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Rediscovery and redescription of *Oxycheila buestani* Wiesner with the first female record and new methodology for observation of *Oxycheila* Dejean and *Oxygonia* Mannerheim (Coleoptera: Cicindelidae)

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Abstract

Biodiversity within the family Cicindelidae (Coleoptera) was studied with respect to ecology in two neighbouring localities on the western slopes of the Andes in central Ecuador. Four different methods were used along two neighbouring streams. One of them, a night vision camera, was successfully used for the first time during the night observation of adults of *Oxycheila* Dejean, 1825 and *Oxygonia* Mannerheim, 1837 to record their natural behaviour. The following six species of Cicindelidae were observed together: *Oxycheila affinis* W. Horn, 1900, *Oxycheila pearsoni* Wiesner, 1999, *Oxycheila brzoskai* Wiesner, 1999, *Oxycheila buestani* Wiesner, 1999, *Pseudoxycheila chaudoiri* Dokhtouroff, 1882 and *Oxygonia oberthueri* W. Horn, 1896. The female of the rare *Oxycheila buestani* is described for the first time here, and the complete redescription of this species, including colour photographs of habitus, habitat and diagnostic characters, is presented.

Key words: Coleoptera, Cicindelidae, *Oxycheila*, *Oxygonia*, taxonomy, ecology, methodology, biodiversity, Ecuador

Resumen

Se realizó el estudio de la biodiversidad de especies de Cicindelidae (Coleoptera), en términos de ecología, en dos localidades adyacentes, en la cordillera occidental de los Andes del centro del Ecuador. Se utilizaron cuatro métodos diferentes de recolección a lo largo de las dos vertientes. La cámara de visión nocturna se utilizó con éxito por primera vez durante la observación nocturna de las especies *Oxycheila* Dejean, 1825 and *Oxygonia* Mannerheim, 1837 para registrar su comportamiento natural. Se observaron seis especies de Cicindelidae: *Oxycheila affinis* W. Horn, 1900, *Oxycheila pearsoni* Wiesner, 1999, *Oxycheila brzoskai* Wiesner, 1999, *Oxycheila buestani* Wiesner, 1999, *Pseudoxycheila chaudoiri* Dokhtouroff, 1882 y *Oxygonia oberthueri* W. Horn, 1896. Esta investigación describe por primera vez la hembra de *Oxycheila buestani* y presenta la redescripción completa de esta especie, incluidas fotografías a color de: hábitos, hábitat y caracteres de diagnóstico.

Introduction

There are four main geographical regions in Ecuador: The Coastal region, the Andean region (the Sierra), the Amazonian region (called El Oriente and refers to the eastern part of Ecuador), and the Galapagos Island region. Lying on the equator, all four of Ecuador's geographic regions generally are affected by a combination of global energy and moisture differences, but these general patterns are often complicated by local peculiarities. These interwoven conditions produce dramatic differences in weather patterns over a small area, and Ecuador has many different rainy seasons and habitats as a result (Pearson *et al.* 1999).

Despite its small territory wide areas of Ecuador are currently a part of two (of the total 36) global biodiversity "hotspots". Paradoxically, its prominent insect richness has been poorly studied and is usually underestimated in biodiversity inventories (Pazmiño-Palomino & Troya 2022).

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Our research presented here targets on biodiversity of Cicindelidae (Coleoptera) species in southern part of western slopes of Ecuadorian Andes in two neighbouring localities- small stream gorges with different human impact. This ecoregion has recently been affected by human activity, especially agriculture, which reaches up to the steep slopes of the deep valleys of the local streams and rivers. In such areas, the species of two Neotropical genera, *Oxycheila* Dejean and *Oxygonia* Mannerheim typically represent the family Cicindelidae and our research mainly focuses on these genera. The sensitivity of these genera to their natural ecosystems should be used in monitoring the stage of disturbance of ecosystems and thus help to find the right solutions in the management of human activities according to the needs of biodiversity protection. The deep knowledge of faunistic records is essential for this way of management.

Pearson & Wiesner (2022) reviewed the extensive information available for tiger beetles species that are useful in adapting biodiversity hotspot conservation to global, regional and local scale. Additional, tiger beetles have already been proposed as bioindicators of other taxa, but only at a regional scale (Carroll & Pearson 1998).

The most recent studies on tiger beetles of Ecuador were done by Pearson *et al.* (1999). They estimated that 86 tiger beetle species are known to occur in Ecuador, 32 of which are considered endemic to the country. Additionally, there are seven species that are hypothetically included that are present in neighbouring countries and could be eventually found in Ecuador. Pearson & Wiesner (2022) stated 113 species, 31 of which are endemic.

Wiesner (1999, 2003) published the revision and additional description of the Neotropical genus *Oxycheila* Dejean (Cicindelidae: Megacephalini). He listed 47 species, 11 of which occur in Ecuador, 8 of which are endemic to the country.

Additional *Oxycheila* studies and descriptions of new species, were published recently (Huber & Brzoska 2000, Cassola 2011, Dheurle 2012, Orsetti & Lopez-Andrade 2018 and Šafránek & Amaya 2020), but without any new record from Ecuador.

A complete revision of 15 Neotropical genera of the subtribe Odontocheilina (Cicindelidae) including genera *Oxygonia* Mannerheim was published quite recently by Moravec (2015, 2017, 2018, 2020), where 20 recognized species of *Oxygonia* were treated, 14 of which occurring in Ecuador, six of them Ecuadorian endemics.

Also, the revisions of Neotropical tiger beetle genera *Tetracha* Westwood, 1883 (Cicindelidae: Megacephalini) (Naviaux 2007), *Pseudoxycheila,* Guérin, 1839 (Cicindelidae: Oxycheilini) (Cassola 1997) and *Ctenostoma* Klug, 1821 (Cicindelidae: Ctenostomatini) (Naviaux 1998) were done in recent decades which considerably affect the number of Ecuadorian taxa.

This study was carried out in order to bring new faunistic records and consequently find a suitable way of monitoring, in addition to a better understanding of the natural history of Cicindelidae as bioindicators.

The rare *Oxycheila buestani* Wiesner, 1999 was observed among recorded Cicindelidae species and its occurrence confirmed nearby the type locality after more than 20 years from the last record. The female of *O. buestani* is described for the first time here and the redescription of this species, including colour photographs of habitus, habitat and diagnostic characters are presented.

The results presented here are as a part of the wider studies based on the recent project "The Studies on Biodiversity of Entomofauna in the Different Agricultural and Natural Localities in Ecuador", within the cooperation between Czech University of Life Sciences, Faculty of Tropical AgriSciences, Prague, Czech Republic and Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador.

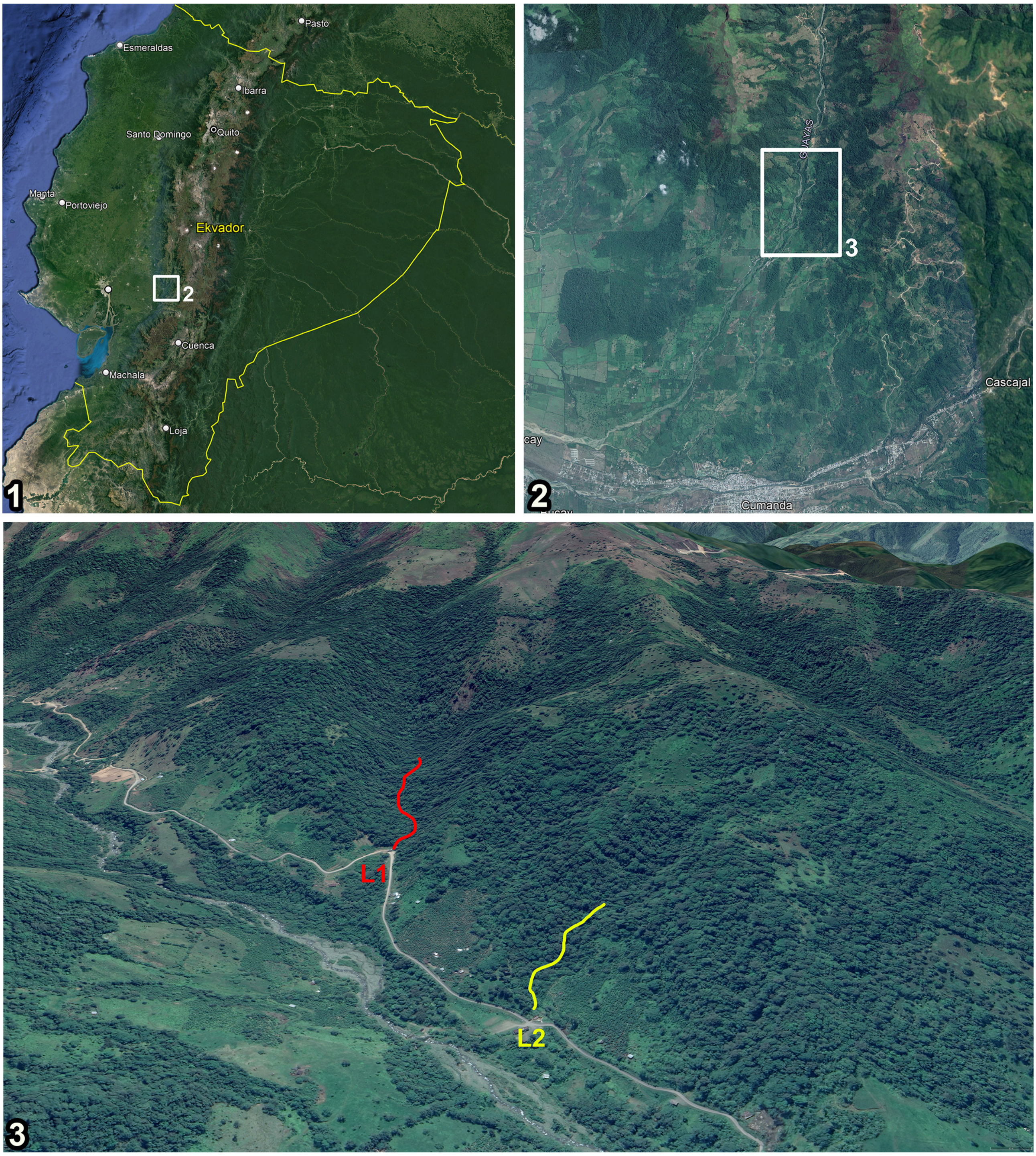
The article is based upon the results of field studies in February 2022 and February 2023.

Methodology of observation

We selected two closely adjacent, approximately equal-sized streams and their valleys on the western slopes of the Andes in central Ecuador in a partially natural locality near the town of Cumandá-Bucay at an elevation of 700–800 m. The second half of February was chosen because of the ongoing rainy season suitable for observing insects.

Day and night observations were made during one day on 17–18 February 2022 at each of these two neighbouring sites and then repeated again on 27–28 February 2023. Limited one-day observation was established to minimize the risk of injury to observers and further negative impact on live insect populations.

The day walking with entomological net and the night walking using headlamp was done in the same intensity on both localities, when wading through the small fast flowing streams.



FIGURES 1–3. 1. Satellite map Ecuador. 2. West sub Andean region north from the town of Cumandá-Bucay. 3. Study area with surveyed transects L1 (red line) and L2 (yellow line).

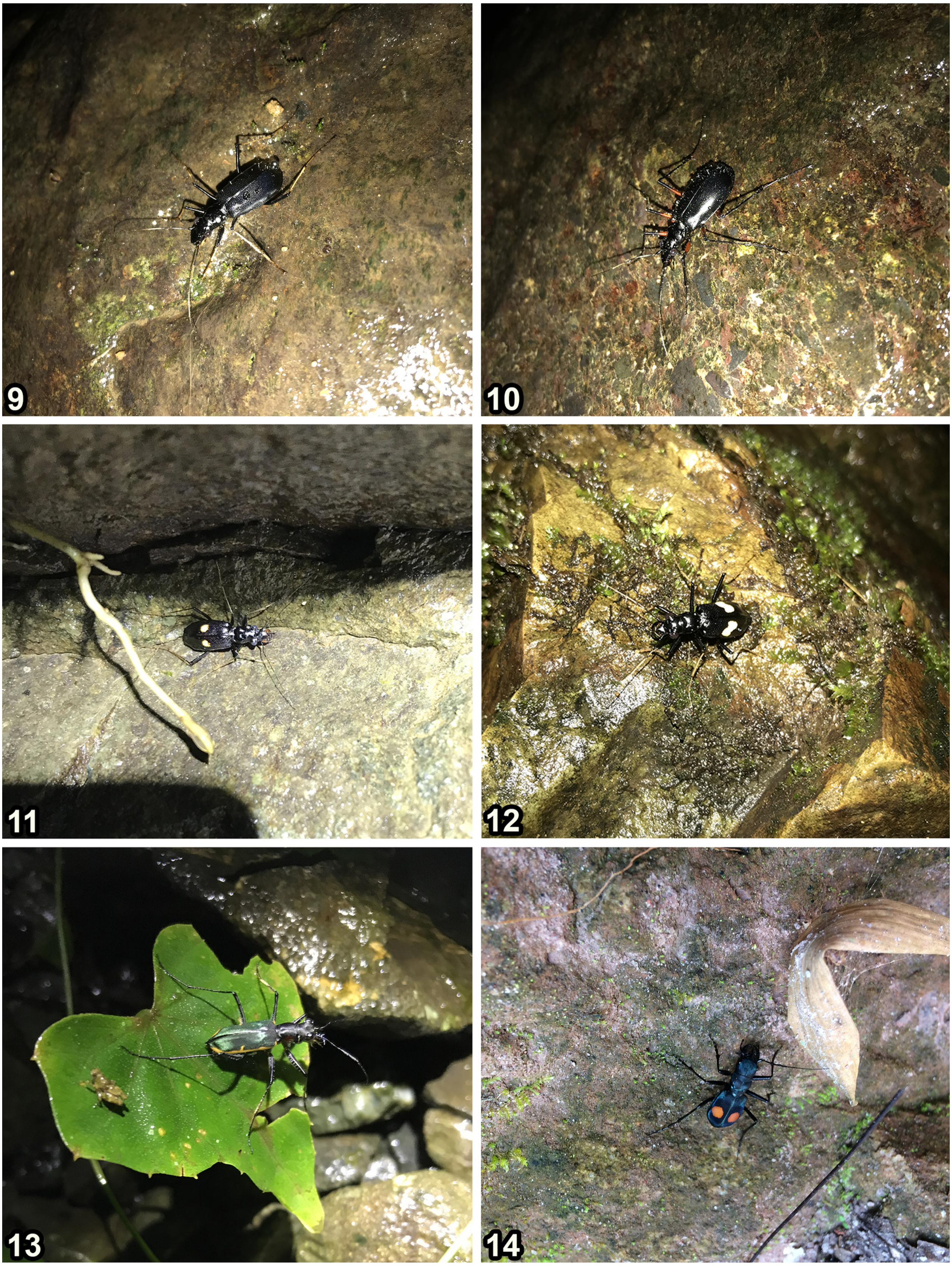
As another attempt, window traps (Figs. 6, 7) were used in both localities, installed at the height of 1m above the water level and in which two different LED lights, UV and white, were used on different days. Vinegar was used for conservation of the samples in the traps.

In addition, we conducted a night-only survey in February 2023 using the night vision camera, to gain experience with this new observational methodology for investigating the natural history of recorded species.

The locality number one (L1) was recently impacted by human activities of water regulation and construction of an unpaved entry road for the purpose of drinking water source in 2020, when complete removal of vegetation on the left bank of the surveyed section was carried out. The original habitat was previously almost natural with closed vegetation and only a small hiking trail that led to a nearby waterfall. A partial removal of the riparian vegetation was still evident during our observations in February 2022 (Fig. 5). In February 2023, a natural restoration process was already in progress, when the construction maintenance was minimal in the meantime (Fig. 4).

The locality number two (L2) is mostly surrounded by natural riparian vegetation and only a small path through its valley is noticeable (Fig. 8). The habitat stayed unchanged before and during our observations between February 2022 and February 2023.

FIGURES 4–8. Localities L1 (Figs 4–6) and L2 (Figs 7,8). 4, 8: habitat; 5: drinking water construction at L1; 6, 7: window trap instalations.



FIGURES 9–14. 9. *Oxycheila affinis* Horn, 1900. 10. *Oxycheila brzoskai* Wiesner, 1999. 11. *Oxycheila buestani* Wiesner, 1999. 12. *Oxycheila pearsoni* Wiesner, 1999. 13. *Oxygonia oberthueri* Horn, 1896. 14. *Pseudoxycheila chaudoiri* Dokhtouroff, 1882.

The study area and collection locations are presented as images obtained from Google Earth 2023 (Fig. 1–3). The pictures of the localities and tiger beetle species (Figs. 4–14) were purchased by cell phone iPhone 7 Plus. The night observation of species natural behaviour was done by the Henbaker CY789 night vision camera.

Results

Six species of Cicindelidae: *Oxycheila affinis* W. Horn, 1900, *O. pearsoni* Wiesner, 1999, *O. brzoskai* Wiesner, 1999, *O. buestani* Wiesner, 1999, *Pseudoxycheila chaudoiri* Dokhtouroff, 1882 and *Oxygonia oberthueri* W. Horn, 1896 were observed together.

We recorded all observed species at L2 in both years. *Oxycheila buestani* and *Pseudoxycheila chaudoiri* were absent at L1 in 2022, but only *P. chaudoiri* was absent in 2023.

Eight individuals of *Oxycheila buestani* were observed among observed Cicindelidae species at L2 in 2022 and confirmed by another eight individuals in 2023. Only a single specimen was recorded at L1 and only in 2023. The female of this species was recorded for the first time.

The most successful method for observing *Oxycheila* species was night wading of streams with a headlamp at both sites in both years.

Only UV LED light was successful when window traps were used, and these installations attracted a sample of individuals of all *Oxycheila* and *Oxygonia* species observed at each site.

The night vision camera made it possible to observe the natural behaviour of more common species, especially *Oxycheila affinis* and *Oxygonia oberthueri* when they occur on boulders in streams. It was possible to record the behaviour of species at a distance of only one meter. The observed species had no reaction to infrared light, only the physical presence of the observer at a short distance of up to 1 meter sometimes caused disturbance.

Taxonomy

Material and methods

All dimensions are measured using a binocular Arsenal STM 706. The total body length is measured excluding labrum, from the anterior margin of the clypeus to the elytral apex. The width of the head is measured as the distance between the outer margins of the eyes. Dimension intervals used in the description part of this manuscript mean the intervals among dimensions of all 17 studied specimens including data from original description. The aedeagus is photographed in its left lateral and ventral position. The colour photographs of *Oxycheila buestani* were taken by Mr. Vladimír Štrunc with a Nikon D850 camera in combination with a Tamron AF SP 90 mm F/2.8 Di Macro 1:1, Raynox DCR-250, Raynox MSN-202, Raynox MSN-505, with macro lens, and final images were assembled using Helicon Focus 8.1. The colour photographs of *Oxycheila pseudostrandi* were taken by Mr. Alex Pazmiño-Palomino and Mr. Michael S. Basantes with Olympus SZ61R stereomicroscope, morphological measurements and photographic recordings were made, adapted with a digital camera (The Imaging Source DFK23UX236) using IC Measure v. 2.0.0.161 software. The format of the description follows the monograph of the genus *Oxycheila* by Wiesner (1999).

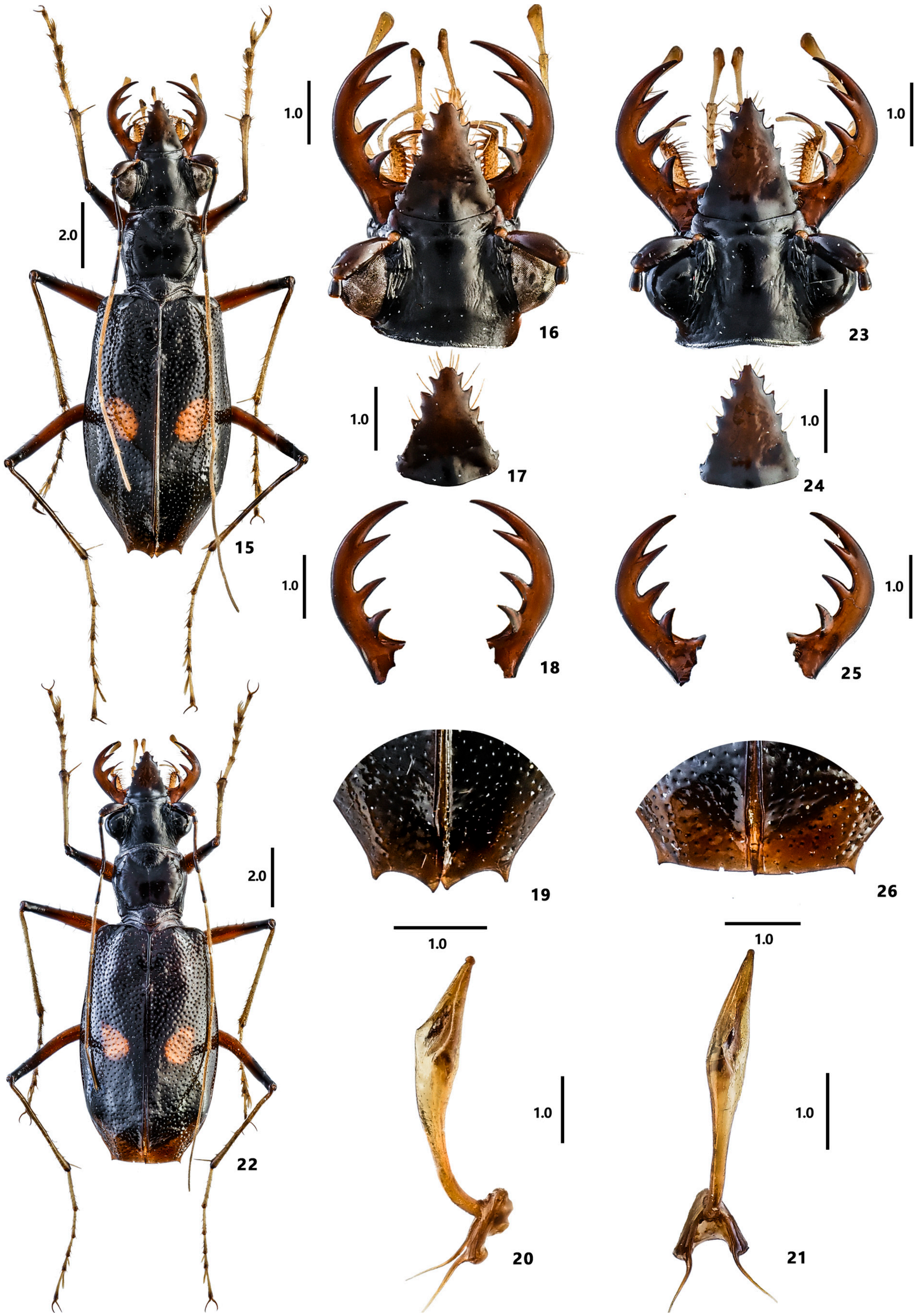
Redescription

***Oxycheila buestani* Wiesner, 1999**
(Figs 15–26)

Oxycheila buestani Wiesner, 1999: 39.

Type locality. Ecuador, Guayas, 2,5 km north of Bucay, Rio Chagüe.

Other localities. ECUADOR: Guayas prov., ca 8 km N of Cumandá, 723 m, Comunidad Shuar, S 02°08´24´´, W 79°07´06´´; ECUADOR: Guayas prov., ca 7 km N of Cumandá, 680 m, Comunidad Shuar, 02°08´43´´, W 79°07´17´´.



FIGURES 15–26. *Oxycheila buestani* Wiesner, 1999. (15–21 male, 22–26 female). 15, 22: habitus; 16, 23: head; 17, 24: labrum; 18, 25: mandible; 19, 26: elytral apex; 20, 21: aedeagus male. Bars in mm.

Redescription. Body (Figs 15, 22) small to medium-sized, 10.4–13.6 mm long, 4.3–5.0 mm wide, dorsal surface of the head and pronotum shiny black, elytra shiny black, on apical part brown-black.

Head (Figs 16, 23) narrower than body, 2.9–3.3 mm wide, concolorous with the rest of dorsal body surface, all parts of head glabrous except for two setae on both left and right borders of eyes and orbital plates.

Mandibles (Figs 18, 25) ochre to reddish-brown, almost symmetrical, each mandible with 4 teeth, very narrow black stripe on periphery, more distinct on fourth teeth.

Labrum (Figs 17, 24) similar in both sexes, thinly triangular, brown with dark brown-black basomedian area and basolateral margins, with protruding black basal part, longer (1.4–1.8 mm) then wide (1.3–1.5 mm), with 6–8 lateral teeth on the margin and about 5–9 anterolateral and 5–7 lateral setae.

Labial and maxillary palpomeres yellow-ochre coloured with darker apical parts.

Antennae extend posterior past the elytral apex, antennomeres 1–4 shiny brownish to blackish, antennomere 4 with yellow-brown basal third, antennomeres 5–11 ochre-brown, dull and with fine setae.

Eyes large and protruding, deep longitudinal groove above the eyes with 2 setae.

Clypeus smooth, black, lateral margins brown-black.

Pronotum slightly longer than wide (mean: 2.75 mm long, 2.53 mm wide), converging slightly anteriad but strongly posteriad, lateral margins distinct and convex; anterior lobe distinctly wider than posterior lobe which is notably higher; surface of pronotal disc almost smooth, indistinctly wrinkled, anterior sulcus with less wrinkled groove than posterior one.

Mesepisternum with deep, pointed impression on the dorsal third of lateral margin in female (cuppling sulcus), while with sharp groove extending from the dorsal lateral margin to ventral lateral margin in male.

Elytra (Figs 15, 22, 19, 26) elongate, lateral margins slightly expanded laterally, widest near the middle, narrower towards apex, more notably in male, length 8.0–9.0 mm, wide 4.3–5.0 mm, ratio of length to width = 1: 0.54 in male and 1: 0.56 in female; surface flattened, almost uniformly shiny black except for brownish-black posterior area, deeply punctate on anterior area, yet punctures sparser and shallower on posterior area; elytral maculation consisting of one, yellow-ochre, almost circular central macula (approximately 1 mm in diameter) placed somewhat towards outer elytral margin; shoulders rounded with barely detectable basal and preapical umbones; elytral apex distinctly sexually dimorphic: in male with distinct, subacute, spine-like outer tooth, in middle deeply excised towards subacute sutural spine; elytral apex in female truncate in middle, with smaller subacute lateral tooth and indistinct sutural spine; the distance between the lateral tooth is ca 1.5 mm in male and ca 2.5 mm in female (Figs 19, 26); membranous flight wings present.

Legs yellow-ochre, femora ochre-brown and black distally, metatibiae darker then protibiae and mesotibiae, tarsal segments usually slightly darkened distally, femoral surface covered with very sparse rather regular rows of erect ochre setae, tibial surface covered with denser irregular setae, more regular on protibiae; mesotibiae with denser setae distally, tarsi covered with denser and rather regular rows of erect ochre setae, second and third tarsomere with brush-like setal structure distally, more distinct on protarsi in female, while protarsi generally more setose in male.

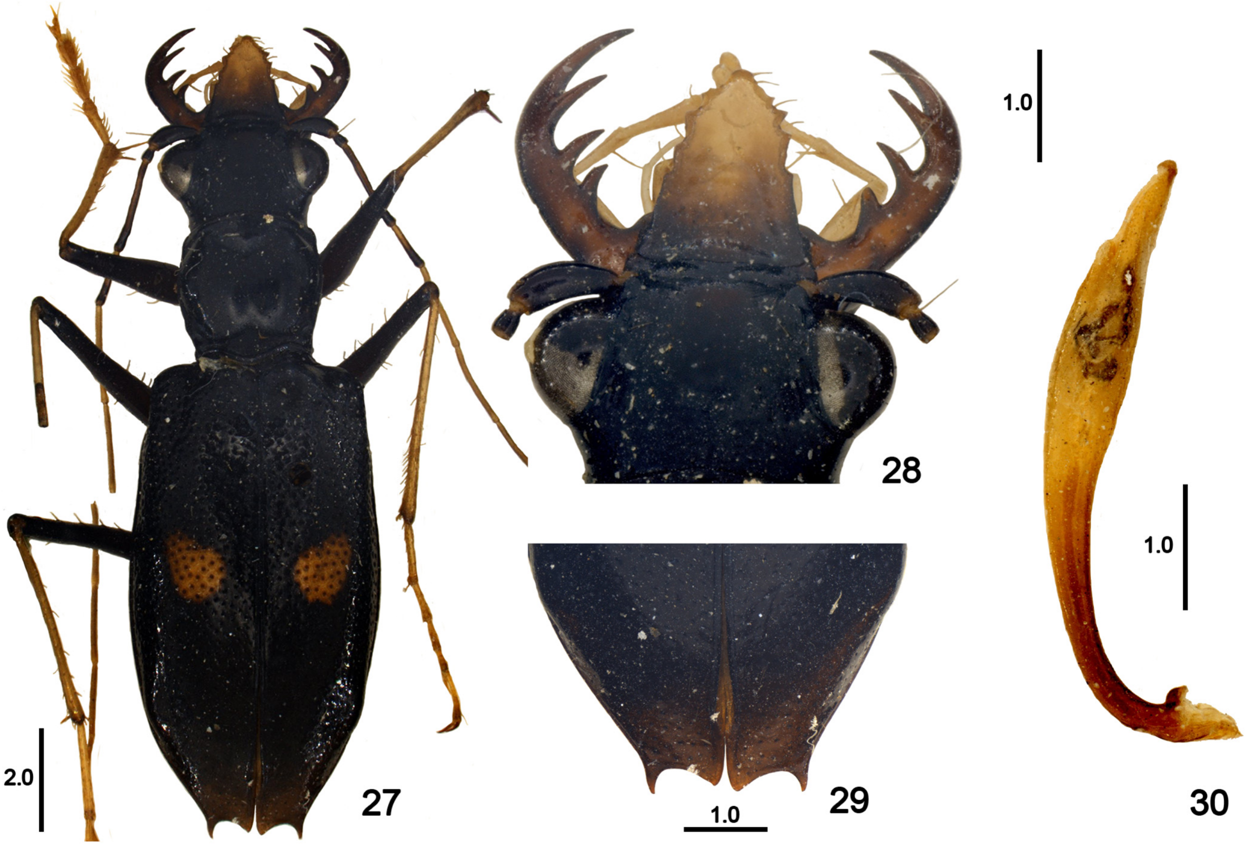
Aedeagus (Figs 20, 21) length 4.0–4.4 mm, width 0.6 mm basal portion short, median portion moderately dilated distally, apical portion conically attenuated towards small, moderately ventrally directed apex, with knob-like tip.

Differential diagnosis. *Oxycheila buestani* Wiesner, 1999 (Figs 15–26) is obviously morphologically close to *Oxycheila pseudostrandi* Wiesner, 1999 (Figs 27–30) but is generally smaller (10.4–13.6 mm) and clearly distinguished by the entire yellow-ochre legs and ochre-brown femora with black knees, labrum is triangular and brown. *O. pseudostrandi* is generally bigger (13.1–14.2 mm), has completely black femora, yellow tibia and tarsi, the labrum is rather trapezoid and predominantly yellow coloured, and, particularly, the male elytral apex possesses longer, acute lateral spine (Fig. 29). Moreover, the internal sac in the examined aedeagi appears different.

Notes to distribution and biology of the observed species

Westerns slopes of Ecuadorian Andes host actually five species of *Oxycheila* and four species of *Oxygonia*, that do not occur on eastern (Amazonian) part, where another five species of *Oxycheila* and eight species of *Oxygonia* are known to occur.

Because of mainly nocturnal behaviour of these genera, only poor knowledge of natural history is known.



FIGURES 27–30. *Oxycheila pseudostrandi* Wiesner, 1999, male. 27: habitus; 28: head; 29: elytral apex; 30: aedeagus. Bars in mm.

Oxygonia Mannerheim, 1837

After the previous papers on the genus (Horn (1905), Kippengan (1997)), 20 recognized (and one uncertain) *Oxygonia* species were presented recently by Moravec (2020), occurring mostly along the Andean mountain streams and distributed from Costa Rica and Panama to Colombia, then southwards to Ecuador, Peru and northern Bolivia. Interestingly enough, *Oxygonia nigricans* W. Horn, 1826 was originally described from a maritiam habitat of the small Georgona Island off the Colombian Pacific coast, yet in Panama was later caught on Rio Cana at altitude 500 m. Fourteen recognized taxa occur in Ecuador, six of which are Ecuadorian endemics.

Some species of this genus can be recorded during the day, some at night, and some both, during day and night. Individuals are mainly found on partially flooded, rather larger boulders and stones, usually in the middle of fast-flowing streams with a width of 1 to 15 m, where they search for prey of smaller aquatic insects. Most species, when disturbed and according to the natural character of the water course, fly to another boulder in the stream or a rock on the bank or to the leaves of coastal vegetation reaching above the water surface, where they also rest during periods of inactivity.

Oxygonia oberthueri (Fig. 13) was the only species of this genus recorded on studied localities. Pearson *et al.* (1995) published the results of natural history observations on nine Ecuadorian species of *Oxygonia*. They mentioned diurnal activity of *Oxygonia oberthueri*, that forages on rocks and moss-covered vegetation near the water's surface. It regularly flies to overhanging foliage to escape danger. It is found along small (< 1 m wide) streams to moderate rivers (> 15 m wide) from 300–1300 m elevation.

Our observations confirm both diurnal and nocturnal activities. The nocturnal activity seems to be preferred by this species according night vision observation however the same behaviour was observed during the day and night. The individuals move quickly on boulder surfaces and often fly from one to another. The mating pair was observed during the night when the female foraged undisturbed during mating. The male held the female with his mandibles on the upper part of her elytra, not in metepisternum as presupposed.

Oxycheila Dejean, 1825

Species of this Neotropical genus occur in wide, mostly mountainous areas from southern Mexico to Atlantic forests in Brazil and Argentina. Wiesner (2020) listed 51 species of the genus, subdivided into nine groups.

Most species occur along running water on sand or boulder faces and are active nocturnally occasionally on cloudy days. During the day they are generally found under rocks, usually on small islands in mountain streams. Some species may spend the day on leaves of bushes or under vegetation along these mountain streams (Pearson *et al.* 1999). Adults of *Oxycheila tristis* (Fabricius, 1775) are also occasionally found far away from water in dry places such as grasslands, forests and mountainous areas (Wiesner 1999).

Individuals search for prey, mostly larval stages of smaller aquatic insects, usually on the wet and downstream side of the boulders covered with algae or moss and often reach the water level or partly submerge. They usually start to run quickly or escape by flying to another boulder, rock or into shore vegetation when disturbed. They also often jump to the water and fly up directly from there immediately or after a couple seconds further downstream as discovered during our night observations. Cummins (1992) observed, that the Costa Rican species of *Oxycheila polita* Bates, 1872, that is often active during the day, could be carried by the stream more than a hundred meters before they flew up directly out of the water.

Oxycheila affinis (Fig. 9) is an Ecuadorian endemic species, that occurs in mountain streams on the west slope of the Andes. An isolated population occurs at a low altitude (800 m) and isolated coastal range of mountains, Montañas de Mache in Esmeraldas province (Pearson *et al.* 1999). Both, *Oxycheila affinis* and *Oxycheila brzoskai* observed by night vision camera ran more slowly and searched for prey using palpomeres on a wet stone surface covered with algal fibres, which they then began to "comb" with their mandibles in a backward movement. After a successful attempt, they stopped and started processing the food. Similar behaviour was observed in *Oxygonia oberthueri* too. *Oxycheila affinis* has been seen forcing *Oxygonia oberthueri* to escape from the same boulder when they come into contact, but *Oxygonia* runs and takes off faster so escapes easily.

Oxycheila brzoskai (Fig. 10) occurs in mountain streams on the west slopes of Andes and reaches southern Columbia. It overlaps in the southern part of its range with *O. affinis* and is locally sympatric with that species. The observed natural behaviour is very similar to *O. affinis*.

Oxycheila pearsoni (Fig. 12) occurs on western slope of Andes in central and southern Ecuador. Its subspecies "*columbiensis"* was described from Columbia (Wiesner 1999). Adults were found on the same sites as the previous *Oxycheila* species and additionally on the rocky shores. It appears to prefer more mossy and not permanently wet surfaces, which may indicate different prey preferences. But when this species was observed alone at another locality, it usually occupied similar sites like *O. affinis* and *O. brzoskai* at the investigated localities. It indicates lower competitive skills predicated by smaller size.

Oxycheila buestani (Fig. 11) is another Ecuadorian endemic that was found only in the area of triple border among the provinces of Bolivar, Chimborazo and Guayas. This rare species was observed on generally smaller stones more or less close to the bank and one specimen was captured directly on the gravel bank reaching the water. When disturbed by lights, it usually escaped quickly by running into shore and hiding or jumping onto current. Sometimes it remains still for long periods when observed in a more sheltered position, even after lights out. It is rather difficult to find individuals of this species, because of its small size, and moreover, it moves on a coloured gravel surface closer to shore hiding spots. The female of this species was observed for the first time.

Pseudoxycheila chaudoiri (Fig. 14) was observed when running on a vertically uncovered soil bank reaching the water level during the day. It is a rather common species that prefers open vertical areas after landslides in forests and dirt roads and its occurrence is not directly linked to watercourses. More about the *Pseudoxycheila* biology in Cassola (1997).

All observed *Oxycheila* species and *Oxygonia oberthueri* are syntopic on studied localities and occupy the same sites within the streams. Although the territory and feeding competition was seen among the species and also within individuals of the same species, relatively rich sources of the prey on these natural localities allows their co-occurrence. Additionally, strong competition of bigger *Oxycheila* species may cause the occasional daytime activity of mainly nocturnal species of *Oxygonia oberthueri*.

Conclusion

The most successful method of *Oxycheila* and *Oxygonia* observation was night walking-wading through the streams using headlamp on both localities. This method requires extreme caution due to the risk of injury when moving on slippery surface in strong current and at the same time a high level of risk of landslides in narrow steep valleys that are very common during the rainy season. We evaluated the use of window traps as a very useful and safer method for quickly detecting the presence of the species. The results of our February 2023 studies show that the observation and collection methodology used in this study did not affect the number of populations of the recorded species at any of the monitored localities.

We have also found the use of a night vision camera to be a very successful tool for *Oxycheila* and *Oxygonia* night observation, where it is possible to record their natural behaviour at a short distance. We believe that other nocturnal species of tiger beetles, especially species from the tribes Megacephalini and Manticorini, can also be observed using this technology.

Night vision or other new technologies must be used more in the future to bring more information about the natural history of nocturnal insects. For example, high-tec technology is currently being used to observe the migration of *Troglophillus neglectus* (Kraus, 1879) (Orthoptera: Rhaphidophoridae) in the Saxon Switzerland National Park in Germany. A microchip weighing 0.18g is attached to the dorsal part of the individuals to record the movement route during the migration from underground shelters to a summer habitat that is not yet known (Jürgen Phoenix pers.com.).

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