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Ultrasonographic examination of the udder in sheep

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ABSTRACT

Objective of the paper is to review work relevant to ultrasonographic examination of the udder of ewes. Udder structures that can be readily imaged ultrasonographically (B-mode or Doppler examination) are mammary parenchyma, the gland cistern, the lactiferous ducts, the mammary vessels, the teat and the supramammary lymph nodes. Conventional diagnostic approaches for mastitis (i.e., combination of clinical, bacteriological and cytological examinations) provide a good means for diagnosis of mastitis; hence, in diagnosis of mastitis, use of ultrasonographic examination has, in general, an ancillary role, for example during investigation of cases, in which clinical diagnosis alone can prove of little help, e.g., in animals with small-sized, deep mammary nodules. The technique can be used at the end of a lactation period as part of routine udder examination performed at that point, which would provide additional useful information, e.g., regarding presence of abcesses or of increased quantity of fibrous tissue. Further, estimation of the dimensions of gland cistern of ewes in a flock would support decisions regarding milking frequency to be applied. Finally, examination of the teat can provide indications regarding optimising use of the milking machine by applying the appropriate settings.

1. Introduction

The importance of the mammary glands in the profitability of ewes, especially in dairy flocks, makes early and accurate diagnosis of its disorders necessary. This will, in turn, support efficient management of cases of diseased animals. The matter is of significance for the welfare of the affected animals (European Food Safety Authority, 2014), as well for their productivity in terms of quantity and quality of milk produced.

The diagnosis of clinical or subclinical mastitis in ewes has been recently reviewed by Fragkou et al. (2014). Various approaches can be employed, which more often include clinical, bacteriological and/or cytological techniques and methodologies. Use of ultrasonography has also been advocated and various publications have indicated the usefulness of the technique in the diagnosis of mammary diseases of ewes. Further, the technique can be employed in management practices in healthy animals, e.g., for selection of animal for increased milk production, based on the volume of the gland cistern. Finally, other workers have used the methodology for research purposes to support the study of various mechanisms in healthy or diseased animals. Objective of the current paper is to review work relevant to ultrasonographic examination of the udder of ewes.

2. Methodology of ultrasonographic examination

2.1. Principles of ultrasonographic examination of the udder of ewes

Ultrasonographic examination can be used to explore the structure of the udder of ewes, as well as to study functional parametres of the organ (Ruberte et al., 1994; Caja et al., 1999; Nudda et al., 2000; Petridis et al., 2014; Barbagianni et al., 2015). By using ultrasonographic examination, monitoring of the udder can be performed and information may be obtained regarding its internal structures, as ultrasonographic images of the mammary gland correspond well to its anatomical structure (Ruberte et al., 1994). The technique can be used for examination of the mammary parenchyma, the gland cistern and/or the teat (Franz et al., 2001) and the supramammary lymph nodes (Hussein et al., 2015), as well as for evaluation of blood flow disorders (Petridis et al., 2014; Barbagianni et al., 2015; Barbagianni, 2016). Further, during ultrasonographic examination details are collected in real time, as processes are developing.

Udder structures that can be readily imaged ultrasonographically are the body of the mammary gland (*corpus mammae*) with the mammary parenchyma, the gland cistern (*sinus lactiferous*),

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Fig. 1. B-mode ultrasonographic presentation of mammary parenchyma; image taken at the 6th month of lactation period, along the long axis of the udder; mildly echogenic mammary parenchyma and section of the external pudendal artery with its echogenic wall and its three branches. Image taken and processed on a MyLab® 30 ultrasonography system (ESAOTE SpA, Genova, Italy) with microconvex transducer, imaging frequency: 3.3 MHz – scanning depth: 120 mm.

Table 1
Summary of references regarding use of transducers during ultrasonographic examination of various structures of the udder of ewes.

Reference	Details of transducer employed	Part of udder examined
Ruberte et al. (1994)	5.0 MHz sector	Gland cistern
Nudda et al. (2000)	3.5 MHz convex sector	Gland cistern
Franz et al. (2001)	12.0 MHz linear	Teat (examination through water filled plastic cup)
Franz et al. (2003)	8.5 MHz	Teat, gland cistern, mammary parenchyma
Mavrogianni et al. (2004)	6.0 MHz sector	Teat (direct application)
Wójtowski et al. (2006)	10.0 MHz linear	Teat (examination through water filled plastic cup)
Castillo et al. (2008)	5.0 MHz sector	Gland cistern
Rovai et al. (2008)	5.0 MHz sector	Gland cistern
Alejandro et al. (2014b)	5.0 and 7.5 MHz linear	Teat (examination through water filled plastic cup)
Petridis et al. (2014)	10.0 MHz linear	Mammary parenchyma
	3.3 MHz microconvex	Gland cistern
Barbagianni et al. (2015)	10.0 MHz linear	Mammary parenchyma
Hussein et al. (2015)	7.5 MHz linear and 4.0 MHz convex	Teat, mammary parenchyma, supramammary lymph nodes
Barbagianni (2016)	12.0 MHz linear	Teat (direct application)

the lactiferous ducts (*ducti lactiferi*), the mammary vessels [especially the external pudendal artery (*arteria pudenda externa*) with the three branches: caudal mammary artery (*arteria mammaria caudalis*), mid mammary artery (*arteria mammaria media*), cranial mammary artery (*arteria mammaria cranialis*) (Fig. 1), as well as the larger mammary veins: mid mammary vein (*vena mammaria media*), cranial mammary vein (*vena mammaria cranialis*), external pudendal vein (*vena pudenda externa*)], the teat (*papilla mammae*) with the teat duct (*ductus papillaris*), the teat cistern (*sinus papillaris*) and the teat arteries (*arteriae papillares*), and the supramammary lymph nodes (*lymphonodi inguinalis superficialis*). Benefits from using udder ultrasonographic examination depend strongly on the operator's experience; more experienced operators would produce better images, with increased repeatability, and leading to more accurate interpretation (Klein et al., 2005; Díaz et al, 2013).

The ultrasonographic examination of the mammary glands in sheep can be performed with the animal in the standing position, under mild restraint by an assistant. Wherever there is availability, the examination can take place in the milking parlour, which would improve work-flow and ease of work for the operator and also decrease time required for the examination. Hairs on the udder should be clipped, to facilitate the procedure and to obtain improved image. Coupling gel should be applied on the udder and the examination starts by placing the transducer on the caudal surface of the udder.

The type of transducer employed for the examination differs depending on the available equipment, the structure of the udder and the specific structure under examination. Types of transducers referenced in the literature are summarised in Table 1.

2.2. Ultrasonographic examination of mammary parenchyma

For ultrasonographic examination of the parenchyma, a linear transducer is used most often. This should be placed transcutaneously, in a position perpendicular to the long axis of the udder. Initially, dorsal sections of the mammary parenchyma are taken, starting from the upper part downwards; then, the transducer is moved around the axis of the udder. The images can be evaluated immediately or can be saved for further processing and detailed

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