



Uncommon *Cysticercus bovis*-induced Liver Lesions in Slaughtered Beef Cattle Imported from Sudan

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IN our country, imported Sudanese cattle are supposed to be an important source of high-quality protein, which is obtained from their meat and milk. Consequently, strict veterinary inspection should be applied to these animals in slaughterhouses before being subjected to human consumption. This study aims to report the unusual migration of *Taenia saginata* larvae (*Cysticercus bovis*) to the liver of these animals and describe the pathological changes stimulated by them. In a survey started in December 2020 and ended by October 2021, 1575 livers were carefully inspected and examined, from which 172 specimens were condemned for different lesions. Prevalence of cysticercosis was 1% (16/1575) among the totally examined livers. However, out of the rejected specimens, cysticercosis occurred at a percentage of 9.3% (16/172). 5 livers showed a single cyst, while 11 showed multiple. The total cyst count was 44, of which 28/44 (63.6%) were viable with thin transparent walls and discharging of spotted scolex on incision. However, 16/44 (36.3%) cysts were degenerated and appeared firm, pale yellowish, with firm consistency. The morphological appearance of the liver varied from normal structure and consistency to swollen with rounded borders. Histopathological analysis showed a fully developed bladder-like cyst with its invaginated scolex in liver tissues resulting in necrotic changes in hepatocytes, fibrosis and inflammatory infiltrate. Due to the significant risk of *Cysticercus bovis* to human health, meat inspection must be carefully considered.

Keywords: Cattle, *Cysticercus bovis*, liver, *Taenia saginata*, zoonosis.

Introduction

Bovine cysticercosis refers to the infection of cattle with *Cysticercus bovis*, the larval stage of the human tapeworm, *Taenia saginata* [1]. It is a world widely distributed disease, particularly in African countries, where it badly affects the economy and public health. In Egypt, the incidence rate of bovine

cysticercosis in cows is 6.6% in El-Minia Governorate [2]. The prevalence was 6.09% in El-Beheira and El-Gharbia provinces [3], 22.8% in Aswan and 0.13% in Assiut Governorates [4]. In Africa, it occurs at a rate of 80% in Ethiopia, 33% in Kenya and 8% in Sudan [5]. Losses are usually attributed to the condemnation of massively infected

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carcasses, restriction of exports and the necessity to boil or freeze infected meat [6].

Concerning the parasitic life cycle, humans, the definitive host of *Taenia saginata*, become infected by consuming raw beef containing viable cysts [7]. After the maturation of adult worms in human bowels, gravid 3-7 proglottids are released daily each containing approximately 40,000 eggs. Cattle, the intermediate host, become infected either directly after grazing on contaminated pastures that contain human feces with *Taenia* eggs, or indirectly through sewage sediment [8]. An infected bovine carcass is capable of infecting more than 10 humans [9]. In contrast, *Cysticercus tenuicollis*, the larval stage of the dog tapeworm, *Taenia hydatigena*, has a similar life cycle. However, it is more prevalent in small ruminants that are considered intermediate hosts and it is isolated from their liver and meat [10, 11].

Ogunremi *et al.* [12] explained that, except with heavy infestation, bovine cysticercosis seldom causes clinical illness and it could be primarily diagnosed via slaughterhouses through visual inspection and incision of muscles particularly internal and external masseter muscles, diaphragm, tongue and heart which were regarded as predilection sites. The present study aimed to record uncommon pathological lesions in the liver of Sudanese beef cattle caused by *Cysticercus bovis*. These animals are considered an important source of meat and should be examined with great caution before being submitting for human consumption.

Material and Methods

Ethical approval

The study protocol was approved by the Animal Ethical Committee for Veterinary Research of the Faculty of Veterinary Medicine, Assiut University, Assiut, Egypt under the No. 06/2023/0098. Used samples in the present study were collected postmortem from condemned infected organs that were unsuitable for human consumption. No animals were killed for the purpose of the study.

Animals and study area

Imported Sudanese cattle were quarantined for up to 21 days under the supervision of Egyptian quarantine veterinarians in Wadi Halfa, a Sudanese city bordering Egypt, then, they were transported to Abu Simbel city, Aswan Governorate, where they were slaughtered at Abu Simbel abattoir. All animals

were males and aged from 2 to 3 years. The Period of study extended from Dec. 2020 to Oct. 2021.

Sampling, visual examination and cysts characters

A total of 1575 slaughtered cattle were inspected and examined with particular attention to liver affections. Suspected cases of *Cysticercus bovis* were discarded, collected and photographed by a digital camera. Specimens were classified into those having single and multiple cysts that were incised to differentiate viable from dead ones. The total cyst count is calculated. Small sections of cubic shapes were taken from all lesions and fixed in 10% neutral buffer formalin for preservation.

Histopathological examination

Sections with 3-5 μ thickness were taken from fixed specimens, processed routinely, stained by Haematoxylin and Eosin, examined by light microscope and imaged using a Sc30 Olympus camera. Masson's trichrome stain was used in some sections as a special stain [13].

Results

Prevalence and incidence

Among the totally examined 1575 livers, cysticercosis was present in 16 cases, with a prevalence of 1%, while the incidence rate was recorded to be 9.3% from the totally affected specimens (16/172) (Fig. 1).

Cyst count, viability and gross morphology

Out of affected specimens, five livers showed single cysts, from which three were viable with a percentage of (3/5) and two cysts were degenerated with a percentage of (2/5) (Tables 1 & 2). Multiple cysts were present in eleven livers in which cyst count ranged from 2-9. Out of which, (25/39) were viable and (14/39) were degenerated (Tables 3 & 4). Total cysts were calculated to be 44 in all affected livers and their overall viability is illustrated in (Fig. 2). Grossly, viable cysts were well demarcated, rounded, grayish-white in color, with approximately 1-2 cm diameter and attached to the surface. They were characterized by a thin transparent wall that gave it the shape of a bladder. Incision of these cysts had resulted in the discharging of clear watery fluid and scolex that had small spots. The liver was slightly swollen with firm consistency and rounded borders (Figure 3a). However, in other cases, it had a nearly normal appearance, bright coloration, normal

structure, size and consistency. Degenerated cysts were pale yellowish in color and small cysts whose sizes ranged from 0.5-1 cm in diameter. They had a firm texture, embedded in hepatic tissue and were distributed throughout the parenchyma in a random pattern (Fig. 3b).

Histopathology

Infection with *Cysticercus bovis* was confirmed histologically following observation of the characteristic cyst with its bladder and parenchymatous portions in the fully developed state. The latter was completely enclosed in the bladder cavity. Clear space and a spherical formation, known as invaginated scolex, were detected inside the bladder wall. Parenchyma surrounding the invaginated scolex showed somewhat thickening which was made up of spindle-shaped cells, horizontally arranged fibrous tissue and muscle fibrils. The folded wall of the invaginating canal contained numerous grooves. Also, within the bladder cavity, the so-called spiral canals were detected that occurred in the form of folds and opened in slit-like spaces leading to the invaginated scolex. The detailed structure of *Cysticercus bovis* is illustrated in (Fig.4). Migration of these larvae and their inoculation in hepatic tissues stimulates a pathological reaction, which was composed mainly of fibrous tissue proliferation, mononuclear cellular infiltration, aggregates of degenerated and necrosed hepatic cells (Fig.5a). The wall of the cyst was surrounded by fibrosis of portal areas and hepatic blood vessels at the site of the lesion showed varying degrees of dilatation (Figs.5b& 5c). On the other hand, degenerated, non-viable cysts were detected at a rate of 36.3% in which the host's immunity succeeded in getting rid of the infection. They retained their outer structure and contained a space with slight turbidity. Neither scolices nor spiral canals were observed. However, similar previous pathological reactions were induced (Fig. 5d).

Discussion

The present study was conducted to record cases of uncommon migration of *Taenia saginata* larvae (*Cysticercus bovis*) to the liver of beef cattle imported from Sudan. This occurred at a rate of 1% from the totally examined specimens. However, the incidence rate was 9.3% among the affected cases. In agreement with our results, Kumar and Berhe, [14] stated that the highest proportions of the detected

cysts were found in the liver with their tendency to multiply. In Ethiopia, Kebede, [15] and Terefe et al. [16] found that *Cysticercus bovis* produced widespread pathological lesions in slaughtered cattle including liver in which the infection rate was 1.53% and 22.6%, respectively. In an experimental study, Lopez et al. [17] inoculated cattle with *Taenia saginata* eggs and recorded the infection rate in different parts of the body. Hepatic cysticercosis had occurred at a percent of 9.3% without denying the fact that carcass musculature was the predilection seat. In Omdurman, Mohamed, [18] reported that cysticercosis was responsible for condemnation of 13.5% from the affected cattle liver specimens.

In disagreement with our observations, El-Dakhly et al. [10] and Borai et al. [11] mentioned that *Cysticercus bovis* had not been isolated from livers of cattle slaughtered at Beni suef and Great Cairo Governorates, respectively and this can be attributed to worse hygienic measures and contaminated pastures to which Sudanese animals were exposed. This parasitic condition occurred more frequently in small ruminants including sheep and goat [10, 11]. In Sharkia, Ameria, [19] recorded hepatic cysticercosis at a percentage of 9.8% in slaughtered sheep. In Dakahlia, Abu-Elwafa et al. [20] reported 6.62%, while, according to El-Hallawany and Abdel-Aziz, [21] prevalence was 10.6% in Giza Governorate. Elkhtam et al. [22] stated that *Cysticercus bovis* was recovered from the head of cattle slaughtered in Menofia province, Egypt. According to El-Alfy et al. [23], the heart was the only organ to be affected in examined cattle slaughtered at Mansoura abattoir. In similar studies, El Sayad et al. [3] and Abdel Aziz et al. [24] reported that these larvae had been isolated only from the tongue, heart, esophagus, and masseter muscles of cattle slaughtered in northern and southern Egyptian provinces, respectively. In Ethiopia, similar results were reported by Abunna et al. [25] who found cysts only in the tongue and shoulder muscles of slaughtered cattle. The authors thought that the liver would not be a preferential site of infection with cysticercosis. In addition, according to Khaniki et al. [26], *Cysticercus bovis* occurred in cattle liver at negligible rate in comparison with other parasitic causes of condemnation.

Based upon our results, 31.25% of the affected livers revealed single cysts, while the majority of specimens (68.75%) showed multiple cysts whose number ranged from two to nine per organ. In contrast, Kumar and Berhe, [14] noticed that cysts

did not occur in a single form and almost all cases contained more than 20 cysts. The total count was calculated to be 44 and according to their viability, we classified cysts into viable, with a higher percentage (63.6%), and non-viable degenerated (36.3%). This is in accordance with results obtained by Dyab *et al.* [27] who reported that the highest proportion of cysts (86%) were viable. viable cysts were rounded, well demarcated, with 1-2 cm diameter and grayish-white coloration. Incision of them revealed clear fluid with spotted scolices. A similar gross picture was reported by Khajuria *et al.* [28]; Borai *et al.* [11] and Regha *et al.* [29] who observed multiple or single, thin-walled, bladder-like cystic structures which were filled with clear watery fluid and white spotted scolex. Detected cysts were attached to the liver capsule by means of a long neck. In addition to that, Nasir and Abebe, [30] described a condition known as hepatitis cysticercosa which was characterized by the formation of haemorrhagic tunnels in affected livers by migrating immature larvae. Degenerated cysts were smaller than viable ones with 0.5 cm diameter, firm texture and yellowish coloration. A similar description of non-viable cysts was previously mentioned by Mellau *et al.* [31] who observed calcified non-infective cysts at a rate of 1.9% in condemned cattle livers. They listed *Cysticercus bovis* as one of the possible causes. According to Terefe *et al.* [16], approximately half of the diagnosed cysts were sorted to be non-viable. Grasey *et al.* [32] explained that cyst viability could be confirmed by incubating them in 30% ox bile dissolved in normal saline at 37 °C up to two hours. Evagination of scolex is evidence of its viability.

Histopathological analysis revealed that the occurrence of well-developed *Cysticercus bovis* with its invaginated scolex and spiral canals resulted in the induction of pathological conditions that consisted of mononuclear cellular infiltration, aggregates of degenerated and necrosed hepatic cells and proliferation of fibrous tissue. A similar reaction was stimulated by degenerated cysts that contained turbid fluid in their cavity with no scolices. In agreement with our histological findings, Al-Mayali, [33]

observed cyst-like channels that were surrounded by erythrocytes and associated with eosinophilic, neutrophilic, lymphocytic infiltration and fibrous tissue proliferation. Phagocytes and giant cells were only seen in chronic cases. According to Borai *et al.* [11], two thin eosinophilic membranes formed the cystic wall that showed dystrophic calcification and was attached to a thickened liver capsule. Cyst was surrounded by mononuclear inflammatory cells, which were also aggregated in portal areas. Congestion of hepatic sinusoids was also detected and hepatocytes in the vicinity suffered from caseous necrosis and fatty change. Later, a different histological picture was mentioned by Sterba and Dykova, [34] who reported that cysts had stimulated a granulomatous reaction in affected hepatic tissues that was accompanied by focal areas of necrosed hepatocytes. Infiltration of lymphocytes and histiocytes was detected in the vicinity of the parenchyma. Detected cysts showed high affinity to portal areas resulting in portal fibrosis.

Conclusion and recommendations

Imported animals from Sudan are an important source of some zoonotic diseases. These animals should be dewormed by applying an effective anthelmintic protocol before slaughtering to reduce losses caused by rejection. Further abattoir surveys concerning different organs with the appropriate veterinary inspection are recommended to minimize public health hazards.

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Conflicts of interest

The authors declare no conflict of interest.

TABLE 1. Forms of cysticerci in affected livers and their percentage.

	No. affected	Single cyst		Multiple cysts	
		No. affected	Percent (%)	No. affected	Percent (%)
Liver	16	5	31.25%	11	68.75%

TABLE 2. Viability of single cysts and their percentage in affected livers.

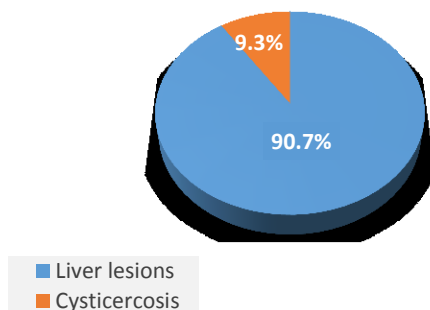
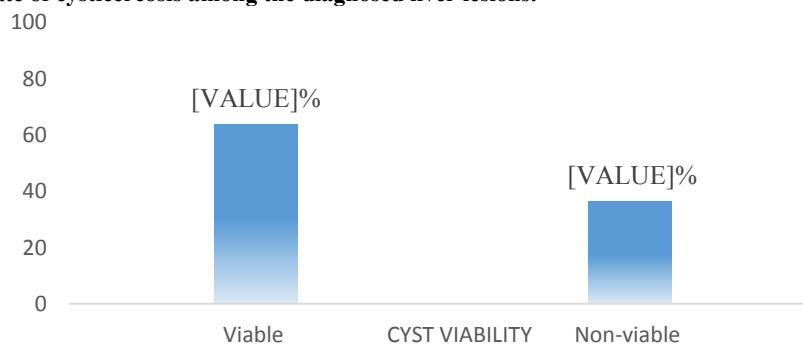
	Viable	Percentage (%)	Degenerated	Percentage (%)	Total
Single cysts	3	60%	2	40%	5

TABLE 3. Average number of cysts and their total count in affected livers.

	Cyst count				Mean per organ	Total
	Single cyst	2-3 cysts	4-5 cysts	More than 5 cysts		
Liver	5	6	4	1	2.75	44

TABLE 4. Viability of multiple cysticerci and their percentage in affected livers.

	Viable	Percentage (%)	Degenerated	Percentage (%)	Total
Multiple cysts	25	64.1%	14	35.9%	39

**Fig. 1. Incidence rate of cysticercosis among the diagnosed liver lesions.****Fig. 2. The overall percentage of viable and non-viable cysts in affected livers.**

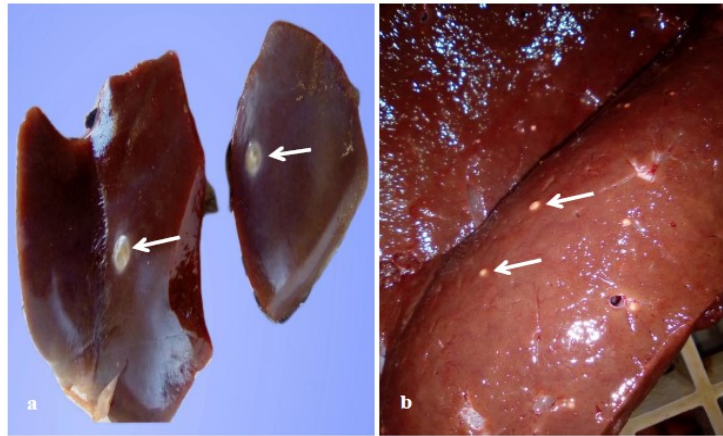


Fig. 3. Photograph of condemned cattle livers due to cysticercosis showing (a): Viable, single, whitish-gray cyst with a thin wall attached to the surface (arrows). Notice the pale coloration and rounded borders of the affected specimens. (b): Dead, multiple, smaller, pale yellowish cysts of varying sizes randomly distributed throughout the hepatic parenchyma (arrows). The affected liver showed normal size, color and consistency.

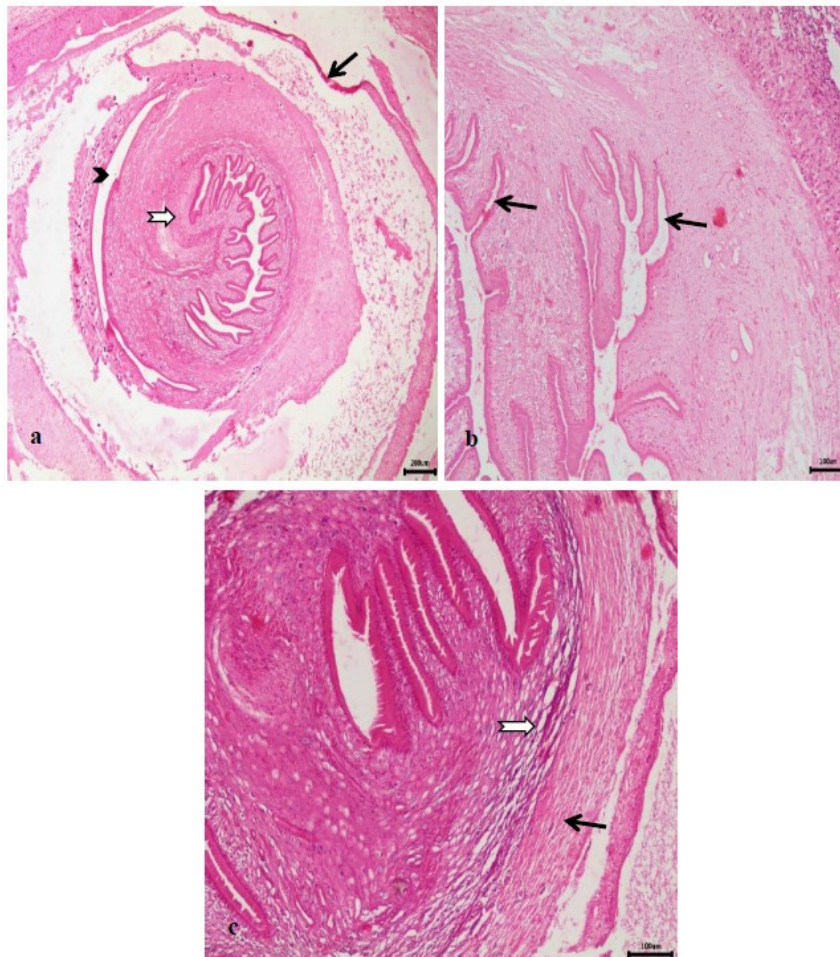


Fig. 4. Photomicrograph showing the cystic structure. (a): Cross section in a fully developed *Cysticercus bovis* that consists of the bladder-like cyst (arrow) encloses invaginated scolex (notched arrow) with its spiral canals and the vestibule (arrowhead). Notice the thickened parenchyma surrounding the scolex (Hx &E. Scale bar =200 μ m). (b): *Cysticercus bovis* with higher magnification showing folds of spiral canals (arrows) that open in slit-like spaces (Hx &E. Scale bar =100 μ m). (c): Scolex is surrounded by thick parenchymatous portion that composes of fibrous tissue (arrow), muscle fibrils and spindle-shaped cells (notched arrow) (Hx &E. Scale bar =100 μ m).

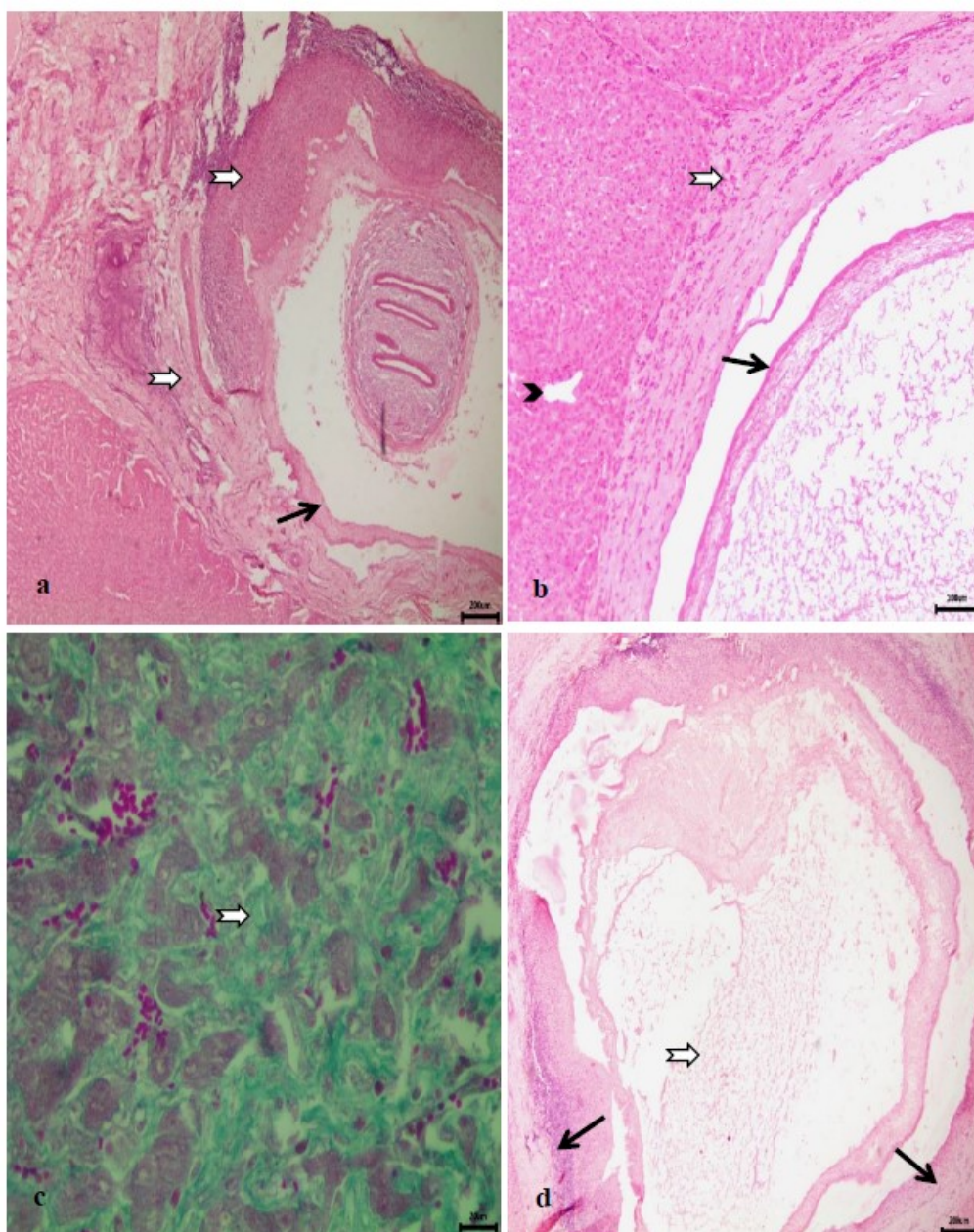


Fig. 5. Photomicrograph showing the reaction of liver tissues to infection with *Cysticercus bovis*. (a): Bladder-like cyst (arrow) is surrounded by inflammatory cellular reaction, fibrous tissue, degenerated and necrotic hepatocytes (notched arrows) (Hx &E. Scale bar =200 μ m). (b): Cystic wall (arrow) is associated with portal fibrosis (notched arrow) and dilated blood vessel (arrowhead) (Hx &E. Scale bar =100 μ m). (c): Section in cattle liver showing fibrous tissue proliferation in the portal area (notched arrow) (Masson's trichrome stain. Scale bar =20 μ m). (d): Degenerated, non-viable cyst retains its structural outlines, having turbid fluid (notched arrow), and is surrounded by fibrosis and inflammatory cells (arrows) (Hx &E. Scale bar =200 μ m).

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إصابات كبدية غير شائعة بطفيل السيستيسركس بوفيس في الأبقار المستوردة من السودان

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⁴ قسم الطفيليات – كلية الطب البيطرى – جامعة أسيوط – مصر.

المستخلص

تُعتبر الماشية السودانية المستوردة من أهم مصادر البروتين الحيوانى على الجودة فى مصر وذلك لتعويض النقص المحلى فى انتاج اللحوم. تهدف هذه الدراسة الى تسجيل إصابات كبدية غير مُعتادة بطفيل السيستيسركس بوفس (الطور اليرقى للدودة الشريطية البشرية التينيا ساجيناتا) والذى غالباً ما يُصيب العضلات الهيكلية والقلب. فى الفترة من ديسمبر 2020 الى أكتوبر 2021 تم الكشف البيطرى على 1575 كبد من هذه العجول التى تم ذبحها فى مجزر ابو سمبل بمحافظة اسوان لتسجيل الإصابات الظاهرية بها وفحصها مجهرياً. أظهرت النتائج وجود حويصلات متفاوتة الأحجام على سطح الكبد فى 16 عينة من إجمالى عدد 172 كبد تم إعدامه لإصابات مختلفة بنسبة 9.3% من إجمالى الإصابات، منها 5 عينات تحتوى على حويلات فى صورة فردية، و 11 عينة تحتوى على حويلات فى صورة متعددة، وبلغ المجموع الكلى للحويصلات فى جميع العينات المُصابة 44. تم تجميع العينات المُصابة وتصويرها وحفظها فى محلول فورمالين، وبعد الفحص الهستوباثولوجى تأكدت الإصابة بطفيل السيستيسركس بوفس بعد ملاحظة الشكل المميز له ميكروسكوبياً. خلُصت هذه الدراسة الى اعتبار العجول السودانية واحدة من مصادر الأمراض المشتركة للإنسان.

الكلمات الدالة: الماشية، سيستيسركس بوفس، الكبد، تينيا ساجيناتا، الأمراض المشتركة.