

RESEARCH ARTICLE

First conservation assessment of selected long-proboscid flies (*Moegistorhynchus* and *Prosoeca*, Diptera: Nemestrinidae) endemic to South Africa's Cape region

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Long-proboscid flies of the genera *Moegistorhynchus* and *Prosoeca* (Nemestrinidae) are charismatic nectar-feeding insects with several species considered to be keystone pollinators, yet their conservation status is unknown. Recent taxonomic work has improved our understanding of some species identities and distributions, therefore providing a basis for conservation assessments. Building on this updated taxonomy, we conducted baseline IUCN Red List assessments for eight endemic species to evaluate their extinction risk. We estimated range-size metrics following IUCN guidelines and incorporated national spatial overlays to assess habitat loss, ecosystem threat status, and protected area coverage. We found that two species are classified as Endangered, one as Near Threatened, three as Data Deficient and two as Least Concern. All species assessed have experienced high habitat loss (28–57%) as a result of agriculture and urban expansion, particularly along coastal areas, and 8–31% of the remaining habitat falls within threatened ecosystems. Less than 11% of the ranges of the Endangered and Near Threatened species overlap with protected areas. Data Deficient species are known from fewer than three localities, underscoring the need for systematic surveys and intensive sampling of these poorly known taxa. Information on distributions, population sizes, host plants, and larval biology remains extremely limited for all taxa and is urgently needed. As the first Red List assessment for flies in South Africa, and for a specialist fly pollinator, this study identifies threatened species, highlights data-deficient taxa, and provides important baseline information for future research and conservation efforts on this hyper-diverse insect group.

INTRODUCTION

Long-proboscid flies of the genera *Moegistorhynchus* Macquart and *Prosoeca* Schiner (Nemestrinidae) are charismatic nectar-feeding insects in the Greater Cape Floristic Region (the 'Cape Region' *sensu* Colville et al. 2014). Several species are highly specialist, keystone pollinators (e.g. Goldblatt & Manning 2000; Barraclough & Slotow 2010), yet their conservation status is unknown. Recent taxonomic work has clarified some species identities and their distributions (Barraclough et al. 2018; Barraclough & Colville 2024), providing an opportunity to undertake conservation assessments (Mace 2004; Cardoso et al. 2011). Assessing extinction risk using the IUCN Red List is a critical step in identifying species of conservation concern, particularly for insects where limited data on geographic ranges, population sizes, and trends pose major challenges (Mace et al. 2008; Cardoso et al. 2011; van Swaay et al. 2011; Fox et al. 2019; Cazalis et al. 2022). Globally, only ~0.3% of Diptera species (431 of 160 042) have undergone IUCN Red List assessments (Kirk-Spriggs & Sinclair 2017; IUCN 2024), indicating that very few fly groups have received any conservation attention, most of which has been concentrated in Europe (Biesmeijer et al. 2006; but see also Vujić et al. 2022). No Diptera have been assessed in South Africa, highlighting a major gap in national conservation priorities for a hyper-diverse and ecologically important order of insects.

Our study focuses on eight endemic species, seven belonging to *Moegistorhynchus* and one to *Prosoeca*. A major catalyst for assessing the conservation status of these flies has been recent taxonomic works (see above), which resulted in the description of four new species. In addition, the authors examined extensive historical and newly collected material and compiled all available distributional data to map species ranges (Barraclough et al. 2018; Barraclough & Colville 2024). *Moegistorhynchus* species are distributed across lowland and montane areas of the Cape Region, whereas *Prosoeca marinus* is confined to the Bokkeveld Plateau (elevations >700 m). All eight species have narrow geographic ranges, which is a key characteristic associated with elevated extinction risk (Gaston & Fuller 2009; Newbold et al. 2018).

The species we focus on are specialist nectar-feeding flies distinguished by their elongated mouthparts. In *Moegistorhynchus*, proboscis length varies—from exceptionally long in *M. longirostris* (2.0–5.5 × body length) to similar to the body length in *M. brevisrostris* (Barraclough & Colville 2024). The large-bodied *P. marinus* has a proboscis 1.5–2.3 times its body length (Barraclough et al. 2018; Krenn et al. 2025). At least half of these species have been shown to be

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DATES

Received: 18 November 2025

Accepted: 24 January 2026

KEYWORDS

data deficient
extinction risk
habitat loss
IUCN Red List
protected area network
threatened

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specialist pollinators of long-tubed flowers of Geraniaceae, Proteaceae, Ericaceae, Iridaceae, and Orchidaceae (Goldblatt & Manning 2000; Manning 2004; Karolyi et al. 2013; Barraclough et al. 2018; Newman & Johnson 2021; Krenn et al. 2025). We know little to nothing about the host plant use of the remaining species. Like many insect specialists that are closely synchronised with a specific set of flowering host plants (Biesmeijer et al. 2006; Fallon et al. 2021), this aspect of their biology increases their vulnerability to decline.

Their narrow geographic ranges and specialist feeding requirements likely make adult flies more sensitive to habitat loss and changes in nectar host plant availability. Additionally, the larvae of all nemestrinids are internal parasitoids of other insects (Barraclough 2006, 2017), thereby introducing additional ecological specialisation and ecological complexity that may further increase their vulnerability to habitat loss. However, despite these potential threats and the sensitivity of the species, remarkably, no conservation actions are in place for long-proboscid nemestrinid flies, thereby underscoring the need and urgency for extinction risk assessments. Accordingly, we assessed the extinction risk of all known *Moegistorhynchus* species and the highly range-restricted *Prosoeca marinusii* following the International Union for Conservation of Nature (IUCN) Red List criteria (Version 16, IUCN Standards and Petitions Committee 2024). Our assessments followed the approach of Melin et al. (2026) for South African bees, using georeferenced occurrence records and IUCN-recommended calculations for the Extent of Occurrence (EOO) and Area of Occupancy (AOO). We also used national spatial overlays to estimate the extent of habitat loss (Skowno et al. 2020, 2021) and calculated, for each fly species, the proportion of remaining habitat within threatened ecosystems in its EOO (Skowno & Monyeke 2021; South African National Biodiversity Institute and Department of Forestry, Fisheries and the Environment 2021). In addition, we assessed the proportion of each species' EOO that lies within South Africa's protected areas network (Department of Environmental Affairs 2020). Given the lack of Red List assessments for flies in South Africa, this study provides critical baseline information to guide future conservation efforts for these ecologically important insects.

MATERIALS AND METHODS

We used a dataset of 80 georeferenced occurrence records (Table 1) obtained from fly specimens in natural history collections, field research, and expert-confirmed iNaturalist observations. Collection localities for three species could not be georeferenced owing to vague locality information (Table 1). For example, *M. braunsi* specimen labels provide only a general locality (the 'Stellenbosch' area). These data were used in the revision of the seven species of *Moegistorhynchus* (Barraclough & Colville 2024) and the species description of *P. marinusii* (Barraclough et al. 2018).

To estimate the AOO, we followed IUCN Red List Guidelines by counting the number of occupied grid cells (based on georeferenced point data) and multiplying this by the standard 4 km² resolution (2 × 2 km cells) (IUCN Standards and Petitions Committee 2024). The EOO was estimated using a minimum convex polygon (MCP) drawn around the point data (a minimum of three points is required), which was then used for further analysis. All spatial metrics (AOO, EOO and elevation range) were estimated using the R package 'red' (Cardoso 2020). For the two species *M. longirostris* and *M. brevirostris* whose EOO polygons extend over marine areas, we clipped the MCPs to the coastline using the `st_intersection()` function in the R package 'sf' (Pebesma 2018).

To estimate habitat loss, ecosystem threat status, and the level of protection within each species' EOO, we conducted spatial

intersections between each species' EOO following Melin et al. (2026) and the relevant spatial layers using the R packages 'sf' and 'terra' (Hijmans 2022). To calculate the proportion of habitat loss and the rate of change (<1990–2018), and to analyse the primary drivers of habitat transformation (e.g., crops, urban expansion), we used the 30 m resolution National Habitat Modification (v6.0) raster dataset (Skowno et al. 2021). We estimated the proportion of the remaining habitat (i.e., excluding habitat loss from the EOO) falling within threatened ecosystems using the South African IUCN Red List of Ecosystems (RLE) categories, which are based on vegetation types defined by Mucina and Rutherford (2006) (Skowno & Monyeke 2021; South African National Biodiversity Institute and Department of Forestry, Fisheries and the Environment 2021). Lastly, we calculated the proportion of each species' EOO that falls within South Africa's protected areas network using the South African Protected Areas Database shapefile (Department of Environmental Affairs 2020).

We undertook all analyses using the program R version 4.1.2 (R Core Team 2021). We used the following additional R packages for data management and manipulation: 'dplyr' (Wickham et al. 2022), 'data.table' (Dowle & Srinivasan 2022), and 'tibble' (Müller & Wickham 2022). To render the maps in Figures 1–5, we used QGIS version 3.40 (QGIS Development Team 2024).

RESULTS AND DISCUSSION

Conservation status

Based on our assessments of eight species of nemestrinid flies, we found that two species are classified as Endangered, one as Near Threatened, three as Data Deficient, and two as Least Concern (see Table 1). These results highlight the vulnerability and data gaps associated with this group of specialised fly pollinators. Of the threatened species, *P. marinusii*—a narrow-range endemic—is restricted to six known localities on the Bokkeveld Plateau in the Northern Cape province and has experienced the greatest estimated habitat loss (57%) (Table 1, Figure 1). Thirty-one per cent of *P. marinusii*'s remaining habitat is classified as threatened (Table 1, Figure 1), emphasising the threat and risk of ongoing habitat decline for this species. Habitat within parts of the species' limited range is increasingly affected by localised pressures, such as overgrazing and rooibos tea cultivation (O'Farrell et al. 2008; Lötter & le Maitre 2014). Like many insect specialists (Biesmeijer et al. 2006; Fallon et al. 2021), *P. marinusii* and species in its sister genus *Moegistorhynchus* exhibit ecological traits that increase their vulnerability to decline, including narrow geographic ranges, dependence on narrow-tubed host plants for nectar, with adult emergence and foraging activity closely synchronised to the flowering phenology of these plants, and likely slow larval development tied to the availability of currently unknown insect hosts (Barraclough 2006). Declines in these pollinators could, in turn, pose a significant risk to the persistence of their host plants, many of which are narrow-range endemics and of conservation concern (e.g., *Babiana vanzijliae* L.Bolus; Near Threatened).

Three of the eight *Moegistorhynchus* species assessed were classified as Data Deficient. Two of the three species have only recently been described and are each represented by fewer than three known collection records (Barraclough & Colville 2024). Among these, *M. braunsi*, is represented by a series of 17 specimens, although the exact collection locality remains unknown (Barraclough & Colville 2024). Given the scarcity of records, the available data are inadequate for assessing the extinction risk of these species (IUCN Standards and Petitions Committee 2024). They are known from either a single specimen or from specimens with uncertain locality information and, as a result, are classified as Data Deficient. The number of threatened *Moegistorhynchus* species is however likely an underestimate, as

Table 1: Red List assessments and classifications for eight nemestrinid fly species in South Africa. The table summarises the proportion of each species' range (Extent of Occurrence, EOO) affected by habitat loss, including the rate, causes and quality of habitat, as well as the proportion occurring within South Africa's protected area network. ['Secondary natural' refers to old and abandoned croplands before 1990 to distinguish these from natural or semi-natural habitats]. IUCN Red List categories: EN (Endangered), NT (Near Threatened), LC (Least Concern), and DD (Data Deficient). Assessments for all species have been submitted to the IUCN Red List but have not yet been published. Therefore, the categories and criteria presented here are considered provisional until formal publication. AOO, Area of Occupancy

Species name (No. of occurrence records)	Category	Criteria	EOO (km ²)	AOO (km ²)	Locations	Elevation (m)	Protected Areas in EOO (%)	Habitat loss (1990–2014) in EOO (%)	Habitat loss (<1990-2018) in EOO (%)	Main cause(s) of habitat loss	Threatened habitat in EOO (%)
<i>Prosoeca marinus</i> (n = 17)	EN	B1ab (iii) + 2ab (ii)	54	24	2–3	702–789	1.3	6.5	56.8	Crops (40.3%), Secondary natural (13.9%), Urban expansion (1.7%)	31.1
<i>Moegistorhynchus brevirostris</i> (n = 10)	EN	B2ab (iii)	7 712–10 126	36	3	15–1317	2.6	4.0	31.6	Crops (20.9%), Secondary natural (6%), Urban expansion (2.8%)	19.1
<i>Moegistorhynchus longirostris</i> (n = 39)	NT	Very close to meeting VU B2ab (iii)	20 740–30 909	92	12	7–765	10.5	3.3	27.8	Crops (18.4%), Secondary natural (5.5%), Urban expansion (1.8%)	16.0
<i>Moegistorhynchus perplexus</i> (n = 7)	LC	-	3196	28	-	457–1640	42.5	4.2	39.9	Crops (33.8%), Secondary natural (3.2%)	8.3
<i>Moegistorhynchus turneri</i> (n = 7)	LC	-	3285	24	-	854–1710	37.9	2.2	30.0	Crops (19.2%), Secondary natural (5.7%), Plantations (1.2%)	29.7
<i>Moegistorhynchus braunsi</i> (n = 1)	DD										
<i>Moegistorhynchus manningi</i> (n = 2)	DD										
<i>Moegistorhynchus strillii</i> (n = 1)	DD										

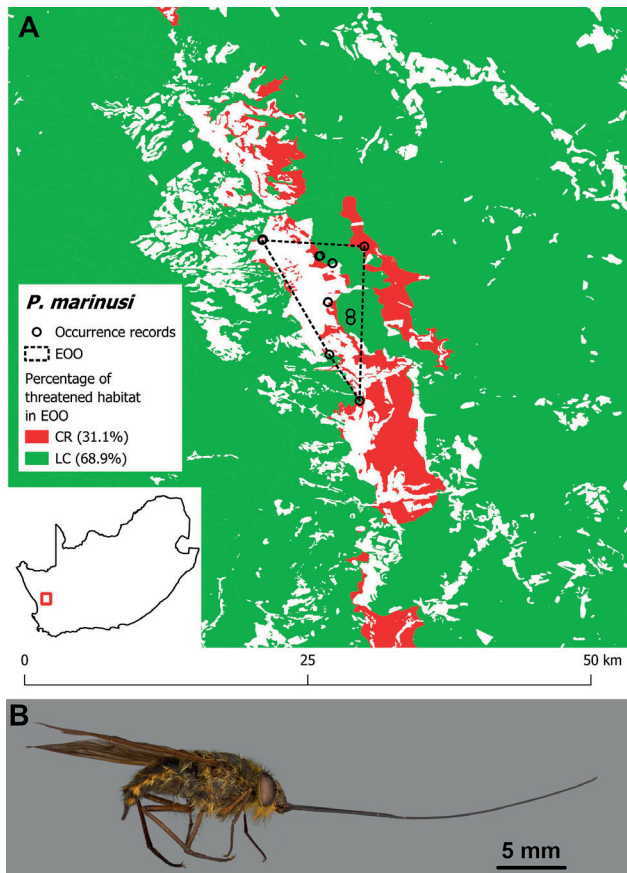


Figure 1: A. Remaining habitat of *Prosoeca marinusi* (excluding areas lost from its Extent of Occurrence, EOO), showing the proportion of ecosystems classified as threatened according to the South African IUCN Red List of Ecosystems. IUCN Red List categories: CR, Critically Endangered; LC, Least Concern. Inset map indicates the location of the EOO in South Africa. B. Profile of *Prosoeca marinusi* ♀. Photo credit: Annalie Melin

recent analyses suggest that more than half of all Data Deficient species may in fact be at risk of extinction once their status is properly assessed (Borgelt et al. 2022).

For the five species with sufficient occurrence records to undertake Red List assessments, when combined with the land cover overlay, we found that 28% to 57% of their EOOs have been lost (Table 1). The main driver of habitat loss within their EOOs is the conversion of natural vegetation to croplands, followed by urban expansion, particularly along coastal areas (Table 1). Such transformation, driven by the spread and intensification of agriculture and expanding urbanisation, is widely recognised as one of the most significant global threats to insect biodiversity, with habitat specialists being among the most vulnerable (Nieto et al. 2014; Fallon et al. 2021; Raven & Wagner 2021). Although this analysis used the most recent land cover change data available (Skowno et al. 2021), the dataset is now over a decade old and likely underestimates more recent habitat transformation. By also incorporating the threatened ecosystem (RLE) status of the remaining habitat, we found that 8% to 31% (Table 1, Figures 1–5) of each species' EOO falls within ecosystems classified as threatened, providing further evidence of habitat vulnerability and emphasising the threat and risk of ongoing habitat decline for nemestrinid flies.

Based on the available data, *M. perplexus* and *M. turneri* are classified as Least Concern despite their small AOOs and EOOs (Table 1). Although both species meet the threshold for Criterion B1 based on EOO and B2 based on AOO, they do not satisfy the required combination of at least two of the three conditions necessary for a threatened category. These species do not occur at ten or less IUCN-defined 'locations' as no 'threatening event'

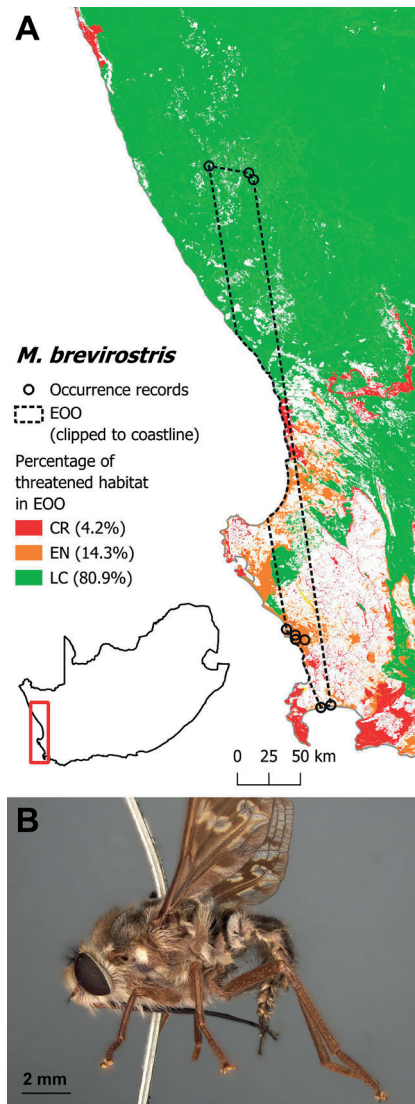


Figure 2: A. Remaining habitat of *Moegistorhynchus breviostris* (excluding areas lost from its Extent of Occurrence, EOO), showing the proportion of ecosystems classified as threatened according to the South African IUCN Red List of Ecosystems. IUCN Red List categories: CR, Critically Endangered; EN, Endangered; LC, Least Concern. Inset map indicates the location of the EOO in South Africa. B. Profile of *Moegistorhynchus breviostris* ♀. Photo credit: Jonathan F. Colville

has been identified that could 'rapidly affect all individuals of the taxon present' (IUCN Standards and Petitions Committee 2024). In addition, while habitat loss has occurred within parts of their EOOs (Table 1), this loss is largely concentrated in lowland areas, whereas both species are largely associated with montane habitats (Barraclough & Colville 2024). Within protected areas, both species were locally abundant during field surveys, further supporting their assessment as Least Concern under the IUCN Red List criteria.

Protected area coverage

The proportion of the species' range falling within South Africa's protected area network is generally low, with three of the five species having less than 11% of their known range within protected areas (Table 1). The two species classified as Endangered have the lowest representation (1.3% and 2.6%) in protected areas (Table 1). Most of the specimens of *P. marinusi* were collected from protected areas including Nieuwoudtville Flower Reserve (World Wildlife Fund) and the Hantam National Botanical Garden (South African National Biodiversity Institute), and Krenn et al. (2025) found the species to be abundant at these

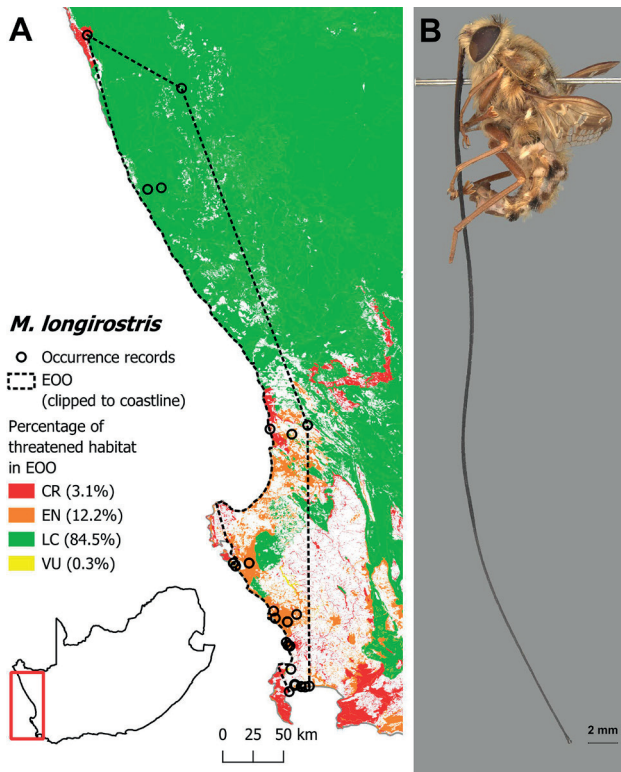


Figure 3: A. Remaining habitat of *Moegistorhynchus longirostris* (excluding areas lost from its Extent of Occurrence, EOO), showing the proportion of ecosystems classified as threatened according to the South African IUCN Red List of Ecosystems. IUCN Red List categories: CR, Critically Endangered; EN, Endangered; LC, Least Concern; VU, Vulnerable. Inset map indicates the location of the EOO in South Africa. B. Profile of *Moegistorhynchus longirostris* ♂. Photo credit: Jonathan F. Colville

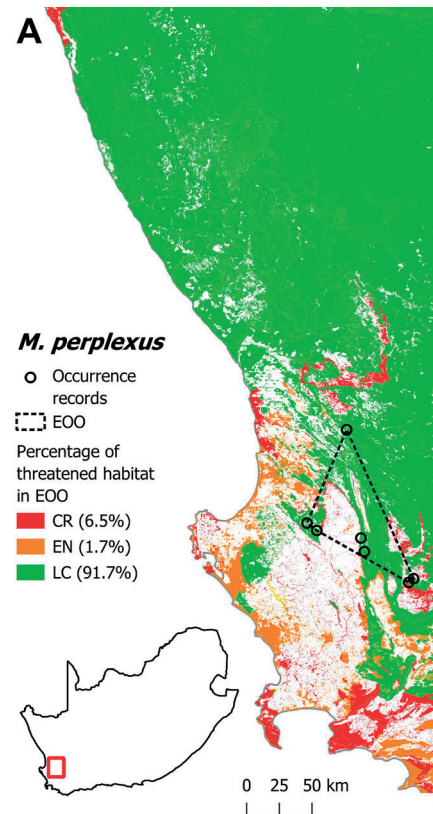


Figure 4: A. Remaining habitat of *Moegistorhynchus perplexus* (excluding areas lost from its Extent of Occurrence, EOO), showing the proportion of ecosystems classified as threatened according to the South African IUCN Red List of Ecosystems. IUCN Red List categories: CR, Critically Endangered; EN, Endangered; LC, Least Concern. Inset map indicates the location of the EOO in South Africa. B. Profile of *Moegistorhynchus perplexus* ♀. Photo credit: Jonathan F. Colville

localities. Consequently, *P. marinusii* is the most well studied South African long-proboscid nemestrinid with regard to habitat and ecology (Karolyi et al. 2012, 2013; Krenn et al. 2021, 2025). However, despite this abundance and research focus, the species' population size and trends remain unknown. Research on population size and trends, host plant use, and insect larval hosts is urgently needed to better understand this species. In the meantime, habitat protection is recommended to safeguard its known populations.

Although *M. perplexus* and *M. turneri* show moderately high representation of their range within protected areas (42.9% and 37.9%, respectively, Table 1), the total number of occurrence records is very low (seven per species), and two of these records fall outside protected areas for *M. perplexus*. Given that *M. turneri* occurs in mountainous terrain (854–1 710 m), with over half of its range in protected areas, the likelihood of habitat loss from agriculture or forestry is considered to be low. Nevertheless, targeted field surveys would be necessary to confirm whether these species continue to persist within protected areas, similar to the approach taken by the Southern African Lepidoptera Conservation Assessment for butterflies (Mecenero et al. 2020).

Data gaps in species distributions

Targeted field surveys are essential to address data gaps for poorly known species. In the Southern African Lepidoptera Conservation Assessment, for example, survey efforts were prioritised for butterfly species known from fewer than three localities (Mecenero et al. 2020). Among the Data Deficient species, *M. strillii* is known only from a single specimen collected 108 years ago in the Groot Winterhoek Mountains north of Tulbagh, with no precise locality coordinates. This

high-elevation species urgently requires systematic surveys and sampling, particularly in the Groot Winterhoek mountains, which fall within the broader Groot Winterhoek Wilderness Area—a designated conservation area—to determine whether it still occurs there. High elevation habitats are known to be at greater risk from climate change, which may threaten the persistence of the species (Miller-Struttman et al. 2015).

Despite recent taxonomic work involving consolidation of material from several different international and local museums, many species remain poorly collected, with clear disjunctures in their distribution patterns—particularly *M. longirostris* and *M. brevisrostris* (Barraclough & Colville 2024). This highlights the need for targeted surveys to clarify their distribution ranges. Citizen science initiatives such as iNaturalist offer valuable opportunities to expand occurrence data. For example, the number of expert-validated records for *M. longirostris* have already contributed to new occurrence records (Barraclough & Colville 2024), likely aided by the distinctive morphology of this species: an extremely elongate proboscis. However, the

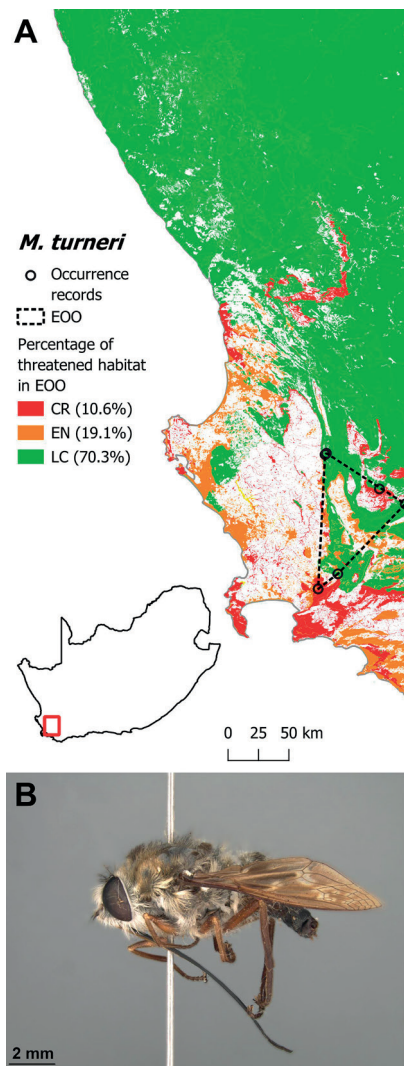


Figure 5: A. Remaining habitat of *Moegistorhynchus turneri* (excluding areas lost from its Extent of Occurrence, EOO), showing the proportion of ecosystems classified as threatened according to the South African IUCN Red List of Ecosystems. IUCN Red List categories: CR, Critically Endangered; EN, Endangered; LC, Least Concern. Inset map indicates the location of the EOO in South Africa. B. Profile of *Moegistorhynchus turneri* ♂. Photo credit: Jonathan F Colville

effectiveness of such data for conservation assessment depends on expert validation and integration with structured survey data, such as presence–absence records, in order to ensure reliability and relevance (Gallagher et al. 2025).

Conclusion

There are currently no known conservation actions in place for the eight nemestrinid fly species assessed here. Using the IUCN Red List to evaluate their extinction risk provides a critical first step in understanding their conservation status (Mace et al. 2008), especially because insect assessments are constrained by limited data on geographic ranges, population sizes, and trends (Cardoso et al. 2011; van Swaay et al. 2011; Fox et al. 2019; Cazalis et al. 2022). Knowledge of the species' habitats, ecology, and larval biology remains extremely limited (Barraclough 2006; Barraclough et al. 2018; Krenn et al. 2025), highlighting substantial gaps in the information available for all eight species.

Nemestrinid larvae are internal parasitoids of other insects, such as beetle larvae and grasshoppers. However, the specific hosts of *Moegistorhynchus* and *Prosoeca* species are unknown. Any conservation efforts focused on these important pollinators

would be of limited value without also understanding and protecting their larval host species.

This study represents the first Red List assessment for flies in South Africa and provides new baseline data for a group of specialist insect pollinators. We have identified two species that qualify as Endangered, one as Near Threatened and three as Data Deficient, highlighting targeted surveys and sampling are needed. Additionally, mapping species distributions relative to protected areas has provided a baseline for evaluating conservation coverage and gaps. Overall, these results provide a foundation for prioritising future research and conservation actions for *Moegistorhynchus* species and *P. marinusi*, particularly the urgent need for improved understanding of key aspects of their biology, including identification of larval hosts.

ACKNOWLEDGEMENTS

A.M. is grateful to Anna Walker, Monika Bohm and Oscar Martínez for providing IUCN Red List Assessor Training. A.M. thanks Elizabeth Parker and the Mapula Trust for postdoctoral funding. D.B. and J.F.C. thank Oppenheimer Generations Research and Conservation, the BRO Trust, and Elizabeth Parker and The Mapula Trust, who all generously contributed funding to this research. The authors would like to thank two anonymous reviewers.

DATA AVAILABILITY STATEMENT

The data used in this study are publicly available from the following repositories:

- The Vegetation of South Africa, Lesotho and Swaziland (Mucina & Rutherford 2006), Version 2018: <http://bgis.sanbi.org/Projects/Detail/186>
- IUCN Red List of Ecosystems (RLE) for South Africa (Skowno & Monyeki 2021; South African National Biodiversity Institute and Department of Forestry, Fisheries and the Environment 2021), based on the above vegetation types, Version 2018: <https://bgis.sanbi.org/Projects/Detail/1233/>
- Land cover-derived terrestrial habitat change map for South Africa (1990–2018) (Skowno et al. 2020, 2021): <https://catalogue.saeon.ac.za/records/10.15493/SAEON.FYNBOS.10000011> <https://doi.org/10.15493/saeon.fynbos.10000011>
- South African Protected Areas Database (SAPAD) (Department of Environmental Affairs 2020), Version SAPAD_IR_2019_Q4_01: <https://www.dffe.gov.za/egis>

AUTHOR CONTRIBUTIONS

Annalie Melin: Conceptualization (equal); Data Curation (lead); Formal Analysis (lead); Funding Acquisition (equal); Methodology (lead); Visualization (lead); Writing – Original Draft (lead), Writing – Review and Editing (lead). David A. Barraclough: Conceptualization (equal); Data Curation (lead); Funding Acquisition (equal); Writing – Review and Editing (equal). Jonathan F. Colville: Conceptualization (equal); Data Curation (equal); Formal Analysis (equal); Methodology (contributing); Writing – Original Draft (contributing), Writing – Review and Editing (equal).

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