# Cestodes of Untreated Large Stray Dog Populations in Algeria: A Reservoir for Herbivore and Human Parasitic Diseases

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**Abstract:** Taeniids are frequent in dogs of Mediterranean countries and most studies have focused on the zoonotic *Echinococcus granulosus*, although several other species of cestodes are usually collected. We necropsied 127 stray dogs in two areas of eastern Algeria, in order to characterize the cestode communities and the factors that may structure these communities in conditions where anthelmintic treatments are not interfering with infection. The maximum number of species in one single dog was four, among *Echinococcus granulosus, Taenia hydatigena, Taenia pisiformis, Taenia multiceps, Dipylidium caninum,* or *Mesocestoides lineatus. T. hydatigena* was the most prevalent in both areas (over 40%) and *E. granulosus* had different prevalences (16 *versus* 42%) in the two areas. The associations between cestode species were studied using pairwise and multivariate methods, the latter being more realistic in case of species associations. *E. granulosus* was positively associated with *T. hydatigena* whereas the other species were negatively associated with the group *T. hydatigena* and *E. granulosus.* The large use of efficient anthelmintics may modify the structure of these communities. Risk factors were evaluated for each species of cestode. Older dogs harbored more *T. hydatigena* and less *T. multiceps*, *M. lineatus* and *D. caninum*. The latter was less frequent in rural areas.

## INTRODUCTION

Taeniids are frequent in intestine of stray dogs in Mediterranean countries [1] Algeria, [2] Tunisia, [3] Morocco, [4] Spain, and [5] Israel, among others]. Apart from *Dipylidium caninum* which concerns only dogs, the other cestode species as larval stage may infect herbivores (*Taenia hydatigena- Cysticercus tenuicollis* mostly in sheep*, Taenia pisiformis- Cysticercus pisiformis* of rabbits and hares*, Taenia multiceps-* mostly in sheep *Coenurus cerebralis* and rarely humans [6], *Mesocestoides lineatus* in many mammals) or man and herbivores (*E. granulosus*). The main interest for public health in those countries is the presence of the zoonotic *Echinococcus granulosus* cestode [7]. *E. granulosus* is very frequent in Algeria with prevalence in dogs ranging from 9 to 41% [8] according to the regions. In the eastern part of Algeria, the condemnations of lung and liver in cattle sheep or goats are frequent in relation to hydatid cysts. In 2003, 20.8% of lungs and 14.8% of liver were condemned in cattle, due to echinococcosis (our unpublished data from Batna region), which is indicative of high prevalence of *E. granulosus*.

The assemblage of species (community) may depend on a variety of factors in nature, such as climate, individual, age, or sex-induced host resistance, and interaction between species. Efficient anthelmintic treatments when frequent may interfere with intensity and assemblages of cestodes. Treatments are not practised in most dogs in Algeria in contrast with most European countries [9, 10] where dogs are kept as companion animals. No highly efficient drug was available in Algeria for years due to restricted imports and flubendazole/niclosamide low dosage preparation with low efficacy has been used among other dogs than stray dogs; and this is a situation with very low anthelmintic pressure. Stray dogs or semi-stray dogs (returning home only at night) are numerous, and they have an easy access to condemned organs and lesions of cestodes from herbivores in butchers shop or from family abattoirs in rural zones, as in Tunisia [11] where over 60% of parasitized organs are available, which may account for high incidence reported in previous surveys in Algeria. The evaluation of associations of cestodes may give an idea on the possibility of multiple dangers for herbivores and man. The intensity of associations determined under natural conditions may correspond to similarities of life cycle. It means that associations in natural infestations do not necessarily reflect interactions between parasite species. Associations between parasites can be estimated pairwise or more efficiently with multivariate analyses [12]. We will investigate the presence and associations of dog cestodes in two locations in eastern Algeria, in the light of putative interactions between species and classical factors such as sex and age.

## MATERIALS AND METHODOLOGY

### Surveys

The first survey was undertaken in 1981 in Constantine dogs. One third of the sampling was from rural areas and the rest from peri-or urban areas. The second survey was undertaken in 2005 in Batna dogs and few were collected in rural areas (Table **1**). Both towns are located in the eastern part of Algeria and are 120 km apart. The climate is semi-arid with 594 mm yearly rainfalls with four dry-months in summer; the winters are fresh with average monthly minimal temperature comprised between 0 and 3°C. In both surveys,

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each sampling site was visited at night with municipal teams intended to regulate populations of stray-dogs; the locations of stray-dogs were determined and the dogs were killed by hunters. For each killed dog, breed, age (according to teeth with Luquet criteria) sex, and location were noted. Intestines were then collected, the worms were recovered after washing at 40°C. The cestodes were cleared with acetic acid 10% and were in some cases colored with chlorhydric carmin. The worms were identified according to [13, 14].

**Table 1. Hosts and Intestinal Cestode Communities of Stray Dogs in Batna and Constantine Regions of Algeria**

| | Batna Region (2005) | Constantine Region (1981) |
|---|---|---|
| Dogs | 58 | 69 |
| % females | 52 | 28 |
| Age in year (SD*) | 2.44 (1.82) | 2.80 (1.67) |
| % rural origin | 14 | 45 |
| Sampled sites | 6 | 7 |
| % *Taenia hydatigena* | 40 ± 13** | 43 ± 13 (0.81/1.71)*** |
| % *Taenia pisiformis* | 24 ± 11 | 19 ± 9 (2.79/8.76) |
| % *Taenia multiceps* | 2 | 13 ± 8 (0.32/1.09) |
| % *Echinococcus granulosus* | 16 ± 10 | 42 ± 6 (2.00/6.02) |
| % *Mesocestoides lineatus* | 0 | 14 ± 8 (10.1/10.3) |
| % *Dipylidium caninum* | 16 ± 10 | 57 ± 12 (0.14/0.53) |

* SD: standard deviation.
** 95% confidence interval=2*square root (p*q/ number of observations), not valid when np or nq<5, where p is the prevalence of the cestode species and q=1-p (see *T. multiceps* in Batna).
*** Abundance and standard deviation.

## Statistical Analyses

The logistic regressions were established on age, sex, sites, rural or urban origin, and cestodes species community. The odds-ratios were calculated from the logistic regressions: for example, a value of five for gender (coded 0 male, and 1 female) indicates that the female dog have a five times higher probability to be infected and a value of 0.5 that females are half less infected than males. The phi-correlation coefficient was used to assess pairwise-associations between species. Correspondence analyses was performed on presence/absence of species with Hill algorithm. The axes were characterized by their variability (inertia in %); a variable was considered related to another variable (here species) when they were found in proximity on the plane defined by the two axes; this relationship was more intense when variable were located far away from the intersection of the axes. Correspondence analysis is particularly susceptible to dominance by unusual, outlying species; this problem can be rectified by removing the outlying cases or if one wishes to retain these cases in the analysis, an alternative approach is to ignore the first axes that exhibit dominance by outliers and focus attention on subsequent axes. Correspondence analyse is also susceptible to the arch effect: the points are arranged in an arched pattern along the first two axes, rather than a linear pattern as would be expected. This problem can be rectified using detrended correspondence analysis. The calculations were run with SIMSTAT [15] and MVSP [16] softwares.

# RESULTS

## Characteristics of Cestodes Communities (Table 1)

Average species richness (no. of species in hosts) were 1.9 (range 0-4) and 1.0 (range 0-2) in Constantine and Batna, respectively.

Cestodes species prevalences (Table **1**) were similar in both regions for most species but were higher in Constantine for *E. granulosus* and *D. caninum*. *Mesocestoides lineatum* was only detected in Constantine.

## Presence of Cestodes in Relation with Dog Age and Sex and Rural Origin (Table 2)

The region was a significant parameter influencing on *D. caninum* (odds-ratio: 12.8), *T. multiceps* (odds-ratio: 9.99) *E. granulosus* (odds-ratio: 3.85). Prevalence was higher in older dogs for *T. hydatigena* and lower for *T. multiceps* and *M. lineatus*. Urban origin was positively related to higher prevalence of *D. caninum*.

**Table 2. Presence of Cestodes and Dog Characteristics, and Urban or Rural Origin Based on Logistic Regressions in Both Regions**

| | R2 Nagelkerke* | Odds-Ratio** and Significance |
|---|---|---|
| *T. hydatigena* | 0.07 | 1.24: more in older dogs (p=0.04) |
| *T. pisiformis* | 0.02 | None |
| *T. multiceps* | 0.20 | 9.99: more in Constantine (p=0.04)<br>0.54: less in older dogs (p=0.07) |
| *E. granulosus* | 0.12 | 3.85: more in Constantine (p=0.004) |
| *M. lineatus* | 0.34 | 0.00: none in Batna (p=0.000)<br>0.54: less in older dogs (p=0.08) |
| *D. caninum* | 0.32 | 12.80: more in Constantine (p=0.000)<br>0.79: less in older dogs (p=0.09)<br>0.33: less in rural zone (p=0.025) |

* This value gives an evaluation of the predictive quality of the logistic regression (maximum 1).
** Odds ratio > 1 means risk increase; Odds ratio < 1 means risk decrease.

## Associations Between Species Based on Bivariate and Multivariate Analyses

The pairwise associations are in Table **3**. The majority were positive associations, except for *T. hydatigena* and *T. pisiformis* or *M. lineatus*.

The multivariate estimations (Fig. **1**) indicate that:

- *E. granulosus* and *T. hydatigena* are co-occurring frequently in Batna and Constantine
- *E. granulosus* and *D. caninum, E. granulosus* and *T. multiceps, E. granulosus* and *T. pisiformis* are in negative associations in both regions
- *M. lineatum* is in negative association with *E. granulosus* and all other cestodes in the Constantine region where it was only found

To avoid effect of dominance by unusual species, *T. multiceps* in Batna, data were reanalyzed without this species but the same relationships were observed between the other

**Table 3. Phi Correlation Coefficient Between Cestodes Species in Dogs from Batna and Constantine (Italics)**

| | ***T. pisiformis*** | ***T. multiceps*** | ***E. granulosus*** | ***D. caninum*** | ***M. lineatus*** |
|---|---|---|---|---|---|
| *T. hydatigena* | **-0.21 (*-0.27*)** | 0.16 (*-0.08*) | **0.24** (*0.14*) | 0.14 (*-0.23*) | **- (*-0.20*)** |
| *T. pisiformis* | | **0.24** (*0.14*) | -0.13 (*-0.19*) | 0.13 **(*0.27*)** | - (*0.12*) |
| *T. multiceps* | | | -0.06 (*-0.07*) | **0.31** | **- (*0.33*)** |
| *E. granulosus* | | | | -0.18 (*-0.08*) | - (*-0.02*) |
| *D. caninum* | | | | | - (*-0.05*) |

Bold: significant at p<0.05 (phi>0.25) or p<0.10 (phi>0.21).

species (data not shown). Detrended correspondence analyses were undertaken to reduce the arch effect and similar relationships between species were obtained (data not shown).

## DISCUSSION

Few studies are available on the prevalence of the community of cestodes in dogs, since most studies used faecal egg counts (in which all taeniied eggs looks alike). Furthermore, focus has often been directed to *E. granulosus*, based on necropsy or faeces collection after treatment. The selective efficacy of anthelmintic treatments will modify the proportion of recovered species: *Taenia* sp are all removed easily by all treatments, whereas *Dipylidium* and *Mesocestoides* are less susceptible to anticestode drugs, and *E. granulosus* is the least susceptible to drugs [14]. The information on *E. granulosus* has been obtained frequently after treatment and purgation which differs from information obtained at necropsy. Schantz [18] reported that of 46 true *E. granulosus* positive dogs identified on post-mortem examination, 30 dogs produced a positive purge following a single treatment with arecholine. Lahmar *et al*. [19] indicated that only 43% of dogs were successfully purged after one arecholine dose; this percentage increased to 76.9% for two doses of arecholine purgation. Budke *et al*. [17] proposed an adjusted prevalence for arecholine evaluation (from 8.4 to 12.7%) but no information is available for other cestodes.

The prevalence of *E. granulosus* in dogs ranged from 16 to 42% in Batna and Constantine, respectively. These figures are in the range of those recorded previously in Algeria [8] or Tunisia [2]. The high infection rate in the Constantine sample may be due to the presence of rural dogs that may feed on infected sheep. Very high prevalence (62%) has been recorded in feral dogs in Australia [20] that feed mostly on infected Wallabies and are never treated: this can be considered as a maximum in natural conditions without human intervention.

Other cestodes than *E. granulosus* found in Algeria are also found in several other sites: *D. caninum* (63% in Mexico [21], 39% in Iran [21], 14% in China [22]), *Mesocestoides lineatus* (27% in Iran [21], 15% in China [23]), *T. hydatigena* (20% in Belgium [10], 53% Iran [22], 20% China [23]).

Within the Algerian cestode community, negative associations between *E. granulosus* and other cestodes (except *T. hydatigena*) were recorded, and the easier removal by anti-cestode drug of non-*Echinococcus* cestodes could

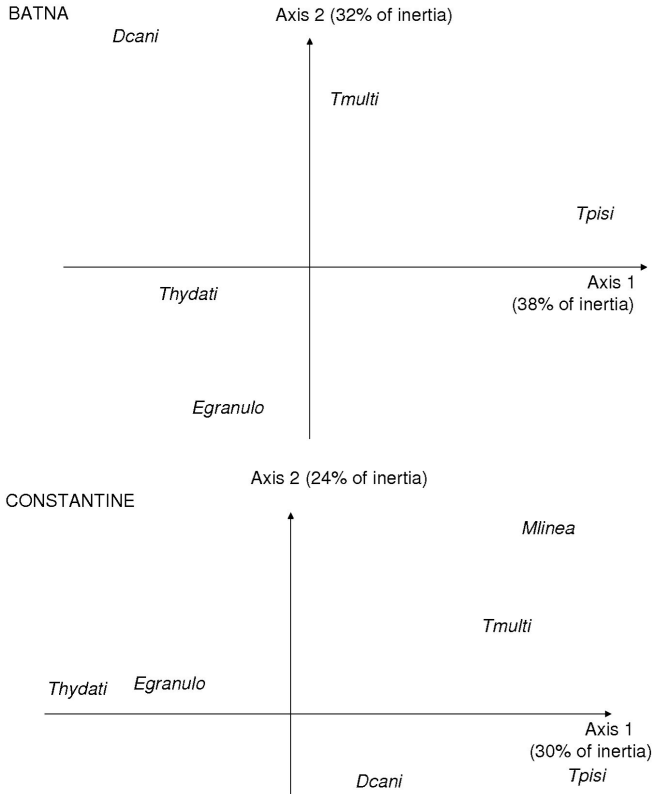


**Fig. (1).** Correspondence analysis of the dog infestations with Taeniids in Batna and Constantine. (Code for species: *Taenia hydatigena*: Thydati; *Taenia psiformis*: Tpisi; *Taenia multiceps*: Tmulti; *Echinococcus granulosus*: Egranulo; *Dipylidium caninum*: Dcani).

possibly promote the extension of *E. granulosus.* The species associations are evaluated differently according to methodology, and pairwise estimates do not provide much support for negative associations, as also found in an other work [19]. Multivariate estimates provide a more contrasted picture, *E. granulosus* being associated positively with *T. hydatigena* and negatively to other species. Budke *et al*. [17] indicated that in the Tibetan plateau, *E. granulosus* was positively associated with *Taenia sp.* but not to *D. caninum*. Multivariate estimates are more realistic since the different species of cestodes may interact, and thus a pairwise estimate is biased (see Portoles *et al*. [12]). The activity of dogs could also modify the structure of cestode community: it has been speculated that *T. multiceps* is more expected in sheepdogs, and that *T. pisiformis* in hunting dogs, *T. hydatigena* and *E. granulosus* in butcher's dogs [14]. Several

risk factors concerning *Echinococcus* sp. were described in Tibet [17]: male dogs were more likely to be infected (which was not recorded in our study) and dogs allowed to roam were more likely to be infected.

The associations were established on presence/absence data, which may not be fully appropriate for *E. granulosus,* which may attain mean abundance over 500 worms [2], since the multivariate method for analysing associations [12] was established on cestodes with low mean abundance (less than 10 worms). However the number of worms (Constantine survey) remained fairly low and suggests that the method we used for interpreting species assemblages in communities is probably convenient.

## CONCLUSIONS

The communities of cestodes in stray dogs of Algeria are diverse and relatively species rich, which explains the high prevalence of larval cestodoses in herbivore and man. The presence of each species was related to various parameters among which region, age of dog, or rural origin, depending on species. *E. granulosus* was positively associated to *T. hydatigena*, and negatively to other cestodes. The complexity of these associations was better described with multivariate analyses than with bivariate ones and should be preferred when studying parasitic communities. The use of anthelmintics may thus modify the proportions of species in the community since their susceptibility to drugs is different.

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