A Hister Beetle *Carcinops pumilio* (Erichson) (Insecta: Coleoptera: Histeridae: Dendrophilinae: Paromalini)[1]

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The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.

Introduction

The hister beetle *Carcinops pumilio* (Erichson) is a predator and natural enemy of the pestiferous house fly, *Musca domestica Linnaeus* (Figure 1). *Carcinops pumilio* has a broad world distribution and is associated with wild bird nests and bat guano piles. This species' ability to limit house fly populations in poultry production settings led to its study as an augmentative biological control agent (Bills 1973; Kaufman et al. 2002a, 2002b; Achiano and Giliomee 2005).

Taxonomy and Synonymy

The taxonomic history of this hister beetle is complicated and marked by confusion of the scientific names *Carcinops pumilio* (Erichson) and *Carcinops quattuordecimstriata* (Stephens) that stems from uncertainty surrounding the publication dates of these. *Carcinops pumilio* was originally described in the genus *Paromalus* from a series of specimens collected in Spain, North America, and Egypt (Erichson 1834). The species was transferred to the new genus *Carcinops* by Marseul (1855), and the classification of the species in the genus *Carcinops* was accepted by most subsequent historical authors (Marseul 1862; Gemminger and Harold 1868; Ganglbauer 1899; Lewis 1905; Reitter 1909; Kolbe 1910; Scott 1913; Bickhardt 1910, Bickhardt 1917; Blackwelder 1944).

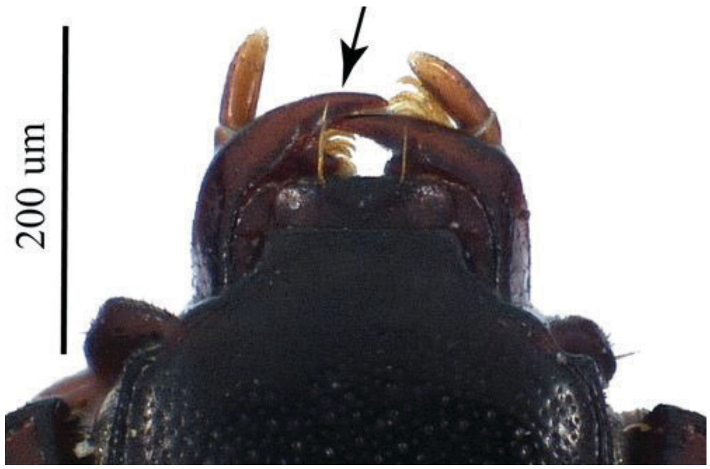

Figure 1. Dorsal view of the head of an adult *Carcinops pumilio*. The arrow indicates the large, sickle-shaped apex of the mandibles.
Credits: Matthew R. Moore, UF/IFAS

However, Stephens's (1835) name *Carcinops quattuordecimstriata*, described from England and referring to the same organism, was considered the senior synonym (i.e., it was thought to be the older name) and the valid name for the species because it was thought to have been described before *Carcinops pumilio* (Erichson). Stephens's (1835) book was published in parts, at separate times, but was labeled as being published in 1832 (see Méquignon 1944; Blackwelder 1949). The pages where *Carcinops quattuordecimstriata* was described were in fact printed in 1835

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(Méquignon 1944; Blackwelder 1949). Once this historical error was discovered, *Carcinops pumilio* was considered the valid scientific name for this hister beetle. A summarized list of synonyms of *Carcinops pumilio* (Erichson) is given below (following Mazur 1997; Bousquet and Laplante 2006; Lackner et al. 2015).

Paromalus pumilio (Erichson, 1834)

Dendrophilus pumilio (Erichson, 1834)

Dendrophilus 14-striatus (Stephens, 1835)

Carcinops 14-striatus (Stephens, 1835)

Carcinops quatuordecimstriata (Stephens, 1835)

Dendrophilus quattuordecimstriatus (Stephens, 1835)

Paromalus quatuordecimstriatus (Stephens, 1835)

Hister nanus (LeConte, 1845)

Phelister nanus (LeConte, 1845)

Epierus krujanensis (Mader, 1921)

Distribution

Carcinops pumilio has a broad world distribution (Figure 2 and Table 1). The association of these beetles with domestic poultry (e.g., chickens and turkey) possibly contributed to their spread across the globe (Legner and Olton 1970). These beetles are also found in the nests of wild birds.

Figure 2. Global distribution of the hister beetle, *Carcinops pumilio* (Erichson). Data are presented at the country-level. Occurrences in solid gray are based on published data from the literature or museum specimen databases. Occurrences in black (Cuba and Mexico) are based on speculation in the literature and online checklists. Grey circles surround the Madeira Archipelago, Azores, Canary Islands, Samoa, Hawaiian Islands, and Seychelles.
Credits: Matthew R. Moore, UF/IFAS; (vector map of the world provided for free by freevectormaps.com (WRLD-EPS-01-0013))

Description

Carcinops pumilio is a holometabolous insect and thus undergoes complete metamorphosis (egg-larva-pupa-adult). Below are descriptions of the life stages of *Carcinops pumilio*.

Eggs

Eggs of *Carcinops pumilio* are elongate and oval. The ends taper, and they have an overall white or cream color (see Achiano and Giliomee 2005 for images of eggs). Completely developed eggs are small. Eggs range from 0.65 mm to 0.92 mm ($< 1/32$ in) in length (Geden and Stoffolano 1987).

Larvae

Larvae newly emerged from the egg are cream-colored, but the head is brown (Achiano and Giliomee 2005). Second instar larvae are about twice as large as the first instar larvae (Achiano and Giliomee 2005) (Figure 3).

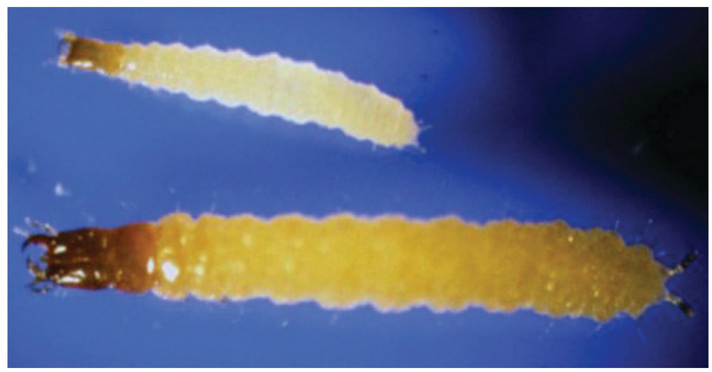

Figure 3. First instar (top) and second instar (bottom) larvae of the hister beetle, *Carcinops pumilio*.
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Pupae

Exarate pupae (pupa with free antennae, wings, and legs) are initially white but later darken to brown and black before adult emergence (see Achiano and Giliomee 2005 for images of pupae).

Adult

Adult *Carcinops pumilio* are small beetles that vary in total length from 1.6–2.7 mm ($\sim 1/16$–$1/8$ in) (Hinton 1945). These black beetles have an oval shape and a glossy cuticle while the legs can be brownish-red (Hinton 1945) (see Figure 1). *Carcinops pumilio* typically has 14 total (7 on each elytron, or wing cover) striations (impressed lines composed of punctures) on the wing covers (Figure 4).

Figure 4. *Carcinops pumilio*, adult specimen. A) View from above. B) Front tibia of the adult. The arrow indicates the characteristic arcuate (curved, bow-like) shape of the front tibia in *Carcinops pumilio*. C) View from the side.
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Life Cycle

Laboratory rearing techniques for *Carcinops pumilio* were investigated due to these beetles' potential use as biological controls of flies in manure. Experiments and observational studies have provided detailed information about the life cycle of *Carcinops pumilio*. *Carcinops pumilio* go through two larval development stages (instars) (Linder 1967; Achiano and Giliomee 2005). Laboratory studies indicate that adult *Carcinops pumilio* will eat an average of 13 house fly eggs per day (Morgan et al. 1983), but this could be an underestimate based on Geden and Axtell (1988) (see section on **Economic Importance**).

Females average 1.8 egg-laying events per day in the lab, but the timing between egg-laying is variable from one to three days (Morgan et al. 1983). Some females can lay eggs from 5 to 12 consecutive days (Morgan et al. 1983). Multiple studies have examined developmental rates of *Carcinops pumilio* (Morgan et al. 1983; Fletcher et al. 1991). At 25.5°C, embryo development within eggs is completed from 2 to 11 days with an average of 6.2 days (Morgan et al. 1983). The larval stage lasts for an average of 15.5 days (Morgan et al. 1983). The pupal stage lasts for an average 17.5 days (Morgan et al. 1983). Total development time from egg to adult is slightly longer for females (42.3 days on average) than males (40 days on average) (Morgan et al. 1983). Fletcher et al. (1991) found a shorter total development time of 34.1 days on average at 25.5°C (77.9°F). The shortest mean total development time of 16.9 days occurred at 32.5°C (90.5°F) (Fletcher et al. 1991). Adult beetles can live for up to two to three years (Linder 1967).

Ecology

Carcinops pumilio beetles are predators of fly eggs and larvae (Figure 5). In natural areas, these beetles have been found in various types of moist organic detritus (wet and decaying plant matter, animal carrion, and animal/human feces) where they can find their immature fly prey (Ganglbauer 1899; Bousquet and Laplante 2006; Bajerlein et al. 2011; Borowski and Mazur 2015). *Carcinops pumilio* have been collected from bird nests and near bat roosts. They have also been collected from the carcasses of birds (Bryan 1926). Data for bird nest associations of *Carcinops pumilio* are summarized for North America (Table 2) and Europe (Table 3).

Figure 5. An example of a caged-layer poultry cage.
Credits: Phillip E. Kaufman, UF/IFAS

Carcinops pumilio has been collected from guano piles of the evening bat (*Nycticeius humeralis* [Rafinesque]) and the little brown bat (*Myotis lucifugus* [LeConte]) (Bernath and Kunz 1981; Whitaker et al. 1991). These beetles can be found near the University of Florida bat houses (Tishechkin 2010a), which serve as roosts for several species of bats (Brazilian free-tailed bats, *Tadarida brasiliensis cynocephala* [LeConte]; southeastern mouse-eared bats, *Myotis austroriparius* [Rhoads]; evening bats) (FLMNH 2016). *Carcinops pumilio* has been collected from underneath tree bark (Arrow 1927) and from inside the terminal shoots of beetle-damaged coniferous trees (Taylor 1928), suggesting dietary or habitat diversity.

Economic Importance

As a biological control agent, *Carcinops pumilio* has attracted research attention due to its voracious appetite for fly pests of poultry production. Research has focused on this hister beetle's life cycle, dietary preferences, ability to disperse as adults, and how it fits into various integrated pest management (IPM) regimes. *Carcinops pumilio* is considered an important biological control agent of house flies (*Musca domestica Linnaeus*) in caged-layer poultry houses (Figure 6 and Figure 7).

Figure 6. Manure pit underneath cage-layer poultry house. The left row of manure has been recently removed. The right row shows poultry manure accumulation.
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Figure 7. Attractant-based Hister House trap. *Carcinops pumilio* are attracted to the bait and enter through the screen on the trap, which is placed in contact with the manure. The screen is fine enough to exclude the omnivorous lesser mealworm, *Alphitobius diaperinus* (Panzer).
Credits: Phillip E. Kaufman, UF/IFAS

Modern, high-density poultry production results in the buildup of manure in pits underneath hen cages. Accumulated manure can be stored for long periods depending on the style of the cage unit used by producers (Figure 7). For example, South African poultry producers can allow manure to accumulate for 2–3 years underneath two-storied cage units before the collection pit is cleaned out (Achiano and Giliomee 2006a). These conditions are excellent for fly development if manure moisture is not minimized.

House flies are the major pest of high-density caged-layer poultry production. In this system, house flies will lay their eggs on the accumulating manure. This is particularly problematic after manure removal has occurred when newly accumulating manure remains very wet. Compounding the challenge of large numbers of eggs being laid are that biological control agents are limited in abundance, largely having been removed with the manure during cleanout. Without proper management (introduced biological control or pesticide applications), fly populations can reach pestiferous levels within two or three weeks. When adult house fly numbers are high, a portion of the fly population may disperse from the poultry facility and accumulate at nearby residential areas, potentially causing conflict at this agricultural-urban interface. To prevent this occurrence, poultry producers actively manage the manure accumulations, including the proactive use of biological control agents such as purchased parasitoid wasps and the within-farm transfer (between poultry buildings) of *Carcinops pumilio*.

A single *Carcinops pumilio* individual can consume over 100 fly eggs and maggots per day depending on temperature (Geden and Axtell 1988). These beetles are considered effective biological control agents of flies in poultry production due to their high rate of fly predation. Manure pit conditions, such as temperature, the age of manure, and manure water content, can influence whether these hister beetles can establish.

All life stages of *Carcinops pumilio* can be found in poultry manure with moisture content between 55% and 80% (Achiano and Giliomee 2006a). First instar larvae are more common in manure with a 55% to 60% moisture content (Achiano and Giliomee 2006a). Second instars and adult beetles are more common in manure with moisture contents between 70% and 75% (Achiano and Giliomee 2006a). These beetles are commonly encountered in manure pits between 21°C and 27°C (69.8°F and 80.6°F) (Achiano and Giliomee 2006a). Poultry producers can enhance populations of *Carcinops pumilio* by keeping manure pits relatively dry and free from sources of excess water (Bills 1973; Achiano and Giliomee 2006a).

Studies have examined whether various IPM regimes for control of house flies can negatively affect beneficial *Carcinops pumilio*. For example, poultry houses treated with *Beauveria bassiana* (a fungal pathogen of house flies) were better able to maintain their populations of *Carcinops pumilio* versus those treated with pyrethrin-based insecticides for control of house flies (Kaufman et al. 2005). Poultry producers sometimes capture *Carcinops pumilio* in their facilities and move them to areas where they are absent or in low numbers.

Black-light trapping (better from March to June) and attractant-based traps (better from June to August) are both effective for collecting *Carcinops pumilio* for this purpose (Kaufman et al. 2002a, b) (Figure 8). However, beetles collected with attractant-based traps may be in better condition than those collected with black-lights (Kaufman et al. 2001a). Populations of *Carcinops pumilio* augmented with attractant-based traps collected individuals that will likely grow more quickly than those augmented with black-light trapped individuals (Kaufman et al. 2001a). Black-light captured *Carcinops pumilio* are hypothesized to be in a state of active dispersal away from an area due to high beetle density or lack of prey and may not stay in the area where released (Kaufman et al. 2000).

Figure 8. Manure pit under a cage-layered poultry house. The mesh bags hanging from the rafters contained the parasitoid wasp *Muscidifurax raptorellus* for release as augmentative biological control agents of house flies.
Credits: Phillip E. Kaufman, UF/IFAS

Alternatively, *Carcinops pumilio* that have an active and sufficient food source tend not to fly and disperse away from an area (Achiano and Giliomee 2008). These trapping strategies for augmentative biological control can both be employed in different situations. Poultry houses with newly cleaned manure pits may benefit from the release of black-light captured beetles that will readily disperse throughout a facility (Kaufman et al. 2000). Beetles captured with attractant-based traps should be released in areas of the poultry house with already active fly population growth for maximum effect (Kaufman et al. 2000).

Rearing *Carcinops pumilio* in sufficient numbers for augmentative biological control releases is not possible. The primary impediment is that these beetles attack each other at high densities (Geden and Stoffolano 1987). Adults will attack larvae (Achiano and Giliomee 2006a) and larvae will attack other larvae (Geden and Stoffolano 1987) when crowded. Laboratory colonies of *Carcinops pumilio* reared on artificial protein diets laid significantly fewer eggs, had a prolonged development time, and had slower rates of egg laying (Achiano and Giliomee 2006b). *Carcinops pumilio* can be reared on the larvae of the fruit fly *Drosophila melanogaster* Meigen (Achiano and Giliomee 2007).

Other beetle species commonly encountered in poultry production can affect the establishment of *Carcinops pumilio* as a biological control agent of house flies. For example, the establishment of *Carcinops pumilio* is impaired when poultry houses have a dense population of the omnivorous lesser mealworm, *Alphitobius diaperinus* (Panzer) (Watson et al. 2001). IPM strategies for establishing populations of *Carcinops pumilio* include the use of low residual pyrethrin insecticides to target adult fly populations while beetle populations increase and insecticidal treatment of the entire poultry house for *Alphitobius diaperinus* after removal of manure packs (Watson et al. 2001). Parasitoid wasp species that attack fly pupae, including *Muscidifurax raptorellus* Kogan and Legner, can be used along with *Carcinops pumilio* in a house fly IPM program in poultry houses (Kaufman et al. 2001b).

Carcinops pumilio can be found in some stored goods, food and animal by-products, and animal remains, where it is a predator on other insects. These beetles are associated with wheat and flour storage and production. For example, *Carcinops pumilio* has been reported from piles of discarded yeast in bakeries (Jennings 1900), stored grain, flour, and waste grain in granaries and flour mills (Dieuzeide and Tempère 1924; Joy 1932; Cotton and Good 1937), and wheat both in the field and storage (Cotton and Winburn 1941; Coombs and Woodroffe 1968). Similarly, *Carcinops pumilio* was collected in association with abandoned, rotting oil palm kernels in Nigeria (Allotey 1988). These beetles also are associated with wild animal remains and some aspects of meat processing. In particular, *Carcinops pumilio* has been reported from bone processing operations (Walker 1916) and glue factories (Fowler and Donisthorpe 1913; Walker 1932).

Medical and Veterinary Importance

Carcinops pumilio is considered to be a beneficial insect due to its ability to limit house fly populations in poultry production settings. Some research, however, has investigated whether beetles can be reservoirs for the bacteria *Salmonella enterica* (the cause of salmonellosis in humans) and *Campylobacter* species (most common bacterial cause of food poisoning in the US) (Gray et al. 1999; Skov et al. 2004). Laboratory experiments determined that *Salmonella*-inoculated *Carcinops pumilio* can harbor the bacterium externally and internally for up to two weeks (Gray et al. 1999). Further experiments conducted in poultry houses suggested that beetles can be *Salmonella* reservoirs in these settings, but this is likely not the case for *Campylobacter* (Skov et al. 2004).

Carcinops pumilio cannot be raised in large enough numbers for the species to be commercially available for purchase. Unable to supplement their natural beetle populations commercially, poultry producers may be tempted to capture and move established beetles into poultry houses with lower numbers, such as facilities recently cleaned of their manure pack (Kaufman et al. 2002b). This practice should be practiced with caution due to a small risk of mechanically moving *Salmonella* bacteria into clean poultry houses on the beetles (Gray et al. 1999). *Carcinops pumilio* also has been reported as a potential intermediate host of the chicken parasitic cestode *Hymenolepis carioca* (Jones 1929).

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Table 1. Country-level locality records for *Carcinops pumilio*. Additional state-level records are provided when available for geographically large countries or countries with overseas or island territories. Some state-level records for the US are based on specimen data from the Florida State Collection of Arthropods (FSCA), Gainesville, FL.

Country	Selected References and Sources of Data
Albania	Lackner et al. 2015
Algeria	Lackner et al. 2015
Andorra	Lackner et al. 2015
Argentina	Blackwelder 1944; Arriagada S. 1986
Australia: Capital Territory, New South Wales, Northern Territory, Queensland, South Australia, Victoria, Western Australia	GBIF 2012; ANICD 2016
Austria	Redtenbacher 1858; GBIF 2012; Lackner et al. 2015
Belarus	Lundyshev 2015; Lackner et al. 2015
Belgium	GBIF 2012; Lackner et al. 2015
Bosnia and Herzegovina	Lackner et al. 2015
Bulgaria	Lackner et al. 2015
Canada: Nova Scotia, New Brunswick, Newfoundland and Labrador, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia	Bousquet and Laplante 2006
Chile	Legner and Olton 1970; Arriagada S. 1986; Retamales et al. 2011
Croatia	Lackner et al. 2015
Cuba (speculation in literature)	Peck and Thomas 1998; Peck 2005
Cyprus	Lackner et al. 2015
Czech Republic	Lackner et al. 2015
Denmark	Skov et al. 2004; Lackner et al. 2015
Egypt	Erichson 1834; Lackner et al. 2015
England	Stephens 1835; Jennings 1900; GBIF 2012; Lackner et al. 2015
Estonia	GBIF 2012; Lackner et al. 2015
Finland	GBIF 2012; Lackner et al. 2015
France: mainland and New Caledonia	Marseul 1862; Wenzel 1955; GBIF 2012; Lackner et al. 2015
Germany	GBIF 2012; Lackner et al. 2015
Georgia	Lackner et al. 2015
Greece	Lackner et al. 2015
Guinea-Bissau	GBIF 2012
Hungary	Merkl et al. 2004; Lackner et al. 2015
Ireland	Lackner et al. 2015
Israel	Legner and Olton 1970
Italy	Penati 2009; Lackner et al. 2015
Japan	Takahashi et al. 2000; GBIF 2012; Lackner et al. 2015
Latvia	Lackner et al. 2015
Libya	Lackner et al. 2015
Liechtenstein	Lackner et al. 2015
Lithuania	Lackner et al. 2015
Luxembourg	Lackner et al. 2015
Macedonia	Lackner et al. 2015
Malaysia	Ong et al. 2016
Malta	Lackner et al. 2015
Mexico (online checklist)	Barriga-Tuñon 2014
Moldova	Lackner et al. 2015
Montenegro	Lackner et al. 2015

Country	Selected References and Sources of Data
Morocco	Lackner et al. 2015
the Netherlands	GBIF 2012; Gielis et al. 2014; Lackner et al. 2015
New Zealand (citizen science data)	Legner and Olton 1970; iNaturalist.org
Nigeria	Allotey 1988
Norway	Hågvar 1975; GBIF 2012; Lackner et al. 2015
People's Republic of China: Beijing, Hebei, Heilongjiang, Shanxi, Yunnan	Zhang and Zhou 2007; Lackner et al. 2015
Poland	Bajerlein et al. 2006, 2011; GBIF 2012; Borowski and Mazur 2015; Lackner et al. 2015
Portugal: mainland, Azores, and Madeira Archipelago	Wollaston 1857, 1865; GBIF 2012; Lackner et al. 2015
Republic of China (Taiwan)	Zhang and Zhou 2007; Lackner et al. 2015
Romania	Lackner et al. 2015
Russia	Lackner et al. 2015
Samoa	Arrow 1927
Serbia	Lackner et al. 2015
Seychelles	Scott 1913
Slovakia	Krištofík et al. 2009; Lackner et al. 2015
Slovenia	Lackner et al. 2015
South Africa	Achiano and Giliomee 2006a
South Korea	Lackner et al. 2015
Spain: The Canary Islands and mainland	Wollaston 1864, 1865; GBIF 2012; Lackner et al. 2015
Sweden	GBIF 2012; Lackner et al. 2015
Switzerland	Lackner et al. 2015
Tunisia	Lackner et al. 2015
Turkey	Lackner et al. 2015
Ukraine	Lackner et al. 2015
United States: Arizona, California, Colorado, Florida, Georgia, Hawaii, Illinois (FSCA), Indiana, Kansas, Louisiana, Maryland, Massachusetts, Michigan (FSCA), Minnesota, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Tennessee (FSCA), Texas, Utah, Washington, Wisconsin (probably also Iowa, Missouri, and Oklahoma based on Larson et al. [2008])	Frost and Dietrich 1929; Cotton and Winburn 1941; Thompson 1966; Legner and Olton 1970; Pfeiffer and Axtell 1980; Bernath and Kunz 1981; Leech 1983; Propp and Morgan 1985; Geden et al. 1987; Whitaker et al. 1991; Seymour and Campbell 1993; Mullens et al. 1996; Rueda and Axtell 1997; Tobin and Pitts 1999; Hinton and Moon 2003; Larson et al. 2008; Tishechkin 2010a, b; UHIM 2011; LSAM 2016; CAS 2016
Uzbekistan	Lackner et al. 2015

Table 2. Bird nest associations of *Carcinops pumilio* in North America.

Bird Common Name	Bird Scientific Name	Country: State or Province	References
Northern saw-whet owl	*Aegolius acadicus* (Gmelin)	Canada: Nova Scotia	Majka et al. 2006
House sparrow	*Passer domesticus* (Linnaeus)	US: Wisconsin	Thompson 1966

Table 3. Bird nest associations of *Carcinops pumilio* in Europe.

Bird Common Name	Bird Scientific Name	Country: State, Region, or County	References
Great tit	*Parus major* Linnaeus	France: Vaucluse	Roy et al. 2013
Tawny owl	*Strix aluco* Linnaeus	Norway: Akershus	Hågvar 1975
Long-eared owl	*Asio otus* (Linnaeus)	Norway: Akershus	Hågvar 1975
Common kestrel	*Falco tinnunculus* Linnaeus	Norway: Akershus	Hågvar 1975
Common buzzard	*Buteo buteo* (Linnaeus)	Norway: Akershus; Belarus	Hågvar 1975; Lundyshev 2015
White stork	*Ciconia ciconia* (Linnaeus)	Poland	Bajerlein et al. 2006
Lesser spotted eagle	*Clanga pomarina* (Brehm)	Slovakia: Orava; Belarus	Krištofík et al. 2009; Lundyshev 2015
Greater spotted eagle	*Clanga clanga* (Pallas)	Belarus	Lundyshev 2015
Black kite	*Milvus migrans* (Boddaert)	Belarus	Lundyshev 2015
Northern goshawk	*Accipiter gentilis* (Linnaeus)	Belarus	Lundyshev 2015
Barn owl	*Tyto alba* (Scopoli)	Netherlands	Gielis et al. 2014
Saker falcon	*Falco cherrug* Gray	Hungary: Heves and Borsod-Abaúj-Zemplén	Merkl et al. 2004