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Description of a new species of *Anagyrus* Howard, 1896 (Hymenoptera: Chalcidoidea: Encyrtidae) from Mexico and USA, with a review of economically important species of the genus

Новый вид *Anagyrus* Howard, 1896 (Hymenoptera: Chalcidoidea: Encyrtidae) из Мексики и США с обзором экономически важных видов рода

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КЛЮЧЕВЫЕ СЛОВА: Hymenoptera, Encyrtidae, *Anagyrus dzhanokmenae* sp.n., таксономия, Мексика, США, биологический метод борьбы с вредителями.

ABSTRACT: *Anagyrus dzhanokmenae* sp.n. from the States of Baja California Sur (Mexico) and California (USA), is described. The new species is compared with *A. argyrus* (Burks, 1952) from USA. Importance of some *Anagyrus* species for biological pest control is discussed; information about 12 species of that kind is presented.

РЕЗЮМЕ: В работе описан *Anagyrus dzhanokmenae* sp.n. из штатов Нижняя Южная Калифорния (Мексика) и Калифорния (США). Новый вид сравнивается с *A. argyrus* (Burks, 1952) из США. Подчёркивается большое значение некоторых видов рода *Anagyrus* для биологического метода борьбы с вредителями и дана информация о 12 таких видах.

Introduction

The genus *Anagyrus* Howard, 1896 belongs to the subtribe Anagyrina, tribe Anagyrini, subfamily Tetracneminae of the chalcidoid family Encyrtidae. Larvae of most Encyrtidae are endoparasitoids of insects, but some of them are endoparasitoids of ixodid ticks and predators of coccid eggs.

The type species of the genus *Anagyrus* is *A. greeni* Howard, 1896 described from Sri Lanka [Howard in: Howard & Ashmead, 1896]. The synonyms of *Anagyrus* are as follows: *Heterarthrellus* Howard, 1898; *Epidinocarsis* Girault, 1913; *Paranusia* Bréthes, 1913; *Philoponectroma* Bréthes, 1913; *Doliphoceras* Mercet, 1921; *Gyranusa* Mercet, 1921; *Gyranusia* Bréthes, 1921; *Protanagyrus* Ev. Blanchard, 1940; *Apoanagyrus* Compere, 1947; *Anathrix* Burks, 1952; *Rhopomorphus* Ghesquiére, 1958; *Aglyptoideus* De Santis, 1964; *Cremesina* Noyes *et* Hayat, 1984; and *Tongyus* Noyes *et* Hayat, 1984.

Judging from the number of already described species (254), *Anagyrus* is the second largest genus of Encyrtidae in the world after *Metaphycus* Mercet, 1917 (having 313 species).

Ninety seven species of *Anagyrus* (i.e. 38%) are known as endoparasitoids of mealybugs (Homoptera: Coccoidea: Pseudococcidae); 3 species were reared from coccids of the family Eriococcidae: 1) *A. bifasciatus* (Bréthes, 1913) from *Eriococcus brasiliensis* Cockerell (De Santis, 1964 — as *Paranusia bifasciata*) in Argentina; 2) *A. hammadae* Trjapitzin *et* Rosanov, 1972, reared from *Acanthococcus salsolae* Borchsenius on *Hammada leptoclada* (M. Pop. ex Iljin) Iljin (fam. Chenopodiaceae) in Uzbekistan [Trjapitzin, 1972]; and 3) *A. quadrimaculatus* Xu *et* He, 1996, reared from *Eriococcus transversus* Green on bamboo in China [Xu *et al.*, 1996]. *A. hammadae* was also reared from the mealybug *Dysmicoccus multivorus* Alexey Kiritshenko in Turkmenistan [Myartseva & Khartshenko, 1988]. Surprisingly, *A. australiensis* (Howard, 1898) was reared from pupae of *Scymnus flavifrons* Blackburn (Coleoptera: Coccinellidae) in Australia [Howard, 1898 – as *Heterarthrellus*]. This is also confirmed by the first author (V.A. Trjapitzin), who studied the type series of this species at the National Museum of Natural History, Washington, D.C., USA, and saw host pupae with exit holes of the parasitoid.

Study of *Anagyrus* species is of practical importance because of their significant role in natural control of different mealybugs. Notes on most important species are given below.

1. *Anagyrus aegyptiacus* Moursi, 1948. This parasitoid is known to be specific for the mealybug *Nipaecoccus viridis* Newstead (earlier identifications: *Pseudococcus filamentosus* Cockerell, *N. filamentosus* Cockerell and *N. vastator* Maskell). It heavily damaged *Albizzia lebbeck*, an important ornamental tree in Egypt. A program was developed during 1933–1939 for introducing its natural enemies from Java. Two parasitoids, *Anagyrus aegyptiacus* and *Leptomastix nigrocoxalis* Compere were introduced into Egypt. These introductions have resulted in a marked decrease of infestations of lebbeck trees by *N. viridis*. In some areas, levels of parasitism reached 98%, and the mealybug almost disappeared in many localities [Kamal, 1951; Bartlett, 1978; Noyes & Hayat, 1994; Etzel & Legner, 1999]. The parasitoid has infiltrated Israel from Jordan, where it parasitizes *N. viridis* [Bar-Zakay *et al*., 1988 (as *A. indicus* Shafee, Alam *et* Agarwal, 1975)].

2. *Anagyrus agraensis* Saraswat, 1975. This species was introduced from Guam into Jordan in 1983–1984 to control *Nipaecoccus viridis* Newstead on *Citrus* spp.; as a result, populations of this mealybug were greatly reduced by 1985 [Meyerdirk *et al.*, 1988 (as *A. indicus*); Noyes & Hayat, 1994].

3. *Anagyrus ananatis* Gahan, 1949. This species was imported into Hawaii from Brazil, and then from Hawaii into Puerto Rico in 1935–1938 to control the pineapple mealybug *Dysmicoccus brevipes* Cockerell [González-Hernández *et al*., 1999; Noyes, 2000]. It has contributed to partial control of this pest in Hawaii.

4. *Anagyrus antoninae* Timberlake, 1920. A well-known parasitoid of the Rhodes grass mealybug *Antonina graminis* Maskell. It is most likely to originate from Oriental Asia, from where it infiltrated some other regions [Bartlett, 1978]. It was introduced into the USA (Texas, Louisiana, and Florida) from Hawaii, and from Texas into Mexico. However, *A antoninae* was displaced in Texas by another introduced encyrtid, *Neodusmetia sangwani* (Subba Rao, 1957) of Indian origin [Schuster & Dean, 1976]. The same situation probably occurred in Mexico [Trjapitzin, 1998]. The introduction of *A antoninae* into Brazil has resulted in complete control of *A. graminis* [Ferrer, 1995].

5. *Anagyrus dactylopii* (Howard, 1898). An important parasitoid of mealybugs in South and South-East Asia. The species was imported into Hawaii from Hong Kong in 1925 to control *Nipaecoccus viridis* Newstead on *Citrus* spp. This introduction was a complete success [Fullaway, 1952].

6. *Anagyrus diversicornis* (Howard, 1894). A Neotropical species. An outbreak of the cassava mealybug, *Pseudococcus herreni* Cox *et* Williams, was observed on *Manihot esculenta* in northeastern Brazil during a prolonged dry period in the 1990s [Bento *et al*., 1999]. Yield losses up to 80% were estimated in some localities. The parasitoid was introduced in 1994–1996 into Brazil from Colombia. After establishing there, it dispersed very rapidly (after 33 months of observation it was found up to 550 km from the release site).

7. *Anagyrus fusciventris* (Girault, 1915). *A. fusciventris* was probably introduced from Australia into Hawaii between 1904 and 1906 [Noyes, 2000]. In 1936, it was shipped from Hawaii to California to control *Pseudococcus longispinus* Targioni Tozzetti, a pest of *Citrus* spp.; however, little success has been observed. In 1971–1976, it was introduced into Israel for biological suppression of *P. longispinus* in avocado orchards. It has been reported to provide reliable control together with another encyrtid, *Tetracnemoidea peregrina* (Compere, 1939) [Swirski *et al.*, 1988].

8. *Anagyrus kamali* Moursi, 1948. This Asian species is an effective parasitoid of the polyphagous pink hibiscus mealybug, *Maconellicoccus hirsutus* Green. It has been successfully imported to Egypt from Java in the mid-1930s [Noyes & Hayat, 1994], and recently introduced into some Caribbean islands from China [Cross & Noyes, 1996; Étienne *et al*., 1998; IIBC, 1997, 1998; Sagarra & Vincent, 1999].

9. *Anagyrus lopezi* (De Santis, 1964). A very important species described from Argentina [De Santis, 1964, as *Apoanagyrus*]. In 1981, *A lopezi*, collected in Paraguay, was imported to Nigeria to control the mealybug *Phenacoccus manihoti* Matile-Ferrero, a dangerous pest of cassava, *Manihot esculenta,* in many tropical countries. Cassava is a root crop that serves as a major energy source for 300–500 million people in approximately 30 countries in tropical regions of the world. *A. lopezi* rapidly established in 25 African countries and became an efficient control agent of the cassava mealybug. The cost-benefit ratio of the project has been estimated to be 1:149 [Bellotti *et al.*, 1999; Kogan *et al*., 1999].

10. *Anagyrus pseudococci* (Girault, 1915). A widely distributed and effective parasitoid of *Planococcus citri* (Risso) on *Citrus* spp. and fig trees [Myartseva & Niyazov, 1986; Noyes & Hayat, 1994]. In Turkmenistan, *A. pseudococci* adapted to parasitize an introduced pest, the Comstock mealybug *Pseudococcus comstocki* Kuwana. An increase in the levels of parasitism on natural populations of *P. comstocki* was observed [Myartseva, 1986, 1987].

11. *Anagyrus sacharicola* Timberlake, 1932. A well-known parasitoid of the mealybug *Saccharicoccus sacchari* Cockerell on sugarcane of South- or East-Asian origin. It has been imported to Hawaii from the Philippines in the 1930s. This introducion has resulted in a spectacular reduction of pest amounts. Later it was introduced into some other countries, such as Australia, Peru, etc. [Noyes, 2000]. It infiltrated many countries (e.g., Mexico) by ecesis [Trjapitzin, 1998; Trjapitzin & Ruíz-Cancino, 2000].

12. *Anagyrus* sp. aff. *kivuensis* Compere. 1939. A parasitoid of the coffee mealybug *Phanococcus kenyae* Le Pelley. Together with some other encyrtids, it was introduced in 1938 from Uganda into Kenya. The parasitoid proved to be very beneficial, with excellent capacities for suppressing mealybug populations on coffee within 6 to 8 months after its release. It also showed a rapid natural dispersion, being capable of maintaining itself on very small host populations [Bartlett, 1978].

As can be seen from this list, *Anagyrus* species have been effectively used on such important cultures as citrus, pineapple, gramineous pasture grasses, cassava, grape, sugarcane and coffee.

A key to Palaearctic species of *Anagyrus* was published by Trjapitzin [1989], a review of Indo-Pacific species — by Noyes & Hayat [1994], and a review of the Costa Rican fauna — by Noyes [2000]. Nearctic species of *Anagyrus* are still very poorly studied.

Materials and methods

In May 1997, the first author visited the Department of Entomology, University of California, Riverside, USA, and received for identification a series of females of an interesting *Anagyrus* sp. The vast collection of Encyrtidae in the Zoological Institute, Russian Academy of Sciences in St. Petersburg together with the monograph by Noyes [2000], and the relevant literature on *Anagyrus* species of the Nearctic Region were used to determine taxonomic affinities of the new species. It appeared to be very closely related to *A. argyrus* (Burks), known only for the USA (Virginia, ex *Ferrisia virgata* Cockerell; Texas). In March 2001, the first author studied five paratypes of *A. argyrus* (females) during his visit to the National Museum of Natural History, Washington, D.C., USA.

Most part of the material on the new species was collected by Professor Paul De Bach in pan traps in the settlement "Las Barracas" in vicinities of La Paz, the capital of the Mexican State of Baja California Sur. Specimens from California (USA) were treated using critical point dryer.

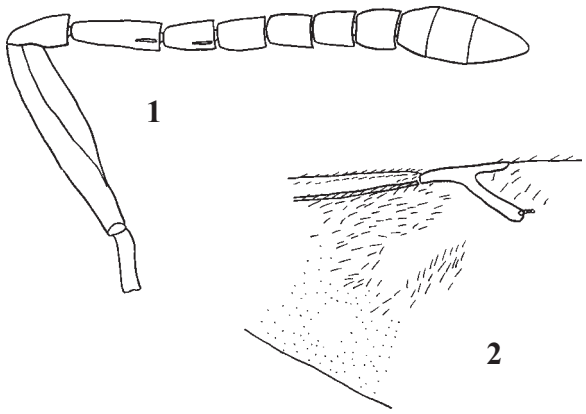
Anagyrus dzhanokmenae Trjapitzin, Myartseva *et* Ruíz, **sp.n.**

Fig. 1, 2.

Type material. Holotype ♀ : México: Baja California Sur; Las Barracas, pantrap, 20-V-1985 (P. De Bach).

Paratypes (♀♀). México, same locality and collector: 7-IV-1985, 1 ♀; 8-IV-1985, 1 ♀; 21-IV-1985, 1 ♀; 20-V-1985, 1 ♀; 5-V-1986, 1 ♀; 10-V-1986, 1 ♀; 12-VI-1986; 1 ♀; 19-VI-1986, 1 ♀; (P. Bach), USA, California: 1) Los Angeles Co. 1/2 mi E. Alder Saddle, Angeles National Forest, 5-VIII-1981, 1 ♀ (G. Gordh); 2) San Diego Co., Coyote Cyn, Anza Borrego, 22-IV-1981, 1 ♀ (J. T. Huber). Antenna and anterior wing of one of the paratypes are on the microscopic slide M 2001-1. The holotype is preserved in the collection of the National Museum of Natural History, Washington, D.C, USA; most of paratypes are in UCR Entomological Collection, Department of Entomology, University of California, Riverside, USA; two paratypes are also in the Zoological Institute, Russian Academy of Sciences, St. Petersburg and in the Insects Museum, UAM Agronomía y Ciencias, Universidad Autónoma de Tamaulipas, Cd. Victoria, Tam., Mexico.

DESCRIPTION. Female (holotype and paratypes). Head lentiform, as broad as high. Minimum width of vertex 0.2–0.4 maximum head width. Inner orbits of eyes strongly diverging anteriorly. Maximum eye diameter about 2 times more than the minimum one. Occipital margin straight and acute. Temples absent (hind margins of eyes almost touching the occipital margin). Ratio of minimum to maximum distance between eyes 11:19 or 8:15. Ocelli form a right-angled triangle, or nearly so; distance between posterior ocelli more than that from posterior to anterior ocellus (7:10; 8.5–9: 14), 7 times more than distance from posterior ocellus to eye margin and about 3 times more than distance to the occipital margin. In a specimen from Mexico, the ocellar triangle is equilateral. Upper margin of torulus at the level of the lowest margin of eye; distance between toruli more than that from a torulus to eye margin (6:5) and to oral margin. Malar space convex, its length about 2.5 times less than maximum eye diameter. Upper border of facial cavity formed by scrobes, at the middle of head height. Oral orifice small. Malar space limited posteriorly by a rather acute keel reaching below mouth margin, and above some distance beyond lower margin of eye. Radicle of antenna (Fig. 1) rather long, about 3.3 times as long as wide at the apex and 4–5 times shorter than scape; scape very long, somewhat widening towards apex and slightly concave on dorsal side, 4–5 times as long as wide near apex; pedicel short, 3.5–4.4 times shorter than scape, about 2.2–3 times as long as wide at apex and 1.3–1.8 times shorter than 1st funicle segment; 1st funicle segment longer than other funicle segments, slightly broadened towards apex, 3–4 times as long as its greatest width; 2nd segment 1.1–2.3 times shorter than the 1st and 1.5-2 times as long as wide; 3rd segment as long and wide as the 2nd; 4th segment a little shorter or longer than the 3rd and about 1.6 times as long as wide; 5th segment somewhat shorter than 4th (8:9; 7:8) and longer than wide (8: 5–6.5); 6th segment as long as 5th, but slightly wider; clava about as long or somewhat shorter as the 3 preceding segments of funicle combined, it equal in width or slightly wider than 6th funicle segment, and 3.3–3.5 times as long as wide; apex of clava pointed. Pronotum short. Mesoscutum 2.2 times as wide as long, its posterior margin with 2 smooth incisions. Scutellum longer than mesoscutum, a little longer its maximum width. Wings not shortened. Forewing about 2.2 times as long as its greater width; costal cell narrow, 13 times as long as wide, with only one incomplete row of setae immediately beneath the marginal row; marginal vein rather long (proportions the same as in Noyes, 1980: 109), 6–8.5 times shorter than the submarginal vein, slightly broadening towards apex; stigmal vein thin, almost straight, weakly broadened apically, longer than marginal one (about 5:3); postmarginal vein approximately 2 times shorter than stigmal one. Basal midtar-



Figs. 1–2. *Anagyrus dzhanokmenae* sp.n., ♀: 1 — antenna (100x); 2 — part of forewing (100x). Orig. drawings by S.N. Myartseva.

Рис. 1–2. *Anagyrus dzhanokmenae* sp.n., ♀: 1 — усик (100x); 2 — часть переднего крыла (100x). Ориг. рис. С.Н. Мярцевой.

sal segment very long, as long as all following tarsal segments combined, middle tibial spur shorter. Propodeum very short in the middle. Gaster (metasoma without petiole) long, conically pointed, somewhat longer than mesosoma (thorax + propodeum) and head combined. Pygostiles near the base of gaster. Ovipositor sheaths not exserted.

Body black, metallic shine generally not strong. Frontovertex with green-bronze and blue shine. Radicula of antenna black; scape yellowish-brown, more or less darkened along its dorsal edge and lightened near apex (in its ventral part); in specimens from the California (USA) scape sometimes dark brown or almost completely black; pedicel and 1st–2nd or 1st–3rd funicular segments black, the rest of the funicle and clava white or yellowish-white; 1st segment of funicle and basal half of the 2nd one sometimes black. Palpi black. Mesoscutum with rather strong green- and bronze-blue shine. Tegulae, axillae and scutellum black; apex of scutellum with green-blue shine. Forewings hyaline, sometimes slightly infuscated near marginal and stigmal veins. Mesopleura with greenish-blue shine. Coxae and femora black; apices of hind femora yellowish-brown; mid tibiae black in their basal half, yellow brown in the apical one; mid tibial spur yellow; fore and mid tarsi brownish-yellow; pegs on apices of mid tibiae and on mid tarsi black; hind tarsi sometimes infuscated in their distal part; last segments of all tarsi black.

Frontovertex rather deeply and finely reticulate as well as densely punctate, mesoscutum with similar sculpture, but punctures more dense. Axillae and scutellum dull, with extremely minute sculpture. Mesopleura finely reticulate, with cells larger in the apical part of the sclerites. Gaster finely reticulate.

Head with white hairs issuing from points. Mesoscutum also with white pubescence, formed by longer and more dense hairs; scutellum with dark hairs. Posterolateral parts of propodeum with white pubescence.

Body length 1.7–1.9 mm (holotype 1.9mm).

Male unknown.

Host unknown.

ETYMOLOGY. The new species is named after Dr. Klarissa Alexeevna Dzhanokmen, a well known taxonomist of the chalcidoid family Pteromalidae (Institute of Zoology, Kazakh Academy of Sciences, Alma–Ata, Kazakhstan).

COMMENTS. *Anagyrus dzhanokmenae* sp.n. belongs to the *A. argyrus* (Burks, 1952) species group (Table 1), which females are characterized in females by lentiform (menisciform) head, punctate frontovertex and slender antennal scape. At least *A. rusticus* (De Santis, 1964) from Argentina and *A. scaea* Noyes, 2000 from Costa Rica also belong to this group.

In all three species antennal funicles are entirely black.

Table 1. Diagnostic characters of *Anagyrus argyrus* and *A. dzhanokmenae* sp.n.
Таблица 1. Диагностические признаки *Anagyrus argyrus* и *A. dzhanokmenae* sp.n.

Anagyrus argyrus (♀)	*Anagyrus dzhanokmenae* sp.n. (♀)
All funicle segments of antenna black; pedicel black	1st–2nd or 1st–3rd funicle segments of antenna black, the remaining segments white; apex of pedicel brown-yellow
Surface of mesoscutum shining, almost smooth, showing very faint surface reticulations	Surface of mesoscutum neither shining nor smooth, having clear minute reticulation and punctures
Only basal 1/2 to 2/3 of each femur black	All femora (except apices) black
Distance between posterior ocelli 3 times more than that from posterior ocellus to eye margin	Distance between posterior ocelli 7 times more than that from posterior ocellus to eye margin

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