 

# Moonlighting proteins of the adult tapeworm *Hymenolepis diminuta* (Cestoda, Hymenolepididae)

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Moonlighting proteins are those which demonstrate multiple functions not associated with gene fusion, multiple RNA splice variants or multiple proteolytic fragments. A few hundred such proteins are known to exist, ranging from receptors and enzymes to transcription factors, adhesins and scaffolds. They have been detected in a range of organisms, including mammals, yeasts, bacteria, plants and certain tapeworms (Taenia pisiformis, Echinococcus granulosus).

Recent studies have reported that a number of the somatic and surface proteins of tapeworm Hymenolepis diminuta may act as moonlighting proteins (Młocicki *et al.,* 2019). The present study identified 17 moonlighting proteins using the MoonProt database (http://www.moonlightingproteins.org). In addition, 11 potential antigenic proteins were found to be moonlighting: EF-2, enolase, fructose-1,6-bisphosphate adolase, glucose 6-phosphate isomerase, HSP60, pyruvate kinase, lactate dehydrogenase A, glutamate dehydrogenase, glyceraldehyde-3-phosphate dehydrogenase, transketolase and triosephosphate isomerase. Also, 14 surface proteins of H. diminuta were moonlighting (6-phosphofructokinase, EF 1-alpha, EF-2, enolase, fructose-1,6-bisphosphate adolase, glyceraldehyde-3-phosphate dehydrogenase, hexokinase, lactate dehydrogenase A, phosphoglycerate kinase, phosphoglycerate mutase, pyruvate kinase, pyruvate kinase isozyme type M2, transketolase, triosephosphate isomerase). Selected moonlighting proteins of H. diminuta and their functions are presented in Table 1.

Although moonlighting proteins are known to be present in parasites, their properties remain poorly understood; in addition, most have been identified in protozoans, and data concerning their presence in helminths is very rare. Our findings are among the first to indicate the presence of moonlighting proteins in cestodes. The moonlighting proteins identified in H. diminuta act as potential mediators in the interactions between parasite and host and testify to the complexity of the relationship. Most are enzymes and chaperone proteins; some of them, enolase for example, have been considered as novel vaccine candidates. However, to better understand the exact function and importance of the moonlighting proteins taking part in the host-Cestode interactions, further experiments are required.

 

Table 1. Examples of moonlighting proteins identified in tapeworm *H. diminuta* (MoonProt database).

| PROTEIN NAME | FUNCTION 1 | FUNCTION 2 |
|---|---|---|
| 6-phosphofructokinase | 6-phosphofructokinase, enzyme ATP + D-fructose 6-phosphate => ADP + D-fructose 1,6-bisphosphate Carbohydrate degradation, glycolysis | binds plasminogen from host organism |
| Elongation factor 1 alpha | translation elongation factor | binds and severs microtubules |
| Elongation factor 2 | translation elongation factor | binding partner for Akt2 signaling molecule |
| Enolase | enzyme 2-phospho-D-glycerate => phosphoenolpyruvate + H2O Catalyzes the reversible conversion of 2-phosphoglycerate into phosphoenolpyruvate Carbohydrate degradation, glycolysis | binds plasminogen |
| HSP60 | prevents misfolding and promotes the refolding and proper assembly of unfolded polypeptides | adhesin |
| Phosphoglycerate kinase | Phosphoglycerate kinase, enzyme ADP + 1,3-bisphosphoglycerate => ATP + glycerate-3-phosphate Carbohydrate degradation, glycolysis | plasminogen binding |