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SYSTEMATIC APPROACH AND BIOCHEMICAL ADAPTATION IN HELMINTH FROM SELECTED RUMINANTS OF NANDURBAR, (M.S.), INDIA

Zoology

K.K.Borse	Parasitology Research Lab., Research and P.G. Dept. of Zoology, NTVS's G.T.Patil Arts, Commerce and Science College, Nandurbar- 425 412 (M.S.)
J.C.Patil	Parasitology Research Lab., Research and P.G. Dept. of Zoology, NTVS's G.T.Patil Arts, Commerce and Science College, Nandurbar- 425 412 (M.S.)
S.R.Badgujar	Parasitology Research Lab., Research and P.G. Dept. of Zoology, NTVS's G.T.Patil Arts, Commerce and Science College, Nandurbar- 425 412 (M.S.)
G.H.Balde	Parasitology Research Lab., Research and P.G. Dept. of Zoology, NTVS's G.T.Patil Arts, Commerce and Science College, Nandurbar- 425 412 (M.S.)

ABSTRACT

Biochemical and Morphological approach into Helminth Parasites of Sheep and Goats explores the multifaceted impact of helminth parasites, including nematodes, cestodes, and trematodes, on sheep and goats. These parasites cause gastrointestinal helminthosis, leading to significant economic losses due to reduced growth, milk production, and fiber quality (***Soulsby, E. J. L. 1982; Bowman, 2009***). The research integrates morphological and biochemical approaches to understand parasite biology, host-parasite interactions, and potential intervention strategies.Morphologically, helminths exhibit diverse adaptations such as specialized structures for attachment (e.g., scolex in cestodes) and complex life cycles involving multiple larval stages (***Hurisa et al., 2021***). For instance, *Monieziaexpansa* features an unarmed scolex with four muscular suckers and proglottids containing reproductive organs (***de Luna et al., 2023***). Nematodes like *Haemonchuscontortus* display cylindrical bodies with a protective cuticle that aids survival in hostile environments (***Lee, 2002; Bird & Bird, 1991***).Biochemically, helminths rely heavily on carbohydrate metabolism to thrive in anaerobic or semi-anaerobic habitats. For example, *H. contortus* utilizes glucose from host blood for energy production (***Thivend, 1974***), while cestodes like *Echinococcus granulosus* exhibit active tricarboxylic acid cycles during larval stages (***Agosin& Repetto, 1963***). The study also highlights the role of fumarate as an electron acceptor in metabolic pathways of Monieziaexpansa (***Cheah & Bryant, 1966***).

KEYWORDS

Biochemical, Helminths, Goat and Sheep, Morphology, Nandurbar

INTRODUCTION

In view of the greater magnitude of roundworms and tapeworms/ flatworms or distribution, the study of these helminth fauna requires the biochemical data of all the worms living in the body of the sheep and the goat. Such a study will can give a better understanding of the various reasons for parasitism.Helminth parasites are a significant health concern for sheep and goats worldwide, impacting their productivity and welfare. These parasites, including nematodes, trematodes, and cestodes, cause gastrointestinal helminthosis, a condition that can lead to severe economic losses for farmers due to reduced growth, milk production, and fiber quality. Effective control of these helminth infections requires accurate identification of the causative parasites. Traditionally, identification relies on morphological characterization, examining features such as body shape, size, and the presence of specific structures (***Soulsby, E. J. L. 1982***). Coupled with modern biochemical investigations, a more complete understanding of parasite biology, host-parasite interactions, and potential intervention strategies can be achieved **(*Soulsby, E. J. L. 1982; Bowman, 2009*)**. Hence for understanding these parasitic mechanisms is critical for improved treatments.This study aims to integrate both morphological and biochemical approach into the common helminth parasites affecting sheep and goats. These are multicellular parasites that have evolved complex life cycles and biochemical strategies to infect and survive within their hosts **(*Taylor, M. A., & et al., 2015*)**.

Biochemical Approach

In spite of this data, nematodes pose another important problem that they are dioecious, and the physiological and biochemical activities of both male and female worms may or may not be different even, in the different stages of cestode, nematodes and trematode which pass through different habitats during the life cycle, have to adapt to their habitats by modifying their physiological activities for the completion of life cycle and continuation of the race. (***Balde, G.H. 2010***)Endoparasite has very long prononunced carbohydrate metabolism. Parasite can living in anaerobic and semi-anaerobic habitat gain their energy almost exclusively through fermentation of carbohydrates because it much better substratum for gaining anaerobic energy than either protein or fats. Occurance of intermediately oxidized groupings in the hexoses molecule gives it "with characteristic sensitivity in condition that induce essentially intramolecular-oxidation reduction and rearrangement" (***Theodor Von Brand, T. 1950***)Observed shorter (1.6 mm) female *H. contortus* collected from resistant sheep (***Salle, G. &etal., 2014***).(***Cheah & Bryant 1966)*** demonstrated that a major respiratory pathway in preparations from *Monieziaexpansa* utilized fumarate as an electron acceptor, Further in 1968, Cheah showed that, while the major cytochrome component of *M. expansa* was implicated in the fumarate-succinate transformation. Hence it was assumed that this pathway was partially responsible for the small oxygen uptake observed when mitochondrial preparations from M. expansa were incubated with succinate, α-glycerophosphate or NADH. (***Prichard & Schofield1968***a) successfully demonstrated the presence of enzymes of the tricarboxylic acid cycle in Fasciola hepatica. Protoscolices of Echinococcus granulosus and Ascaris muscle have also been shown to have an active cycle (***Agosin& Repetto, 1963;Oya et al., 1965***)**.** The only cestode up to now investigated which has been shown to possess an active tricarboxylic acid cycle is E. granulosus**(*Agosin& Repetto, 1963*)** Glucose is a very important energy source for many helminths inhabiting the alimentary tract of vertebrates. Adults of the nematode, H. contortus, have a readily available and constant source of this material in the blood that they suck from the wall of the abomasum of sheep and it would be surprising if they did not utilize it. The level of glucose in circulating sheep blood is around 60 mg/100 ml, but there is some evidence that in blood draining from the abomasum it is higher (***Thivend, 1974***). Although detailed studies have been made of the energy metabolism of the larvae of H. contortus (***Ward, Schofield & Johnstone, 1968***) very little is known about the metabolism of the adult worm. (***Prichard 1970***) reported that adult H. contortus, incubated in a salt solution containing glucose, excreted acetic, propionic and w-butyric acids, but no experimental details were given. The aim of the present study was to measure the end-products of glucose catabolism in adult H. contortus, both those excreted in solution and those expired as a gas. D-[U-14C] glucose was used and particular attention was paid to the recovery of radioactivity to make sure that no major catabolite was overlooked**(*WardP.F.V., 1974*)**Adaptation and loss of genetic capacity both are contribute significantly to an improved understanding of present knowledge, as well as useful in the formulation of new experiments. The biochemical investigation of adaptations at all stages of removal from gene action is desirable. The quite different functions of the 4-carbon dicarboxylic acid systems in adult and embryonic Ascaris lumbricoides suggest that similar but highly distinctive proteins (isozymes) are synthesized during the life cycle. (***Fairbairn, 1970***)Ascaris lumbricoides is a parasitic intestinal helminth whose metabolism is predominantly anaerobic (***Bueding 1949***)Bueding and Farrow (***Buedino et al., 1956***) have demonstrated that succinate was one of the major end products produced by this nematode. In addition to succinate, the organism produces acetylmethylcarbinol (***Saz et al., 1958***) and acetic, propionic, butyric, a-methylbutyric, n-valeric, cis-a-methylcrotonic (tiglic), and volatile Cg acids (***Buedinc 1953***), (***Bueding1955***) have partially purified a potent succinic oxidase from the muscle of these helminths. (***Saz, H.J. 1957***) have demonstrated the presence of fumarase, malic dehydrogenase, and a "malic enzyme," the latter of which in many respects is similar to the enzymes described previously by (***Ochoa 1947***) and (***Kori 1948***) The present study has revealed evidence which indicates that succinate is formed in Ascaris muscle by CO2 fixation into pyruvate followed by reduction to succinate. In addition, evidence has been obtained for the formation of propionate by the decarboxylation of succinate in a manner similar to that of the succinate decarboxylase systems previously reported only in bacteria (***Delwiche 1948),(Johns 1951),(Leaver. F. W. & et al., 1955)***The study reveals the comparision of the host response on single and trickle infections of *H. contortus* in Malpura lambs selected for either resistance or susceptibility to *H. contortus*. 12 Malpura male lambs (6 each from resistant - R and susceptible - S lines; 9-12 months old) were used during two periods of 10 weeks. The host response was measured in terms of body weight, fecal egg count, and hematological and biochemical characters for 10 weeks post-challenge (***Swarnkar, C. P., 2017)(Scheibel &Saz 1966***) investigated intermediary metabolism in *Hymenolepisdiminuta* and concluded that the tricarboxylic acid cycle was not active. Other cestodes have also been shown to accumulate succinic acid, and as early as 1933 this was demonstrated in *M. expansa* (***yon Brand, 1933, 1966***). It was therefore of considerable interest to determine whether the cytochrome oxidase system of *M. expansa* was associated with tricarboxylic acid cycle activity. (***Davey, R.A. 1969***)Incorporation of Glucose-C14 into Succinate-When glucose-l-C14, glucose-2-C14, or glucose-6-C14 was incubated with Ascaris muscle strips, the recovered succinate was found to contain a significant amount of isotope. The large dilution of the isotope would be expected since the muscle strips have a high glycogen content (27) which competes with the exogenous substrates as a source of glucose. The succinate-Cl4 formed would also be diluted by 1 (***Saz, H. J. 1959***)Folin phenol reagentwould seem to be recommended because of its great sensitivity and the simplicity of procedure possible with its use, it has not found great favor for general biochemical purposes. it has been studied with regard to effects of variations in pH, time of reaction, and concentration of reactants, permissible levels of reagents commonly used in handling proteins, and interfering substances(***Lowry, O. 1951***)Biochemically, helminths like Haemonchuscontortus cause significant changes in the host, including anemia and immune modulation (***Arsenopoulos, K. V.et al., 2021***). Morphologically, helminths exhibit diverse structures adapted to their parasitic lifestyle, such as the complex life cycle of strongyle nematodes (***Kelemework, S. et al., 2016***). Control of helminth infections is challenging due to factors like drug resistance and climate change. Strategic deworming and integrated management practices are recommended to mitigate these issues (***Potârniche, A. V et al., 2024***). (***Maurizio, A. et al., 2023***).

Morphological Approach

Helminths exhibit a wide range of morphological adaptations that enable them to thrive as parasites within their hosts. These adaptations are crucial for understanding the pathogenesis of helminth infections and for developing effective diagnostic tools. For example, strongyle nematodes have a complex life cycle involving multiple larval stages, which are crucial for their survival and transmission. The morphology of these parasites is essential for understanding their pathogenesis and developing effective diagnostic tools. *Monieziaexpansa*, a common cestode in sheep and goats, has a characteristic scolex with four suckers and a strobila composed of numerous segments, each containing reproductive organs ***(Hurisa, G., et al., 2021).***

Cestodes (Flat Worm)

Cestodes exhibit unique morphological adaptations that facilitate their parasitic lifestyleScolex is the anterior attachment organ equipped with suckers, hooks, or both for anchoring to the host's intestinal wall. For example, *Monieziaexpansa* has unarmed scolex with four muscular suckers (***de Luna, M., & et al., 2023***).***Taenia solium*** has armed scolex with hooks and suckers (***Heyneman D, 1996***).Strobila is the segmented body composed of proglottids. Each proglottid is hermaphroditic, containing both male and female reproductive organs (***Scholz T, Kuchta R. 2022***).Tegument of Cestodes lack a digestive system; instead, they absorb nutrients directly through their tegument, which is a specialized syncytial layer that protects against host digestive enzymes (***Alves, P. V., & et al., 2017***).Proglottids are formed continuously at the neck region and mature as they move distally along the strobila. Immature Proglottids are found near the neck; lack developed reproductive organs (***Dezfuli, B. S., & et al., 2024***).Mature Proglottids contain fully developed male and female reproductive systems (***Heyneman D, 1996***).Eggs vary in size and morphology depending on the species but generally contain a hexacanth embryo (oncosphere) surrounded by a thick protective embryophoreTaenia spp.: Eggs measure 30–40 µm in diameter (***Scholz T, Kuchta R. 2022***).Moniezia spp.: Eggs are larger, measuring 50–60 µm (***de Luna, M., & et al., 2023***).

Eggs of the cestodes are highly resistant to environmental conditions and can survive for extended periods (***Scholz T, Kuchta R. 2022***). Eggs are ingested by intermediate hosts (e.g., arthropods, rodents, or herbivores). Gastric enzymes dissolve the embryophore, releasing the hexacanth embryo (oncosphere), which penetrates the intestinal wall and migrates to specific tissues such as liver or muscles (***Caira, J. N., & et al., 2020***). The oncosphere develops into larval forms called metacestodes in intermediate hosts. Types of metacestodesinclude Cysticercus, a fluid-filled cyst with a single invaginated scolex (Taenia solium) (***Heyneman D, 1996***). Hydatid Cyst, a large cyst with brood capsules containing protoscolices (Echinococcus granulosus) (***Caira, J. N., & et al., 2020***). Cysticercoid, a solid larval stage found in arthropod intermediate hosts (Monieziaexpansa) (***de Luna, M., & et al., 2023***). Definitive hosts ingest infected intermediate hosts while grazing or consuming contaminated food/water. Metacestodes attach to the intestinal mucosa via their scolex and mature into adult tapeworms (***Dezfuli, B. S., & et al., 2024***).Adults of the *Echinococcus granulosus* (Hydatid Cyst)are small (2–7 mm) with an armed rostellum. Larvae form hydatid cysts in organs like the liver and lungs. (***Walker, M. D., &Zunt, J. R. 2005)***

Nematodes (Round Worms)

Nematodes are cylindrical, unsegmented worms with a pseudocoelom and a complete digestive system. A flexible, multilayered outer covering of cuticle provides protection and aids in locomotion. The cuticle is periodically shed during molting stages. (***Lee, D. L. (Ed.). 2002 ;(Bird, A. F., & Bird, J. 1991***). Bilaterally symmetrical, with a tapered anterior and posterior end. The body cavity (pseudocoel) functions as a hydrostatic skeleton. (***Phylum Nematoda 2017***) Nematodes have a complete digestive tract, including a mouth, pharynx, intestine, and anus. This allows for efficient digestion and nutrient absorption. (***Bird, A. F., & Bird, J. 1991)*** Most nematodes are dioecious (separate sexes), with males possessing spicules for mating. Females are typically larger than males and produce eggs that vary in size and morphology depending on the species. (***Lee, D. L. (Ed.). 2002 ;Phylum Nematoda 2017***).The nematode life cycle generally consists of six stages: egg, four larval stages (L1–L4), and adult. Molting separates each stage, allowing for growth and development. (***Lee, D. L. (Ed.). 2002 ;Nematode Life Cycle 2023***). Eggs are laid by adult females and excreted in the host's feces or deposited in the environment. Eggs may be embryonated (containing larvae) or unembryonated (undeveloped) when laid. (***Nematode Life Cycle 2023 ;Zhao, J., & et al., 2022***). Larvae hatch from eggs and undergo four molts (L1 to L4) before becoming adults. The infective stage is typically L3, which can survive in the environment until ingested or penetrates the host's skin. (***Nematode Life Cycle 2023 ;Zhao, J., & et al., 2022***). In direct life cycles, L3 larvae infect the definitive host through ingestion or skin penetration. In indirect life cycles, larvae develop within an intermediate host before infecting the definitive host. (***Nematode Life Cycle 2023)*** Adults reside in specific tissues or organs (e.g., gastrointestinal tract) of the host, where they reproduce sexually. Eggs are released into the environment to continue the cycle. (***Lee, D. L. (Ed.). 2002 ;Nematode Life Cycle 2023***).Adults of the *Haemonchuscontortus*(Barber's Pole Worm) measure 10–30 mm in length. Females exhibit a "barber's pole" appearance due to alternating red (blood-filled intestine) and white (reproductive organs) stripes. Males possess a copulatory bursa with spicules for mating. (***Kaplan, R. M. 2004).*** The adults of *Teladorsagiacircumcincta*(Brown Stomach Worm) are slender and measure 6–10 mm in length. Cervical papillae are present near the anterior end. (***Sutherland, I. A., &Leathwick, D. M. 2011).***The adults of nematodirusbattus measure up to 25 mm long with slender bodies. Eggs are large (150–200 µm) with parallel sides and tapered ends. (***Taylor, M. A., & et al., 2015).*** The male of

Nematodirusspathiger(Railliet, 1896) has filiform body (12–14 mm), spicules (0.9–1.2 mm) with bifurcated distal ends, and caudal bursa with distinct ray patterns. Females vulva surrounded by cuticular folds; tail tapers to a spike. Males has 40 parameters, including spicule length (0.9–1.2 mm) and bursal ray arrangement. Females has 25 parameters, such as vulval cuticular formations and tail spike dimensions. (***Melnychuk, V., & et al., 2021***)Males of *Trichuris skrjabini*(Baskakov, 1924) has short spicules (1.8–2.0 mm) fully enclosed by a spicule sheath. Vulva of the Females is non-everted, distinguishing it from T. ovis. rDNA ITS2 sequences confirm differentiation from T. ovis and other Trichuris spp.. (***Afshan, K., et al. 2023***) The adults of *Bunostomumtrigonocephalum* (Hookworm) (Railliet, 1900) are 10–30 mm long, with a hook-like buccal capsule and ventral cutting plates for mucosal attachment. Larvae has three preparasitic stages; infective L3 larvae retain a protective sheath from the second-stage cuticle. Infection occurs via skin penetration or ingestion. Larvae migrate to lungs within 6 days, then intestines, maturing into adults with buccal lancets in 9–10 weeks. ***(Ortlepp, R. J. 1939)***Higher infection rates in goats (86.3%) than cattle (28.7%), with *Cooperia spp.* and *Haemonchus spp.* identified via ITS2 PCR. Meat goats have 9.3× higher infection odds than dairy goats, while dairy cattle are 5.1× more susceptible than meat cattle. ***(Income N & et al., 2021)*** The adultsof the Strongyloidespapillosus (Intestinal Threadworm)are small (2–5 mm), with females being larger than males. The esophagus is long and filiform in adults. (***Soulsby, E. J. L. 1982***) Strongyle infections is linked to villus atrophy and reduced packed cell volume (PCV) in sheep and goats. (***Income N & et al., 2021*** ;***Melnychuk, V., & et al., 2021***). Goats exhibit greater T. skrjabini (24.8%) and N. spathiger infections (35.9% mixed). (***Afshan, K., et al. 2023 ;Melnychuk, V., & et al., 2021***)

Trematodes (Flukes)

Reproductive system is hermaphroditic (except schistosomes), enabling self-fertilization. (***Hemphill, A. 2010).*****Paramphistomum spp. (Rumen Fluke)**Eggs are oval, operculated eggs measuring 120–180 µm. (***Hemphill, A. 2010)***

Sustainable Control Strategies

Sustainable control strategies include the use of natural bioactive compounds and genetic selection for resistance and resilience to helminth infections. In Italy, studies have shown that certain breeds of goats are more resistant to gastrointestinal nematodes, highlighting the potential for genetic selection as a control method (***Maurizio, A., et al., 2023***)

OBSERVATION TABLE

Biochemical Approach into Helminth Parasites of Sheep and Goats

Parasite	Observation
General Helminths	Primarily rely on carbohydrate metabolism due to anaerobic or semi-anaerobic habitats. (*Theodor Von Brand, T. 1950; Balde, G.H. 2010)*
Haemonchuscontortus (Adult)	Utilizes glucose from host blood for energy. Excretes acetic, propionic, and w-butyric acids when incubated with glucose. (*Thivend1974 ; Prichard 1970 ; Ward P.F.V. 1974)*
Monieziaexpansa	Utilizes fumarate as an electron acceptor in a major respiratory pathway. (*Cheah & Bryant 1966 ; Cheah 1968)*
Fasciola hepatica	Possesses enzymes of the tricarboxylic acid cycle. (*Prichard & Schofield 1968a)*
Echinococcus granulosus (Protoscolices)	Exhibits an active tricarboxylic acid cycle. (*Agosin& Repetto 1963)*
Ascaris lumbricoides	Predominantly anaerobic metabolism. Succinate is a major end product. (*BUEDING 1949,; BUEDINO et al. 1956 ; Saz et al. 1958)*
Hymenolepisdiminuta	Tricarboxylic acid cycle not active; accumulates succinic acid. (*Scheibel &Saz1966 ; yon Brand 1933, 1966)*

Morphological Approach into Helminth Parasites of Sheep and Goats

Parasite	Observation
General Helminths	Exhibit diverse structures adapted to their parasitic lifestyle. (*Kelemework, S. et al. (2016)*
Strongyle Nematodes	Complex life cycle involving multiple larval stages. (*Kelemework, S. et al. (2016)*
Monieziaexpansa	Scolex with four suckers, strobila composed of numerous segments containing reproductive organs. (*Hurisa, G., et al. (2021); de Luna, M., & et al. (2023)*
Cestodes (General)	Flat, ribbon-like body; lack digestive system; absorb nutrients through tegument. Scolex with suckers/hooks for attachment.. (*Alves, P. V., & et al. 2017; Scholz T, Kuchta R. 2022; de Luna, M., & et al. 2023)*
Taenia solium	Armed scolex with hooks and suckers. (*Heyneman D (1996))*
Cestode Eggs	Generally contain a hexacanth embryo (oncosphere) surrounded by a thick protective embryophore. (*Scholz T, Kuchta R. (2022))*
Taenia spp. Eggs	30–40 µm in diameter.. (*Scholz T, Kuchta R. (2022))*
Moniezia spp. Eggs	50–60 µm in diameter. (*de Luna, M., & et al. 2023*)

MATERIAL AND METHODS

This section outlines the methodology for a literature review On biochemical and morphological approach of helminth fauna from sheep and goat. A comprehensive literature search was conducted using major databases such as PubMed, Google Scholar, and ScienceDirectShodhganga etc. The search terms included "helminth parasites," "sheep," "goats," "biochemical approach ," and "morphological characteristics." The search was limited to peer-reviewed articles published in English. Studies were included if they provided information on the biochemical and morphological aspects of helminth parasites in sheep and goats. Reviews, case reports, and studies focusing mainly on host of interest. Relevant data were extracted from included studies, focusing on the prevalence, species composition, biochemical effects, and morphological characteristics of helminth parasites. The extracted data were synthesized to provide a comprehensive overview of the biochemical and morphological approach into helminth parasites of sheep and goats.

RESULTS AND DISCUSSION

Helminth parasites are a significant health concern for sheep and goats worldwide, causing gastrointestinal helminthosis that can lead to substantial economic losses. Studies have shown that gastrointestinal helminths are widespread among these animals, with species such as *Haemonchuscontortus, Trichostrongyluscolubriformis, and Monieziaexpansa* being commonly found (***Hurisa et al., 2021; Kelemework et al., 2016***). The integration of biochemical and morphological analyses reveals critical approach into the survival and pathogenicity of helminth parasites in sheep and goats. Biochemically, these parasites exhibit a strong reliance on carbohydrate metabolism, often fermenting glucose in anaerobic conditions, exemplified by *Haemonchuscontortus* utilizing glucose from the host's blood for energy, and *Monieziaexpansa* employing fumarate as an electron acceptor (***Thivend, 1974; Cheah & Bryant, 1966***). Morphologically, species like *M. expansa* possess specialized structures such as a scolex with suckers for intestinal attachment and proglottids for reproduction (***de Luna, M., & et al., 2023; Hurisa, G., et al., 2021***).

CONCLUSION

The study highlights the critical interplay between biochemical and morphological characteristics of helminth parasites in sheep and goats, emphasizing the necessity of integrating these approach for effective parasite management. The distinct metabolic pathways, such as the reliance on glucose fermentation in *Haemonchuscontortus* and fumarate utilization in *Monieziaexpansa* (***Thivend, 1974; Cheah & Bryant, 1966***), alongside unique morphological adaptations like the specialized scolex structures of cestodes (***de Luna, M., & et al., 2023; Hurisa, G., et al., 2021***), underpin the parasites' survival and pathogenicity. As challenges like drug resistance and climate change intensify (***Potârniche, A. V et al., 2024***), a comprehensive understanding of these integrated aspects is crucial for developing targeted interventions, optimizing deworming strategies, and ultimately mitigating the economic and health impacts of helminth infections in livestock.This research work will really be helpful right from agro-based industries animal husbandry to many household business in which domestic animals like sheep and goats are involved. Such kind of research work will help in growing economy of our country. And most important is the health of such a kind of animals too.

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