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ALIEN BEETLE SPECIES IN THE REPUBLIC OF MOLDOVA: A REVIEW OF THEIR ORIGIN AND MAIN IMPACT

© 2014 Munteanu N.[1], Moldovan A.[1], Bacal S.[2], Toderas I.[1]

[1] Laboratory of Systematics and Molecular Phylogeny, Institute of Zoology, Moldova Academy of Sciences, MD 2028, Chisinau, Academiei 1, Republic of Moldova, e-mail: munteanu_natalia_v@yahoo.com
[2] Laboratory of Entomology, Institute of Zoology, Moldova Academy of Sciences, MD 2028, Chisinau, Academiei 1, Republic of Moldova

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A list of beetles considered to be of alien origin in the Republic of Moldova has been set up, with data on their origin, habitat, trophic range and economic impact. Altogether, 75 alien beetle species have been revealed, which represents 2.98% of local coleopteran fauna. The most numerous taxonomic groups are Curculionidae (30 species), Staphylinidae and Chrysomelidae (by 11). The majority of non-native beetles originates in Europe, Asia and Mediterranean region, while comparable less number of species originates in Africa and North America. From the total number of the investigated alien beetles 26.67% are agricultural, forest and storage pests.

Key words: alien species, beetles, Republic of Moldova.

Introduction

Invertebrates, and among them arthropods, represent the greatest part of alien animals and are of pronounced importance in agriculture, horticulture and forestry, with a major economic impact. Their activity can alter ecosystems structure and functioning and eventually lead to the extinction of native species, inducing biodiversity losses [Elton, 1958; Nentwig, 2008; Hulme et al., 2009]. Vulnerability of ecosystems to alien species is probably one of the least studied and most difficult questions. Knowledge of alien species effects and potential threats is still insufficient being crucial for managing the risks related to species transfer.

Establishment of first alien arthropods checklists in Europe started in 2002 and covered Austria [Essl, Rabitsch, 2002], Germany [Geiter et al., 2002], the Netherlands [Reemer, 2003], the Czech Republic [Šefrová, Laštůvka, 2005], the United Kingdom [Hill et al., 2005, Smith et al., 2007], Serbia and Montenegro [Glavendekić et al., 2005], Switzerland [Kenis, 2005], Israel [Roll et al., 2007], Albania, Bulgaria and Macedonia [Tomov et al., 2009], and Russia [Maslyakov, Izhevsky, 2011].

The geographical position of the Republic of Moldova at the crossing point of three biogeographical zones (Central European, Eurasian and Mediterranean) along with the intense human activities makes it especially prone to alien species entry. Despite this, the problem of alien species on the investigated territory was not treated in the scientific literature. Available information contains some data on certain taxa or groups of beetles, their trophic preferences and distribution but it does not always contain information on their origin.

The main goal of this study was to determine which alien beetle species entered, spread and/or established in natural transitional, forest and agricultural ecosystems of the Republic of Moldova, its origin and impact, in order to better understand how to manage non-native beetles. Only in this manner the most

Table 1. Composition of alien beetle species in individual families; S – eusynanthropic, C – casual, N – naturalized non invasive, *N – naturalized post invasive, I – invasive.

Taxon	Spp. RM	Aliens	% of all	S	C	N	*N	I
Staphylinidae	321	11	3.42	–	–	–	11	–
Scarabaeidae	124	1	0.8	–	–	–	1	–
Dermestidae	14	1	7.1	–	–	–	1	–
Ptinidae	22	1	4.54	–	–	–	1	–
Coccinellidae	33	1	3.03	–	–	–	–	1
Tenebrionidae	52	5	9.61	5	–	–	–	–
Meloidae	26	1	3.84	–	–	–	1	–
Cerambycidae	125	2	1.6	–	1	–	1	–
Chrysomelidae	197	11	5.58	2	1	3	4	1
Brentidae	90	8	8.88	–	–	3	5	–
Dryophthoridae	5	3	60	2	1	–	–	–
Curculionidae	510	30	5.88	–	7	16	6	1
Total Coleoptera	**2512**	75	**2.98**	**9**	**10**	**22**	**31**	**3**

efficient methods to prevent new arrivals and/or disseminations, and reduce their impacts, can be proposed and implemented.

Material and methods

To initiate the first list of non-native beetle species in the Republic of Moldova, we reviewed professional published and unpublished information and available reports, particularly checklists of Miller, Zubowsky [1917], Medvedev, Shapiro [1957], Adashkevich [1972], Poiras [1991, 1994, 1998, 2006], Neculiseanu, Matalin [2000], Neculiseanu, Bacal [2005], Munteanu [2006], Bacal, Stan [2006], Bacal, Derunkov [2010], Derunkov, Bacal [2011]. Also, museum specimen collection of the Institute of Zoology, Academy of Sciences of Moldova and alien invasive species inventories websites were used.

Data were compiled into a preliminary list of non-native beetles documented in the country (either currently or historically). For each species we included information about its origin, first report, habitat, trophic preferences and host. Further, based on evidence in the literature, we identified a number of non-native species known as pests of agricultural crops, fruit trees, forests, ornamental plants and storage products. Distribution in alien species categories (eusynanthropic, casual, naturalized non invasive, naturalized post invasive and invasive) was performed [Šefrová, Laštůvka, 2005; Nentwig, Josefsson, 2010].

The taxonomy of the beetle species is based primarily on the works of Kryzhanovskij [1965] and Bouchard et al. [2011]. Biological and geographical classification was done according to concepts of Darlington [1966] and Banarescu [1970].

Results and discussions

In the Republic of Moldova about 2512 beetle species are known [Bacal et al., 2013]. From the total number, 75 ones (2.98%) represent alien species. Among them, 9 species (12%) create short or long-term populations only in heated spaces, with the ability to survive outside only during warm periods of the year, but not under winter conditions. A group of 10 species (13.33%) creates occasionally short-term populations in outdoor environments. The populations of these species are usually decimated by adverse weather conditions, surviving winter with difficulty or gradually disappearing for other reasons. Another 56 species (74.66%) can be considered naturalized; their populations survive for long time tolerating easily the local climatic conditions. Between these species, 22 (29.33% of aliens) ones remain non-invasive, other 31 (41.33%) species are post-invasive at present, and 3 species (4%) are invasive. The categories of aliens with the numbers of species are shown in the Table 1.

The greatest number of identified alien species (30) belongs to Curculionidae

family, followed by Staphylinidae, Chrysomelidae, Brentidae and Tenebrionidae. The largest proportion of species of alien origin is in Dryophthoridae (60%) and Tenebrionidae (9.61%), while for the rest it varies between 0.8–8.88 percent. By contrast, no alien species were documented in other 57 coleopteran families which occur in the Republic of Moldova.

The majority of revealed eusynanthropic alien species (5) are naturally found in tropical and subtropical regions; other two species are cryptogenic and by one are from North America and Asia. The group of casual species is represented by four European, three Asian and three Mediterranean species. Among 22 naturalized non-invasive species 8 ones originate in Eurasia and Mediterranean region, 5 species are Mediterranean, by three European and Eurasian, two Euro-Mediterranean and one North American species. Concerning naturalized post-invasive species the most of them (8) derive from Eurasia and Mediterranean region, five are Eurasian, four Asian, three European, by two African and Mediterranean, and one from America. This group also contains six cryptogenic species. Invasive species originate from North America (2) and Asia (1). Detailed information on each species is presented in the Table 2.

From the total number of non-native beetles the majority originates in Europe, Asia and Mediterranean region and spreads with the progress of human civilization, expansion of agricultural crops and for other various reasons. Comparable less number of species originates in America; their dissemination is partly due to the human travel and trade activity, spontaneous spreading of those species is being almost impossible (the geographical barrier is difficult to pass without human intervention).

Alien species impact on economy and environment is a result of trophic and habitat preferences. Concerning habitats around 41.33% of the established alien beetle species colonize cultivated habitats. The second most populated are urban settlements (38.66%). Grasslands are also frequent habitats (28%). Woodlands and forest habitats are occupied by 20% of the non-native beetles. Heathlands, hedgerows and shrubs are populated by 5.33% of the species and only 4% occur in wetlands.

Table 2. Characteristics of alien beetle species in the Republic of Moldova.
Status of alien species and their occurrence: S – eusynanthropic, C – casual, N – naturalized non invasive, *N – naturalized post invasive, I – invasive; Habitats: B – coastal habitats; E – grasslands; F – heathlands, hedgerows and shrub plantations; G – woodlands and forests; H – cultivated habitats; J – urban settlements, N/A – data non available; Trophic range: Pr – Predator, De – Detritivorous, Ph – Phytophagous (herbiphagous (her), spermatophagous (spe), leaf/stem browser (lbw), root browser (rbw), root borer (rbo), phloeophagous (phl), saproxylophagous (sxp), xylomycetophagous (xmp), Un – Unknown.

Species	Origin	Status	Habitat	Trophic range	Host	Reference
Staphylinidae						
Cilea silphoides (Linnaeus, 1767)	Cryptogenic	*N	J	Pr	Cattle dung	Mihailov, 2012
Atheta oblita (Erichson,1839)	Northern Europe	*N	G, J	Pr	Fungus, cattle dung	Adashkevich, 1972
Carpelimus corticinus (Gravenhorst, 1806)	Cryptogenic	*N	B, E	Ph	Floodplains, river banks, sand	Adashkevich, 1972
C. gracilis (Mannerheim, 1830)	Cryptogenic	*N	B, E	Pr	Floodplains, river banks, sand	Adashkevich, 1972
C. pusillus (Gravenhorst, 1802)	Cryptogenic	*N	B, E	Pr	Floodplains, river banks, sand	Adashkevich, 1972
Lithocharis nigriceps Kraatz, 1859	Asia-Tropical	*N	H, J	Pr	Compost	Neculiseanu, 1984
L. ochracea (Gravenhorst, 1802)	Eurasia	*N	J	Un	Dried vegetals	Miller, Zubowsky, 1917

Gabrius nigritulus (Gravenhorst, 1802)	Eurasia	*N	J	Un	Fungus	Yatsentkovsky, 1912
Philonthus concinnus (Gravenhorst, 1802)	Eurasia	*N	J	Pr	Fungus, cattle dung	Adashkevich, 1972
P. discoideus (Gravenhorst, 1802)	Northern Africa, Eurasia	*N	J	Pr	Dung	Adashkevich, 1972
P. longicornis Stephens, 1832	Eurasia	*N	J	Pr	Dung	Miller, Zubowsky, 1917
Scarabaeidae						
Pleurophorus caesus (Creutzer, 1796)	Eurasia, America	*N	E	De	Dung	Miller, Zubowsky, 1917
Dermestidae						
Dermestes ater De Geer, 1774	Cryptogenic	*N	J	De	Necrophagous	Miller, Zubowsky, 1917
Ptinidae						
Ptinus fur (Linnaeus, 1758)	Cryptogenic	*N	J	De	Waste, dried vegetals	Miller, Zubowsky, 1917
Coccinellidae						
Harmonia axyridis (Pallas, 1773)	Asia	I	H	Pr	Polyphagous, predator mainly aphids and coccids	Iazlovetchi, Sumenkova, 2013
Tenebrionidae						
Tribolium castaneum (Herbst, 1797)	Cryptogenic	S	J	De	Stored products	Neculiseanu, Bacal, 2005
T. confusum Jacquelin du Val, 1868	Africa	S	J	De	Stored products	Medvedev, Shapiro, 1957
T. destructor Uyttenboogaart, 1933	Tropical	S	J	De	Stored products	Neculiseanu, Bacal, 2005
Alphitobius diaperinus (Panzer, 1797)	Tropical, Subtropical	S	J, G	Pr, De	Residues, inhabitant of chicken houses, on faeces and wastes	Neculiseanu, Bacal, 2005
Alphitophagus bifasciatus (Say, 1823)	Cryptogenic	S	J, G	De	Residues, compost, rotten fruits, under bark old stumps	Neculiseanu, Bacal, 2005
Meloidae						
Mylabris variabilis (Pallas, 1781)	Eurasia	*N	E	Pr, Ph (her)	Adult floricolous, larvae parasite of Acrididae	Miller, Zubowsky, 1917
Cerambycidae						
Rosalia alpine (Linnaeus, 1758)	Central Europe, Alps	C	G, H, J	Ph (sxp)	*Fagus*, and other deciduous trees	Miller, Zubowsky, 1917
Monochamus sutor (Linnaeus, 1758)	Northern and Central Europe	*N	G	Ph (sxp)	*Picea, Pinus*	Baban, 2006
Chrysomelidae						
Callosobruchus chinensis (Linnaeus, 1758)	Asia-Temperate	C	H, J	Ph (spe)	Stored legumes	Munteanu, 2006
Bruchus pisorum (Linnaeus, 1758)	Asia-Temperate	S	H, J	Ph (spe)	*Lathyrus, Pisum, Vicia*	Medvedev, Shapiro, 1957
B. rufimanus Boheman, 1833	Africa	*N	H, J	Ph (spe)	*Phaseolus, Lathyrus, Lupinus, Pisum, Lens, Cicer, Vicia*	Medvedev, Shapiro, 1957
B. signaticornis Gyllenhal, 1833	Mediterranean region	*N	H, J	Ph (spe)	*Lathyrus, Lens, Vicia* seeds	Munteanu, 2009
Bruchidius lividimanus (Gyllenhal, 1833)	Mediterranean region	*N	H	Ph (spe)	*Genistea, Ononis, Cytisus* seeds	Munteanu, 2006
Acanthoscelides obtectus Say, 1831	America	S	H, J	Ph (spe)	*Phaseolus* seeds, wild and cultivated legumes outdoors	Medvedev, Shapiro, 1957

A. pallidipennis (Motschulsky, 1874)	North America	N	H, J	Ph (spe)	Fabaceae	Munteanu, 2006
Cassida atrata Fabricius, 1787	Central, South East Europe	N	H	Ph (her)	*Lamiaceae*	Calestru, 2003
Crioceris asparagi (Linnaeus, 1758)	Europe, Central Asia	N	H, J	Ph (her)	*Asparagus*	Medvedev, Shapiro, 1957
Leptinotarsa decemlineata Say, 1824	Northern and Central America	I	H	Ph (her)	*Solanum tuberosum*, other Solanaceae	Vorotyntseva, 1971
Gonioctena fornicate (Brüggemann, 1873)	Eastern Europe	*N	H	Ph (her)	*Medicago*	Medvedev, Shapiro, 1957
Brentidae						
Aspidapion validum (Germar, 1817)	Asia-Temperate	*N	H, F	Ph (spe)	*Alcea rosae*	Miller, Zubowsky, 1917
A. radiolus (Marsham, 1802)	Asia, Europe, Mediterranean region	*N	N/A	Ph (her)	Malvaceae	Medvedev, Shapiro, 1957
Alocentron curvirostre (Gyllenhal, 1833)	Asia-Temperate	*N	H, F	Ph (spe)	*Alcea rosae*	Solodovnikova, Talitskii, 1972
Squamapion leucophaeatum (Wencker, 1864)	Mediterranean region	N	E	Ph (spe)	No data	Solodovnikova, Talitskii, 1972
Taeniapion rufulum (Wencker, 1864)	Europe, Mediterranean region	N	E, F	Ph (her)	*Urtica dioica*	Poiras, 1994
Rhopalapion longirostre (Olivier, 1807)	Asia-Temperate	*N	H	Ph (spe)	*Alcea rosae*	Miller, Zubowsky, 1917
Trichopterapion holosericeum (Gyllhenal, 1833)	Asia, Europe, Mediterranean region	N	G	Ph (spe)	*Carpinus betulus, C. orientalis*	Poiras, 1998
Ischnopterapion virens (Herbst, 1797)	Asia, Europe, Mediterranean region	*N	N/A	Ph (her)	*Trifolium*	Poiras, 1994
Dryophthoridae						
Sitophilus oryzae (Linnaeus, 1763)	Asia-Tropical	S	J	Ph (spe)	Grain	Poiras, 1998
S. granarius Linnaeus, 1758	Africa	S	J	Ph (spe)	Stored grains, *Secale Triticum, Zea mays*	Miller, Zubowsky, 1917
Acentrus histrio Boheman, 1845	Mediterranean region	C	E	Ph (her)	*Glaucium*	Medvedev, Shapiro, 1957
Curculionidae						
Lignyodes bischoffi (Blatchley, 1916)	North America	I	G, H	Ph (spe)	*Fraxinus, Syringa*	Poiras, 1987
Tychius caldaria Dieckmann, 1986	Mediterranean region	N	E	Ph (her)	*Dorycnium suffruticosum, D. pentaphyllum*	Medvedev, Shapiro, 1957
Rhynchaenus sparsus Fahraeus, 1843	Mediterranean region	N	G	Ph (lbw)	*Quercus robur, Q. pubescens*	Poiras, 1991
Baris janthina Boheman, 1836	Asia, Europe, Mediterranean region	N	E	Ph (lbw)	*Caradaria draba*	Medvedev, Shapiro, 1957
Baris prasina (Boheman, 1836)	South Europe	C		Ph (lbw)	Brassicaceae	Poiras, 1998
Rhinoncus pericarpius (Linnaeus, 1758)	Asia, West Mediterranean region, Europe	*N	E, H	Ph (rbo)	*Rumex, Medicago, Melilotus*	Miller, Zubowsky, 1917
Thamiocolus uniformis (Gyllenhal, 1837)	Asia, Europe, Mediterranean region	N	E	Ph (her)	*Phlomis pungens*	Poiras, 1998

Ranunculiphilus kuntzei (Smreczynski, 1957)	Mediterranean region	N	E	Ph (her)	No Data	Poiras, 1998
Otiorhynchus albidus Stierlin, 1861	Asia, West Mediterranean region, Europe	*N	E, H	Ph (lbw)	*Cerasus, Juglans, Populus, Tamarix, Tilia*	Ruscinski, 1937
Trachyphloeus spinimanus Germar, 1824	Europe, Asia	C	N/A	Ph (rbw)	*Cynodon*	Poiras, 1998
Phyllobius canus Gyllenhal, 1834	Mediterranean region, Asia	C	G, H	Ph (lbw)	Rosaceae, *Quercus robur*	Plugar, 1963
Cycloderes canescens (Rossi, 1792)	Mediterranean region	C	E	Ph (lbw)	*Plantago*	Poiras, 1998
Sitona lineatus (Linnaeus, 1758)	Asia, Europe, Mediterranean region	*N	H, J	Ph (rbw)	Fabaceae	Medvedev, Shapiro, 1957
S. macularius (Marsham, 1802)	Asia, Europe, Mediterranean region	*N	H, J	Ph (rbw)	*Trifolium*	Medvedev, Shapiro, 1957
S. puncticollis Stephens, 1831	Asia, Europe, Mediterranean region	*N	H	Ph (rbw)	*Trifolium, Melilotus*	Ruscinski, 1937
Aparopion costatum Fahraeus, 1843	Europe, Mediterranean region	C	E	Ph (her)	No data	Arnoldi et al., 1965
Hypera nigrirostris (Fabricius, 1775)	Asia, Europe, Mediterranean region	N	E, J	Ph (lbw)	*Ononis, Trifolium*	Medvedev, Shapiro, 1957
H. postica (Gyllenhal, 1813)	Asia, Europe, Mediterranean region	*N	H, J	Ph (lbw)	Fabaceae	Antonova, 1977
H. pastinacae (Rossi, 1790)	Asia, Europe, Mediterranean region	N	G, H	Ph (lbw)	*Pastinaca sativa, Daucus carota*	Medvedev, Shapiro, 1957
H. contaminata (Herbst, 1795)	Europe	N	E	Ph (lbw)	*Lathyrus tuberosus*	Ruscinski, 1937
Rhabdorhynchus menetriesi Gyllenhal, 1842	East Mediterranean region	N	E	Ph (her)	No data	Poiras, 2001
Lachnaeus horridus Reitter, 1890	Asia	C	E	Ph (her)	*Inula*	Poiras, 1998
Lixus astrachanicus Faust, 1883	Asia	C	E	Ph (her)	No data	Poiras, 1998
Pissodes castaneus (De Geer, 1775)	Asia, Europe, Mediterranean region	N	G	Ph (phl)	*Pinus*	Poiras, 1991
Scolytus laevis Chapuis, 1873	Europe	N	G, H	Ph (phl)	*Ulmus*	Poiras, 2001
S. rugulosus (Ratzeburg, 1837)	Asia, Europe, Mediterranean region	N	H	Ph (phl)	Rosaceae trees	Miller, Zubowsky, 1917
Xyleborinus saxesenii (Ratzeburg, 1837)	Asia, Europe, Mediterranean region	N	H	Ph (xmp)	*Laurus, Pinus, Castanea*	Miller, Zubowsky, 1917
Pteleobius kraatzii (Eichhoff, 1864)	Europe, West Mediterranean region	N	H, G, F	Ph (phl)	*Ulmus*	Miller, Zubowsky, 1917
Hylastes angustatus (Herbst, 1793)	South Europe, Asia	N	G	Ph (phl)	*Pinus*	Stark, 1952
H. ater (Paykull, 1800)	Europe, Asia	N	G, H	Ph (phl)	*Pinus*	Miller, Zubowsky, 1917

According to larvae trophic preferences 54 species of investigated beetles are phytophagous, 12 are predators and 7 detritivorous; adults of *Alphitobius diaperinus* and *Mylabris variabilis* are being detritivorous and phytophagous, respectively. For remaining 2 species information on their diet is not available.

Most of the phytophagous beetles (29.09%) are herbiphagous. Spermatophagous is the second most important feeding group (27.27%), followed by leaf/steam browsers (18.18%), phloeophagous (10.9%), root browsers (7.27%) and saproxylophagous (3.63%). The remaining (by 1.81%) are root borers and xylomycetophagous. From the total number of the investigated alien beetles 26.67% are agricultural, forest and storage pests. All non-native species occurring in closed spaces (9) are storage pests. Depending on their food bonds and population dynamics, post-invasive and invasive species have various degrees of importance, among them *Leptinotarsa decemlineata*, *Sitona lineatus* and *Rhopalapion longirostre* cause the biggest losses in agricultural crops yield [Vorotyntseva, 1971; Poiras, 2006; Munteanu et al., 2012], while *Lignyodes bischoffi* is one of the most dangerous forest pest [Poiras, 1987, 2006]. Of the alien species living under outdoor conditions, the species of casual occurrence and naturalized non-invasive species do not have great significance, because they are active only in short-terms or inhabit a very small territory.

Revealed alien predators belong to Staphylinidae and Coccinelidae families. Detritivorous species belong to Tenebrionidae, Ptinidae, Dermestidae and Scarabaeidae. Their influence on environment can be considered beneficial or neutral as long as they occur in small numbers and do not affect native species. A representative case of alien species expansion in the Republic of Moldova is *Harmonia axyridis* (Pall., 1773). The first unpublished information on this species, according to Timus and Stahi [2013], dates from 1970, which could be related to the earlier release of this species for introduction in Ukraine [Katsoyannos et al., 1997]. Published data regarding establishment of *H. axyridis* in the Republic of Moldova appeared recently, [Iazlovetchi, Sumenkova, 2013; Timus, Stahi, 2013]. Within *H. axyridis* populations five forms were identified: *H. axyridis* var. *novemdecimsignata*, *H. a.* var. *siccoma*, *H. a.* var. *succinea*, *H. a.* var. *spectabilis* and *H. a.* var. *conspicua* [Timus, Stahi, 2013]. Iazlovetchi and Sumenkova [2013] mention that the species represented 42% of all coccinellids recorded in 2011, the proportion has reached 86% in 2012, and 90% in 2013, successfully eliminating autochthon coccinellids *Coccinella septempunctata* L. and *Adalia bipunctata* L.

The effects of an alien species entry in a new ecosystem can be diverse. Most significant is a direct competition with native species for food and space, an increasing abundance in the new environment until a complete replacement of native residents occurs. Despite that a large amount of attested alien beetles does not produce economic damages, it should not be ignored because non-invasive status does not mean that it will not become invasive. It could be just a matter of time and circumstances (biotic and abiotic conditions that may change) until it becomes invasive. That's why knowledge of species peculiarities and behavior in a new environment is extremely important for determining the factors that can lead to an alien species uncontrollable expansion and invasive statute modification.

Unfortunately, the hazards caused by alien species did not cause that much concern among scientists, nor did it attract public awareness as much as would have been expected [Hulme et al., 2009]. Conducted researches comprise too large regions and cannot solve the problems of restricted areas. In the Republic of Moldova, for example, this is the first study highlighting alien species. The location of the republic at the interference of biogeographical zones causes a continuous pressure of alien species that

are at the limits of their distribution area. Thus, detailed researches in this territory will allow the monitoring and forecasting of new invasions.

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