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"OUR PLANET REVIEWED" 2015

LARGE-SCALE BIOTIC SURVEY IN MITARAKA, FRENCH GUIANA

Edited by Julien TOUROULT

The "Our Planet Reviewed" Mitaraka 2015 expedition: a full account of its research outputs after six years and recommendations for future surveys

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Couverture / Cover :

Mitaraka Sud Massif showing inselbergs and associated forest vegetation (photo: Xavier Desmier). In medallion: preparation and management of the specimens for short term storage in the field laboratory.

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ABSTRACT
Six years after the expedition “Our Planet Reviewed – French Guiana 2015” in the Mitaraka massif, we present a synthesis of the taxonomic and faunistic results obtained from the analysis of the 108 published articles and the 10 600 observations that were databased and disseminated. In this relatively short period of time, 218 new species for French Guiana including 127 species new to science, and also four genera new to science have been published based on the expedition material. These are primarily insects, notably Coleoptera (98), Diptera (60), Lepidoptera (16) and Orthoptera (17). For the 2015 to 2020 period, approximately 13% of the descriptions of new animal species in French Guiana use material from the expedition. The 3100 species identified in Mitaraka represent nearly 15% of the 21 042 animal species known from French Guiana. The observation data from the expedition that are open access via the Global Biodiversity Information Facility (GBIF) portal render the Mitaraka massif the area with the greatest documented and disclosed entomological richness on the Guiana Shield. Feedback has enabled us to draw up some recommendations for inventories aimed at taxonomic discovery: assign a person per taxonomic group to mobilize, coordinate, and motivate the taxonomic experts involved; deploy a variety of collecting strategies, from interception and attractive traps to active search; invest heavily in the sample processing phase; get a journal editor engaged to dedicate issues to thematic publications on the survey; and disclose the survey data through GBIF data sets and/or datapapers.

MOTS CLÉS
Neotropics,
Tumuc Humac,
Guiana Shield,
Amazonian forest,
ATBI,
sampling strategy,
collecting methods,
Linnean shortfall.

RÉSUMÉ
L'expédition « La Planète revisitée » Mitaraka 2015 : bilan des résultats scientifiques après six ans et recommandations pour de futurs inventaires.
Six ans après l'expédition « La Planète revisitée – Guyane 2015 » dans le massif du Mitaraka, nous présentons une synthèse des résultats taxonomiques et faunistiques obtenus à partir de l'analyse des 108 articles publiés et des 10 600 données bancarisées et diffusées. Dans ce relativement court laps de temps, 218 nouvelles espèces pour la Guyane dont 127 nouvelles espèces pour la Science, ainsi que quatre genres nouveaux pour la Science ont été publiés à partir du matériel de l'expédition. Il s'agit très majoritairement d'insectes, notamment Coleoptera (98), Diptera (60), Lepidoptera (16) et Orthoptera (17). Pour la période 2015-2020, environ 13% des descriptions d'espèces animales nouvelles de Guyane utilisent du matériel issu de l'expédition. Les 3 100 espèces identifiées à Mitaraka représentent près de 15% des 21 042 espèces animales connues de Guyane. Les données de l'expédition diffusées en libre accès dans le portail du Global Biodiversity Information Facility (GBIF) font du massif du Mitaraka la zone avec la plus grande richesse entomologique documentée et partagée pour le plateau des Guyanes. Le retour d'expérience nous permet de formuler quelques recommandations pour les inventaires visant à la découverte taxonomique : identifier un responsable par groupe taxonomique pour coordonner et animer l'expertise ; déployer une diversité de stratégies de récolte, par interception, recherche active et pièges attractifs ; investir massivement dans la phase de tri du matériel ; prévoir un ouvrage thématique regroupant les articles sur la mission ; et documenter les données produites par un ou plusieurs datapapers.

MOTS CLÉS
Région néotropicale,
Tumuc Humac,
Plateau des Guyanes,
forêt amazonienne,
ATBI,
stratégie
d'échantillonnage,
méthodes de collecte,
handicap taxonomique.

INTRODUCTION

A large-scale biodiversity survey, part of the "Our Planet Reviewed" program, was organised in the Mitaraka range, in the southwest of French Guiana, in February-March and August 2015. Among the objectives pursued (Touroult *et al.* 2018), this concluding paper of the *Zoosystema* thematic issue focuses on the four objectives related to faunistic inventory and taxonomic discovery: 1) to discover species new for science and to describe them in a short time frame; 2) to discover and publish first records for the French Guiana territory (i.e., species known in other countries but not yet reported from French Guiana in the literature); 3) to carry out a biodiversity inventory as complete as possible of the fauna of a remote location in French Guiana. This should serve as a benchmark for biogeographical studies and conservation strategies at the scale of the Guiana Shield and, possibly, for the whole Amazonian basin; and 4) to manage and share these data with conservation managers and the scientific community within the framework of the "Inventaire national du Patrimoine naturel" (INPN, French natural heritage inventory), and the Global Biodiversity Information Facility (GBIF) at the international level.

Regarding these goals, we list the main results obtained until December 16, 2021 i.e., about six years after the fieldwork was completed, provide analyses with regard to the contribution of new knowledge for French Guiana and attempt to formulate methodological guidance for this type of wide-ranging biodiversity inventories.

As stated in the authors' conclusion of the introductory paper to the Mitaraka survey (Touroult *et al.* 2018), we aim at assessing the contribution of the survey in terms of both discovering and publishing species new to science and first records for the territory of French Guiana (objectives 1 and 2). In other words, compared to the current background rate of discovery and taxonomic publications on French Guiana biodiversity (Brûlé & Touroult 2014), did the Mitaraka expedition generate a significant increase of scientific discoveries? A linked technical feedback question, that could improve the organisational aspect of biological inventories, refers to sampling methods and associated sample examination processes: what types of collecting techniques were used to find the novelties that were described? Also, should we favour passive traps (interception) or also keep targeted and "direct" collecting techniques (visual search, sieving, sweeping, light trap, etc.) in terms of sampling efficiency?

For the completeness of the species inventory (objective 3): have we been able to deliver new information on orders or classes of invertebrates that were hitherto poorly known in French Guiana? Has the project been able to mobilize post-field expertise beyond the one currently operational in this region? For objectives 3 and 4 (i.e., disclosure of collected biodiversity data), we checked how the Mitaraka inventory stands compared to other available data on insects at the Guiana Shield level. For data dissemination, we also analysed the management of traceability, the citation and deposition of specimens, requirements that are constrained by the implementation of the Nagoya protocol since 2014. In other words, for our Mitaraka case study: what is the proportion of publications that meets the different citation requirements? And finally, we questioned what factors affect this traceability?

MATERIAL AND METHODS

Study site and taxonomic field protocols

The study site and the taxonomic field protocols are described in detail in Touroult *et al.* (2018). Thirteen different trap

types were used including four types of interception traps and nine types of attraction-based traps. Active search methods (13 techniques) and extraction from the substrate (five techniques, including Winkler sieves, emergence from dead wood, etc.) completed the sampling framework.

Specimen management

As for other projects of the "Our Planet Reviewed" program, the organization of the transmission of specimens to taxonomic experts after sorting has been developed through the appointment of a few key people, i.e., the taxonomic group coordinators (list given in Touroult *et al.* 2018). The benefit of this approach is twofold: first, the coordinators bring their own expertise and their network of experts to the project, adding to those already mobilized by the general project management. They also facilitate the splitting up of the samples into workable fractions for the experts, and the dissemination of these fractions. After a sorting phase that lasted less than a year for most groups, a network of 165 taxonomic experts was mobilized by the 12 coordinators to study the sorted specimens.

Data management

An online database, CardObs (https://cardobs.mnhn.fr/), developed since 2007 to facilitate the entry of French data collected by naturalists, was used. This application is linked to TAXREF, the national French taxonomic backbone (Gargominy *et al.* 2019). In CardObs, taxa that are not (yet) recognized as described, are assigned to the appropriate higher taxonomic level. A free data entry field is provided to store the morphospecies name assigned by the identifier, or left empty if the genus is the most reliable level of identification. This database was updated each time identification lists were returned by coordinators or experts and/or when articles were published, ensuring a link between the specimen, the publication and the observation data. This database is connected to the portal of the National Inventory of Natural Heritage (INPN: https://inpn.mnhn.fr), which is periodically uploaded to the international portal of the Global Biodiversity Information Facility (GBIF: https://www.gbif.org).

Identification and characterization of scientific publications as of July 31, 2021

Since the Mitaraka fieldwork was accomplished in 2015, we have been tracking actual publications citing material from the expedition by keeping close contact with participants and by monitoring Google.scholar and the Zoological Record websites. For each publication using or citing at least one specimen from the expedition, we retrieved the following characteristics from the publications:

- taxon cited;
- date of publication and bibliographic reference;
- indication whether the publication is part of a thematic issue of the following journals or not: the current series of *Zoosystema* or ACOREP-France on the Beetles of French Guiana;
- species status: species new to science or only recorded for the first time in French Guiana;
- whether all the material, especially the holotype, originates from the expedition;
- collecting technique for the holotypes;
- compliance to the requirements for citation of the shipment, citation of the Access and Benefit-sharing (ABS) permit, and deposition of types and part of non-type specimens in the MNHN collections.

For this screening and the analyses of the taxonomic results provided in this article, we did not take into account: 1) new citations for French Guiana that appeared in the identification lists but were not published; 2) new citations made in the survey report (unpublished literature); nor 3) the first genus records for French Guiana when they were not associated with a precisely identified species.

References for comparing the output of this survey

For comparison purposes, we used periods of 5 or 5.5 years, corresponding to the baselines used and the time when the analysis was carried out.

We used the national taxonomic backbone TAXREF (Version 14, Gargominy *et al.* 2020) as a reference to describe the pattern of descriptions of species of the French Guiana fauna, which lists all the cited species in French Guiana with their year of publication. From these data of the period prior to the survey (e.g. 2003-2013, analysed by Brûlé & Touroult 2014), it is possible to compare the production of new species in the 5.5 years period between July 1, 2015 December 31, 2020 and to infer the proportion that can be directly assigned to the Mitaraka survey (i.e. species described on the basis of Mitaraka 2015 survey specimens only).

We treat the GBIF portal (www.gbif.org) as reference for shared data. In this respect, on August 20, 2020, we examined the volumes of insect data (Insecta class in the GBIF search module) accessible in the Guiana Shield Region, with a precise geolocation of less than 1 km.

RESULTS

We identified 108 publications related to the Mitaraka expedition (see references) including 100 taxonomic papers (see Table 1). New species and first records are listed in Appendix 1.

New species and first records (objectives 1 and 2)

By July 31, 2021, 218 new species for the fauna of French Guiana had been published, based in whole or in part, on the material collected during the expedition. There are 127 species new to science, including 99 with a holotype produced by the Mitaraka 2015 survey (Table 1). Another 91 are first published records for French Guiana of species already known from elsewhere. Of these 218 new entries, 128 (60 new species and 68 first records) are based solely on samples collected at Mitaraka. Insects make up the bulk of these novelties (214), notably Coleoptera (98), Diptera (60), Orthoptera (17) and Lepidoptera (16). There were also discoveries in less diversified taxa, with two new scorpions (Arachnida, Scorpiones) and two new frogs (Amphibia, Anura) (Table 1).

TABLE 1. — Summary of the number of species described or reported for the first time for French Guiana on the basis of material collected during the Mitaraka expedition. The "first country records" do not include the new species described.

Higher classification	Number of new species described based on material: from Mitaraka survey only	Number of new species described based on material: not exclusively	Number of first country records published based on material: from Mitaraka survey only	Number of first country records published based on material: not exclusively	References
Actinopterygii (fishes)	**–**	**–**	**–**	**–**	Brosse *et al.* 2019; Cilleros *et al.* 2017, 2019
Amphibia, Anura	**1**	**1**	**–**	**–**	Fouquet *et al.* 2019b
Aromobatidae	1	–	–	–	Fouquet *et al.* 2019a; Vacher *et al.* 2017
Bufonidae	–	1	–	–	Rojas *et al.* 2018
Arachnida, Scorpiones	**2**	**–**	**–**	**–**	Lourenço 2018
Buthidae	1	–	–	–	Lourenço 2016
Chactidae	1	–	–	–	Lourenço 2018
Insecta, Blattodea	**–**	**–**	**1**	**–**	Evangelista *et al.* 2019
Ectobiidae	–	–	1	–	Evangelista *et al.* 2019
Insecta, Coleoptera	**18**	**39**	**9**	**13**	
Brendidae (incl. Apioninae)	–	5	2	3	Mantilleri 2015, 2017, 2018; Rheinheimer 2018
Buprestidae	4	–	–	–	Brûlé 2015; Curletti & Brûlé 2015, 2016
Cantharidae	4	24	1	4	Biffi & Constantin 2018; Constantin 2015, 2016a, 2017a, 2018
Cerambycidae	2	1	–	–	Dalens 2016; Dalens & Touroult 2015; Touroult & Dalens 2015
Chrysomelidae	–	1	–	–	Constantin 2017b
Curculionidae	–	1	–	–	Rheinheimer 2017
Elateridae	2	6	–	1	Chassain 2016, 2018; Chassain & Touroult 2016, 2017, 2018
Histeridae	–	1	–	–	Degallier *et al.* 2015
Paussidae	5	–	–	–	Deuve 2018
Phengodidae	1	–	–	–	Constantin 2016b
Scarabaeidae (incl. Dynastinae)	–	–	2	3	Boilly 2015, 2018; Boilly *et al.* 2016; Dupuis 2016; Rojkoff 2016; Touroult *et al.* 2017
Tenebrionidae	–	–	4	2	Gonzales *et al.* 2015; Gonzales & Yvinec 2016
Insecta, Dermaptera	**–**	**–**	**2**	**1**	Girod & Matzke 2020
Spongiphoridae	–	–	2	1	Girod & Matzke 2020
Insecta, Diptera	**20**	**–**	**40**	**–**	
Agromyzidae	–	–	2	–	Boucher & Pollet 2021
Asilidae	–	–	11	–	Vieira *et al.* 2019
Chloropidae	1	–	1	–	Riccardi 2020 ; Riccardi *et al.* 2020
Dolichopodidae	7	–	4	–	Brooks *et al.* 2018; Pollet *et al.* 2018; Runyon & Pollet 2018
Drosophilidae	–	–	1	–	Pirani & Grimaldi 2019
Keroplatidae	3	–	–	–	Blagoderov & Pollet 2020
Muscidae	1	–	–	–	Gomes & de Carvalho 2018
Pipunculidae	1	–	3	–	Marques *et al.* 2019
Psychodidae	2	–	–	–	Curler 2020
Ropalomeridae	–	–	2	–	Ale-Rocha & Pollet 2019
Sciomyzidae	1	–	1	–	Mortelmans & Pollet 2018
Sepsidae	1	–	8	–	Silva & Pollet 2020
Tabanidae	–	–	9	–	Krolow *et al.* 2017
Tipulidae	3	–	–	–	Mederos & Pollet 2019
Insecta, Hemiptera	**–**	**1**	**–**	**1**	
Coreidae	–	1	–	–	Brailovsky 2017
Pentatomidae	–	–	–	1	Lupoli 2019
Insecta, Hymenoptera	**3**	**2**	**6**	**2**	
Braconidae	1	2	–	1	Belokobylskij *et al.* 2017
Dryinidae	1	–	–	–	Olmi *et al.* 2019a
Embolemidae	1	–	–	–	Olmi *et al.* 2019b
Formicidae	–	–	6	1	Ladino & Feitosa 2020; Leponce *et al.* 2019
Insecta, Lepidoptera	**1**	**12**	**–**	**–**	
Apatelodidae	–	2	–	–	Herbin 2017
Erebidae	1	5	–	–	Barbut 2016; Cerda 2016; Gibeaux 2016a; Gibeaux 2016b; Laguerre & Vincent 2016

Table 1. — Continuation.

Higher classification	Number of new species described based on material: from Mitaraka survey only	Number of new species described based on material: not exclusively	Number of first country records published based on material: from Mitaraka survey only	Number of first country records published based on material: not exclusively	References
Geometridae	–	–	–	–	Lévêque 2015
Lycaenidae	–	2	–	–	Faynel 2019; Martins *et al.* 2016
Noctuidae	–	1	–	–	Barbut & Lalanne-Cassou 2019
Nymphalidae	–	2	–	–	Fratello *et al.* 2015; Zacca *et al.* 2017
Saturniidae	–	–	3	–	Bénéluz 2021
Insecta, Mantodea	**1**	**–**	**–**	**–**	Roy 2019
Photinaidae	1	–	–	–	Roy 2019
Insecta, Odonata	**1**	**1**	**–**	**–**	–
Corduliidae	1	1	–	–	Fleck 2017; Fleck & Juillerat 2019
Insecta, Orthoptera	**11**	**3**	**3**	**–**	–
Acrididae	–	–	1	–	Pocco & Cigliano 2020
Gryllidae	3	3	–	–	Vicente & Robillard 2017; Campos & Desutter-Grandcolas 2020
Phalangopsidae	8	–	–	–	Desutter-Grandcolas & Faberon 2020
Pseudophyllinae	–	–	1	–	Hugel 2019
Romaleidae	–	–	1	–	Pocco & Cigliano 2020
Insecta, Phasmatodea	**–**	**1**	**–**	**–**	
Pseudophasmatidae	–	1	–	–	Conle *et al.* 2020
Total	58	60	61	17	–

Publications started soon after the survey and continued at a steady pace until mid 2021, with no downward trend (Fig. 1). In the first two years, many of the descriptions included only paratypes from Mitaraka, suggesting that the work had already been in progress prior to the survey and that additional specimens from the expedition had been swiftly integrated and/or triggered the publication. In contrast, since 2018, the vast majority of descriptions uses holotype material from the expedition (Fig. 1), suggesting specific work triggered by the dissemination of the expedition material.

Compared to the global rate of description of animal species from French Guiana (Fig. 2), publications related to the "Our Planet Reviewed" expedition encompass 13% of the 938 species described between 2015 and 2020. There are considerable differences between certain groups of insects though (Fig. 3A-C): the material from the expedition contributes moderately to the on-going dynamics of discoveries in Coleoptera and Lepidoptera but brings a strong increase in descriptions for some other orders of insects notably Diptera, Orthoptera and Hymenoptera.

In addition to this species-level analysis, four new genera are described with a type species from Mitaraka: two Psychodidae (Diptera)- (Curler 2020), *Polletomyia* Curler, 2020 and *Myiomystax* Curler, 2020; and two Orthoptera (Desutter-Grandcolas & Faberon 2020), *Aracopsis* Desutter-Grandcolas, 2020 and *Mellomima* Desutter-Grandcolas, 2020.

In most of the groups, except for Lepidoptera and vertebrates, a large number of morphospecies were recognized which did not yet lead to new species descriptions. This has a significant impact on the conservative numbers given in this paper, considering only published novelties. For example, one of the coordinators (Marc Pollet) has received identification results on some very small Diptera families that were considered not sufficient to dedicate a publication to, but might represent first records for French Guiana all together. And several unpublished identification lists (Pollet *et al.* 2018) include even genera new to science or for French Guiana that are discarded in the current analysis.

Biodiversity Open Access data (objectives 3 and 4)

Two datasets were produced compiling the results of each survey (February-March and August 2015) based on the lists of identifications delivered by the experts, and on the novelties published. These datasets are freely available and are updated once a year on the GBIF portal since the end of 2015 (Touroult *et al.* 2020a, b).

Both datasets combined contain 599 collecting events and 10 594 observations. These observations cover four animal phyla, 10 classes, 51 orders and 261 families, identified by 78 taxonomists, covering 3100 accurately identified species. These observations also include 2730 records concerning more than 550 taxa not identified to the species level. The 3100 identified species represent about 15% of the 21 042 terrestrial and freshwater animal species recorded from French Guiana (Gargominy *et al.* 2020).

These datasets include groups which have not been the subject of taxonomic or faunistic publications thus far: birds (223 species), reptiles (60 species), mammals (11 species, including one record cited by Catzeflis 2017), Gastropoda (31 taxa), and Clitellata (three taxa). Among insects, data are also available on the insect orders Blattodea (47 taxa), Neuroptera (11 taxa) and Megaloptera (one species).

As of 20 August 2020 (five years after the Mitaraka survey), GBIF contained 30 020 species level data on insect species with

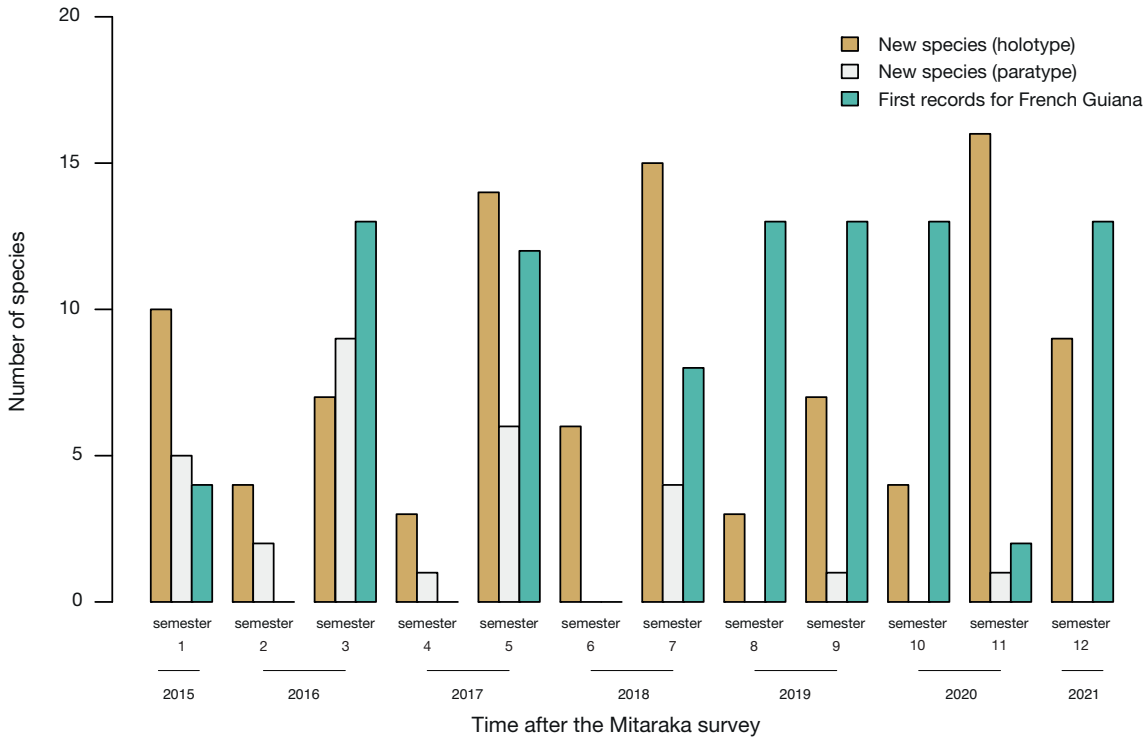

Fig. 1. — Number of species published by semester from the end of the expedition, with first semester: July-December 2015, and last semester: January-July 2021. The expedition was accomplished in August 2015.

a geographical accuracy < 1 km for a vast area largely covering the Guiana Shield (GBIF.org, 20 August 2020, https://doi.org/10.15468/dl.4ukp5y). Among the 49 corresponding datasets, the February/March Mitaraka survey dataset is the largest (6805 insect data) and the August Mitaraka survey dataset ranks eighth, with 1 186 data.

For 30% of the insect species for which data is available in GBIF at the scale of the Guiana Shield, the Mitaraka datasets are providing the only geographically accurate data. More than half (56%) of the species from the Mitaraka datasets do not have any other geographically accurate data available.

The data density map shows a clear concentration of data in the Mitaraka zone, in the southwesternmost corner of French Guiana (Fig. 4). This renders Mitaraka, despite its remoteness and challenging accessibility, the area with the highest documented species richness in the Guiana Shield region, based on accurate entomological open access data.

The Diptera data are compiled separately and will be made available at a later date, as part of a datapaper in preparation. This Diptera dataset currently contains over 4200 occurrence data of more than 1000 different species in 28 families with a combined total number of approx 13 700 studied specimens, compiled on the basis of the identifications provided by 39 taxonomists. Both the total species richness and the proportion of new species for science varies greatly among families. Some families, like Dolichopodidae, even show an unprecedented species richness not documented anywhere else in the world (Pollet *et al.* 2018).

Collecting techniques that produced most new species to science (objective 3)

Measured by the holotype collecting technique (i.e., the technique that produced the ultimate holotype specimen), the three main collecting strategies which produced the most new species were (Fig. 5): 1) active search, 2) interception, and 3) attraction (see Touroult *et al.* 2018 for a descriptive summary of these strategies and methods). The substrate extraction techniques did not add any new species. Traps based on light attraction (classical light trap and light trap coupling a LED to a cross interception trap) brought the most novelties, mainly among Coleoptera and Lepidoptera. The passive interception traps, especially those of the Malaise type (SLAM and large Malaise trap of 6m), have also collected a lot of new species, in more groups, including Diptera, Hymenoptera, Coleoptera and even Odonata. The "active" techniques provided 22 holotypes, including the vast majority of Orthoptera (active search at night).

Compliance with standard principles commitment (objective 4)

Our monitoring of publications precisely citing specimens from the survey (n = 90) shows overall good compliance with Access and Benefit-sharing (ABS) citation, acknowledgement and deposition of material (type and non-type) clauses. The most respected clause is that of depositing part of the material in the MNHN collections (93% of the articles), followed by the citation of the survey in the Acknowledgements section (91% with more or less complete acknowledgements, and 78% fully compliant). The reference to the ABS authorization

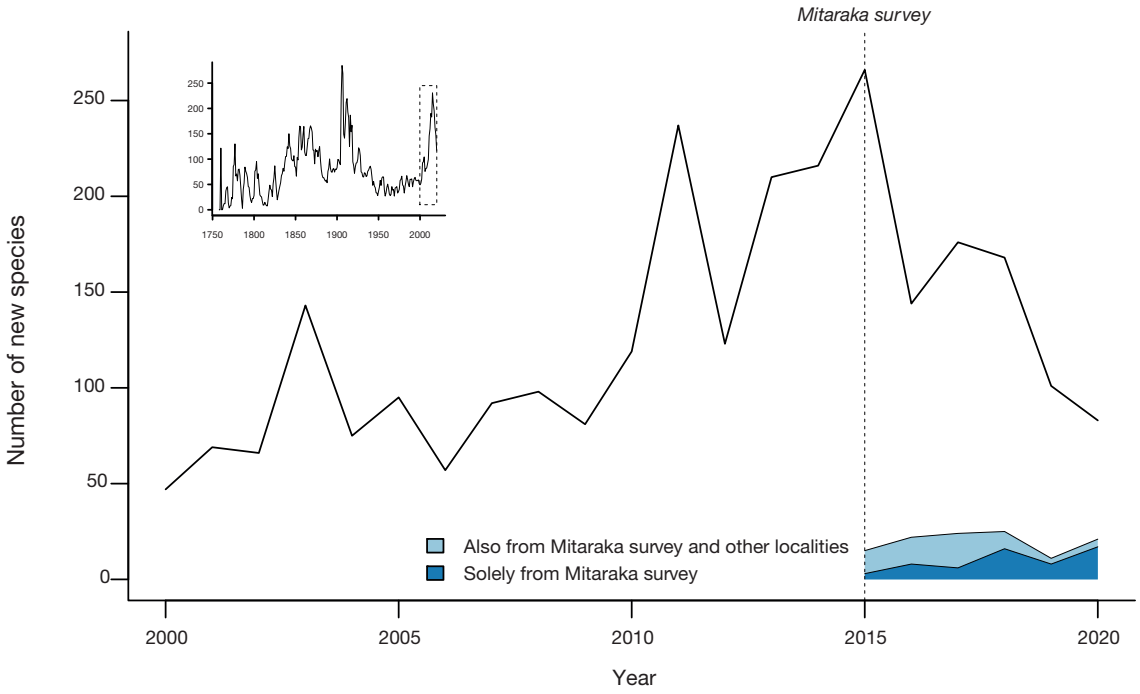

FIG. 2. — Number of new (non-marine) animal species of French Guiana's fauna described since 2000. New species collected during the Mitaraka survey are indicated in colour.

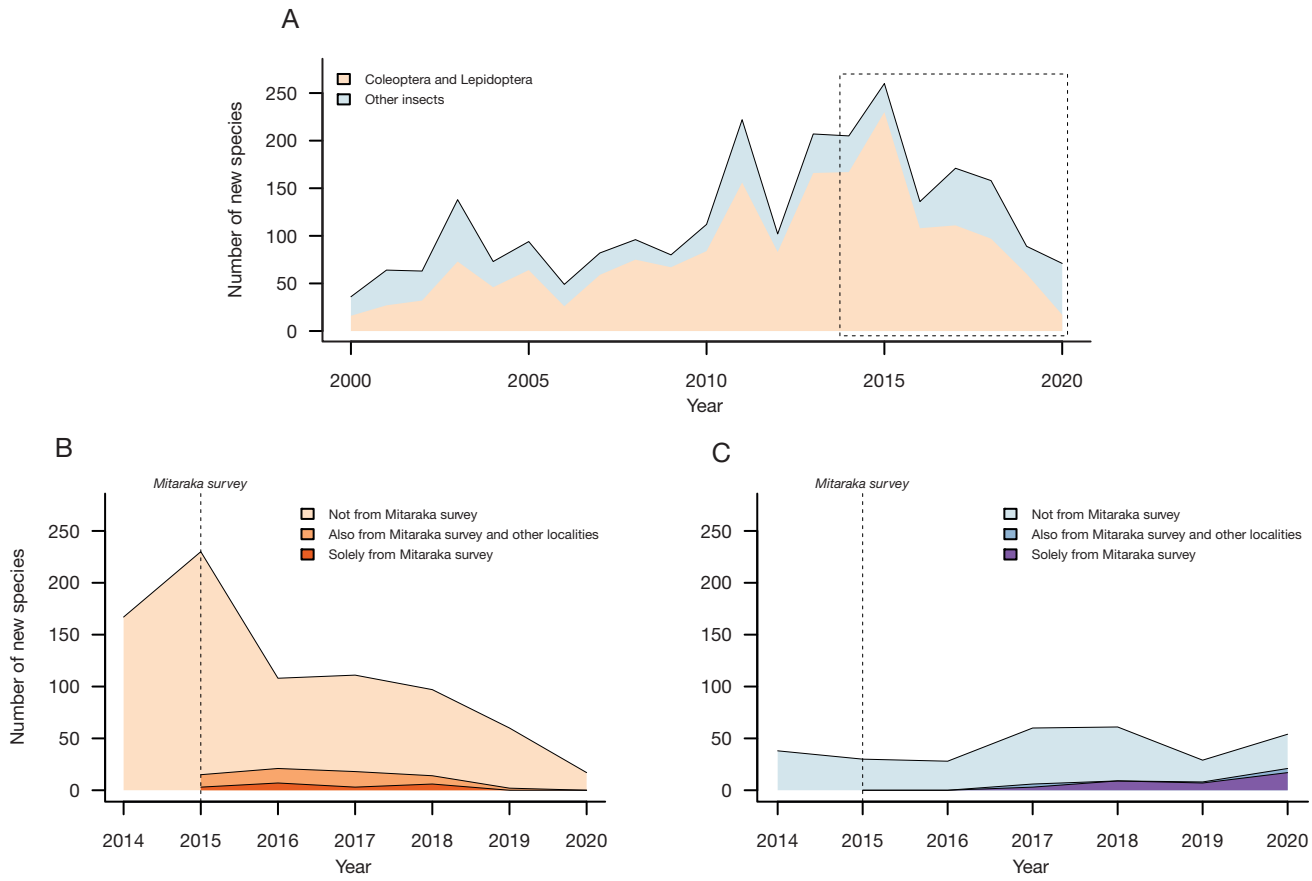

FIG. 3. — Number of new insect species in the fauna of French Guiana, described since 2000: **A**, all insect orders; **B**, Coleoptera and Lepidoptera; **C**, other insect orders (including Diptera, Hymenoptera, Orthoptera), both displaying the proportion from the Mitaraka survey.

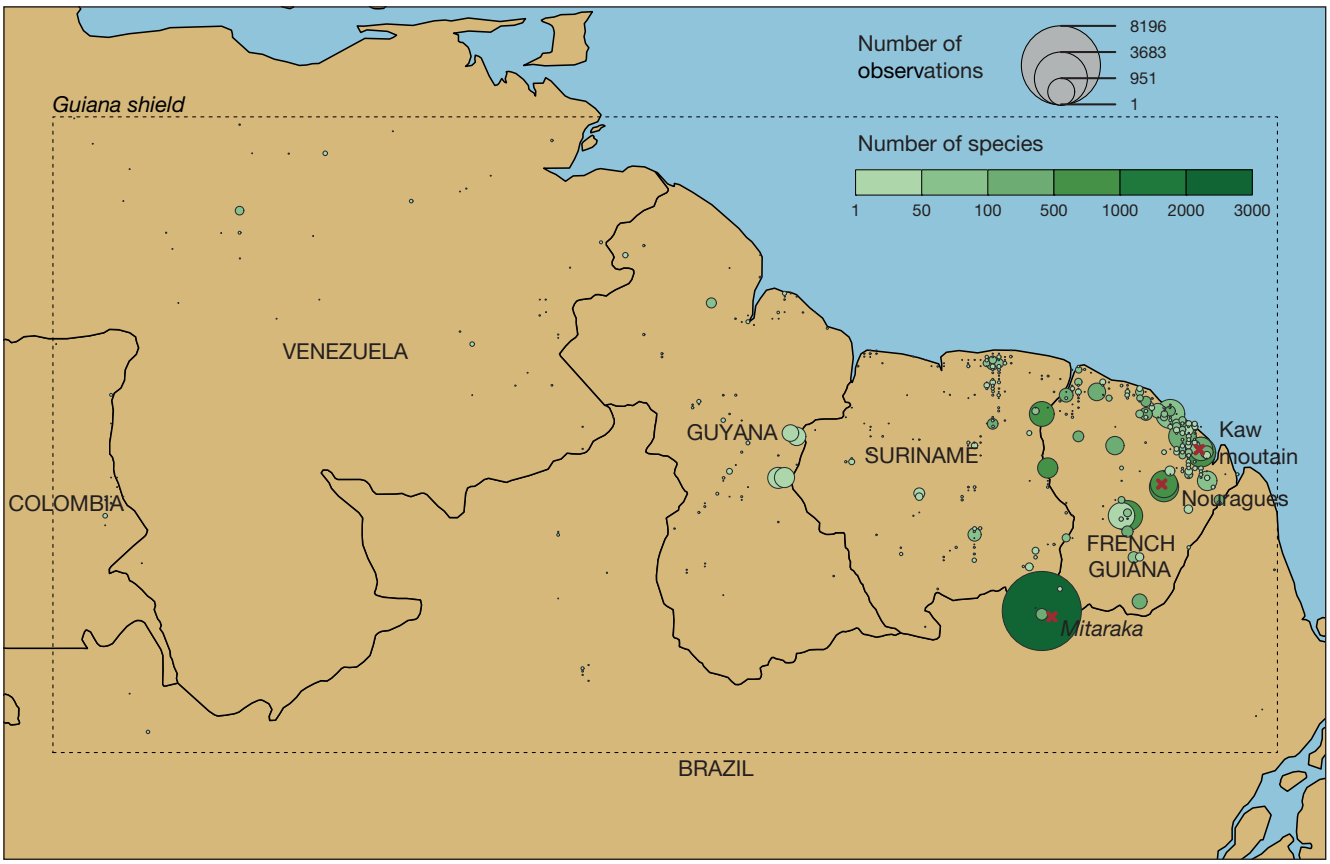

FIG. 4. —Density map of the shared data from the GBIF portal (https://www.gbif.org) for insects at the scale of the Guiana Shield. Only data with a high occurrence resolution (< 1 km) are included.

in relation to specimens (either in the Material and methods section, or better in the citation of the Material examined part of the species records) is respected in 79% of the articles.

The actual deposition of type material (and holotypes in particular) in the Paris Museum collections has been verified. As of November 15, 2020, only 19% of the holotypes of the new published species were accessible online on the MNHN collection portal (https://science.mnhn.fr/all/search). A survey of about a quarter (27%) of the new species with holotypes reported as ultimately being deposited in the museum collections reveals that this delay is partly (53%) due to the time required to digitize the specimens at the Museum (in-house delay) and to another part (47%) to the delay in sending specimens to the Museum by contributors (external delay) especially in a pandemic context.

We also analyzed possible reasons for not respecting instructions in 19 articles with the greatest violation of the rules. The interaction of two criteria significantly characterized the articles that did not comply with the clauses (Chi2 = 35.8, df = 3, p<.001). These are articles produced by scientists not directly involved in the survey and published outside the *Zoosystema* thematic issues on Mitaraka or ACOREP-France on the French Guiana Beetles (Fig. 6).

Moreover, after reading all the articles, it appeared that those which do not comply with the clauses are often articles mobilising a vast amount of material, of which the Mitaraka specimens present only a small part (e.g., one specimen from Mitaraka out of more than 100 from other sources) and non-type material.

DISCUSSION

WITH RESPECT TO THE GOAL OF FINDING NEW SPECIES (OBJECTIVES 1 AND 2)

It is difficult to conclude if the publication of 218 new taxa (either for science or as first record for French Guiana) makes a real difference, especially if we place this figure in relation to the work that remains to be accomplished globally. Being able to describe new species at a reasonable rate to fill the immense gap in invertebrate knowledge seems a losing battle to many biologists (Costello *et al.* 2013). Nevertheless, placing this discussion in the current depressing general context is largely irrelevant. Indeed, this global vision covers very different aspects and French Guiana represents a special case, since it is one of the (rare) territories that is still rich in biodiversity and where research has been conducted for decades. These are essential reasons for having chosen French Guiana for this edition of "Our Planet Reviewed" and we will thus narrow down the discussion to the Guiana case which enables some comparisons and lessons from the "with" or "without the Our Planet Reviewed expedition" scenarios.

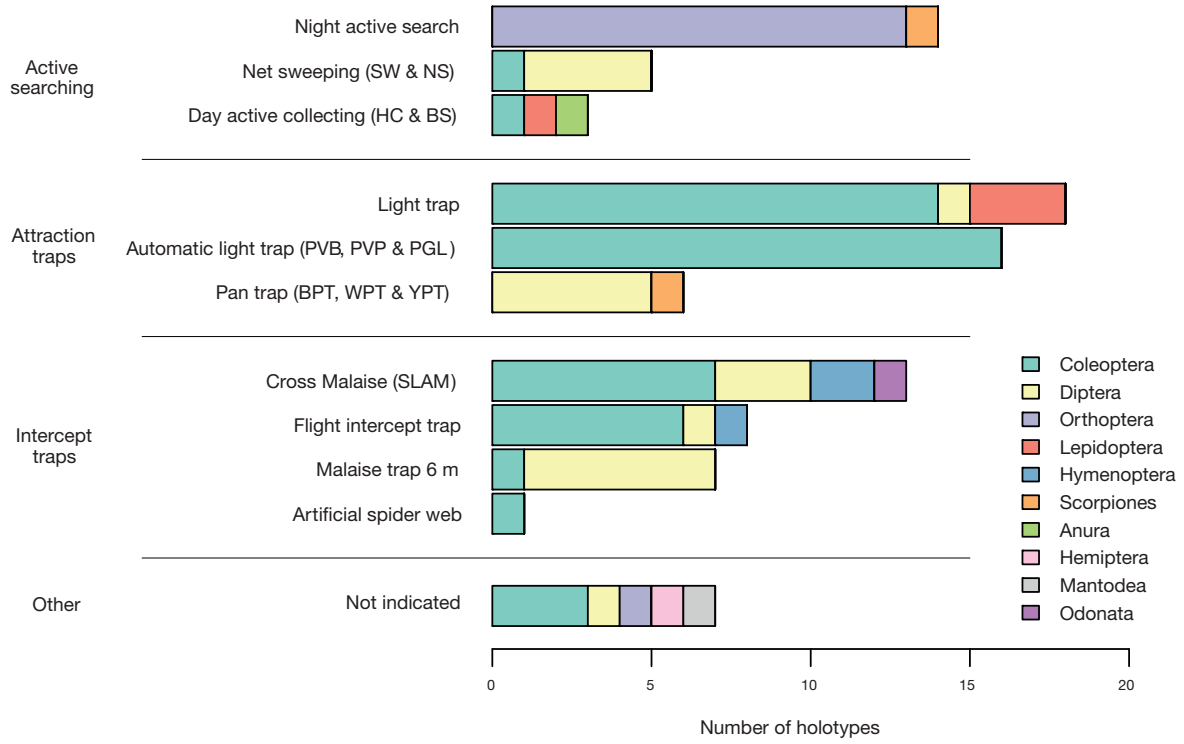

FIG. 5. — Number of holotypes collected according to the different techniques used. Abbreviations: **BS**, beating sheet; **HC**, hand collecting; **PVB**, cross flight intercept trap with a blue LED; **PVP**, *idem*, with pink LED; **PGL**, *idem*, with GemLight; **BPT**, blue pan trap; **SLAM**, sea and land air malaise trap; **SW & NS**, sweeping & net sweeping; **WPT**, white pan trap; **YPT**, yellow pan trap (for a more detailed description of the techniques, see Touroult *et al.* 2018).

Focusing on insects, which represent a major part of the remaining terrestrial species to be discovered (Mora *et al.* 2011) in French Guiana as everywhere else in the world, the analysis of publication rates and an estimate of the number of species potentially present in French Guiana shows that the recent rate of discovery is faster than in the past (see Fig. 2). It, however, would still take about 250 years to obtain a "complete" inventory (Brûlé & Touroult 2014). At the time of the expedition (2015), the publication rate of entomological discoveries in French Guiana was estimated at 180 published species per year (Brûlé & Touroult 2014). The contribution of the Mitaraka expedition corresponds to about 22% of this 2014 baseline, or to 13% of the total production of new species described between 2015 and 2020. Some of these publications could have been published without the Mitaraka survey, based on available specimens from other localities in French Guiana (Table 1); therefore, the figure of 128 discoveries published solely with Mitaraka material is perhaps more accurate, i.e., about 13% of the pre-expedition discoveries background rate (or 6% of the new species published between 2015 and 2020). It is therefore a significant quantitative contribution, even though it will not solve the taxonomic impediment ("Linnean shortfall", Whittaker *et al.* 2005). This result is not unexpected, as a short-term expedition makes it possible to explore sites that are hardly accessible and attract experts, while knowing it cannot have the ambition of a pluri-annual ATBI (see Ichter *et al.* 2017). Also, it is certainly not a substitute for in-depth, long term research and monitoring by local research institutions and associations.

As indicated in the ATBI guidelines (Leponce *et al.* 2010), the use of numerous collecting techniques and the combination of interception traps, attractive traps and active search remains essential to obtain novelties in many groups. We anticipated that the massive use of techniques of interception, coloured plates (pan traps) and automatic light traps (light source + interception) would have brought by far the most novelties, as this trap diversity and numbers are not often employed in the same manner as applied in Mitaraka. It can be noted that in terms of performance, the various Malaise traps and the automatic light traps were particularly effective. The pan traps technique, hardly employed in French Guiana, has, indeed, made it possible to collect new species but with a surprisingly low yield (Pollet *et al.* 2018). The "traditional" light trap remained an essential technique to collect many insect orders, although it requires a significant amount of time in the field compared to automatic traps.

In terms of active collection, search on sight at night is also advisable for many orders. This is especially true when individuals are mainly detected by their sound or their movement. Active search also provides more precise ecological information than large spectrum traps. Finally, it should be noted that for some groups, the collecting method has a strong influence on the quality of the study material: for example, some taxa rapidly degrade the preservative liquid quality in interception traps (Blattodea, Orthoptera). For these groups, active sampling is undoubtedly the preferred technique.

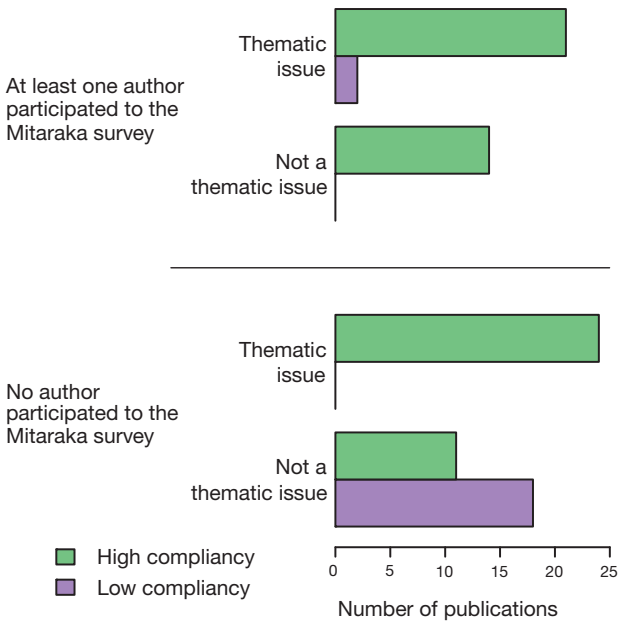

FIG. 6. — Level of compliance with recommendations for citation of expedition, ABS authorization and deposit of specimens according to two discriminating variables (n = 90 articles).

Two techniques, light trap and visual search, when applied by experts, make it possible to collect rarely encountered species in a very targeted manner. This can certainly accelerate the taxonomic work as the taxonomically most interesting specimens may be immediately sorted by the expert.

In contrast, interception traps and sieving will provide a lot of material, not very targeted and often of small size. A non-negligible part of these samples is not necessarily ready for further study quickly, with thousands of specimens in certain families of Hymenoptera, Coleoptera and Diptera, which must then be sorted to (sub-)family or eventribe to be studied by the appropriate experts, in case they exist.

Overall, no single collection strategy clearly outperformed the others and it is rather the combination of methods and their variants that produces the diversity in discoveries during the survey.

With respect to the goal of dealing with poorly studied taxa in French Guiana (objective 3)

Analysis of the taxonomic groups with new species from Mitaraka shows that 39 species discovered (new to science or first country records) belong to groups already relatively (rather) well studied in French Guiana: amphibians, Cerambycidae and Scarabaeidae (Coleoptera), Formicidae (Hymenoptera), Lepidoptera, Mantodea, Odonata, Acrididae (Orthoptera) and Scorpiones. For these groups, intensive and rather equivalent sampling efforts have been performed in other French Guianan study sites (see further). For the species described on the basis of a type specimen originating from Mitaraka (21 species), these discoveries suggest a biogeographical originality of the Mitaraka area on the French Guiana scale. This may highlight either a center of endemism for (i) species that are not mobile (amphibians and Scorpiones for example); and/or (ii) species associated with isolated inselberg environments (case of *Zeale granvillei* Touroult & Dalens, 2015); and/or (iii) species with a wide Amazonian distribution reaching their northern limit in southern French Guiana (Boilly 2018; Bénéluz 2021).

Groups that have been poorly studied thus far also delivered many new species, thanks to the involvement of taxonomists working less regularly on the fauna of French Guiana. The most noticeable example is the order Diptera, which was considered one of the megadiverse but under-studied orders in French Guiana and globally (Brûlé & Touroult 2014). As a consequence of the mobilization of no less than 39 experts and the permanent motivation by the coordinator, 20 new species and 40 first records have been published (17 publications, see Table 1), and many more species still await description (see e.g., Pollet *et al.* 2018; Vieira *et al.* 2019). Without producing as many first records, an updated synthesis of Dermaptera has been published incorporating Mitaraka specimens (Girod & Matzke 2020).

Also noteworthy are the numerous discoveries of crickets (Grylloidea) (Vicente & Robillard 2017; Campos & Desutter-Grandcolas 2020; Desutter-Grandcolas & Faberon 2020). Within the well-studied group of the Orthoptera, crickets exhibit a high rate of speciation, even at the scale of the Guiana shield (Desutter-Grandcolas & Faberon 2020). This implies that there remain more species to be discovered as compared to groups with a lower speciation rate.

Many of the groups targeted by the survey have not yet been published. As an order of magnitude, the publications cover approximately 25% of the families which yield occurrence data recorded in the datasets. In some cases, the provided species lists contain first records, in other cases there are no lists available yet. Among the groups that were sampled during the survey but which have not yet reported first records or new species are: Annelida (Clitellata, see Maggia *et al.* 2021 for an ecological analysis including Mitaraka barcoding data), Blattodea, Gastropoda, Araneae and Opiliones, many families of Hemiptera (in particular Auchenorrhyncha) and Hymenoptera. For the latter group, the need for a revision of entire New World families and genera certainly compromises the descriptions of new species in the near future. Beetles encompass the most novelties (66 new species, 32 first records, 41 publications) but with substantial heterogeneities in the progress of studies among families. For example, the family Cantharidae, poorly studied before the work of Robert Constantin, produced more than 28 species new to science (Constantin 2015, 2016a, 2017a, 2018; Biffi & Constantin 2018). In contrast Mitaraka Curculionidae (including Scolytinae), Elmidae, Erotylidae, Nitidulidae, and Staphylinidae are still being studied or have not been studied due to a lack of taxonomic expertise. The latter observation holds true for a number of lesser-known families in Diptera and Hymenoptera as well.

With respect to the goal of documenting and disseminating information about the fauna of Mitaraka (objectives 3 and 4)

Analysis of the insect data available in GBIF reveals a major contribution of the Mitaraka expedition to the regional biogeographic knowledge, by providing numerous accurate data for many taxa, in a poorly accessible and hardly studied region, both on the French Guiana side and in adjacent areas in Brazil and Suriname. In spite of the satisfaction of making a significant contribution to the international reference database for biodiversity, this strong exposure rather highlights the lack of data compilation and sharing at the regional level of the Guiana Shield, at least for French Guiana, where we know that these surveys and associated databases exist. In terms of volume of shared data, Mitaraka stands out, as do other sites in French Guiana that have been studied regularly and intensively for a long time i.e., the Nouragues Research Station and the coastal area of Montagne de Kaw / Montagne des Chevaux. However, our knowledge of the work carried out in French Guiana since many years suggests that the massive inventories carried out by the Société entomologique Antilles-Guyane (SEAG) at the Montagne des Chevaux (12 years of inventory with intercept traps), Saül (one complete year of sampling with various traps – Brûlé *et al.* 2014), Les Nouragues (two years of massive sampling – Brûlé *et al.* 2011, and also other academic works in this research station) and/or on Mount Itoupé (at least three field surveys with the same type of insect traps as the one used in Mitaraka – Brûlé & Dalens 2012) could easily surpass the Mitaraka expedition in terms of species richness and associated data. In Mitaraka, pan traps were the most noticeable addition to sampling technics but cannot explain the larger amount of shared data (see Fig. 5). One explanation for this lack of data exposure is that the abovementioned inventories did not have a proper data management plan nor sufficient resources to do so. It was one of the challenges – not to say duties – of a large scale biodiversity survey such as the "Our Planet Reviewed" program, driven by an academic institution, to proceed as far as possible in terms of management and public dissemination of data.

Even if it is likely not the largest biotic survey carried out to date in French Guiana, when considering the shared data, the expedition clearly renders Mitaraka the site of the Guiana Shield with the best documented faunal biodiversity. We sincerely hope that this outcome might trigger other researchers and entomologists to speed up data disclosure.

Choice of study site locality

The rationale for choosing the Mitaraka site was given in Touroult *et al.* (2018). The high diversity of habitat types and topography, forest landscapes and associated animal, plant and fungal communities accessible in a limited study area (15 km^2) were all indicators of a potentially high yield during the sampling campaign. The great diversity of trees observed in the field (*c.* 200 tree species / ha) subsequently confirmed the soundness of this choice, considering the highly positive correlation between arthropod richness, notably insects, and tree richness (Basset *et al.* 2012; Zhang *et al.* 2016). However, as surprising as it may sound in a scientific paper, not all the reasons for choosing a location that would lead to a successful biodiversity inventory are science-related. Beyond the rational, science-based criteria of choice, it is generally recommended to take into account also more subjective criteria. Remoteness, "unknown" places (so-called terra incognita), are important factors to raise interest by naturalists, most of who are very occupied and in great demand to participate in inventory and identification operations, especially since they do so pro-bono. Wisely making use of this taste for the unknown, commonly shared within the naturalist community, is obviously to be recommended in the choice of the location. This is difficult to understand for researchers residing in French Guiana who live and work in a territory that they - rightly - think of as globally interesting and therefore able to satisfy the objectives of such a project almost anywhere. The Mitaraka expedition success certainly benefited from the mysterious and romantic aura of the Tumuc Humac Mountains chain.

CONCLUSION: LESSONS LEARNED AND RECOMMENDATIONS

Monitoring of research output

Undoubtedly, we might have overlooked a few published papers during the post publication tracking exercise. This is hard to avoid for publications using material but incorrectly citing its origin. It should be noted that the level of compliance with the instructions (ABS, deposit of specimens, acknowledgements) would not have been as good if it had not been for the thematic issues of *Zoosystema* and the issues on French Guiana beetles. Also, coordinators widely distributed the relevant guidelines (generated by the expedition management, see appendix 3 in Touroult *et al.* 2018) among the involved taxonomic experts. The engagement of the editorial board of *Zoosystema* to dedicate a number of issues to this survey, and the deadline of September 2017 to submit a first MS, were a major motivation to many contributors. Indeed, many of the initially submitted manuscripts did not fully conform to the instructions but were ultimately adjusted in this respect and published.

Instead of monitoring the literature for papers including data collected during the concerned survey – which is time-consuming and not entirely error-proof –, we would recommend that participants/authors should be offered opportunities to engage in a centrally managed publication framework. This approach is also time-consuming but much more rewarding both in terms of compliance with the instructions concerning the content of articles and follow-up on results.

In the present paper, as well as in the taxonomic backbone TAXREF, we only considered first country records as valid when they are published in any kind of scientific (mostly peer-reviewed) literature; unpublished data sets were thus omitted in this respect. Such conservative approach underlines the importance of providing one or more additional datapapers (Chavan & Penev 2011) that describe the entire

dataset or large parts of it and include first country records and suspected novelties next to other occurrence data, while respecting the rules of the International Code for Zoological Nomenclature. In this way data from identification lists that would never be published for various reasons, can be disclosed. Such a datapaper will be published in the forthcoming years, at least for the Diptera of the expedition.

Investment in post fieldwork sample processing

We cannot stress enough the importance of putting an equal amount of effort and resources into the post survey sample processing as in preparing the field operation. Before being studied and eventually described, the collected specimens must first reach a competent taxonomist. To do this, samples have to be sorted by taxon (sometimes order, but more often family). This sorting phase is of the utmost importance, and funding for this phase should be thoroughly considered when planning the costs of a large biotic survey (Villemant *et al.* 2015). Planning and mobilizing beforehand (i.e., well before the fieldwork takes place) a large network of experts who formally engage to study the material is at least as important as the richness or size parameters of the target taxonomic groups (see Pollet *et al.* 2014). This step was relatively well managed for Mitaraka, with a budget and including a sorting phase by the participants just after the survey, precise sorting by some coordinators (e.g., Diptera), and a sorting phase by SEAG. However, two limitations, already pointed out by Villemant *et al.* (2015), can be noted: the technical capacity to sort a very large group of families and the difficult management of several phases of dissemination of the material over time. We found that the management was more efficient when the material was transmitted in one go (as was the case with Diptera). Indeed, on the contrary we faced difficulties in obtaining and managing all the data when there had been two or three shipments of specimens. For future surveys, we would recommend a simultaneous dissemination of the material to the specialists, even if this implies a delay in the examination phase of the process.

The human factor

The role of the project scientific managers (including taxonomic group coordinators) as leaders, facilitators and coaches is crucial and must be sustained over the many years after the survey to produce the expected research outputs. Beyond the capacity to face new tasks which inevitably accumulates, the stability of the position of the leaders must be taken into account. This long-term management and monitoring work is actually better suited for those with a stable academic position (e.g., employed taxonomists or employed academics able to dedicate time to taxonomy), even though other researchers and even amateur naturalists are ever more important to deal with the tremendous amount of material coming from the field. To that purpose, collaboration between the academic and non-academic experts have to be strengthened (Fontaine *et al.* 2012).

One of the lessons learned about the organization of the specimen processing chain is the key role of the taxonomic group coordinators, as this is an effective way of multiplying and facilitating access to the collected material by a large community of experts worldwide. However, while this is undoubtedly a plus, choosing the right person for this job is all but sufficient: it is as crucial to ensure the commitment of both group coordinators and expert taxonomists by negotiating beforehand the terms of a signed agreement. This agreement is not really binding as no financial aspect is involved but the material retainment/return clauses offer a certain level of reward and assurance that can motivate the experts (see appendix 3 in Touroult *et al.* 2018). But no matter how professional these taxonomic group coordinators are, there is always the risk that they face critical obstacles if their favorite group of organisms finds itself in a situation of taxonomic chaos on a scale larger than that of the region under consideration. The time needed to restore some order before assigning a species to a genus or even to a family may go well beyond the objective of a project like this. This raises a question, involving a certain amount of frustration, for a future inventory project in this format on whether or not to maintain collection and / or processing efforts in groups that require an almost total revision for their taxonomy. We cannot avoid to collect taxonomic groups in chaos when using wide spectrum collecting techniques as we did in the Mitaraka survey. The project management could have decided not to extract "orphan" taxa from the samples, but on the other hand, these specimens might just be the key to resolving systematic problems. We still think that splitting up all samples into workable fractions is the best guarantee for further disclosure of the material, regardless of present or future opportunities for study.

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APPENDIX

APPENDIX 1. — List of the new taxa and published first records based on the Mitaraka expedition specimens. Abbreviation: **TS**, type species of a new genus.

Higher classification	species	new species: described from Mitaraka	new species: holotype from Mitaraka	first country record	novelty based on material from Mitaraka survey only	references	comments
Amphibia, Anura							
Aromobatidae	*Anomaloglossus mitaraka* Fouquet, Vacher, Courtois, Deschamps, Ouboter, Jairam, Gaucher, Dubois & Kok, 2019	×	×	–	Yes	Fouquet *et al.* 2019a	–
Bufonidae	*Amazophrynella teko* Rojas, Fouquet, Ron, Hernández-Ruz, Melo-Sampaio, Chaparro, Vogt, Carvalho, Pinheiro, Avila, Farias, Gordo & Hrbek, 2018	×	–	–	No	Rojas *et al.* 2018	–
Arachnida, Scorpiones							
Buthidae	*Ananteris polleti* Lourenço, 2016	×	×	–	Yes	Lourenço 2016	–
Chactidae	*Guyanochactas touroulti* Lourenço, 2018	×	×	–	Yes	Lourenço 2018	–
Insecta, Blattodea							
Ectobiidae	*Ischnoptera hercules* Rehn, 1928	–	–	×	Yes	Evangelista *et al.* 2019	–
Insecta, Coleoptera							
Brentidae	*Apionion aeneocaeruleum* Rheinheimer, 2018	×	×	–	No	Rheinheimer 2018	–
	Fonteboanius lamellipes Senna, 1893	–	–	×	Yes	Mantilleri 2018	–
	Neacratus obtusus (Lund, 1800)	–	–	×	No	Mantilleri 2017	–
	Neacratus pascali Mantilleri, 2017	×	×	–	No	Mantilleri 2017	–
	Neacratus viridis Mantilleri, 2018	×	×	–	No	Mantilleri 2018	–
	Parateramocerus enervatus (Kleine, 1927)	–	–	×	No	Mantilleri 2018	–
	Parateramocerus teko Mantilleri, 2018	×	×	–	No	Mantilleri 2018	–
	Rugosacratus eximius Mantilleri, 2015	×	–	–	No	Mantilleri 2015	–
	Rugosacratus punctirostris Boheman, 1840	–	–	×	No	Mantilleri 2015	–
	Teramocerus pulcher Soares & Dias, 1971	–	–	×	Yes	Mantilleri 2015	–
Buprestidae	*Agrilus (Agrilus) emicyaneus* Curletti & Brûlé, 2016	×	×	–	Yes	Curletti & Brûlé 2016	–
	Agrilus (Agrilus) esasignatus Curletti & Brûlé, 2016	×	×	–	Yes	Curletti & Brûlé 2016	–
	Agrilus ittericus Curletti & Brûlé, 2021	×	×	–	Yes	Curletti & Brûlé 2021	–
	Agrilus miserrimus Curletti & Brûlé, 2016	×	×	–	Yes	Curletti & Brûlé 2016	–
	Paradomorphus caelatus Curletti & Brûlé, 2015	×	×	–	Yes	Curletti & Brûlé 2015	–
Cantharidae	*Caccodes decoratus* Constantin, 2018	×	–	–	No	Constantin 2018	–
	Caccodes rubricollis Constantin, 2018	×	–	–	No	Constantin 2018	–
	Caccodes tuberosus Constantin, 2018	×	×	–	No	Constantin 2018	–
	Chauliognathus reductipennis (Pic, 1927)	–	–	×	No	Constantin 2016a	–
	Chauliognathus subsericeus Pic, 1937.	–	–	×	No	Constantin 2016a	–
	Daiphron (Championellum) proteum Gorham, 1881	–	–	×	Yes	Constantin 2016a	–
	Daiphron abrahami Pic, 1927	–	–	×	No	Constantin 2016a	–
	Discodon arcuatum Constantin, 2015	×	–	–	No	Constantin 2015	–
	Discodon dalensi Constantin, 2015	×	×	–	No	Constantin 2015	–
	Discodon francillonnei Constantin, 2015	×	×	–	No	Constantin 2015	–
	Discodon itoupense Constantin, 2015	×	×	–	No	Constantin 2015	–
	Discodon mantillerii Constantin, 2015	×	×	–	No	Constantin 2015	–
	Discodon pascali Constantin, 2015	×	×	–	No	Constantin 2015	–
	Discodon platycorne Constantin, 2015	×	–	–	No	Constantin 2015	–
	Discodon touroulti Constantin, 2015	×	×	–	No	Constantin 2015	–
	Discodon yvineci Constantin, 2015	×	×	–	No	Constantin 2015	–
	Macromalthinus guyanensis Biffi & Constantin, 2018	×	×	–	No	Biffi & Constantin 2018	–
	Macromalthinus santaremensis Brancucci, 1981	–	–	×	No	Constantin 2016a	–

Appendix 1. — Continuation.

Higher classification	species	new species: described from Mitaraka	new species: holotype from Mitaraka	first country record	novelty based on material from Mitaraka survey only	references	comments
Cantharidae (continuation)	*Malthesis mitarakaensis* Constantin, 2016	×	×	–	No	Constantin 2016a	–
	Malthoichthyurus guyanensis Constantin, 2016	×	–	–	No	Constantin 2016a	–
	Maronius mitarakaensis Constantin, 2016	×	×	–	Yes	Constantin 2016a	–
	Peltariosilis lamellata Constantin, 2017	×	×	–	Yes	Constantin 2017a	–
	Peltariosilis mitarakaemontis Constantin, 2017	×	×	–	Yes	Constantin 2017a	–
	Plectonotum hirticorne Constantin, 2018	×	–	–	No	Constantin 2018	–
	Polemius costatulus Constantin, 2017	×	×	–	No	Constantin 2017a	–
	Polemius robini Constantin, 2017	×	×	–	No	Constantin 2017a	–
	Polemius similis Constantin, 2017	×	×	–	No	Constantin 2017a	–
	Silis brulei Constantin, 2017	×	×	–	No	Constantin 2017a	–
	Silis dalensi Constantin, 2017	×	–	–	No	Constantin 2017a	–
	Silis mitarakaensis Constantin, 2017	×	×	–	Yes	Constantin 2017a	–
	Silis roseicollis Constantin, 2017	×	×	–	No	Constantin 2017a	–
	Silis spinifera Constantin, 2017	×	×	–	No	Constantin 2017a	–
	Silis touroulti Constantin, 2017	×	×	–	No	Constantin 2017a	–
Cerambycidae	*Cacostola apyraiuba* Martins & Galileo, 2008	–	–	×	No	Robin & Dalens 2021	–
	Eupromera pascali Dalens, 2016	×	×	–	No	Dalens 2016	–
	Pseudosparna ubirajara Dalens & Touroult, 2015	×	×	–	Yes	Dalens & Touroult 2015	–
	Zeale granvillei Touroult & Dalens, 2015	×	×	–	Yes	Touroult & Dalens 2015	–
Chrysomelidae	*Andiroba egleri* Bechyné & Bechyné, 1965	–	–	×	No	Constantin 2021a	–
	Carecuruna egleri Bechyné & Bechyné, 1965	–	–	×	Yes	Constantin 2021a	–
	Heikertingeria nigripennis (Clark, 1865)	–	–	×	No	Constantin 2021a	–
	Myrmeconycha dogueti Constantin, 2017	×	×	–	No	Constantin 2017b	–
	Pedila rufa Clark, 1865	–	–	×	No	Constantin 2021a	–
	Sparnus rufonitidus Bechyné & Bechyné, 1965	–	–	×	No	Constantin 2021a	–
	Stenophyma modesta Weise, 1921	–	–	×	No	Constantin 2021a	–
Curculionidae	*Coptoborus gracilens* Wood, 2007	–	–	×	Yes	Smith & Cognato 2021	–
	Coptoborus tolimanus (Eggers, 1928)	–	–	×	Yes	Smith & Cognato 2021	–
	Coptoborus vespatorius (Schedl, 1931)	–	–	×	Yes	Smith & Cognato 2021	–
	Cylindrocorynus v-nigrum Rheinheimer, 2021	×	×	–	No	Rheinheimer 2021	–
	Eubulus gymenti Rheinheimer, 2021	×	×	–	No	Rheinheimer 2021	–
	Heilipodus bifenestratus Reinheimer, 2017	×	×	–	No	Rheinheimer 2017	–
	Semnorhynchus perrinae Rheinheimer, 2021	×	×	–	No	Rheinheimer 2021	–
Dynastidae	*Cyclocephala brevis* Höhne, 1923	–	–	×	No	Dupuis 2016	–
	Stenocrates rufipennis (Fabricius, 1801)	–	–	×	No	Dupuis 2016	–
Elateridae	*Achrestus dogueti* Chassain, 2018	×	×	–	Yes	Chassain 2018	–
	Atractosomus amazonicus Casari, 2012	–	–	×	No	Chassain & Touroult 2017	–
	Atractosomus submetallicus Chassain & Touroult, 2017	×	–	–	No	Chassain & Touroult 2017	–
	Pterotarsus touroulti Chassain, 2016	×	–	–	No	Chassain 2016	–
	Spilus candezei Chassain & Touroult, 2016	×	–	–	No	Chassain & Touroult 2016	–
	Spilus mitarakensis Chassain & Touroult, 2016	×	×	–	Yes	Chassain & Touroult 2016	–
	Spilus nigriceps Chassain & Touroult, 2016	×	–	–	No	Chassain & Touroult 2016	–
	Spilus rubriceps Chassain & Touroult, 2016	×	–	–	No	Chassain & Touroult 2016	–
	Spilus serraticornis Chassain & Touroult, 2016	×	–	–	No	Chassain & Touroult 2016	–

Appendix 1. — Continuation.

Higher classification	species	new species: described from Mitaraka	new species: holotype from Mitaraka	first country record	novelty based on material from Mitaraka survey only	references	comments
Histeridae	*Degallierister greglamarrei* Degallier, 2015	×	–	–	No	Dégallier *et al.* 2015	–
	Nymphister unstriatus Dégallier & Tishechkin, 2021	×	×	–	No	Dégallier *et al.* 2021	–
	Plagiogramma amplistria Kovarik & Dégallier, 2021	×	×	–	No	Dégallier *et al.* 2021	–
	Plagiogramma erwini Kovarik & Dégallier, 2021	×	×	–	No	Dégallier *et al.* 2021	–
Melyridae	*Tucumanius mitaraka* Constantin, 2021	×	×	–	Yes	Constantin 2021b	–
Paussidae	*Goniotropis touroulti* Deuve, 2018	×	×	–	Yes	Deuve 2018	–
	Tachypeles mantillerii Deuve, 2018	×	×	–	Yes	Deuve 2018	–
	Tachypeles mitaraka Deuve, 2018	×	×	–	Yes	Deuve 2018	–
	Tachypeles perditus Deuve, 2018	×	×	–	Yes	Deuve 2018	–
	Tachypeles simulans Deuve, 2018	×	×	–	Yes	Deuve 2018	–
Phengodidae	*Pseudomastinocerus mitarakae* Constantin, 2017	×	×	–	Yes	Constantin 2016b	–
Scarabaeidae	*Aegidinus tricornis* Colby, 2009	–	–	×	Yes	Rojkoff 2016	–
	Dichotomius latilobatus Boilly & Vaz-de-Mello, 2021	×	×	–	No	Boilly & Vaz-de-Mello 2021	–
	Dichotomius longiceps Taschenberg, 1870	–	–	×	No	Boilly 2015	–
	Eurysternus howdeni Génier, 200	–	–	×	Yes	Boilly 2018	–
Tenebrionidae	*Adelonia deplanatus* (Pic, 1923)	–	–	×	Yes	Gonzales & Yvinec 2016	–
	Gnatocerus cornutus (Fabricius, 1798)	–	–	×	Yes	Gonzales & Yvinec 2016	–
	Platydema quindecimmaculata Chevrolat, 1878	–	–	×	No	Gonzales *et al.* 2015	–
	Uleda diaperoides Laporte, 1840	–	–	×	No	Gonzales & Yvinec 2016	–
	Ulomoides ocularis (Casey, 1891)	–	–	×	Yes	Gonzales & Yvinec 2016	–
	Xenius corallifer Gebien, 1928	–	–	×	Yes	Gonzales & Yvinec 2016	–
Insecta, Dermaptera							
Spongiphoridae	*Cosmogerax doesburgi* Brindle, 1982	–	–	×	Yes	Girod & Matzke 2019	–
	Eugerax poecilum Hebard, 1917	–	–	×	Yes	Girod & Matzke 2019	–
	Spongiphora buprestoides (Kirby, 1891)	–	–	×	No	Girod & Matzke 2019	–
Insecta, Diptera							
Asilidae	*Andrenosoma pyrrhacra* (Wiedemann, 1828)	–	–	×	Yes	Vieira *et al.* 2019	–
	Andrenosoma sarcophaga (Hermann, 1912)	–	–	×	Yes	Vieira *et al.* 2019	–
	Aphractia vivax (Hermann, 1912)	–	–	×	Yes	Vieira *et al.* 2019	–
	Dissmeryngodes amapa Artigas, Papavero & Serra, 1991	–	–	×	Yes	Vieira *et al.* 2019	–
	Dissmeryngodes nigripes (Macquart, 1838)	–	–	×	Yes	Vieira *et al.* 2019	–
	Holcocephala oculata (Fabricius, 1805)	–	–	×	Yes	Vieira *et al.* 2019	–
	Hybozelodes dispar (Hermann, 1912)	–	–	×	Yes	Vieira *et al.* 2019	–
	Lampria clavipes (Fabricius, 1805)	–	–	×	Yes	Vieira *et al.* 2019	–
	Ommatius spinosus Scarbrough, 1993	–	–	×	Yes	Vieira *et al.* 2019	–
	Pilica pyrrhopyga (Wiedemann, 1828)	–	–	×	Yes	Vieira *et al.* 2019	–
	Pilica rubidapex (Hermann, 1912)	–	–	×	Yes	Vieira *et al.* 2019	–
Chloropidae	*Chaethippus flavus* Riccardi, 2020	×	×	–	Yes	Riccardi 2020	–
	Metasiphonella magnifica Duda, 1930	–	–	×	Yes	Riccardi *et al.* 2020	–
Dolichopodidae	*Cheiromyia brevitarsis* Brooks, 2010	–	–	×	Yes	Brooks *et al.* 2018	–
	Cheiromyia fuscipennis Pollet & Brooks, 2018	×	×	–	Yes	Brooks *et al.* 2018	–
	Cheiromyia pennaticornis (Parent, 1931)	–	–	×	Yes	Brooks *et al.* 2018	–

Appendix 1. — Continuation.

Higher classification	species	new species: described from Mitaraka	new species: holotype from Mitaraka	first country record	novelty based on material from Mitaraka survey only	references	comments
Dolichopodidae (continuation)	*Enlinia bova* Runyon & Pollet, 2018	×	×	–	Yes	Runyon & Pollet 2018	–
	Enlinia colossicornis Runyon & Pollet, 2018	×	×	–	Yes	Runyon & Pollet 2018	–
	Enlinia dalensi Runyon & Pollet, 2018	×	×	–	Yes	Runyon & Pollet 2018	–
	Enlinia loboptera Runyon & Pollet, 2018	×	×	–	Yes	Runyon & Pollet 2018	–
	Enlinia mitarakensis Runyon & Pollet, 2018	×	×	–	Yes	Runyon & Pollet 2018	–
	Enlinia touroulti Runyon & Pollet, 2018	×	×	–	Yes	Runyon & Pollet 2018	–
	Neotonnoiria maculipennis (Van Duzee, 1929)	–	–	×	Yes	Pollet *et al.* 2018	–
	Neurigona brevitibia Naglis, 2003	–	–	×	Yes	Pollet *et al.* 2018	–
Drosophilidae	*Stegana penicillata* (Kertész, 1901)	–	–	×	Yes	Pirani & Grimaldi 2019	–
Keroplatidae	*Lygistorrhina (Probolaeus) conica* Blagoderov & Pollet, 2020	×	×	–	Yes	Blagoderov & Pollet 2020	–
	Lygistorrhina (Probolaeus) maculipennis Blagoderov & Pollet, 2020	×	×	–	Yes	Blagoderov & Pollet 2020	–
	Lygistorrhina (Probolaeus) mitarakensis Blagoderov & Pollet, 2020	×	×	–	Yes	Blagoderov & Pollet 2020	–
Muscidae	*Souzalopesmyia polleti* Gomes & de Carvalho, 2018	×	×	–	Yes	Gomes & De Carvalho 2018	–
Pipunculidae	*Cephalops amapaensis* Rafael, 1991	–	–	×	Yes	Marques *et al.* 2019	–
	Cephalosphaera aurata Souza & Ale-Rocha, 2009	–	–	×	Yes	Marques *et al.* 2019	–
	Clistoabdominalis mitarakensis Marques & Rafael, 2019	×	×	–	Yes	Marques *et al.* 2019	–
	Eudorylas fortis Rafael, 1995	–	–	×	Yes	Marques *et al.* 2019	–
Psychodidae	*Myiomystax trilineata* Curler, 2020	×	×	–	Yes	Curler 2020	TS
	Polletomyia subulata Curler, 2020	×	×	–	Yes	Curler 2020	TS
Ropalomeridae	*Ropalomera clavipes* (Fabricius, 1805)	–	–	×	Yes	Ale-Rocha & Pollet 2019	–
	Ropalomera tibialis Walker, 1852	–	–	×	Yes	Ale-Rocha & Pollet 2019	–
Sciomyzidae	*Thecomyia diedericki* Mortelmans, 2018	×	×	–	Yes	Mortelmans & Pollet 2018	–
	Theocomyia longicornis Perty, 1833	–	–	×	Yes	Mortelmans & Pollet 2018	–
Sepsidae	*Archisepsis armata* (Schiner, 1868)	–	–	×	Yes	Silva & Pollet 2020	–
	Archisepsis diversiformis (Ozerov, 1993)	–	–	×	Yes	Silva & Pollet 2020	–
	Archisepsis peruana (Ozerov, 1994)	–	–	×	Yes	Silva & Pollet 2020	–
	Meropliosepsis sexsetosa Duda, 1926	–	–	×	Yes	Silva & Pollet 2020	–
	Microsepsis armillata (Melander & Spuler, 1917)	–	–	×	Yes	Silva & Pollet 2020	–
	Microsepsis furcata (Melander & Spuler, 1917)	–	–	×	Yes	Silva & Pollet 2020	–
	Microsepsis mitis (Curran, 1927)	–	–	×	Yes	Silva & Pollet 2020	–
	Palaeosepsioides erythromyrmus (Silva, 1991)	–	–	×	Yes	Silva & Pollet 2020	–
	Palaeosepsioides mitarakensis Silva, 2020	×	×	–	Yes	Silva & Pollet 2020	–
Tabanidae	*Catachlorops amazonicus* Henriques & Gorayeb 1999	–	–	×	Yes	Krolow *et al.* 2017	–
	Chlorotabanus flagellatus Krolow & Henriques, 2009	–	–	×	Yes	Krolow *et al.* 2017	–
	Chrysops ecuadorensis Lutz, 1909	–	–	×	Yes	Krolow *et al.* 2017	–
	Chrysops incisus Macquart, 1846	–	–	×	Yes	Krolow *et al.* 2017	–
	Cryptotylus cauri Stone, 1944	–	–	×	Yes	Krolow *et al.* 2017	–
	Phaeotabanus phaeopterus Fairchild, 1964	–	–	×	Yes	Krolow *et al.* 2017	–

Appendix 1. — Continuation.

Higher classification	species	new species: described from Mitaraka	new species: holotype from Mitaraka	first country record	novelty based on material from Mitaraka survey only	references	comments
Tabanidae (continuation)	*Philipotabanus stigmaticalis* (Kröber, 1931)	–	–	×	Yes	Krolow *et al.* 2017	–
	Stypommisa captiroptera (Kröber, 1930)	–	–	×	Yes	Krolow *et al.* 2017	–
	Tabanus amapaensis Fairchild, 1961	–	–	×	Yes	Krolow *et al.* 2017	–
Tipulidae	*Lecteria (Lecteria) mitarakanea* Mederos & Pollet, 2019	×	×	–	Yes	Mederos & Pollet 2019	–
	Lecteria (Lecteria) teko Mederos & Pollet, 2019	×	×	–	Yes	Mederos & Pollet 2019	–
	Lecteria (Lecteria) wayana Mederos & Pollet, 2019	×	×	–	Yes	Mederos & Pollet 2019	–
Insecta, Hemiptera							
Coreidae	*Lucullia guilberti* Brailovsky, 2017	×	×	–	No	Brailovsky 2017	–
Pentatomidae	*Phalaecus lineatus* Grazia, 1983	–	–	×	No	Lupoli 2019	–
Insecta, Hymenoptera							
Apatelididae	*Pantelodes iracoubo* Herbin, 2017	×	–	–	No	Herbin 2017	–
	Pantelotes organabo Herbin, 2017	×	–	–	No	Herbin 2017	–
Braconidae	*Pedinotus columbianus* Enderlein, 1912	–	–	×	No	Belokobylskij *et al.* 2017	–
	Pedinotus dispar Belokobylskij et Zaldívar-Riverón, 2017	×	–	–	No	Belokobylskij *et al.* 2017	–
	Pedinotus guyanensis Belokobylskij et Zaldívar-Riverón, 2017	×	–	–	No	Belokobylskij *et al.* 2017	–
	Pedinotus nitidus Belokobylskij et Zaldívar-Riverón, 2017	×	×	–	Yes	Belokobylskij *et al.* 2017	–
Dryinidae	*Dryinus dalensi* Olmi, Capradossi & Guglielmino, 2019	×	×	–	Yes	Olmi *et al.* 2019a	–
Embolemidae	*Ampulicomorpha poirieri* Olmi, Capradossi & Guglielmino, 2019	×	×	–	Yes	Olmi *et al.* 2019b	–
Formicidae	*Camponotus trapezoideus* Mayr, 1870	–	–	×	Yes	Leponce *et al.* 2019	–
	Pheidole flavens Roger, 1863	–	–	×	Yes	Leponce *et al.* 2019	–
	Pheidole kukrana Wilson, 2003	–	–	×	Yes	Leponce *et al.* 2019	–
	Pheidole obscurior Forel, 1886	–	–	×	Yes	Leponce *et al.* 2019	–
	Pheidole pepo Wilson, 2003	–	–	×	Yes	Leponce *et al.* 2019	–
	Pheidole tristops Wilson, 2003	–	–	×	Yes	Leponce *et al.* 2019	–
	Prionopelta dubia Ladino & Feitosa, 2020	–	–	×	No	Ladino & Feitosa 2020	–
Insecta, Lepidoptera							
Erebidae	*Bertholdia neglecta* Gibeaux, 2016	×	–	–	No	Gibeaux 2016b	–
	Metria pascali Barbut, 2016	×	×	–	Yes	Barbut 2016	–
	Myrmecopsis wayampica Cerda, 2016	×	–	–	No	Cerda 2016	–
	Neonerita martinezi Laguerre & Vincent, 2016	×	×	–	No	Laguerre & Vincent 2016	–
	Ruforbifer coccinommatus Gibeaux, 2016	×	–	–	No	Gibeaux 2016a	–
	Ruforbifer dicyclophorus Gibeaux, 2016	×	–	–	No	Gibeaux 2016a	–
Lycaenidae	*Chalybs mitaraka* Faynel, 2019	×	×	–	No	Faynel 2019	–
	Theritas silma Martins, Faynel, & Robbins, 2016	×	–	–	No	Martins *et al.* 2016	–
Noctuidae	*Callopistria longipilosa* Barbut & Lalanne-Cassou, 2019	×	×	–	No	Barbut & Lalanne-Cassou 2019	–
Nymphalidae	*Euptychia aquila* Fratello, Nakahara & Brévignon, 2015	×	–	–	No	Fratello *et al.* 2015	–
	Magneuptychia andrei Zacca, Casagrande & Mielke, 2017	×	–	–	No	Zacca *et al.* 2017	–
Saturniidae	*Dirphia aculea* Vuillot, 1892	–	–	×	Yes	Bénéluz 2021	–
	Hylesia ernestonis Strand, 1920	–	–	×	Yes	Bénéluz 2021	–
	Hylesia inducayalex Brechlin & Meister, 2016	–	–	×	Yes	Bénéluz 2021	–
Insecta, Mantodea							
Photinaidae	*Microphotina viridula* Roy, 2019	×	×	–	Yes	Roy 2019	–

Appendix 1. — Continuation.

Higher classification	species	new species: described from Mitaraka	new species: holotype from Mitaraka	first country record	novelty based on material from Mitaraka survey only	references	comments
Insecta, Odonata							
Corduliidae	*Navicordulia pascali* Fleck & Juillerat, 2019	×	–	–	No	Fleck & Juillerat 2019	–
	Navicordulia tumucurakensis Fleck, 2017	×	×	–	Yes	Fleck 2017	–
Insecta, Orthoptera							
Acrididae	*Schistocerca pallens* (Thunberg, 1815)	–	–	×	Yes	Pocco & Cigliano 2020	–
Gryllidae	*Adenophallusia legendrei* Campos & Desutter-Grandcolas, 2020	×	×	–	Yes	Campos & Desutter-Grandcolas 2020	–
	Cylindrogryllus (Apterotrypa) guyanensis Campos & Desutter-Grandcolas, 2020	×	×	–	No	Campos & Desutter-Grandcolas 2020	–
	Cylindrogryllus (Apterotrypa) mitarakensis Campos & Desutter-Grandcolas, 2020	×	×	–	No	Campos & Desutter-Grandcolas 2020	–
	Ligypterus najtae Vicente & Robillard, 2017	×	×	–	Yes	Vicente & Robillard 2017	–
	Stenoecanthus planixiphus Campos & Desutter-Grandcolas, 2020	×	×	–	No	Campos & Desutter-Grandcolas 2020	–
	Tafalisca hugeli Campos & Desutter-Grandcolas, 2020	×	×	–	Yes	Campos & Desutter-Grandcolas 2020	–
Phalangopsidae	*Aracopsis hugeli* Desutter-Grandcolas, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	TS
	Ectecous lamelliferus Desutter-Grandcolas, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	–
	Lerneca mitarakensis Desutter-Grandcolas & Faberon, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	–
	Luzaridella maculata Desutter-Grandcolas & Faberon, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	–
	Luzaridella miniata Desutter-Grandcolas & Faberon, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	–
	Mellomima guyanensis Desutter-Grandcolas, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	TS
	Paraclodes cunicula Desutter-Grandcolas, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	–
	Paraclodes furcata Desutter-Grandcolas, 2020	×	×	–	Yes	Desutter-Grandcolas & Faberon 2020	–
Tettigoniidae	*Panoploscelis scudderi* Beier, 1950	–	–	×	Yes	Hugel 2019	–
Romaleidae	*Trybliophorus sulcatus* Descamps, 1981	–	–	×	Yes	Pocco & Cigliano 2020	–
Insecta, Phasmatodea							
Pseudophasmatidae	*Parastratocles fuscomarginatus* Conle, Hennemann, Bellanger, Lelong, Jourdan & Valero, 2020	×	–	–	No	Conle *et al.* 2020	–