The Lonchaeidae family (lance flies) comprises an important group of fruit flies. Several species are associated with the decomposition of organic matter of plant origin. However, some species are considered of economic importance because they attack fruits and flower buds (McAlpine & Styskal 1982). Species of the genera Neosilba and Dasiops are reported as primary invaders of certain fruit trees, obtaining pest status for some plant species of Euphorbiaceae, Myrtaceae, Rutaceae, Sapotaceae and Passifloraceae (UchôA & Nicácio 2010; Raga et al. 2011; Gisloti et al. 2017; AdAime et al. 2017). Some lance fly species are polyphagous, and few species are known to be monophagous or oligophagous (Strikis 2011).

In around the State of São Paulo, Brazil, the distribution, infestation rate and infestation period of fruit flies (Tephritoidea) vary due to different agroecosystems, climatic diversity, peculiar phytophysiology and, the origin of the fruit sample (rural or urban region) (Raga et al. 2011).

Regional research is crucial to provide basic information for the management of insect pest populations (UchôA et al. 2002). Therefore, it is important to examine historical and current research data on lance flies (Lonchaeidae), their distribution and host plants to help understanding the population dynamics of this insect group insects and developing management strategies.

The first reports of Lonchaeidae associated with fruits in São Paulo occurred when Hempel (1901) associated Lonchaea glaberrima Wiedemann [Neosilba glaberrima (Wiedemann)] with passion fruit Passiflora sp. However, the main reports of association of lance flies with host fruits, occurred in the 1980s, when dozens of species of host fruits were listed for several Brazilian states, including São Paulo (Malavasi et al. 1980; Malavasi & Morgante 1980).

Here, after 30 years of random fruit collections in different regions of São Paulo, we compile the state records of lonchaeids, based on all available publications of plant hosts, monitoring, distribution, species descriptions, and unpublished records. The present study reinforces the biological diversity and the economic importance of Lonchaeidae species within superfamily Tephritoidea.

MATERIAL AND METHODS

An extensive search of available printed or digital publications on field-collected lance flies was carried out from 1980 to 2020. This search period was considered the resumption of scientific works on Lonchaeidae in São Paulo, after the taxon redefinition and description of many species.

For each publication, we provide the complete references on lance flies and their geographical distribution. Each study was categorized into two insect collection categories: fruit or trapping. This approach was used to relate the Lonchaeidae species with plant hosts. Data from traps helping to create specific maps. With the analysis of the data of all publications, a table of relation of lance fly/hosts and distribution maps were available.

We removed duplicate records from abstracts, conference proceedings and thesis. In addition to the list of records based on early publications, we add unpublished data of Lonchaeids recovered from plant samples collected in the Instituto Biológico, São Paulo, Brazil. In total, 18 species of Lonchaeidae, belonging to the genera Dasiops, Lonchaea and Neosilba were registered in São Paulo, and associated with 111 host plant species and 27 botanical families. New records are listed and geographical distribution is available by specific maps.

Keywords: Insecta; Tephritoidea; Neosilba; Dasiops; fruit hosts.
belonging to the genera *Dasiops*, *Lonchaea* and *Neosilba*. Currently, 111 host species of vonchaeids are identified, belonging to 27 botanical families (Table 1), from which 47 are introduced species (Table 1). Species of *Neosilba* are the most commonly lance flies found in São Paulo, where 15 species are reported: *N. glaberrima*, *Neosilba pendula* (Bezzi), *Neosilba zadolicha* McAlpine & Steyskal, *Neosilba certa* (Walker), *Neosilba dimidiata* (Curran), *Neosilba inesperata* Strikis & Prado, *Neosilba perezi* (Romero & Ruppel), *Neosilba laura* Strikis, *Neosilba bifida* Strikis & Prado, *Neosilba cornophallus* Strikis, *Neosilba pradoi* Strikis & Lorenz, *Neosilba parva* Hennig, *Neosilba bella* Strikis & Prado, *Neosilba delvechioi* Strikis and *Neosilba parameterolatus* Strikis. Only two *Dasiops* species were registered: *Dasiops inedulis* Steyskal and *Dasiops frieseni* Norrbom & McAlpine. Both species of *Dasiops* are associated with *Passiflora edulis* Sims. *Lonchaea* was exhibited only at the genus level according to the record of original paper.

Myrtaceae has the largest number of host plants of *Lonchaeidae*, followed by Rosaceae, Rutaceae, Fabaceae and Rubiaceae (Table 1). The botanical species with the greatest diversity of lance flies is *Eriobotrya japonica* (Thunb.) (Rosaceae), with 10 associated species (nine species of *Neosilba* and one *Lonchaea* sp.), followed by *Coffea* spp. with 9 species. *Neosilba zadolicha* is highly polyphagous species among Lonchaeids in São Paulo, where is associated with 75 hosts and 22 families.

The distribution of lonchaeids in São Paulo is represented in Figure 1. There are reports of lonchaeids in 99 municipalities of São Paulo. *Neosilba pendula*, *N. zadolicha*, *N. certa*, *N. inesperata* and *N. glaberrima* are the most widely distributed

Table 1. Lonchaeidae (Diptera: Tephritoidea) host plants (N = Native; I = Introduced) in São Paulo, Brazil.

| Botanical Family (number of Lonchaeidae species) | Native Introduced | Lonchaeidae species | Reference |
|-------------------------------------------------|-------------------|---------------------|-----------|
| Anacardiaceae (4)                               |                   |                     |           |
| Lithraea molleoides (Vell.) Engl.               | N                  | *N. glaberrima*, *N. pendula* | RAGA et al. 2015 |
| Mangifera indica L.                             | I                  | *N. zadolicha*      | RAGA et al. 2015 |
| Spondias dulcis Parkinson                       | I                  | *N. pendula*        | RAGA et al. 2015 |
| Spondias mombin L.                              | N                  | *N. certa*, *N. pendula*, *N. zadolicha* | GISLotti et al. 2017 |
| Spondias purpurea L.                            | I                  | *N. pendula*, *N. zadolicha* | RAGA et al. 2015; GISLotti et al. 2017 |
| Spondias tuberosa Arruda                        | N                  | *N. zadolicha*      | GISLotti et al. 2017 |
| Spondias venulosa (Engl.) Engl.                 | N                  | *N. zadolicha*      | GISLotti et al. 2017 |
| Annonaceae (4)                                  |                   |                     |           |
| Annona coriacea Mart.                           | N                  | *N. zadolicha*, *N. certa* | RAGA et al. 2015 |
| Annona emarginata (Schldtl.) H. Rainer          | N                  | *N. certa*          | RAGA et al. 2015 |
| Annona mucosa Jacq.                             | N                  | *N. zadolicha*, *N. certa* | RAGA et al. 2015 |
| Annona reticulata L.                            | I                  | *N. zadolicha*      | RAGA et al. 2015 |
| Annona neoserica H. Rainer                      | N                  | *N. dimidiata*, *N. zadolicha*, *N. glaberrima* | RAGA et al. 2015 |
| Annona squamosa L. x A. cherimola Mill.         | I                  | *N. zadolicha*, *N. pendula* | RAGA et al. 2015 |
| Annona sylhetica A. St.-Hil.                    | N                  | *N. zadolicha*      | RAGA et al. 2015 |
| Annona sylhetica A. St.-Hil.                    | N                  | *N. zadolicha*, *N. glaberrima* | GISLotti et al. 2017 |
| Apocynaceae (1)                                 |                   |                     |           |
| Hancornia speciosa Gomes                        | N                  | *N. zadolicha*      | GISLotti et al. 2017 |
| Areaceae (2)                                    |                   |                     |           |
| Bactris gasipaes Kunth                           | N                  | *N. zadolicha*, *N. glaberrima* | GISLotti et al. 2017 |
| Cactaceae (2)                                   |                   |                     |           |
| Pereskiopsis aculeata Mill.                     | I                  | *N. glaberrima*     | New record |
| Hylocereus setaceus (Salm-Dyck ex DC.) Ralf Bauer | N                  | *N. zadolicha*, *N. glaberrima* | GISLotti et al. 2017 |
| Caricaceae (1)                                  |                   |                     |           |
| Carica papaya L.                                | I                  | *Lonchaea* sp.      | RAGA et al. 2015 |
| Caryocaraceae (2)                               |                   |                     |           |
| Caryocar brasiliensis A. St.-Hil.               | N                  | *N. zadolicha*, *N. pendula* | GISLotti et al. 2017 |
| Combretaceae (4)                                |                   |                     |           |
| Terminalia catappa L.                           | I                  | *N. zadolicha*, *N. inesperata*, *N. certa*, *N. glaberrima* | RAGA et al. 2015 |
| Cucurbitaceae (1)                               |                   |                     |           |
| Cucurbita maxima Duchesne                       | N                  | *N. zadolicha*      | RAGA et al. 2015 |
| Cucurbita moschata Duchesne                     | I                  | *N. zadolicha*      | RAGA et al. 2015 |

to be continued...
| Botanical Family (number of Lonchaeidae species) | Native Introduced | Lonchaeidae species | Reference |
|-----------------------------------------------|-------------------|---------------------|-----------|
| C. moschata Duchesne x C. maxima Duchesne    | I                 | N. zadolicha        | RAGA et al. 2015 |
| Ebenaceae (1)                                 |                   |                     |           |
| Diospyros kaki L.f.                           | I                 | N. zadolicha        | RAGA et al. 2015 |
| Euphorbiaceae (1)                             |                   |                     |           |
| Manihot esculenta Crantz                      | N                 | N. perezi           | LOURENÇÃO 1996; GISLOTI & PRADO 2011; RAGA et al. 2015 |
| Fabaceae (9)                                  |                   |                     |           |
| Dalbergia brasiliensis Vogel                  | N                 | N. laura            | STRIKIS 2011 |
| Inga spp.                                     | N                 | N. zadolicha; N. certa; N. glaberrima; N. pendula; N. laura; N. bifida; N. inesperata; N. cornphallus | STRIKIS 2011; RAGA et al. 2015 |
| Inga vera Willd.                              | N                 | N. certa; N. pendula; N. pradoi; N. zadolicha | GISLOTI et al. 2017 |
| Leucacena leucocephala (Lam.) de Wit          | I                 | N. certa; N. pendula | RAGA et al. 2015 |
| Swartzia langsdorffii Raddi                   | N                 | N. zadolicha; N. glaberrima; N. certa | RAGA et al. 2015 |
| Ginkgoaceae (1)                               |                   |                     |           |
| Ginkgo biloba L.                              | I                 | N. zadolicha        | New record |
| Lauraceae (5)                                 |                   |                     |           |
| Persea americana Mill.                        | I                 | N. zadolicha; N. certa; N. glaberrima; N. pendula; N. parva | RAGA et al. 2015 |
| Malpighiaceae (8)                             |                   |                     |           |
| Bunchosia armeniaca (Cav.) DC.                | I                 | N. pendula          | RAGA et al. 2015 |
| Byrsonima crassifolia (L.) Kunth              | N                 | N. bella; N. glaberrima; N. inesperata; N. pendula; N. pradoi; N. zadolicha | GISLOTI et al. 2017 |
| Malpigia emarginata DC.                       | I                 | N. pendula; N. inesperata; N. zadolicha; N. certa; N. cornphallus; N. glaberrima; N. perezi | STRIKIS & Lerena 2009; RAGA et al. 2015; GISLOTI et al. 2017 |
| Malvaceae (1)                                 |                   |                     |           |
| Gossypium hirsutum L.                         | I                 | N. zadolicha        | RAGA et al. 2015 |
| Moraceae (6)                                  |                   |                     |           |
| Ficus carica L.                               | I                 | N. certa; N. zadolicha; N. glaberrima; N. bifida; N. cornphallus | RAGA et al. 2015 |
| Ficus sp.                                     | N                 | N. certa; N. pendula; N. zadolicha | RAGA et al. 2015 |
| Morus nigra L.                                | I                 | N. zadolicha        | RAGA et al. 2015 |
| Musaceae (1)                                  |                   |                     |           |
| Musa x paradisiaca L. (cv. Nanica)            | I                 | N. zadolicha        | RAGA et al. 2015 |
| Myrtaceae (11)                                |                   |                     |           |
| Acca sellowiana (O. Berg) Burret              | N                 | N. zadolicha        | GISLOTI et al. 2017 |
| Campomanesia auera O. Berg                    | N                 | N. pradoi           | GISLOTI et al. 2017 |
| Campomanesia guazumifolia (Cambess.) O. Berg  | N                 | N. pradoi; N. zadolicha | GISLOTI et al. 2017 |
| Campomanesia phaea (O. Berg.) Landrum         | N                 | N. pradoi; N. zadolicha | GISLOTI et al. 2017 |
| Eugenia brasiliensis Lam.                     | N                 | Neosilba sp.; N. pradoi; N. zadolicha | RAGA et al. 2015; GISLOTI et al. 2017 |
| Eugenia dyssenterica DC.                      | N                 | N. inesperata; N. pendula; N. zadolicha | GISLOTI et al. 2017 |
| Eugenia involucrata DC.                       | N                 | N. certa; N. pradoi; N. laura; N. pendula; N. zadolicha | RAGA et al. 2015; GISLOTI et al. 2017 |
| Eugenia sellol B. D. Jacks.                   | N                 | N. pendula; N. zadolicha | GISLOTI et al. 2017 |
| Eugenia leiptoni D. Legrand                   | N                 | N. glaberrima; N. zadolicha | RAGA et al. 2015 |
| Eugenia pitanga (O. Berg) Nied.                | N                 | N. zadolicha        | GISLOTI et al. 2017 |
| Eugenia pyriformis Cambess.                   | N                 | N. zadolicha; N. certa; N. pendula; N. pradoi; N. inesperata; N. laura | RAGA et al. 2015; GISLOTI et al. 2017 |
| Eugenia lambertiana DC.                       | N                 | N. pendula; N. inesperata; N. zadolicha; N. bella | RAGA et al. 2015 |
| Eugenia stipitata McVaugh                     | N                 | N. bella; N. pendula | GISLOTI et al. 2017 |

*to be continued...*
| Botanical Family (number of Lonchaeidae species) | Native Introduced | Lonchaeidae species | Reference |
|-------------------------------------------------|-------------------|---------------------|-----------|
| Eugenia uniflora L. | N | N. bella; N. pendula; N. inesperata; N. zadolicha | RAGA et al. 2015; GISLOTI et al. 2017 |
| Myrciaria dubia (Kunth) McVaugh | N | N. zadolicha | GISLOTI et al. 2017 |
| Plinia cauliflora (Mart.) Kausel | N | N. certa | RAGA et al. 2015 |
| Myrciaria glazioviana (Kiaersk.) G. M. Barroso ex Sobral | N | N. inesperata; N. pendula; N. certa | RAGA et al. 2015 |
| Plinia edulis (Veit.) Sobral | N | N. bifida | RAGA et al. 2015 |
| Psidium cattleianum Afzel. ex Sabine | N | N. certa; N. inesperata; N. pendula; N. pradoi; N. bifida; N. dimidiata; N. zadolicha | RAGA et al. 2015; GISLOTI et al. 2017 |
| Psidium guajava L. | N | N. zadolicha; N. pendula; N. certa; N. glaberrima; N. bifida; N. cornuphallus; N. inesperata; N. bella; N. dimidiata | RAGA et al. 2015; GISLOTI et al. 2017 |
| Psidium guineense Sw. | N | N. pendula; N. zadolicha | GISLOTI et al. 2017 |
| Syzygium jambos (L.) Alston | I | N. pendula; N. zadolicha | RAGA et al. 2015 |
| Syzygium samarangense (Blume) Merr. & L. M. Perry | I | N. pendula; N. certa | RAGA et al. 2015 |
| Oxalidaceae (6) | | | |
| Averrhoa carambola L. | I | N. certa; N. inesperata; N. pendula; N. glaberrima; N. bella | RAGA et al. 2015 |
| Passifloraceae (7) | | | |
| Passiflora alata Curtis | N | N. zadolicha; N. glaberrima; N. certa; Lonchaea sp.; Dasiops inedulis | RAGA et al. 2015 |
| Passiflora edulis Sims | N | N. zadolicha; N. certa; N. inesperata; Lonchaea sp.; Dasiops inedulis; D. fieseni | RAGA et al. 2015 |
| Rhamnaceae | | | |
| Ziziphus joazeiro Mart. | N | N. pendula | RAGA et al. 2015; GISLOTI et al. 2017 |
| Rosaceae (10) | | | |
| Eriobotrya japonica (Thunb.) Lindl. | I | N. pendula; N. certa; N. zadolicha; N. glaberrima; N. inesperata; N. bella; N. bifida; N. pradoi; N. cornuphallus; Lonchaea sp. | STRIKS & PRADO 2005; STRIKS & PRADO 2009; RAGA et al. 2015 |
| Malus domestica Borkh. | I | N. zadolicha; N. certa; N. pendula | RAGA et al. 2015 |
| Prunus mume (Siebold) Siebold & Zucc. | I | N. certa | RAGA et al. 2015 |
| Prunus persica (L.) Batsch. | I | N. zadolicha; N. certa; N. pendula; N. inesperata; N. glaberrima; N. bifida; Lonchaea sp. | RAGA et al. 2015 |
| Prunus salicina Lindl. | I | N. certa; N. pendula; N. inesperata | RAGA et al. 2015 |
| Pyrus communis L. | I | N. certa | RAGA et al. 2015 |
| Rubus ulicifolius Poir. | N | N. inesperata; N. pendula | GISLOTI et al. 2017 |
| Rubus sp. | N | N. zadolicha; N. pendula; N. certa | RAGA et al. 2015 |
| Rubiaceae (9) | | | |
| Coffea spp. | I | N. pendula; N. zadolicha; N. inesperata; N. bella; N. certa; N. bifida; N. laura; N. delvechioi; Lonchaea sp. | RAGA et al. 1997; STRIKS 2011; RAGA et al. 2015 |
| Rutaceae (9) | | | |
| Citrus x aurantium L. | I | N. zadolicha; N. glaberrima | RAGA et al. 2015 |
| Citrus x microcarpa Bunge | | N. delvechioi | STRIKS 2011 |
| Citrus limon (L) Osbeck | I | N. zadolicha; N. glaberrima; N. pendula; N. certa | RAGA et al. 2015 |
| Citrus mitis Blanco | I | N. pendula; N. glaberrima; N. zadolicha; N. certa; N. laura; N. inesperata | RAGA et al. 2015 |
| Citrus reticulata Blanco cv. Ponkan | I | N. zadolicha; N. pendula; N. inesperata | RAGA et al. 2015 |
| Citrus reticulata Blanco cv. Cravo | I | N. zadolicha; N. glaberrima; N. pradoi; N. parva | RAGA et al. 2015 |
| C. reticulata Blanco x C. sinensis (L) Osbeck | I | N. zadolicha; N. certa | RAGA et al. 2015 |
| Citrus sinensis (L) Osbeck | I | N. zadolicha; N. glaberrima; N. certa; N. pendula; N. inesperata; N. bifida | RAGA et al. 1997; RAGA et al. 2015 |

*to be continued...*
Table 1. Continue...

| Botanical Family (number of Lonchaeidae species) | Native Introduced | Lonchaeidae species | Reference |
|-------------------------------------------------|-------------------|---------------------|-----------|
| *Fortunella* sp. | I | *N. zadolicha;* *N. certa;* *N. pendula* | RAGA et al. 2015 |
| **Salicaceae (2)** | | | |
| *Doyyalis abyssinica* (A. Rich) Warb. | X | *N. zadolicha;* *N. pendula* | New records |
| *Doyyalis hebecarpa* (Gardner) Warb. | I | *N. zadolicha;* *N. pendula* | RAGA et al. 2015 |
| **Sapotaceae (7)** | | | |
| *Chrysophyllum cainito* L. | I | *N. zadolicha;* *N. pendula* | RAGA et al. 2015 |
| *Chrysophyllum mexicanum* Brandegee | I | *N. zadolicha* | RAGA et al. 2015 |
| *Manilkara zapota* (L.) P. Royen | I | *N. zadolicha* | RAGA et al. 2015 |
| *Mimusops balata* (Aubl.) C. F. Gaertn. | I | *N. glaberrima;* *N. certa* | RAGA et al. 2015 |
| *Pouteria caimito* (Ruiz & Pav.) Radlk. | N | *N. zadolicha;* *N. glaberrima;* *N. pendula;* *N. bella;* *N. certa* | RAGA et al. 2015; GISLOTI et al. 2017 |
| *Pouteria torta* (Mart.) Radlk. | N | *N. dimidiata;* *N. zadolicha;* *N. glaberrima;* *N. paramerolatus* | RAGA et al. 2015 |
| **Solanaceae (8)** | | | |
| *Capsicum* sp. | I | *N. glaberrima;* *N. certa;* *N. zadolicha;* *N. pendula;* *N. inesperata;* *N. laura* | RAGA et al. 2015 |
| *Capsicum annuum* L. | I | *N. parva;* *N. zadolicha;* *N. certa;* *N. glaberrima;* *N. pendula* | RAGA et al. 2015 |
| *Mandragora officinarum* L. | I | *Neosilba* sp. | RAGA et al. 2015 |
| *Solanum aethiopicum* L. | I | *N. zadolicha;* *N. parva;* *N. certa;* *N. pendula;* *N. glaberrima;* *N. pradoi;* *N. inesperata* | STRIKIS & PRAIO 2005; RAGA et al. 2015 |
| *Solanum lycopersicum* L. | I | *N. zadolicha;* *N. certa* | RAGA et al. 2015 |
| *Solanum lycopersicum var. cerasiforme* | I | *N. certa;* *N. parva* | New records |
| *Solanum mammosum* L. | N | *N. zadolicha;* *N. certa;* *N. parva* | RAGA et al. 2015 |
| *Solanum melongena* L. | N | *N. zadolicha;* *N. parva;* *N. glaberrima* | STRIKIS & PRAIO 2005; RAGA et al. 2015 |
| *Solanum variabile* Mart. | N | *N. inesperata* | RAGA et al. 2015 |
| **Verbenaceae (4)** | | | |
| *Citharexylum myrianthum* Cham. | N | *N. pendula;* *N. cornuphalus;* *N. bifida;* *N. bella.* | STRIKIS 2011; RAGA et al. 2015 |

in the state, where they were registered on 64, 59, 40, 32 and 26 municipalities, respectively.

**DISCUSSION**

Until the 1980s, lance flies were neglected and often discarded in surveys of frugivorous flies in Brazil, due to a lack of taxonomic knowledge and, mainly because they were not considered fruit pests (GATTIELI et al. 2008). There has been a significant increase in the number of studies related to the Lonchaeidae family since the 1990s.

RAGA et al. (2011) recovered Lonchaeidae from the majority of Tephritidae host plants collected in São Paulo, and concluded that it is not an opportunistic group, although fruits with previous infestation by tephritids showed physical-chemistry changes and facilitate further lonchaeid infestation.

An extensive survey of fruit samples in 94 municipalities of São Paulo was performed by RAGA et al. (2015), totalling 113 botanical species related to 31 plant families. Lonchaeidae species were found in 77 plant species, corresponding to 68% of the plant species collected. GISLOTI et al. (2017) sampled fruits from 35 species and found that almost 90% of the sampled plants were colonized by Neosilba species. Although most of the bibliography mentioned in the present study recorded the occurrence of species of lonchaeids in plants of economic importance, some native botanical species were sampled in places bordering the conservation areas.

Neosilba zadolicha, *N. pendula,* *N. inesperata* and *N. glaberrima* are frequently recovered in fruit samples (UCHOA et al. 2012; LEMOS et al. 2015; RAGA et al. 2015). All mentioned species occur in São Paulo all year long (RAGA et al. 2015). Neosilba perezi occurs in cassava sprouts (LOURENÇO et al. 1996; GISLOTI & PRAIO 2011). Polyphagous species have a wider geographic distribution than species considered to be specialists, in many cases exhibit niche overlap, and many species can infest the same host (MALAVASI & MORGANTE 1980; RAGA et al. 2011). The polyphagia of Neosilba pendula and *N. zadolicha* represents high adaptation to introduced plant species, being responsible for their wide geographic distribution in the state of São Paulo (Figure 1). Twenty-four plant species reported here are both hosts of *N. zadolicha* and *Ceratitis capitata* (Wied.) (Tephritidae) in São Paulo. Neosilba zadolicha exhibits dominance similar to *C. capitata* in urban areas (RAGA et al. 2011).

Lonchaeidae’s knowledge in São Paulo is not yet consolidated. It is necessary to continue efforts to learn about the diversity of Lonchaeidae species, their host plants, and specially the economic losses in horticulture crops, as well as an increase in studies on biology and behaviour. The data from the present study emphasize the relevance of Lonchaeidae species to the main crops of economic importance in São Paulo.
Figure 1. The known distribution of *Neosilba* and *Dasiops* species (Lonchaeidae) in São Paulo, Brazil.
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