) and males (390; 1.5%) comprising of 9 species were collected. The most commonly collected species was *Culicoides punctatus* (73.0%) followed by *C. arakawae* (25.7%), while the remaining 7 species accounted for <1.0% of all *Culicoides* spp. collected. The mean number of *Culicoides* spp. collected per trap night (Trap Index [TI]) was highest for *C. punctatus* (409.3), followed by *C. arakawae* (144.2), *C. tainanus* (4.1), *C. oxystoma* (1.2), *C. circumscriptus* (0.7), *C. homotomus* (0.6), *C. erairai* (0.4), *C. kibunensis* (0.3), and *C. nipponensis* (0.04). Peak TIs were observed for *C. punctatus* (1,188.7) and *C. arakawae* (539.0) during July and August, respectively. *C. punctatus* and *C. arakawae* have been implicated in the transmission of arboviruses and other pathogens of veterinary importance that adversely impact on animal and bird husbandry.

Key words: *Culicoides punctatus*, *Culicoides arakawae*, biting midge, seasonal abundance

INTRODUCTION

Members of the genus *Culicoides* Latreille (Diptera: Ceratopogonidae), often referred to as biting midges or no-see-ums, are small (0.5-2.0 mm in length) bloodsucking insects of medical and veterinary importance [1]. *Culicoides* spp. have a broad distribution and impact on human and veterinary health as vectors of viruses (e.g., bluetongue virus, African horse sickness, epizootic hemorrhagic disease of deer, Akabane, Aino, Chuzan, and bovine ephemeral fever), protozoan parasites (e.g. *Haemoproteus* spp. and *Leucocytozoon* spp.), and filarial worms (e.g., *Onchocerca* spp. and *Dipetalonema* spp.) throughout their range [2-10]. In addition, the bites of *Culicoides* often result in extreme annoyance, itching, lesions, and secondary infections that impact on both animal and human health [11,12].

The majority of *Culicoides* spp. records from the Republic of Korea (ROK) were made by foreign researchers from 1918 to 1960 [13-19], with the first nationwide surveys of *Culicoides* spp. reported in the 1970s [20,21]. Currently, 28 described species of *Culicoides* are reported from the ROK [21]. Of these, *C. arakawae* (Arakawa), *C. oxystoma* Kieffer, *C. pulicaris* (L.), *C. actoni* Smith, and *C. obsoletus* (Meigen) have been implicated in the transmission of domestic livestock pathogens [9,22-24].

More recently, Kang and Yu [25] reported on the seasonal abundance and host blood meal analysis of *Culicoides* spp. collected from cattle and poultry farms in Gyeonggi Province. Lee [26] conducted ecological surveys that provided information on the host-seeking activity, host preferences, and seasonal and geographical distributions of *Culicoides* spp. at Incheon Metropolitan City and 12 other localities from 1992-1993. Since 1993, there have been no ecological or epidemiological surveys for *Culicoides* spp. reported in the ROK, even though they transmit pathogens of veterinary importance in the ROK [10].

As part of the vector-borne disease surveillance, the Entomo-

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logy Section, 5th Medical Detachment (MED DET), 168th Multifunctional Medical Battalion, 65th Medical Brigade, in coordination with Kosin University conducted monthly surveys to determine the species composition and seasonal and geographical distributions for *Culicoides* spp. collected at black light traps at cowsheds in the southern part of the ROK.

MATERIALS AND METHODS

Black light traps (model 'Black Hole' by BioTrap, http://www.bio-trap.com), equipped with fine mesh screen nets and two 4-watt black light bulbs as the attractant and dependent upon local electrical sources, were used for surveillance of *Culicoides* spp. at 9 cowsheds distributed throughout Jeongeup (126° 50′ 50.60″ E, 35° 06′ 26.88″ N) in Jeollabuk-do (Province), Damyang (126° 59′ 13.94″ E, 35° 20′ 25.45″ N) and Gurye (127° 27′ 20.74″ E, 35° 12′ 10.80″ N) in Jeollanam-do, Yeongcheon (128° 52′ 18.95″ E, 36° 10′ 30.94″ N) and Gunwi (128° 44′ 08.37″ E, 36° 09′ 58.56″ N) in Gyeongsangbuk-do, Jinju (128° 06′ 02.28″ E, 35° 06′ 26.88″ N), Changnyeong (128° 26′ 33.57″ E, 35° 31′ 17.67″ N) and Yangsan (129° 02′ 53.12″ E, 35° 25′ 11.95″ N) in Gyeongsangnam-do, and Ulju (129° 10′ 22.72″ E, 35° 39′ 21.11″ N) in Ulsan Metropolitan City in the southern part of the ROK (Fig. 1). Black light traps were placed 1.5 m above the ground and operated for one night each month (June-October) from 06:00 p.m. to 08:00 a.m. the following day at each of the 9 cowsheds. Specimens were collected the following morning after each trap night, trap contents transported on dry ice to the 5th MED DET, and *Culicoides* spp. separated and identified using the keys of Arnaud [18] and the checklist of Cho and Chong [21]. Voucher specimens are lodged in the Australian Quarantine and Inspection Service Northern Territory (AQISNT) collection, Darwin, Northern Territory, Australia.

RESULTS

A total of 25,242 *Culicoides* females (24,852; 98.5%) and males (390; 1.5%) comprising 9 species were collected. The most commonly collected species was *Culicoides punctatus* (Meigen) (73.0%), followed by *C. arakawae* (25.7%), *C. tainanus* Kieffer (0.73%), *C. oxystoma* (0.21%), *C. circumscriptus* Kieffer (0.13%), *C. homotomus* Kieffer (0.11%), *C. erairai* Kono and

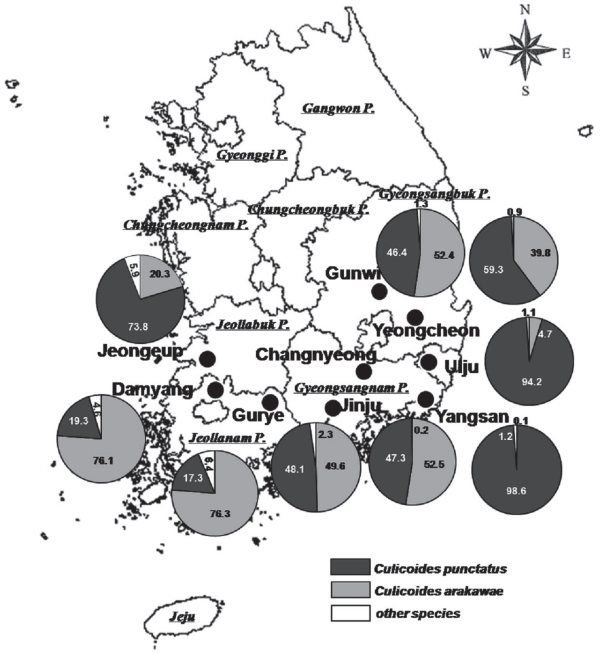

Fig. 1. Surveyed areas and relative proportion of *Culicoides* spp. collected by black light traps in each collection site, Republic of Korea, 2010.

Table 1. Number (%) of *Culicoides* spp. collected from 9 surveyed areas from June to October 2010

Species	Jeongeup	Damyang	Gurye	Gunwi	Yeongcheon	Ulju	Changnyeong	Yangsan	Jinju	Total
Culicoides arakawae	41 (20.3)	83 (76.1)	612 (76.3)	122 (52.4)	4,399 (39.8)	26 (4.7)	480 (52.5)	11 (0.1)	717 (49.6)	6,491 (25.7)
Culicoides circumscriptus	0	0	0	3 (1.3)	24 (0.2)	1 (0.2)	2 (0.2)	0	2 (0.1)	32 (0.1)
Culicoides erairai	0	1 (0.9)	0	0	7 (0.1)	1 (0.2)	0	7 (0.1)	0	16 (<0.1)
Culicoides homotomus	0	0	1 (0.1)	0	0	0	0	0	27 (1.9)	28 (0.1)
Culicoides tainanus	12 (5.9)	1 (0.9)	3 (0.4)	0	51 (0.5)	3 (0.5)	0	114 (1.1)	1 (0.1)	185 (0.7)
Culicoides nipponensis	0	0	0	0	0	0	0	0	2 (0.1)	2 (<0.1)
Culicoides oxystoma	0	3 (2.8)	41 (5.1)	0	7	0	0	2 (<0.1)	0	53 (0.2)
Culicoides kibunensis	0	0	6 (0.7)	0	6 (0.1)	1 (0.2)	0	1 (<0.1)	1 (0.1)	15 (<0.1)
Culicoides punctatus	149 (73.7)	21 (19.3)	139 (17.3)	108 (46.4)	6,547 (59.3)	520 (94.2)	433 (47.3)	9,807 (98.6)	696 (48.1)	18,420 (73.0)
Total	202	109	802	233	11,041	552	915	9,942	1,446	25,242

Table 2. Monthly trap indices of *Culicoides* spp. collected from black light traps at 9 collection sites (cowsheds) in the southern part of the ROK, 2010

Culicoides species	June	July	August	September	October	Trap Index[b]
C. arakawae	21.0[a]	155.9	539.0	4.2	1.1	144.2
C. circumscriptus	0.4	2.4	0.7	0	0	0.7
C. erairai	0.2	0.9	0.7	0	0	0.4
C. homotomus	1.8	1.3	0	0	0	0.6
C. tainanus	0.1	3	14.9	0	2.6	4.1
C. nipponensis	0.1	0	0.1	0	0	<0.1
C. oxystoma	0	0.4	5.3	0	0.1	1.2
C. kibunensis	0.4	0.1	1.1	0	0	0.3
C. punctatus	114.4	1,188.7	622.8	75.7	45.1	409.3
Total	138.4	1,352.7	1,184.6	79.9	48.9	560.8

[a]Monthly trap index = number of each species of biting midges collected per month per trap night.
[b]Total trap index = total number of each species of biting midges collected per trap night.

Takahashi (0.06%), *C. kibunensis* Tokunaga (0.06%), and *C. nipponensis* Tokunaga (< 0.01%) (Table 1). *C. punctatus* was the most frequently collected species at Yangsan and Yeongcheon, and these sites accounted for 53.2% and 35.9% of all *C. punctatus* collected, respectively. *C. arakawae* was the most frequently collected species at Yeongcheon (Gyeongsangbuk-do), Jinju (Gyeongsangnam-do), Gurye (Jeollanam-do), and Changnyeong (Gyeongsangnam-do) and accounted for 67.8%, 11.4%, 9.4%, and 7.4% of all *C. arakawae* collected at these sites, respectively.

Monthly and total trap indices (TIs) (mean number of *Culicoides* spp. collected/trap night) are shown in Table 2. Overall TIs were highest for *C. punctatus* (409.3), followed by *C. arakawae* (144.2), *C. tainanus* (4.1), *C. oxystoma* (1.2), *C. circumscriptus* (0.7), *C. homotomus* (0.6), *C. erairai* (0.4), *C. kibunensis* (0.3), and *C. nipponensis* (0.04) (Table 2). Peak populations of *C. punctatus* and *C. arakawae* were observed during July (TI = 1,188.7) and August (539.0), respectively (Table 2).

The relative proportion of *C. punctatus*, *C. arakawae*, and other *Culicoides* spp. for each site surveyed is shown in Fig. 1. Geographically, collections with the highest proportions of *C. punctatus* were observed at Yangsan (98.6%), Ulju (94.2%), and Jeongeup (73.8%), Yeongcheon (59.3), while at the other surveillance sites the proportions ranged from 17.3% to 48.1%, with the lowest proportions observed at Damyang (19.3%) and Gurye (17.3%), Jeollanam Province. Conversely, the highest proportions of *C. arakawae* were observed at Damyang (76.1%) and Gurye (76.3%).

DISCUSSION

Culicoides species (biting midges) are vectors of both medical and veterinary importance, and as such, may impact on the economy of the animal industry in the ROK. *Culicoides punctatus* and *C. arakawae* were the primary species collected during this study and have been associated with important livestock diseases in other countries, e.g., *Leucocytozoon caulleryi* [21] and fowl pox [27], Fukuoka [28], Aino, and Ibaraki viruses [29,30]. Consequently, surveillance of these and other species of *Culicoides* and the pathogens they transmit are an important part of the veterinary health service to identify relative vector populations, their distributions, and associated pathogen infection rates (reported separately).

The dominance of *C. punctatus* and *C. arakawae* is similar to findings by Lee [26], who reported that *C. punctatus*, *C. arakawae*, and *C. tainanus* were the most commonly collected species at inland sites similar to those in our study. Whereas *C. nipponensis* and *C. sinanoensis*, which were not collected during our survey, were the predominant species collected from the southern coastal and eastern areas in the ROK. However, Kang and Yu [25] found that *C. nipponensis* was the dominant species (975.3/trap/night), followed by *C. punctatus* (misidentified as *C. pulicaris*) (73.5), and *C. arakawae* (38.8) among a total of 13 species collected from a cattle farm in Gyeonggi Province. The disparity from these studies suggests that *Culicoides* populations in the ROK are highly localized and extrapolations between areas must be viewed cautiously.

The dominance of *C. punctatus* around cowsheds agrees with the host preference of this species for cattle [26,29,30]. Although *C. arakawae* appears to have a preference for feeding on birds [31] it also readily feeds on cattle [25,26], which would explain its abundance around cowsheds. Further studies on *Culicoides* spp. geographical and seasonal distributions, host attraction (i.e., placement of traps near human habitation and poultry, cattle, and swine farms) and biting activity, pathogen infection rates, and their role as potential vectors of zoonotic pathogens that impact on human and animal health are warranted. Although limited, these data provide a better understanding of the biology, ecology, and environmental parameters that affect relative population abundance of *Culicoides* spp. that can be used to predict potential human and animal health risks and develop and implement mitigation strategies.

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