New genus of Gyrodactylidae (Monogenea) from Lake Kariba, Zimbabwe, with an insight on the phylogeny of the family

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INTRODUCTION

The family Gyrodactylidae currently contains 24 valid viviparous only genera (Boeger et al. 2020). Until recently both, viviparous and oviparous genera were grouped into one family, however, Harris (1983) proposed a separate family for oviparous genera, the Oogyrodactylidae, which was recently reinstated by Boeger et al. (2020) to include all South American oviparous genera. More than 90% of the genera (i.e., n=22) in the Gyrodactylidae primarily parasitize fish hosts with only two exceptions, *Gyrdicotylus* Vercammen-Grandjean, 1960 and *Insancistrum* de Beauchamp, 1912, that infect frogs and cephalopods, respectively (de Beauchamp 1912, Vercammen-Grandjean 1960) . Seven gyrodactylid genera are currently known from Africa of which six are geographically limited to the continent only and four of these African genera remain monotypic. But the true diversity of this family and the genera within remains hidden and awaits the findings from extensive and comprehensive programmes of sampling.

MATERIAL AND METHODS

Sampling
Lake Kariba
August 2011

→ *Marcusenius macrolepidosus*
(Mormyridae)
n=2,TL= 25.3–28 cm

↓ Parasites collection for morphometric and genetic characterization

Molecular work
- DNA isolation
- 18S rDNA sequencing
- Alignment **MEGA X**
- Trimming **trimAl v 1.2**

Phylogeny
- Model test
- Bayesian inference **Mr Bayes**
- Malimum Likelihood

PhyML v.3.0

Light microscopy
measurements and drawings of hard pasts of attachment haptor and male copulatory organ

RESULTS

Both studied specimens of *M. macrolepidotus* were infected with gill parasites. The presence of a developing embryo within the uterus of a few specimens indicated that the specimens were viviparous and that they belong to the Gyrodactylidae, but the overall arrangement of the opisthaptoral hard parts, as well as the unique morphology of the male copulatory organ (MCO), indicated that the discovery represented a new genus.

References
Boeger W.A., Kritsky D.C., Patella L., Bueno-Silva M. 2020. Zoologica Scripta 50: 112–124; **De Beauchamp P. 1912** Bulletin della Societe Zoologique. Francaise. 37: 96–99; .**Harris P.D. 1983** Parasitology 87: 405–420; **Luus-Powell W.J., Mashego S.N., Khalil L.F.** 2003 Folia Parasitologica 50: 49–55; **Přikrylová I., Luus-Powell W.J. 2014** Folia Parasitologica 61: 529–536.; **Přikrylová I., Matějusová I., Musilová N., Gelnar M., Harris P.D. 2009** Jornal of Parasitology 95: 555–560.; **Přikrylová I., Blažek R., Vanhove M.P.M. 2012** Parasitology Research 110: 1185–1200.; **Přikrylová I., Shinn A.P., Paladini G. 2017** Parasitology Research 116: 218–292.; **Řehulková E., Seifertová M., Přikrylová I., Francová K. 2018** In: Scholz, T., Vanhove, M.P.M., Smit, N., Jayasundera, Z., Gelnar, M. (Eds). Abc Taxa 18: 185–243.; :**Vercammen-Grandjean P.H. 196** Science Zoologiques. 5: 51–60.; **Vianna R.T., Boeger V.A., Dove A. 2007**: Acta Zoologica. 88: 89–9.

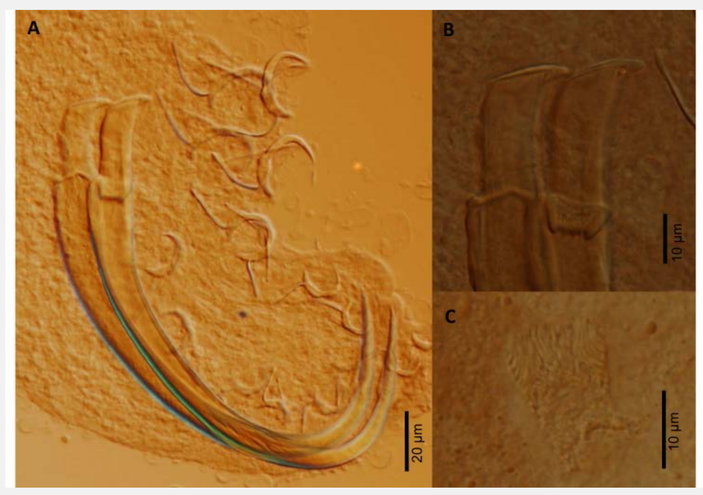

Fig. 1. Light microscope photographs of new genus from *M. macrolepidotus.* A – opisthaptor; B – hamuli root, ventral and dorsal bars details; B – male copulatory organ.

Differentiating features:

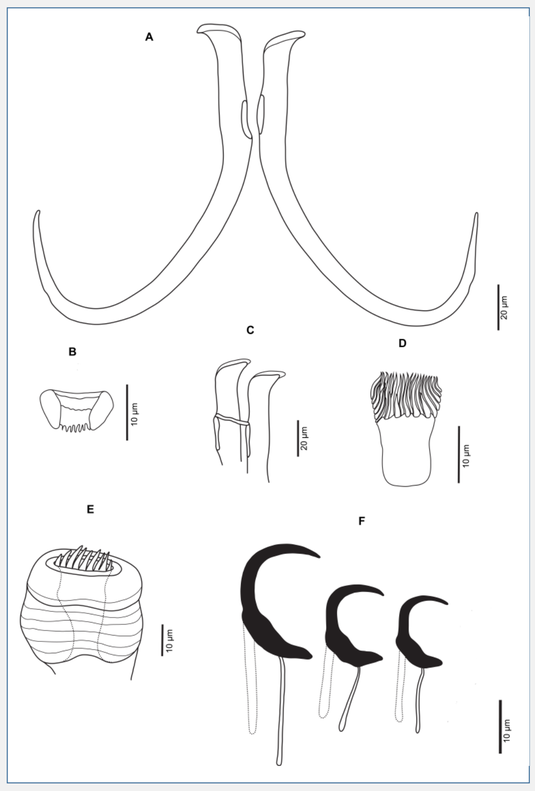

Fig. 2. Line drawings of newly identified genus. from *M. macrolepidotus.* A – hamuli; B – ventral bar; C – details of hamuli roots and dorsal bar; D – male copulatory organ; E – pharynx; F – marginal hooks.

- Male copulatory organ consists of a muscular pouch, positioned ventrally, close to the bifurcation of the intestinal crura, armed with approximately 30 gracile spines (Figs. 1c, 2d).
- Opisthaptor bearing a single pair of large, slender hamuli with a constriction on the outer edge between the shaft and point regions on each hamulus. Hamuli root prominently flattened (Figs. 1b, 2c); ventral terminus of the hamulus cap tapered. Small and simple ventral bar, without antero-lateral processes; thin lingulate membrane present. Thin, simple dorsal bar. Sixteen marginal hooks with large falculate sickles of one morphological type, but of three different sizes, the length of each sickle being approximately equal in length to that of their handle (Fig 2f).

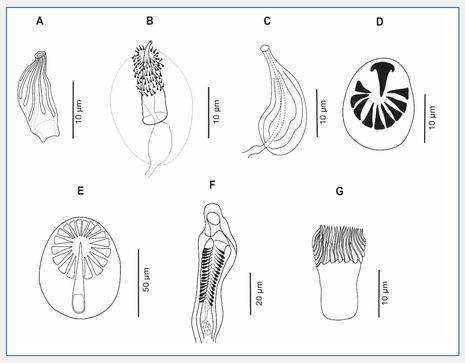

Fig 3. Line drawings of male copulatory organs of genara of Gyrodactylidae parasitizing African freshwater fishes. A – *Afrogyrodactylus* (modified from Přikrylová and Luus-Powell, 2014); B – *Citharodactylus* (original drawing from Přikrylová et al. 2017); C – *Diplogyrodactylus* (modified from Přikrylová et al. 2009); D – *Gyrodactylus* (modified from Přikrylová et al. 2012); E – *Macrogyrodactylus* (modified from Řehulková et al. 2018); F – *Mormyrogyrodactylus* (modified from Vianna et al. 2007); G – *NEW GENUS* (present study)..

Table 1 Uncorrected pairwise genetic distances between African taxa

		1	2	3	4	5	6
1	New genus						
2	*Afrogyrodactylus girgifae*	8.94					
3	*Citharodactylus gagei*	8.48	7.23				
4	*Diplogyrodactylus martini*	6.19	10.99	8.98			
5	*Macrogyrodactylus congolensis*	8.11	10.63	8.67	7.02		
6	*Macrogyrodactylus polypteri*	8.15	10.49	9.22	7.69	1.43	
7	*Mormyrogyrodactylus gemini*	6.47	9.57	8.36	7.03	7.88	8.41

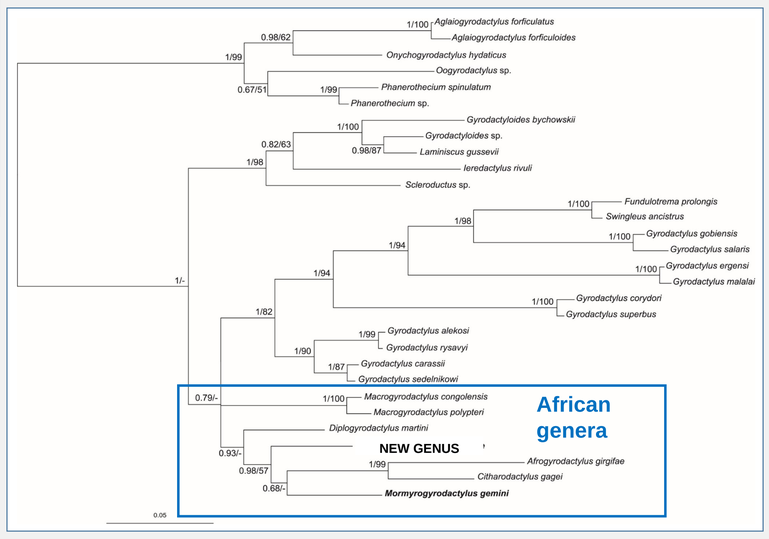

Fig. 4. Phylogenetic tree inferred from Bayesian inference (BI) based on 18S rDNA sequences alignment of 1434 bp. Nodal support values are given as BI/ML (maximum likelihood). Support values lower than 50 (ML) are not presented. Newly generated sequences are highlighted in bold.

PHYLOGENY

New genus clustered as a part of the lineages including solely African genera, i.e., *Afrogyrodactylus, Citharodactylus*, *Diplogyrodactylus* and *Mormyrogyrodactylus*, in the range of distances 6.19–8.94% with *Diplogyrodactylus* being the closest related (Fig. 3, Table 1). The position of *Macrogyrodactylus* remains unresolved but being related to the new genus along with the other African genera, 8.11% for *Macrogyrodactylus congolensis* Prudhoe, 1957 and 8.15% for *Macrogyrodactylus polypteri* Malmberg, 1957.

CONCLUSION

Present study demonstrates that African continent still hides an undiscovered parasite diversity. Four of six African genera of Gyrodactylidae were identified in last two decades (Luus-Powell et al. 2003, Přikrylová et al. 2009, 2017, present study) and for now, they remain monotypic. Parasites from five genera which formed well defined African clade have non bulbous type of MCO, representing quite unusual diversity compare to many genera with the bulbous type as known for *Gyrodactylus* or *Macrogyrodactylus*.