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Meta-Analysis of Global Prevalence of Cystic Echinococcosis in Livestock Animals

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ABSTRACT

Cystic echinococcosis (CE), a zoonotic disease caused by Echinococcus granulosus, is a significant public health and economic burden, especially in developing countries where traditional farming is prevalent, and slaughterhouses are not controlled. This research aimed to compare CE prevalence in livestock (sheep, goats, cattle, camels, and pigs) across Africa, Asia, and Europe using a statistical meta-analysis approach.

Method: According to systematic review methodology and adherence to PRISMA guidelines, 14 studies from the past 15 years were analyzed, excluding data from the Americas and Australia due to very low prevalence and successful control measures.

Results: In Africa, CE prevalence was highest in cattle (46.8%) in Ethiopia and Sudanese camels (29.7%), mainly due to primitive slaughter practices and limited veterinary care. Asia showed very variable prevalence rates: Saudi Arabian camels had 32.8% prevalence in nomadic herds but only 0.51% in commercial farms, while China maintained low rates (sheep: 3.5%, cattle: 4.1%) due to stringent abattoir controls. The meta-analysis of sheep data showed that the pooled prevalence in Africa was 5.73% (95% CI: 20.01–38.59%), notably lower than that of Europe, 7% (CI: 2–14%), but higher than that of Asia at 3% (CI: 1–6%). The alternative hypothesis, then, is accepted. However, data in Europe is inflated by the prevalence in Sardinia, Italy.

Conclusions: Data suggested that the CE rate in animals is higher in Africa than in Europe and Asia. This is mainly due to poor hygiene, slaughtering of animals without adequate veterinary supervision, and the lack of dog deworming and community education.

1. Introduction

Echinococcosis, also known as hydatid disease, is a zoonotic parasitic infection caused by the larval stages of the Echinococcus tapeworm, primarily Echinococcus granulosus and Echinococcus multilocularis. The larval stage affects primarily livestock that ingest these tapeworm eggs excreted by infected dogs (which serve as the definitive host) or sometimes other wild canine species such as foxes.

Specifically, the disease caused by Echinococcus granulosus is a significant public health and economic burden, especially in developing countries where traditional farming is prevalent, and slaughterhouses are not controlled (World Health Organization, 2021). There is a need for a

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systematic review with meta-analysis to compare CE prevalence in livestock (sheep, goats, cattle, camels, and pigs) across Africa, Asia, and Europe, with a focus on differences between these regions (Carmena & Cardona, 2014).

The literature suggested that CE prevalence in developing countries is more likely to be higher because echinococcosis (mostly the E. granulosus), as there is close contact between livestock, dogs, and wildlife, and this is common in countries with pastoral farming practices, especially in Africa, Central Asia, the Middle East, and China (Craig et al., 2017).

Prevalence of CE in Livestock Animals Worldwide

CE is prevalent in many parts of the world, particularly in developing countries where poor sanitation, lack of education, and poor animal husbandry practices increase the risk of transmission. According to a report by the World Health Organization, CE is endemic in many parts of Africa, Asia, the Middle East, and South America (World Health Organization, 2017). Globally, the prevalence of CE in livestock animals can range from 1% in Northern Spain (Basque Country) after strict control programs (Carmena & Cardona, 2014).to 70%, in pastoral communities in Kenya (Craig et al., 2017). Therefore, the CE prevalence depends largely on the geographical location and the animal species (Carmena and Cardona, 2014), and the practice and hygiene of slaughtering domestic animals

In Europe, CE is found in sheep-raising countries, particularly in the Mediterranean region. The highest prevalence rates have been reported in Türkiye, Greece, and Italy, where up to 30% of sheep are infected (Scala et al., 2015). In other European countries, such as Spain, Portugal, and France, the prevalence of CE is lower, but it still represents a significant health and economic burden (Gottstein et al., 2015).

One of the key challenges in investigating CE in livestock animals is the lack of diagnostic tools and resources in many endemic areas. In many developing countries, veterinary services are under-resourced, and there is a lack of trained personnel to carry out diagnostic tests and implement control measures (World Health Organization, 2017). Therefore, there is a need to develop cost-effective and reliable diagnostic tools that can be used in resource-limited settings.

2. Aim

The aim of this systematic review is to estimate the prevalence of cystic echinococcosis in livestock based on recent cross-sectional studies and records from slaughterhouses and to compare prevalence in developing countries (Africa and Asia) and developed countries (Europe).

3. Methods

The systematic review methodology applied in this is based on and adheres to the guidelines of the Cochrane Collaboration and PRISMA checklist (Page et al., 2021).

4. Search strategy

The broad search used key terms like (cystic echinococcosis or hydatid cyst) AND Prevalence Filters: Full text, Observational Study, in the last 10 years. The search string in PubMed was as follows:

((("echinococcosis"[MeSH Terms] OR "echinococcosis"[All Fields] OR ("cystic"[All Fields] AND "echinococcosis"[All Fields])
OR "cystic echinococcosis"[All Fields]
OR ("echinococcosis"[MeSH Terms]
OR "echinococcosis"[All Fields]
OR ("hydatid"[All Fields] AND "cyst"[All Fields])
OR "hydatid cyst"[All Fields])) AND ("epidemiology"[MeSH Subheading]
OR "epidemiology"[All Fields]

OR "prevalence"[All Fields] OR "prevalence"[MeSH Terms]

OR "prevalance"[All Fields]

OR "prevalences"[All Fields]

OR "prevalence s"[All Fields]

OR "prevalent"[All Fields]

OR "prevalently"[All Fields]

OR "prevalents"[All Fields])) AND ((y_10[Filter]) AND (observationalstudy[Filter])

5. Selection process:

The studies identified in the literature search are screened and selected based on the following defined inclusion and exclusion criteria:

1) Inclusion Criteria:

1) Cross-sectional studies, published slaughterhouse surveys, or epidemiological studies reporting on the prevalence of echinococcosis in livestock. Prevalence studies or surveys should cover a reasonable number of animals. Case studies of only one or a few (fewer than 10 animals) will be excluded, as this could cause bias.
2) Studies published in peer-reviewed journals, conference proceedings, or official reports.
3) Full-text studies availability is a reason for inclusion, as unavailable texts are hard or expensive to obtain.
4) Studies from both developed (Europe) and developing countries (Africa and Asia), with clear regional classification according to the World Bank.
5) Livestock (e.g., sheep, cattle, goats, camels, etc.) are tested for Echinococcus infections by serology, when slaughtered, or by molecular diagnostic tests.
6) Studies published within the last 10 years, to ensure recent data on prevalence.
7) Clear reporting of echinococcosis prevalence in livestock (percentage of infected animals).
8) Studies that provide regional or national prevalence rates to allow for comparison.

2. Exclusion criteria:

1) Studies with poor design or that contain a small number of animals investigated are excluded.
2) Systematic reviews or opinion pieces.
3) Studies in languages other than English are excluded, as it is impossible in the time frame of this work to translate them.
4) Studies on humans are also excluded, as the aim here is to investigate the prevalence of CE in livestock animals only.

6. Quality assessment of the studies

The Joanna Briggs Institute (JBI) tool was used for quality assessment. It is a set of "Critical appraisal tools which have been developed by the JBI and collaborators and approved by the JBI Scientific Committee following extensive peer review" (JBI, 20-17).

The questions asked in this tool are as follows:

1. Was the sample frame appropriate to address the target population?
2. Were study participants sampled in an appropriate way?
3. Was the sample size adequate?
4. Were the study subjects and the setting described in detail?
5. Was the data analysis conducted with sufficient coverage of the identified sample?
6. Were valid methods used for the identification of the condition?
7. Was the condition measured in a standard, reliable way for all participants?
8. Was there an appropriate statistical analysis?
9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

Data Extraction
The data required were the prevalence rate and the sample size.

Primary outcome
Point Prevalence of hydatic cysts expressed as a percentage % or a proportion (out of 1). Any infestation of an animal is considered. The number of cysts in each animal may be reported, but it does not affect the infection rate.

7. Data synthesis

A meta-analytic approach was used to calculate the total infestation rate in the different regions based on information from each country and region (study). Data on the prevalence as a proportion (out of 1) or a percentage (out of 100) was used, and a table of these data, plus the number of populations investigated, was created. All this information was adequate in case of sheep prevalence and thus was inserted into a free statistical software available freely online to produce Forest plots for each region (Africa, Asia and Europe) to compare between these three different areas of the world: Initial search suggested that the disease is almost eliminated from Australia and North America and there was scarce literature from South America and therefore were not use
The software used for meta-analysis was available at metaanalysisonline.com, which is an online statistical tool for performing meta-analysis and generating forest plots, funnel plots, and Z-score plots. The developers of this software claim that they "develop and implement a user-friendly tool for conducting meta-analyses, addressing the need for an accessible platform that simplifies the complex statistical procedures required for evidence synthesis while maintaining methodological rigor" (Fekete and Győrffy, 2025). The systematic review methodology applied in this is based on and adheres to the guidelines of the Cochrane Collaboration and PRISMA checklist (Page et al., 2021).
Search strategy:

8. Results

The PRISMA flow chart (Figure 1 shows the selection process, and the total number of selected studies was 14, in which there was a study from Europe containing data on 6 European countries (EFSA, 2011). Data on countries from the Americas and Australia and New Zealand were not included
because the condition is well controlled, and the prevalence of CE is very low (Keong et al. 2018).

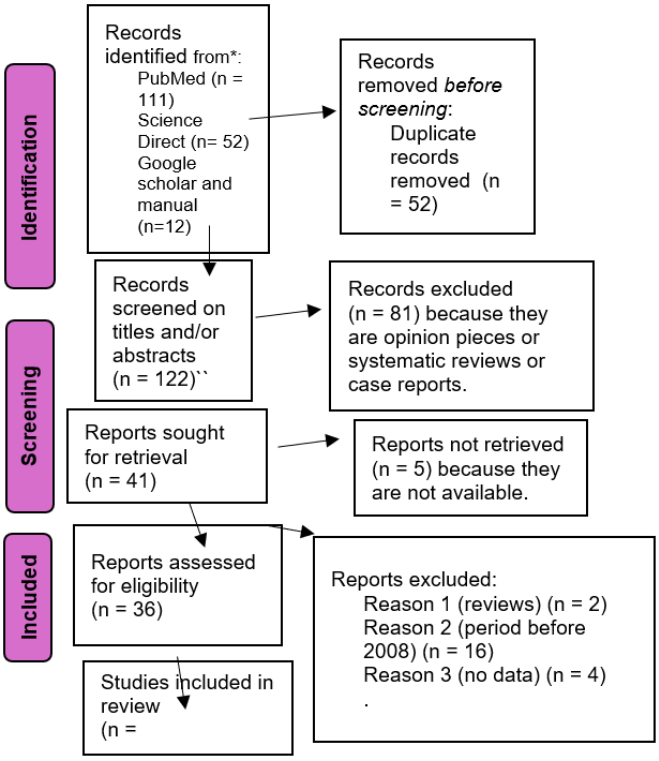

Figure 1 PRISMA flow chart of the selection process after the databases (PubMed and Science Direct) and search engine (Google Scholar) were searched.

Quality assessment of the studies

Using the JBI tool, the results suggested that most studies scored well in all 9 items of the tool, reflecting that their methodology is robust as long as the sample size, descriptions of subjects, and methods of diagnosis and analysis are adequate. Two studies from Africa scored low on sample size (lower than 100), which is considered low for prevalence studies. There are also drawbacks in African studies on the sampling process and sampling frame (Appendix 1).

Characteristics of the Studies

Table 1 presents the characteristics of the included studies, showing the prevalence of CE in various livestock species—sheep, goats, cattle, camels, and pigs—across multiple countries in **Africa, Asia, and Europe**. The data is expressed as percentages with the number of cases in brackets. There were many variations in the data showing regional differences, as in Africa, the prevalence varies greatly between species and countries, while one study from Saudi Arabia had a higher prevalence in camels at 29.7%. Several countries in Europe showed very low prevalence. Among species, Sheep showed a higher prevalence rate of CE, while pigs' data were few but, in general, very low.

Table 1. Data on the prevalence of CE in different regions

Study	Country	% (n) in sheep	% (n) in goats	% (n) in cattle	% (n) in camels	% (n) in pigs
Africa						
Getaw et al (2010)	Ethiopia	29.3 (92)	6.7 (208)	46.8 (852)	NR	NR
Erbeto et al (2010)	Ethiopia	19.9 (1053)	16.0 (638)	NR	NR	NR
Addy et al (2012)	Kenya	16.5 (430)	10.8 (194)	25.8 (587)	NR	NR
Mbaya et al (2014)	Kenya	4.62 (65).	0.37 (2,955)	1.92 (4,595)	6.94 (216)	NR
Omondi et al (2020)	Kenya	8.2 (329)	9.9 (687)	14.4 (118)	29.1(234)	NR
Ibrahim et al (2011)	Sudan	0.6 (4378)	NR	2.7 (2310	29.7 (101)	NR
Asia						
Borji et al (2010)	Iran	4.0 (4,547,618)	7.8 (172,704)	7.9 (411,163)	NR	NR
Guo et al (2011)	Japan	NR	NR	1.8 (47,686)	NR	NR
Ibrahim (2010)	Saudi Arabia	12.6 (6525)	6.6 (3578)	8.3 (2668)	32.8 (140)	NR
Amer et al (2018)	Saudi Arabia	7.89 (126642)	NR	2.76 (4347)	0.51 (18525)	NR
Guo et al (2019)	China	3.5 (1270)	NR	4.1 (759)	NR	NR
Latif et al (2010)	Pakistan	7.5 (15,857)	5.5 (15,001)	5.2 (2990)*	17.3 (590)	NR
Europe						
EFSA, 2011	Italy	11.3 (306,048)	2.5 (27,055)	0.2 (1730438)	NR	0.1 (6,093,180}
Conchedda et al (2012)	Italy	64.8 (1414)	NR	NR	NR	NR
EFSA, 2011	Germany	0.8 (265)	NR	NR	NR	NR
EFSA, 2011	Bulgaria	7.0 (581,285)	10.5 (4149)	5.1 (38,300)	NR	0.1 (531,631)
EFSA, 2011	Austria	0.1 (121,547)	0.0 (4967)	0.1 (619,617)	NR	0.0 (5,537,389)
EFSA, 2011	Greece	1.8 2,126,481)	0.5 (654,468)	1.0 (161,06)	NR	0.1 (826,783)
EFSA, 2011	Romania	3.4 (318,102)	0.3 (1910)	26.1 (131,013)	NR	0.7 (3,023,757)

Kenya

The prevalence of CE in different species ranges as follows.

Sheep: 4.6% (Mbaya et al., 2014, n=65) to 16.5% (Addy et al., 2012, n=430).

Goats: 0.37% (Mbaya et al., 2014, n=2,955) to 10.8% (Addy et al., 2012, n=194).

Cattle: 1.9% (Mbaya et al., 2014, n=4,595) to 25.8% (Addy et al., 2012, n=587).

Camels: 6.9% (Mbaya et al., 2014, n=216) to 29.1% (Omondi et al., 2020, n=234).

Sudan

The prevalence in sheep was extremely low (0.6%, Ibrahim et al., 2011, n=4,378), in Cattle: 2.7% (n=2,310), and in Camels: 29.7%

(n=101), confirming their role as a critical reservoir.

Prevalence of CE in Asia

Iran

In sheep, analysis of slaughterhouse records revealed the prevalence in this species was 4.0% (Borji et al., 2010, n=4.5M). And was 7.8% (n=172,704) in goats and 7.9% (n=411,163) in cattle.

Saudi Arabia

Prevalence was as follows: Sheep: 7.89–12.6% (Amer et al., 2018; Ibrahim, 2010) and in camels: 0.51% (Amer et al., 2018, n=18,525) to 32.8% (Ibrahim, 2010, n=140).

China and Pakistan

Low prevalence in sheep (3.5%) and cattle (4.1%) (Guo et al., 2019) in China and much higher rates in Pakistan with sheep (7.5%), goats (5.5%), cattle (5.2%), camels (17.3%) (Latif et al., 2010).

Prevalence of CE in Europe

Italy

Italy has higher rates in sheep: 11.3% (EFSA, 2011, n=306,048) to 64.8% (Conchedda et al., 2012, n=1,414). But very low rates in cattle (0.2%, EFSA, 2011) and pigs: Minimal (0.1%).

Germany and Austria

CE in these countries is very low (lower than 0.1%), indicating it is almost eliminated.

Romania and Bulgaria

There is a very high cattle prevalence in Romania (26.1%, EFSA, 2011) and rates of 7.0% in sheep and 10.5% in goats in Bulgaria.

Meta-analysis of sheep data

Forest plots of CE prevalence of CE in Sheep were suitable for meta-analysis because of non-missing data and were conducted and shown in Figure 1 (for Africa), Figure 2 (for Asia), and Figure 3 (for Europe). Given that the data were sourced from diverse countries, a random effects model

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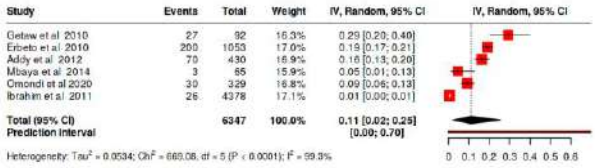

Figure 1 Forest plot of CE prevalence in sheep in Africa showing an overall effect size of 0.11 as a proportion or 11% as a percentage with a narrow confidence interval.

In the Forest plot for the prevalence of CE in sheep in Africa, 6 studies were analyzed with a total of 6347 subjects. Based on the analysis performed using a random effects model. The summarized proportion is 0.11 with a 95% confidence interval of 0.02 - 0.26.

However, there was a significant heterogeneity detected ($p<0.01$), suggesting inconsistent effects in magnitude and/or direction. The I^2 value indicates that 99% of the variability among studies arises from heterogeneity rather than random chance.

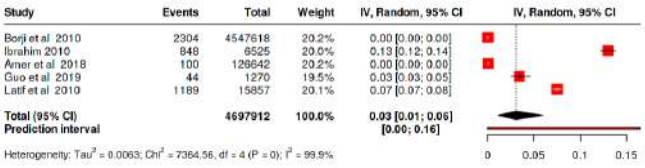

Figure 2 Forest plot of CE prevalence in sheep in Asia showing an overall effect size of 0.03 as a proportion or 3% as a percentage with a narrow confidence interval.

Using 5 studies with a total of 4697912 subjects, and based on the analysis performed using a random effects model, the summarized proportion is 0.03 with a 95% confidence interval of 0.01 - 0.06. However, a significant heterogeneity was detected ($p<0.01$), suggesting

inconsistent effects in magnitude and/or direction. The I^2 value indicates that 100% of the variability among studies arises from heterogeneity rather than random chance.

Figure 3 Forest plot of CE prevalence in sheep in Asia showing an overall effect size of 0.03 as a proportion or 3% as a percentage with a narrow confidence interval

Altogether 7 studies were analysed with a total of 3455142 subjects. Based on the analysis performed using a random effects model, the summarised proportion is 0.07 with a 95% confidence interval of 0.02 - 0.14. But there was a significant heterogeneity ($p<0.01$), suggesting inconsistent effects in magnitude and/or direction. The I2 value indicates that 100% of the variability among studies arises from heterogeneity rather than random chance.

9. Discussion

The main findings of this meta-analysis suggested that the rate of CE prevalence in Africa is higher than that of Europe, but the rate of infection in Asia is much lower than that of Europe, and all these differences are significant ($p<0.01$). Therefore, the alternative hypothesis is accepted. This is very interesting and an unexpected result, as Asia was much lower than Europe. The explanation of this result lies in the higher rate of infection in Sardinia, where the farming practice is not well advanced, and also in the results in Eastern Europe compared to Germany and Austria. In Western Europe, the disease is almost eliminated because of very effective control measures that include increasing people's awareness of contact with animals, deworming of dogs, and hygienic slaughter of animals for meat consumption.

Other results worthy of discussion are that there are differences between countries within regions, suggesting that the reservoir of *E.granulusos* cysts is camels in Sudan and cattle in Ethiopia. In Europe, the main reservoir was sheep. The high rates in Africa can be due to domestic and unregulated slaughter of animals and the abundance of stray dogs. The cases in Saudi Arabia and Pakistan suggested nomadic pastoralism and also unregulated slaughter of animals (especially camels). In Turkana in Kenya, there was an alarmingly high rate of disease in camels, as 1 in 4 were infected (Addy et al. 2012). In Sardinia, the risk factors could be the traditional farming and lack of enforcement of parasitic control, as suggested by Conchedda et al. (2012).

Another interesting finding was the low prevalence in sheep in Sudan. This is possibly due to genetic resistance or underdiagnosis, but there is a lack of studies. Sudan's high camel prevalence contrasts sharply with low sheep/cattle rates, suggesting camels are the primary transmission source in arid regions.

The findings presented her were in general agreement with an earlier systematic review reported from many studies in both the definitive hosts (dogs and foxes) and intermediate hosts and concluded that the main epidemiological factors responsible for higher rates of CE are feeding dogs raw offal and leaving the dogs free to eat dead animals and lack of anthelmintic treatment of dogs (Otero-Abad and Torgerson, 2013).

Strengths and limitations

One strength of this study is the application of meta-analysis to compare regions, which was lacking in the earlier systematic review by Otero-Abad and Torgerson (2013).

The research question of comparing regions was also very useful to understand the different practices and geographical factors that may affect the prevalence. However, there are certain limitations in this review as the focus was only on *E.granulosus* and the dog as the main

definitive host. Cases of E. *multilocularis* were not included as it is almost nonexistent in Africa. Another limitation may be that publication bias was not addressed, as it is suspected. In addition, meta-analysis of CE in other species apart from sheep was not performed, but this was mainly because of the lack of some data in those studies about the rate in this species.

10. Conclusion

The rate of prevalence in Africa is higher than that of Asia and Europe, even with the high rate of Sardinia at 65% in sheep, which is included in the European figure. Asia's sheep infection rate with cysts is quite low because of a relatively low rate in Saudi Arabia, mainly because of the nomadic lifestyle and dependence on camels, and also low in China because of good control measures. The higher rate of infection in sheep is mainly due to unsanitary animal slaughter practices without adequate veterinary supervision and the lack of dog deworming and community education. This study highlights the need for standardized diagnostics and updated surveillance in Africa.

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Conflict of interest: The authors certify that there are no conflicts of interest.

Authors contributions

Both authors wrote the first draft and approved the last draft. The First author conducted the meta-analysis.

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Appendices

Appendix 1. JBI quality assessment of the studies scores (YES, if the quality item was met, NO if not, UC if it was unclear in the study and NA if it is not applicable.

1. Was the sample frame appropriate to address the target population?
2. Were study subjects sampled in an appropriate way?
3. Was the sample size adequate?
4. Were the study subjects and the setting described in detail?
5. Was the data analysis conducted with sufficient coverage of the identified sample?
6. Were valid methods used for the identification of the condition?
7. Was the condition measured in a standard, reliable way for all subjects?
8. Was there appropriate statistical analysis?
9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

Study	1-sample frame	2 study subjects	3 sample size	4 Description of subjects	5 data covered	6 valid methods	7 Standard measurement	8 analysis	9 the response rate
Africa									
Getaw et al (2010)	**UC**	**NO**	**NO**	YES	YES	YES	YES	YES	UC
Erbeto et al (2010)	**UC**	**UC**	YES	YES	YES	YES	YES	YES	UC
Addy et al (2012)	**UC**	**UC**	YES	YES	YES	YES	YES	YES	UC
Mbaya et al (2014)	**NO**	**NO**	**NO**	YES	YES	YES	YES	YES	UC
Omondi et al (2020)	YES	YES	YES	YES	YES	YES	YES	YES	UC
Ibrahim et al (2011)	YES	**NO**	YES	YES	YES	YES	YES	YES	UC
Asia									
Borji et al (2010)	YES	YES	YES	YES	YES	YES	YES	YES	UC
Guo et al (2011)	YES	YES	YES	YES	YES	YES	YES	YES	UC
Ibrahim (2010)	**UC**	**UC**	YES	YES	YES	YES	YES	YES	UC
Amer et al (2018)	YES	YES	YES	YES	YES	YES	YES	YES	UC
Guo et al (2019)	YES	YES	YES	YES	YES	YES	YES	YES	UC
Latif et al (2010)	YES	YES	YES	YES	YES	YES	YES	YES	UC
Europe									
EFSA, 2011	YES	YES	YES	YES	YES	YES	YES	YES	YES
Conchedda et al (2012)	YES	YES	YES	YES	YES	YES	YES	YES	UC
EFSA, 2011	YES	YES	YES	YES	YES	YES	YES	YES	YES
EFSA, 2011	YES	YES	YES	YES	YES	YES	YES	YES	YES
EFSA, 2011	YES	YES	YES	YES	YES	YES	YES	YES	YES
EFSA, 2011	YES	YES	YES	YES	YES	YES	YES	YES	YES
EFSA, 2011	YES	YES	YES	YES	YES	YES	YES	YES	YES