

Scientific Note

Distribution and larval habitat characteristics of *Anopheles Hyrcanus* Group and related mosquito species (Diptera: Culicidae) in South Korea

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The *Anopheles Hyrcanus* Group consists of several species that are vectors of malaria and other mosquito-borne diseases in the Oriental and Palearctic Regions. The group has about three-quarters of the species that comprise the Myzorrhynchus Series of genus *Anopheles* Meigen subgenus *Anopheles* in the two regions. It has about 30 species, including two newly described species, *An. belenrae* Rueda and *An. kleini* Rueda (Rueda 2005). In South Korea (Republic of Korea), there are only six known species of the Hyrcanus Group, i.e., *An. sinensis* Wiedemann, *An. sineroides* S. Yamada, *An. lesteri* Baisas and Hu, *An. pullus* M. Yamada (Tanaka et al. 1979), and *An. belenrae* and *An. kleini* (Rueda 2005). Other non-Hyrcanus Group species of *Anopheles* (*Anopheles*) in South Korea are *An. koreicus* Yamaha and Watanabe and *An. lindesayi japonicus* S. Yamada (Tanaka et al. 1979). Because of the limited information about the distribution and larval habitat characteristics of the Hyrcanus Group and its associated species, we conducted this study from 1998-2004 in South Korea.

Anopheles sinensis is considered the most common *Anopheles* species in South Korea (Chai 1999), but its distribution within Korea is not well documented, except in Jeju Province (Kim et al. 2005a). In China, Rueda et al. (2005a) noted the occurrence of this species in eight provinces and one city (Beijing). Adults of *An. sinensis* have been incriminated as the natural and/or experimental malaria (*Plasmodium vivax*) vectors in South Korea (Lee et al. 2002), Japan (Otsuru and Ohmori 1960), China (Ho et al. 1962) and Indonesia (O'Connor 1980). Although it is found in Thailand, *An. sinensis* has minimal or no importance as a malaria vector in that country (Harrison and Scanlon 1975). In South Korea, it was found to be the major vector involved in the transmission of *P. vivax* along the border with North Korea since 1993 (Ree et al. 2001, Kim et al. 2005b).

Anopheles lesteri is a very important vector of malaria in many parts of China (Tang et al. 1991, Gu et al. 1996). In the Philippines, it is not known as a malaria vector (Rueda et al. 2005b). In South Korea, Shin et al. (2002) confirmed that *An. lesteri* was able to carry Korean malaria parasites and they noted its vector competence in that country. However, its status as a primary vector of malaria needs to be investigated because of its low population density compared with *An. sinensis*. Based on a combination of published and newly generated rDNA ITS2 sequences, Wilkerson et al. (2003) found that *An. lesteri* from the Philippines (type locality of *lesteri*) and South Korea, and *An. anthropophagus* Xu and Fen from China are indistinguishable, and placed *An. anthropophagus* in synonymy with *An. lesteri*. Gao et al. (2004) disagreed with Wilkerson et al. (2003) in their "*lesteri*" interpretation because the original type locality (Sta. Mesa, Manila, Philippines) conditions no longer exist and that it is possible that the specimens collected by the latter were not really "*lesteri*" but something else. However, Rueda et al. (2005b) designated and described the neotype of *An. lesteri* from the new type locality (Calauan, Philippines) to clarify and stabilize the taxon. This new type locality is the same place where the "cotypes" of the original *lesteri* were collected in 1936 by Baisas and Hu (1936). According to the International Code of Zoological Nomenclature (ICZN 1999), Article 76.3, page 87, the place of origin of the neotype becomes the type locality of the species-group taxon, despite any previously published statement of the type locality.

Anopheles pullus is a known malaria vector in South Korea (Shin et al. 2002). Hong⁶ initially confirmed the presence of sporozoites of *P. vivax* from wild adult females and oocysts from experimental infections of *An. pullus* in Korea. *Anopheles belenrae* and *An. kleini* have been recently

Keyword Index: Mosquitoes, *Anopheles*, Hyrcanus Group, malaria, Diptera, Culicidae, Korea.

⁶Hong, H.K. 1977. Ecological studies on Korean mosquitoes mainly found in human habitation (in Korean). Unpublished Ph.D. thesis, Tongkook Univ., South Korea.

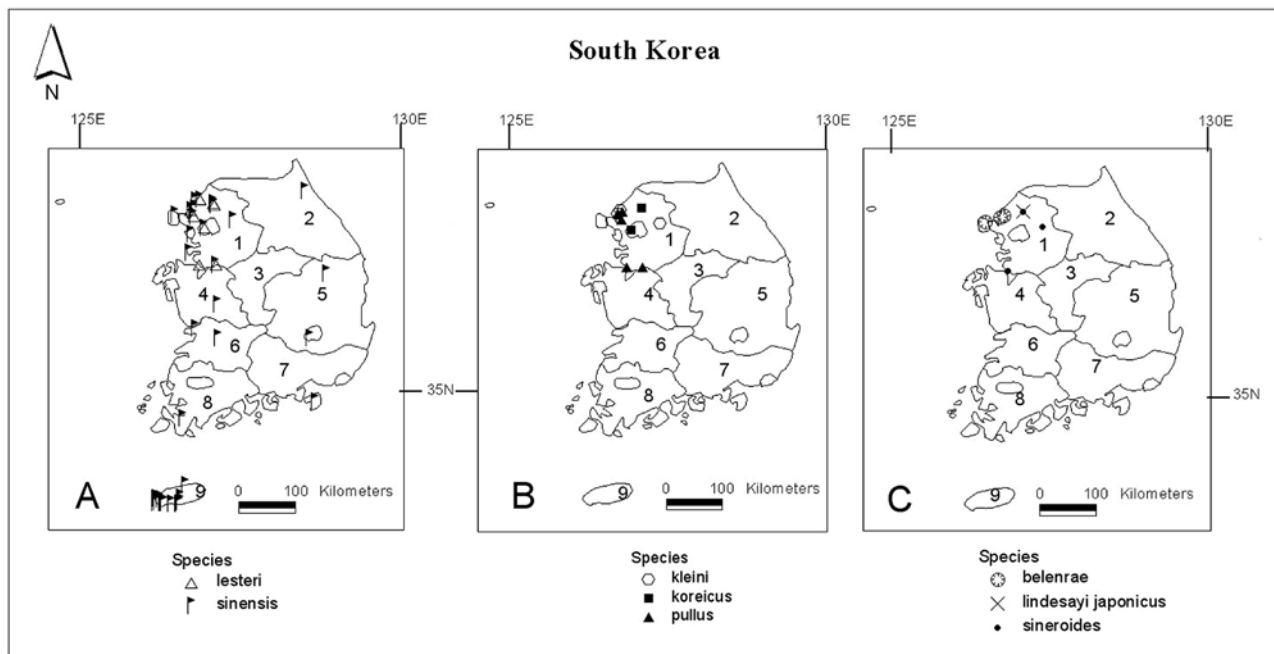


Figure 1. Collection sites of *Anopheles* mosquitoes in South Korea. A. *An. lesteri* and *An. sinensis*. B. *An. kleini*, *An. koreicus*, and *An. pullus*. C. *An. belenrae*, *An. lindesayi japonicus*, and *An. sineroides*. Province Identification: (1) Gyeonggi, (2) Gangwon, (3) Chungcheongbuk, (4) Chungcheongnam, (5) Gyeongsangbuk, (6) Jeollabuk, (7) Gyeongsangnam, (8) Jeollanam, and (9) Jeju.

described from reared specimens whose original parents were collected from cowsheds (Rueda 2005). Their biting behavior, larval habitats, and medical importance are unknown. *Anopheles sineroides*, *An. koreicus*, and *An. lindesayi japonicus* are also non-malaria vectors in Korea and Japan (Tanaka et al. 1979).

We collected mosquitoes from 204 locations in South Korea from 1998-2004. This resulted in 2,804 individually reared pinned adults, 782 individually reared adults, and 155 larvae preserved in 100% ethyl alcohol for molecular tests, and 3,644 exuviae of larvae and pupae and whole larvae. *Anopheles* adults, particularly those fully engorged with blood, were collected from cattle sheds, allowed to lay eggs, and then reared for larvae, pupae, and adults. We initially targeted larval collections from habitats where *Anopheles* mosquitoes were likely to be found. Larvae and pupae from various habitats were collected using dippers and individually reared to the adult stage (Walter Reed Biosystematics Unit 2001). Larval and pupal skins were preserved in 80% ethyl alcohol and slide mounted using standard protocols. Emerged adults were pinned, labeled with appropriate collection data, and identified. Some adults and whole larvae were separately preserved in 100% ethyl alcohol for molecular analysis. Adult specimens and associated larval/pupal exuviae were identified using characters in Tanaka et al. (1979), and confirmed using rDNA ITS2-based method (Wilkerson et al. 2003, Li et al. 2005). Voucher specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Figure 1 shows the collection sites of eight *Anopheles* species from South Korea. We collected specimens of *An.*

sinensis from different provinces throughout South Korea, except Chungcheongbuk-do, and *An. pullus* from Gyeonggi-do and Gyeongsangbuk-do. *Anopheles lesteri*, *An. belenrae*, *An. kleini*, *An. koreicus*, and *An. lindesayi japonicus* were found only in Gyeonggi-do. Based on both our collection data and published records (Table 1), all eight species were found in Gyeonggi-do, four in Jeju-do, three in Gyeongsangbuk-do and one each in Chungcheongnam-do, Gyeongsangnam-do, Gangwon-do, Jeollabuk-do, and Jeollanam-do. No *Anopheles* species have been reported in Chungcheongbuk-do.

Table 2 shows the summary of collection localities and larval habitats for eight *Anopheles* species in South Korea. Adults of *Anopheles* species that were collected resting in cow barns or attracted to Centers for Disease Control (CDC) light traps also were recorded. Larvae of *An. sinensis* were collected from various habitats either alone or in association with the following *Aedes* or *Culex* species: *Cx. (Culex) tritaneorhynchus* Giles larvae (in rice fields, irrigation and roadside ditches, marsh and drainage areas, ground pits, and ground and drain pools at Gyeonggi-do, Gangwon-do, and Jeju-do); *Cx. (Lophoceraomyia) infantulus* Edwards (roadside ditches at Gyeonggi-do); *Cx. (Cux.) orientalis* Edwards, *Cx. (Cux.) mimeticus* Noe, *Cx. (Cux.) pipiens pallens* Coquillett and *Cx. (Eumelanomyia) hayashii hayashii* Yamada (stream pools at Gyeonggi-do); *Cx. (Neoculex) rubensis* Sasa and Takahashi (roadside ditches at Gyeongsangbuk-do), *Aedes (Aedimorphus) vexans* (Meigen) (marshy ground depressions, drain pools, roadside ditches at Gyeongsangbuk-do), and *Ae. (Finlaya) koreicus* (Edwards) (garden ponds, water drums at Gyeongsangbuk-do). Aside from *An. sinensis*,

Table 1. Larvae, pupae, and adults of *Anopheles* species previously recorded from seven provinces of South Korea.

Species	Provinces*							
	CH	GA	GB	GE	GN	JE	JO	JU
<i>An. belenrae</i>	-	-	-	R, X**	-	-	-	-
<i>An. kleini</i>	-	-	-	R, X	-	-	-	-
<i>An. koreicus</i>	-	-	-	T, X	-	-	-	-
<i>An. lesteri</i>	-	-	-	C, X	-	-	-	K, T
<i>An. lindesayi japonicus</i>	-	-	-	X	-	-	-	L, T
<i>An. pullus</i>	-	-	T, X	C, H, T, X	-	-	-	-
<i>An. sinensis</i>	T, X	T, X	X	C, T, X	X	W, X	X	K, L, X
<i>An. sineroides</i>	-	-	T	T, X	-	-	-	L, T

*Provinces: CH (Chungcheongnam), GA (Gangwon), GE (Gyeonggi), GB (Gyeongsangbuk), GN Gyeongsangnam), JE (Jeollabuk), JO (Jeollanam), JU (Jeju).

**References: C (Claborn et al. 2002), H (Shin and Hong 2001), K (Kim et al. 2005b), L (Lee 1994), R (Rueda 2005); S (Shin et al. 2002), T (Tanaka et al. 1979), W (Whang et al. 2002), X (this survey).

no *Anopheles* species were collected from any larval habitats in association with *Aedes* or *Culex* species. The taxonomic classification used in this paper follows that of Knight and Stone (1977).

Table 3 shows the number and frequency of the environmental conditions for five *Anopheles* species (*An. lesteri*, *An. pullus*, *An. sinensis*, *An. sineroides*, and *An. koreicus*) from larval collections in four provinces in South Korea. Villages with rice fields and rural parks (43%) had the greatest number of positive larval habitats of *Anopheles*, followed by military camps (38%). About 30% of positive larval habitats had algae and 98% with vegetation. Among habitats with vegetation, 31% had submerged plants and 29% had emergent and submerged plants. Habitats with clear, standing water having partial or no plant shade were more frequently positive for larvae (74%) as compared to other habitats. Irrigation and other ditches (29%), stream pools (20%), ponds (10%), rice fields and/or swamp drainage areas (8%), and ground and/or drain pools (8%) were common habitats of mosquito larvae during our survey.

Our findings on *Anopheles* distribution and larval habitat characteristics will be of interest to preventive medicine personnel, public health workers, and others tasked with malaria vector control in South Korea.

Acknowledgments

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official or reflecting the views of the Department of the Army or the Department of Defense.

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Table 2. Summary of collection localities and larval habitats for eight *Anopheles* species in South Korea (1998-2004).

Province	Locality	Grid Coordinates		Collection Date	Habitat type*	Collection No.	Stage	<i>Anopheles</i> Species
		Latitude	Longitude					
Chungcheongnam-do	Shingyo-ri, Bujeok-myeon, Nonsan-si	36° 07' 29" N	127° 06' 00" E	5 Aug 2003	RC ¹	KS 03-4 (1-8)	Adult	<i>sinensis</i>
Gangwon-do	Sokcho-si	38° 08' 30" N	128° 35' 34" E	16, 21 Jun 2001	RC	KS 4 (1)	Adult	<i>sinensis</i>
Gyeonggi-do	Dongducheon-si, Kyungi, Korean Trng. Ctr.	37° 32' 59" N	126° 55' 48" E	Sep 1999	SP, RR	KS 005, 006	Larva	<i>sinensis, koreicus, lesteri</i>
Gyeonggi-do	Dongducheon-si, Camp Casey	37° 54' 15" N	127° 05' 23" E	26 Jul 2002	RC	KS 02-5(1-5)	Adult	<i>koreicus</i>
Gyeonggi-do	Gunnae-myeon, Paju-si, Camp Greaves	37° 58' 12" N	126° 47' 59" E	21, 26 Jun 2001	RC	KS 5-1, 7(1)	Adult	<i>sinensis</i>
Gyeonggi-do	Gunnae-myeon, Paju-si, Camp Greaves	37° 58' 12" N	126° 47' 59" E	22 Jun 2001	MG	KS 6	Larva	<i>sinensis</i>
Gyeonggi-do	Cheongpyeong	37° 39' 59" N	127° 23' 11" E	2 Aug 2002	RC	KS 02-6(2)	Adult	<i>kleini</i>
Gyeonggi-do	Cheongpyeong	37° 39' 59" N	127° 23' 11" E	2 Aug 2002	RC	KS 02-6(1, 3, 5)	Adult	<i>sinensis</i>
Gyeonggi-do	Cheongpyeong	37° 39' 59" N	127° 23' 11" E	2 Aug 2002	RC	KS 02-6(4, 6)	Adult	<i>sineroides</i>
Gyeonggi-do	Dongducheon-si, Camp Casey	37° 54' 15" N	127° 05' 23" E	30 Sep 1999 Sep, 20 Oct 1999	RD, SP	KS 008, 010	Larva	<i>sinensis, lesteri</i>
Gyeonggi-do	Dongducheon-si, Camp Casey	37° 54' 15" N	127° 05' 23" E	Sep 1999	GT	KS 013	Larva	<i>sinensis, lesteri</i>
Gyeonggi-do	Gunnae-myeon, Paju-si, Camp Greaves	37° 55' 35" N	127° 04' 13" E	Sep 1999	SM	KS 007	Larva	<i>sinensis, lesteri</i>
Gyeonggi-do	Dongducheon-si, CP Hovey	37° 54' 15" N	127° 05' 21" E	29, 30 Sep 1999	RC	KS 014 (1, 3)	Adult	<i>lindesayi japonicus, sinensis</i>
Gyeonggi-do	Dongducheon-si, Cp Hovey	37° 54' 15" N	127° 05' 21" E	30 Sep 1999	RP	KS 012	Larva	<i>sinensis, sineroides, koreicus</i>
Gyeonggi-do	Dongducheon-si, Cp Hovey	37° 54' 15" N	127° 05' 21" E	30 Sep 1999	RP	KS 015	Larva	<i>lesteri</i>
Gyeonggi-do	Anjeong-ri, Pyeongtaek-si, Cp Humphreys	36° 58' 07" N	127° 06' 22" E	20 Oct 1999	PS	KS 015	Larva	<i>pullus</i>
Gyeonggi-do	Anjeong-ri, Pyeongtaek-si, Cp Humphreys	36° 58' 07" N	127° 06' 22" E	20 Oct 1999	PS	KS 015	Larva	<i>pullus</i>
Gyeonggi-do	Anjeong-ri, Pyeongtaek-si, Cp Humphreys	36° 58' 07" N	127° 06' 22" E	20 Oct 1999	PS	KS 015	Larva	<i>pullus</i>
Gyeonggi-do	Ganghwa, Incheon	37° 45' 00" N	126° 29' 00" E	1 Sep 2001	RC	KS 9 (8)	Adult	<i>belenrae</i>
Gyeonggi-do	Ganghwa, Incheon	37° 45' 00" N	126° 29' 00" E	1 Sep 2001	RC	KS 9 (8)	Adult	<i>belenrae</i>
Gyeonggi-do	Ilсан, Goyang-si	37° 41' 12" N	126° 46' 08" E	24 Jul 2003	RC	KS 03-2(7)	Adult	<i>lesteri</i>
Gyeonggi-do	Ilсан, Goyang-si	37° 41' 12" N	126° 46' 08" E	24 Jul 2003	RC	KS 03-2(2, 9)	Adult	<i>pullus</i>
Gyeonggi-do	Ilсан, Goyang-si	37° 41' 12" N	126° 46' 08" E	24 Jul 2003	RC	KS 03-2(3-6, 8)	Adult	<i>sinensis</i>
Gyeonggi-do	Bangchuk-dong, Gyeyang-gu, Incheon	37° 27' 13" N	126° 43' 54" E	8 Sep 2001	RC	KS 10 (1-6)	Adult	<i>sinensis</i>

Table 2. Continued.

Province	Locality	Grid Coordinates		Collection Date	Habitat type*	Collection No.	Stage	Anopheles Species
		Latitude	Longitude					
Gyeonggi-do	Majeong-ri, Munsan-up, Paju-si Manwoo-ri, Thanhun-myeon, Paju-si	37° 52' 46" N	126° 45' 31" E	5 Jun 2004	RC	KS 04-2 (1, 17)	Adult	<i>kleini</i>
Gyeonggi-do	Manwoo-ri, Thanhun-myeon, Paju-si	36° 58' 00" N	126° 51' 00" E	2 Jun 2003	RC	KS 03-1(9, 10)	Adult	<i>lesteri</i>
Gyeonggi-do	Manwoo-ri, Thanhun-myeon, Paju-si	36° 58' 00" N	126° 51' 00" E	2 Jun 2003	RC	KS 03-1(1-8, 11, 12), 2(1, 10)	Adult	<i>pullus</i>
Gyeonggi-do	Manwoo-ri, Thanhun-myeon, Paju-si	36° 58' 00" N	126° 51' 00" E	2 Jun 2003	RC	KS 03-1(13)	Adult	<i>sineroides</i>
Gyeonggi-do	near Panmunjeom	37° 59' 14" N	126° 51' 22" E	25 Jul 1998	ID	KS 1	Larva	<i>sinensis</i>
Gyeonggi-do	near Panmunjeom	37° 59' 14" N	126° 51' 22" E	25 Jul 1998	RD, WC	KS 2-4	Larva	<i>sinensis</i>
Gyeonggi-do	near Panmunjeom	37° 59' 14" N	126° 51' 22" E	Sep 1999	SP	KS 002-004	Larva	<i>sinensis, lesteri</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	29 Jul 2001	RC	KS 8 (12)	Adult	<i>belenrae</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	14 Apr 2002	RC	KS 02-1(6)	Adult	<i>kleini</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	14 Apr 2002	RC	KS 02-1(3)	Adult	<i>lesteri</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	14 Apr 2002	RC	KS 02-1(1), (2)	Adult	<i>pullus</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	22 Jul 2002	RC	KS 02-3(2-4, 6, 7)	Adult	<i>pullus</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	29 Jul 2001	RC	KS 8 (10, 16, 31), KS 8 (35, 39, 42), KS 8 (48, 51, 57, 59), KS 8 (62, 76, 86, 88), KS 8 (96, 104, 107), KS 8 (111, 113, 124, 130)	Adult	<i>pullus</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	14 Apr 2002	RC	KS 02-1(4, 5, 7, 8), KS 02-3(1, 5)	Adult	<i>sinensis</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	29 Jul 2001	RC	KS 8 (1)	Adult	<i>sinensis</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	29 Jul 2001	RC	KS 8 (5, 20, 27, 45, 67, 77), KS 8 (94, 140, 143, 145)	Adult	<i>sinensis</i>
Gyeonggi-do	Ogeum-ri, Thanhun-myeon, Paju-si	37° 49' 00" N	126° 43' 00" E	14 Apr 2002	RC	KS 02-2(2)	Adult	<i>sinensis</i>
Gyeonggi-do	Tongilchon, Paju-si, Sokcho	37° 51' 00" N	126° 42' 00" E	12 Jul 2001	RC	KS 7 (27)	Adult	<i>belenrae</i>
Gyeonggi-do	Tongilchon, Paju-si, Tongilchon	37° 51' 00" N	126° 47' 00" E	26 Jun 2001	RC	KS 7 (6, 8)	Adult	<i>pullus</i>
Gyeonggi-do	Tongilchon, Paju-si, Tongilchon	37° 51' 00" N	126° 47' 00" E	26 Jun 2001	RC	KS 7 (5, 7, 9-14, 16, 17, 19),	Adult	<i>sinensis</i>

Table 2. Continued.

Province	Locality	Grid Coordinates		Collection Date	Habitat type*	Collection No.	Stage	Anopheles Species
		Latitude	Longitude					
Gyeonggangbuk-do	Taegu, Cp Carrol	35° 49' 00" N	128° 35' 00" E	22 Jul 2003	GP, RD	KS 7 (22-25, 28-30, 32-40)	Larva	<i>sinensis</i>
Gyeonggangbuk-do	Taegu, Apsan Park Sacheon-ri, Dansa-myeon, Geoje Is., Yeongju-si	35° 49' 36" N	128° 05' 24" E	18 Jul 2003	GD, WP	KS 59	Larva	<i>sinensis</i>
Gyeonggangnam-do		37° 57' 00" N	128° 49' 29" E	29 Jun 2004	LT	KS 04 (1-5)	Adult	<i>sinensis</i>
Jeju-do	Andeok-myeon, Namjeju-gun	33° 15' 04" N	126° 18' 11" E	22 Sep 2003	ID	KS 93	Larva	<i>sinensis</i>
Jeju-do	Andeok-myeon, Namjeju-gun	33° 15' 02" N	126° 19' 00" E	24 Sep 2003	GD	KS 99	Larva	<i>sinensis</i>
Jeju-do	Andeok-myeon, Namjeju-gun	33° 15' 04" N	126° 18' 11" E	22 Sep 2003	RC	KS 105	Adult	<i>sinensis</i>
Jeju-do	Chocheon-eup, Bukjeju-gun	33° 31' 37" N	126° 38' 19" E	22 Sep 2003	SW	KS 140	Larva	<i>sinensis</i>
Jeju-do	Daejeong-eup, Namajeju-gun	33° 14' 49" N	126° 16' 35" E	22 Sep 2003	GD	KS 94	Larva	<i>sinensis</i>
Jeju-do	Daejeong-eup, Namajeju-gun Hangkyeong-myeon, Namjeju- gun	33° 15' 13" N	126° 12' 50" E	22 Sep 2003	GD	KS 95	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 19' 06" N	126° 10' 40" E	8 Jun 2004	ID	KS 96, 119	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 18' 46" N	126° 10' 50" E	8 Jun 2004	ID	KS 120	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 14' 01" N	126° 10' 53" E	8 Jun 2004	ID	KS 121	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 17' 22" N	126° 11' 10" E	11 Jun 2004	ID	KS 136	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 19' 17" N	126° 11' 02" E	11 Jun 2004	GD	KS 137	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 19' 18" N	126° 11' 02" E	11 Jun 2004	RF	KS 138	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 15' 22" N	126° 10' 07" E	11 Jun 2004	ID	KS 139	Larva	<i>sinensis</i>
Jeju-do	Hangkyeong-myeon, Namjeju- gun	33° 21' 30" N	126° 11' 20" E	22 Sep 2003	ID	KS 97	Larva	<i>sinensis</i>
Jeju-do	Namwon-eup, Namjeju-gun	33° 19' 45" N	126° 33' 29" E	22 Sep 2003	LT ID, GT,	KS 146	Adult	<i>sinensis</i>
Jeju-do	Seogwipo-si	33° 14' 37" N	126° 32' 16" E	19 Sep 2003	MG	KS 80, 81, 135	Larva	<i>sinensis</i>
Jeju-do	Seogwipo-si	33° 14' 30" N	126° 25' 16" E	26 Sep 2003	GP	KS 102	Larva	<i>sinensis</i>
Jeju-do	Seogwipo-si	33° 16' 05" N	126° 33' 29" E	26 Sep 2003	LT	KS 147	Adult	<i>sinensis</i>
Jeju-do	Seogwipo-si	33° 14' 24" N	126° 32' 44" E	19 Sep 2003	GP	KS 83	Larva	<i>sinensis</i>
Jeollanam-do	Haenan	34° 34' 27" N	126° 35' 51" E	4 Aug 2003	RC	KS 03-3(1-6)	Adult	<i>sinensis</i>
Jeollabuk-do	Jeonju	35° 49' 19" N	127° 8' 56" E	26 Jul 2002	RC	KS 02-4(1-5)	Adult	<i>sinensis</i>
Jeollabuk-do	Kunsan	35° 58' 43" N	126° 47' 41" E	2 Aug 2002	RC	KS 02-7(1-6)	Adult	<i>sinensis</i>
Jeollabuk-do	Nonsan-si	36° 07' 29" N	127° 06' 00" E	5 Aug 2003	RC	KS 03-4(1-8)	Adult	<i>sinensis</i>

*GD (garden and/or permanent pond, lake), GP (ground and/or drain pool), GT (ground pit), ID (irrigation, roadside and/or drainage ditch), LT (light trap at cowshed), MG (marshy ground depression), RC (resting collection), RF (rice field), RP (rock hole, pool), RR (road rut, track), SM (stream margin), SP (stream pool), SW (stream water drainage), WC (well/cistern), WD (water drum).
 †Adults were collected while resting in cattle barns, usually engorged. They were used as parents for progeny rearing.

Table 3. Characterization of larval habitats positive for five *Anopheles* species from four provinces in South Korea (1998-2004).*

	n	Frequency (%)	Provinces**
Environment			
Military camp	21	38	CH, GE
Swamp	4	7	CH, GE
Urban park	7	13	CH, JU
Village (rice fields, rural park)	24	43	GE, JU
Algae			
Absence	30	70	CH, GE, JU, GA
Presence	13	30	GE, JU, GA
Vegetation			
Absence	1	2	CH, GE, JU
Presence	42	98	CH, GE, JU, GA
Type of vegetation			
Emergent	9	21	CH, GE, JU
Floating	5	12	GE, JU
Submersed	13	31	JU
Emergent and floating	12	29	CH, GE, JU
Emergent and submersed	3	7	GE, JU
Condition of larval habitat			
Clear, standing water with partial or no plant shade	35	74	CH, GE, JU, GA
Clear, slow or moderate flowing water with no plant shade	5	11	GE, JU
Clear, fast flowing water, with partial plant shade	2	4	GE
Turbid, standing water with partial or no plant shade	5	11	CH, GE, JU
Type of larval habitat			
Garden and/or permanent pond	5	10	CH, JU
Ground and/or drain pool	4	8	CH, JU
Ground pit	3	6	GE, JU
Marshy ground depression	1	2	GE, JU
Rice field and/or swamp drainage area	4	8	GE, JU
Irrigation, roadside and/or drainage ditch	15	29	CH, GE, JU
Rock pool	3	6	GE
Road rut/track	2	4	GE
Stream margin	2	4	GE, GA
Stream pool	10	20	GE, GA
Well/cistern	1	2	GE
Water drum	1	2	CH

**Anopheles lesteri*, *An. pullus*, *An. sinensis*, *An. sineroides*, *An. koreicus*.

**Provinces: CH (Chungcheongnam), GE (Gyeonggi), JU (Jeju), GA (Gangwon).

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