



Seasonal phenology and diurnal activity of *Promachus yesonicus* (Diptera: Asilidae), a predator of scarabs, on Korean golf courses



Dong Woon Lee ^a, David R. Smitley ^b, Sang Myeong Lee ^a, Harry K. Kaya ^c, Chung Gyo Park ^d, Ho Yul Choo ^{d,*}

^a Major of Applied Biology, School of Ecological Environment and Tourism, Kyungpook National University, Sangju, Gyeongbuk 742-711, Republic of Korea

^b Department of Entomology, Michigan State University, East Lansing, MI 48824, USA

^c Department of Nematology, University of California, Davis, CA 95616, USA

^d Department of Applied Biology BK21+ Program, College of Agriculture and Life Science, Institute of Agriculture and Life Sciences, Gyeongsang National University, Jinju, Gyeongnam 660-701, Republic of Korea

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ABSTRACT

The robber fly, *Promachus yesonicus*, a predator of scarab adults and larvae was observed on golf clubs in Korea to determine its seasonal activity, daily activity, and relationship to scarab adult activity. *P. yesonicus* adult density varied more than 10-fold among the four golf clubs where it was observed, with the most activity being at golf clubs with the most scarab adults in June and July. At Yongwon Golf Club *P. yesonicus* activity closely tracked *Popillia quadriguttata* activity and both peaked in late June and early July. The ratio of scarab adults (mostly *P. quadriguttata*):*P. yesonicus* adults was 8:1. On average mean of 7.5% of all *P. yesonicus* adults observed in visual surveys were holding captured prey. 50% of all captured prey was a scarab turf pest, *P. quadriguttata*. At Yongwon Golf Club, regression analysis indicates that *P. quadriguttata* activity explains 75% of the variation in activity of *P. yesonicus*. The potential impact of *P. yesonicus* on populations of *P. quadriguttata* and other scarab turf pests is discussed.

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Introduction

The scarab beetles (Melolonthidae and Rutelidae) and their larvae are serious pests on golf courses in Korea and Japan (Yoshida, 1975; Hatsukade, 1995; Lee et al., 1997; Choo et al., 1998; Choi et al., 2001). The adults damage flowers or leaves of ornamental plants, and the larvae consume turfgrass roots (Jackson, 1992; Potter, 1998; Choo et al., 2002a; Lee et al., 2002a,b,c,d). Adults of some species make small mounds around emergence holes on greens which interfere with putting (Lee et al., 1997; Choo et al., 1999). Infestations of scarab larvae may also lead to the secondary turf damage from wild birds searching for them (Choo et al., 2002a; Kim et al., 2009). Because superintendents of Korean golf clubs use insecticides to control scarab beetles and other turf pests, there is a growing concern about the run-off of insecticides into non-target areas and the potential for groundwater contamination (Lee et al., 2002d). In order to reduce insecticide use on golf courses, more information is needed about natural enemies of scarabs that may help suppress populations below a damaging level. In particular, the most important natural enemies and their habits need to be identified, so that golf course superintendents can avoid practices that

would adversely affect natural enemies (Hatsukade, 1995; Potter, 1998; Vittum et al., 1999; Choo et al., 2000, 2002b; Lee et al., 2002d).

One family of natural enemies that may help suppress populations of scarab turf pests in Korea is the robber flies (Asilidae). Three species of robber flies can be found on golf courses in Korea: *P. yesonicus* Bigot, *Cophinopoda chinensis* (Fabricius), and *Philonicus albiceps* (Meigen) (Choo et al., 2000). Of these, *P. yesonicus* is by far the most abundant, and is frequently seen flying with captured adults of scarab turf pests including *P. quadriguttata* (Fabricius), *Exomala orientalis* (Waterhouse), *Adoretus tenuimaculatus* Waterhouse, *Ectinohoplia rufipes* (Motschulsky) and *P. flavosellata* Fairemaire (Choo et al., 2000, Fig. 1). Robber fly larvae in the genus *Promachus* feed on soil-dwelling insects while adults feed on a wide range of flying insects (Kinoshita, 1940; Wei et al., 1995). In a 7-year study of cultivated fields in Henan province, China, Wei et al. (1995) found that the density of scarab larvae in the soil was inversely related to the density of *P. yesonicus* larvae. *P. yesonicus* larvae were also reared in the laboratory and introduced into wheat field plots along with *Anomala antique* Gyll. and *A. corpulenta* Motschulsky larvae, where one *P. yesonicus* larva per 5.0 m² plot consumed 21% of the 30 scarab larvae, and 8 *P. yesonicus* larvae per 5.0 m² consumed 99% of the scarab larvae (Wei et al., 1995).

Although *P. yesonicus* larvae have been shown to control scarab larvae in the soil, and *P. yesonicus* adults to consume adult turf pests, it is not known how closely populations of *P. yesonicus* are related to infestations of scarab beetles because *P. yesonicus* adults are known to feed

* Corresponding author at: Department of Applied Biology, Gyeongsang National University, Jinju, Gyeongnam 660-701, Republic of Korea. Tel.: +82 55 772 1923.

E-mail address: hychoo@gnu.ac.kr (H.Y. Choo).



Fig. 1. Adult *Promachus yesonicus* in connection.

on at least 29 species of insects in 5 families of Coleoptera, Diptera, and Hymenoptera (Kinoshita, 1940). In Hokkaido, Japan, *P. yesonicus* has a 2-year life cycle but in other locations it may have a 1-year life cycle (Kinoshita, 1940; Hatsukade, 1995; Wei et al., 1995). However, very little is known about the life history of *P. yesonicus* in Korea, or its status as a predator of turf pests (Choo et al., 2000).

Because *P. yesonicus* can be potential control agent of major pests, scarab beetles including *P. quadriguttata* in golf courses, parks, and sports grounds planted with turfgrasses, our objectives were to investigate activity and distribution of *P. yesonicus* on golf courses in Korea and to compare with activity of *P. quadriguttata* on golf courses.

Materials and methods

Golf course study sites

Studies were conducted at four Golf Clubs: Anyang Benest Golf Club at Gunpo (37° 35' N, 126° 94' E), Seven Hills Golf Club at Anseong (37° 00' N, 127° 31' E), Glanrose Golf Club at Yongin (37° 29' N, 127° 21' E), and Yongwon Golf Club at Jinhae (35° 00' N, 128° 83' E). Although many Korean golf clubs have a two-green system where each fairway ends in two different greens to speed-up play by golfers (Lee et al., 2007), Anyang Benest Golf Club is an 18-hole golf course on 860 ha with a one-green system. This golf club was constructed in 1971 and is surrounded by homes in lowland hills (80–100 m above sea level). The tees consist of *Festuca arundinacea* Schreb., *Lolium perenne* L., and *Poa pratensis* L.; the fairways and roughs of *Zoysia matrella* (L) Merr.; and the greens of *Agrostis palustris* Huds. Every hole is landscaped with a special type of plant after which the hole is named. Seven Hills Golf Club is a 36-hole golf course on 2311 ha, constructed in 1999 with a one-green system. The fairways roll over low hills 200–400 m above sea level. The tees, fairways, and roughs consist of *Z. japonica* Steud. and the greens consist of *A. palustris* Huds.. Glanrose Golf Club

is a 9-hole public course constructed in 1999 with a two-green system. It is located in a low mountain valley 100–200 m above sea level and is surrounded by recreational lands. The tees, fairways, and roughs consist of *Z. japonica* Steud., and the greens consist of *A. palustris* Huds.. The main ornamental tree is sawtooth oak, *Quercus acutissima* Carruthers. Yongwon Golf Club was opened in 1991 with 27 holes and a two-green system. It lies at an altitude of 80 m on 1750 ha between the sea and cultivated land. The tees consist of *Z. sinica* Hance, the fairways and roughs of *Z. matrella* (L) Merr., and the greens of *A. palustris* Huds.. The dominant ornamental tree is black pine (*Pinus thunbergii* Parlatore).

P. yesonicus adult activity on four golf clubs

In 2000, adult activity of *P. yesonicus* was observed on the tees, greens, fairways and roughs at Anyang Benest, Seven Hills, Glanrose and Yongwon Golf Clubs (Table 1). The first three clubs were sampled every two weeks from July to August and Yongwon was sampled every two weeks from June to August. Observation areas were also marked in the fairway and rough near each of the holes where the tees and greens were observed. Observation areas were chosen to be outside of the most heavily traveled paths of golfers because *P. yesonicus* will fly when disturbed. Observation areas were marked with paint in late May before *P. yesonicus* began to emerge. They varied in size from 358 m² to 2475 m² depending on the length of the hole. On each observation date *P. yesonicus* adults were counted visually while walking the marked area from 10:00 to 12:00 for reduced difference depending on time variation. Identification was confirmed by collecting 5–10 of the observed robber flies with a sweep-net on each sample date for examination under a dissecting microscope. The total number of adults were transformed to mean number of adults observed per 1000 m² on each sampling site of hole, and means \pm SD were determined for the golf club with each hole serving as a replicate (n = 3).

Table 1
Site and date of survey golf club for activity of adult *Promachus yesonicus* at 2001.

Survey golf club	Survey site in golf courses	Date
Anyang Benest	Tee in 10, 12, and 14 hole	7/2, 7/12, 7/31, 8/14, 8/31
Glanrose	Green in 1st, tee in 6th, and rough in 8th hole	7/3, 7/18, 8/1, 8/14, 8/28
Seven Hills	Tee in 1st, and 4th hole of West, and 5th hole of North	7/2, 7/18, 8/1, 8/14, 8/28
Yongwon	Tee in 1st, and 3rd hole of Baeggu, and green of the 1st hole of Baegro	6/5, 6/14, 6/20, 6/27, 7/5, 7/10, 7/13, 7/19

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