Species of the Genus *Helix* (*Mollusca, Gastropoda*) in Georgia

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Abstract. In this article I provide an up-to-date information on the distribution of Caucasian *Helix* species in Georgia. The aim was to provide a compendium of my personal collection and bibliographic information which can be used for future monitoring purposes since the existing data on the species distribution is fragmentary or unavailable. Current knowledge of the systematics, ecology and conservation of *Helix* spp. is also briefly summarized, in order to underline the gaps and future research needs.

Introduction

Knowledge of a species geographic distribution has primary importance for their protection and conservation [1]. In particular, the changes in species distribution boundaries, local extinction and colonization in response to rapidly changing environment can aid in estimation the risks of species extinction. Unfortunately, the distributional data of molluscs (and invertebrates in general) is very scarce and mostly inaccurate to be used in this respect. This is particularly true for Caucasian mollusc fauna, mainly due to the lack of intensive field data for last several decades, while old information on the distribution of any particular species is mostly inaccurate (e.g.: "surroundings of the Tbilisi city" as a finding location). Snails are especially difficult to control considering their small size and hiding life habits. Hence, it is important to know where exactly the species live and what their environmental demands are.

Species of the genus *Helix* Linnaeus, 1758 (Mollusca, Gastropoda, Helicidae) are the largest terrestrial snails distributed throughout the western Palaearctic region [2]. The genus has economic importance since some species are used as food in many countries [3, 4] and some species are agriculturalpests [5, 6]. Besides, the species of *Helix* are frequently used as a model system in various studies (e.g. [7]). The genus *Helix* is rather purely studied in spite of its great popularity among scientific community as well as among general public. Yet, there is a trend of reviving interest towards the genus. There are some case studies of taxonomically or geographically limited species complexes within the *Helix* [8 - 10] and two recent studies [11, 12] have greatly improved resolution in systematics and phylogeography of the genus. However, many contradictions still exist and need further research (especially for Caucasian *Helix*). The ecology of *Helix* species is mostly unknown except for few taxa such as: *H. pomatia* Linnaeus, 1758 (e.g. [13] and references therein), *H. litescens* Rossmässler, 1837 [14], *H. lucorum* Linnaeus, 1758 [15]. Even the distributional data of many *Helix* species are very sporadic and incomplete, especially in the southeastern part of the distribution area of the genus (Turkey, Caucasus).

In Georgia (and in the Caucasus as a whole) four species of *Helix* are known. Two of them (Garden snail (or Turkish snail) - *H. lucorum* and *H. albescens*) are widespread (i.e. occurs outside the Caucasus) and the remaining two (Buchi's snail - *H. buchii* Dubois de Montpéreux, 1839 and Goderdzi's snail - *H. godrdziana* Mumladze, Tarkhnishvili & Pokryszko, 2008) are Caucasian

endemics. The ecology and worldwide distribution of *H. lucorum* is rather well known, in contrast to the other Caucasian species. The aim of the present contribution is to provide the exact distributional information for the *Helix* species in Georgia based on my personal collection and to compare it with the bibliographic data. I also tried to briefly synthesize existing knowledge for each species in order to identify gaps in the knowledge and future research needs.

Materials and Methods

The data presented here is based on the personal collection accumulated during the last eleven years of field work. The most complete distributional data of some *Helix* species (*H. lucorum*, *H. buchii* and *H. goderdziana*) in Georgia is provided in my previous publications [9, 16], that are based on own, precisely georeferenced data. However new field data were collected following this publication. Georeferenced distributional information of *H. albescens* was never published from Georgia. For bibliographic distributional data, I used online resource (http://www.caucasus-snails.uni-hamburg.de/CaucasianLandSnailsDateien/Checklist.html) which is the most up-to-date compendium of the classification and distribution of Caucasian terrestrial malacofauna [17].

Abbreviations used below are as follows: ME – materials examined (since I provide only shell measurements, ME reports the shell numbers used for these measurements), H – shell height (for all measurements there is standard deviation provided in brackets), W – shell width. Voucher specimens (either shells only or tissue samples as well) are deposited in my personal collection.

Management of occurrence data and mapping the species distribution was performed using Google Earth v. 7.1.2. (Google Inc., CA) and ArcGIS 9.3 (ESRI Inc., Redlands, CA, USA) respectively.

Results and Discussion

Phylum **Mollusca Linnaeus, 1758**

Class **Gastropoda Cuvier, 1795**

Family **Helicidae Rafinesque, 1815**

Genus ***Helix* Linnaeus, 1758**

H. lucorum Linnaeus, 1758

Fig. 1; ME>900; H=40mm (±0.3); W=4.2mm (±0.3)

Remarks on life history: The species is the best known among its congenerics (Fig. 1). It has circum-Mediterranean distribution, but it is also invading northern European countries [2]. In Georgia *H. lucorum* is one of the easiest snail species to be recognized, living mainly anthropogenically disturbed landscapes [18].

This is a highly variable species. Numerous synonyms and sub-specific classifications (e.g. [11, 19]) is a result of its high variability. However, recently one of the synonymized species was resurrected based on molecular studies. This resulted in reduction of the distribution area of *H. lucorum* in Italy [8]. This case indicates needs of comprehensive studies of intraspecific morphological variation as well as of the worldwide phylogeography.

Figure 1. *H. lucorum.*

In Georgia *H. lucorum*is a very frequent species. However, this is just a false impression because this species occurs mainly in and around the settlements, along the roads, agricultural and arable lands, while in wild it is very rare, only exception is limestone rocks where the species can be found with high density. This species is very tolerant to different climates (living in western and eastern Georgia with the extreme values of humidity), however elevation is a strong limiting factor (Mean elevation is 550 m a.s.l, highest elevation occurrence is 1250 m a.s.l. in Kojori near Tbilisi; data are based on 117 occurrence records). There is a hypothesis that *H. lucorum* only recently (i.e. during last glaciations) invaded Georgia (or the Caucasus) with the help of humans [20]. This idea needs to be further tested.

The ecology of *H. lucrum* is rather well known (e.g. [15]). In 1941 Georgian malacologist - G. Javelidze has published a doctoral dissertation [21] where he already then reported the results of some of the ecological observations (such as the periods of hibernation, copulation, egg laying and egg development) on *H. lucorum* in natural and laboratory conditions.

Conservation: The species has very large distributional area which is still getting larger [22]. There are no signs of its decline anywhere. Furthermore it is frequently considered as a synanthrop species or pest. In Georgia it is truly synanthropic considering its distributional pattern and can be regarded as Least Concern (LC) according to IUCN Red List Categories and Criteria (v. 3.1; 2001). Appearance of *H. lucorum* in a wilderness can serve as a good indicator of declining quality of a given habitat.

Distribution in Georgia: The species occurs all over the Georgia. However the mountain forests, subalpine areas and very dry lowlands in extreme south-east Georgia seem to be unsuitable for this species; it is extremely rare in Colchis lowland and it seems that this area is not suitable for *H. lucorum* as well (Fig. 2). Climatically suitable area of *H. lucorum* was studied in detail in a recent publication [20]. Here I provide an updated map of its distribution with bibliographic data (Fig. 2; Supplement).

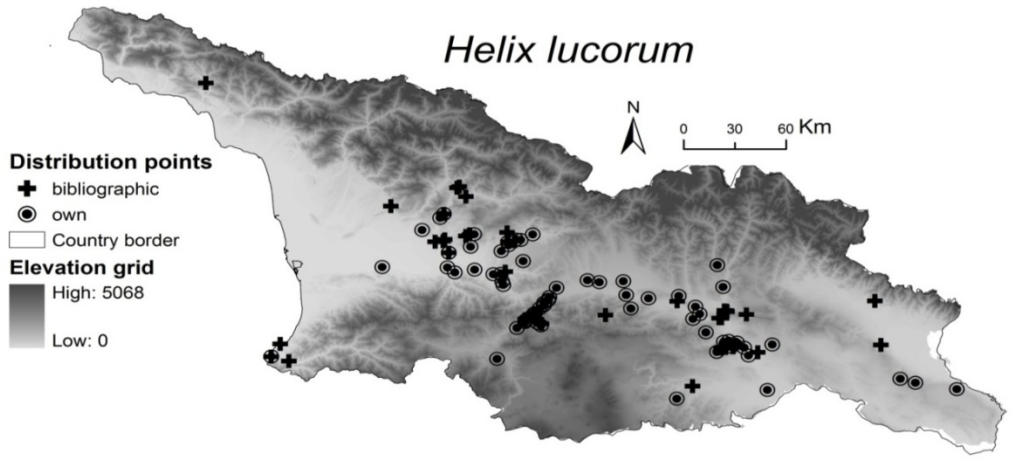

Figure 2. Distribution of *H. lucorum* in Georgia

Figure 3. *H. buchii.*

H. buchii Dubois de Montpéreux, 1839

Fig. 3; ME=120; H=48.3mm (±0.4); W=50.5mm (±0.4)

Remarks on life history: Buchi's snail (*H. buchii*) is one of the largest representatives of the genus (Fig. 3). The species is a forest dweller generally, however it can rarely be found close to human settlements (several records from apple orchards of mountain villages). It inhabits lower subalpine zone, close to the upper-forest line (in Zekari pass, Mravaldzali village in Racha and Batsara natural reserve in Kakheti region).

The populations of Buchi's snail are usually characterized with very low density (1-2 individuals on100 sq. meters). Sometimes, during the dry seasons, it can be found attached on the Beech trees (e.g. near village Mokhva in Sachkhere), yet not everywhere. In some cases, individuals are concentrated in humid habitat patches. It is very hard to detect the species in natural, undisturbed forests. The only area where species is represented with unusually high density (1- to 5 individuals per sq. meter) is mixed forest on a limestone substrate close to the village Sakire - south from the Tbilisi (personal unpublished data).

Unfortunately, nothing is known on the life history traits of Buchi's snail. There is only one paper dealing with the distribution and environmental preferences of Buchi's snail [20]. According to this article *H. buchii* is strongly restricted to the forest vegetation.

Conservation: Buchi's snail is an endemic species for the south Caucasus; most of its range is located within Georgia. Ecology and life history of the species is mostly unknown, yet it can be said that populations of Buchi's snail are characterized by a very low density and the species is strongly associated with mountain forests. Hence the fragmentation of forests, disturbance (e.g. logging) and climate change may drive the species to extinction risk. Currently species should be regarded as Least Concern (LC) according to IUCN Red List Categories and Criteria (v. 3.1; 2001) and the recommendations adopted for invertebrate animals [23]. However, it is recommended to monitor the Buchi's snail populations in order to detect the trends of population distribution and abundance changes.

Distribution in Georgia: Buchi's snail is a typical inhabitant of mountain forests of the Lesser Caucasus and southern slopes of Great Caucasian. There are two records from north slopes of the Greater Caucasus Mountains (http://www.caucasus-snails.uni-hamburg.de/index.html), although, no living specimens were found there yet. Hence, these are doubtful localities and further research is needed to confirm the occurrence of Buchi's snail in the north of the Greater Caucasus. In Georgia, the species does not occur in Colchis lowland, Abkhazia region; Javakheti plateau and dry south-eastern belt (Fig. 4).

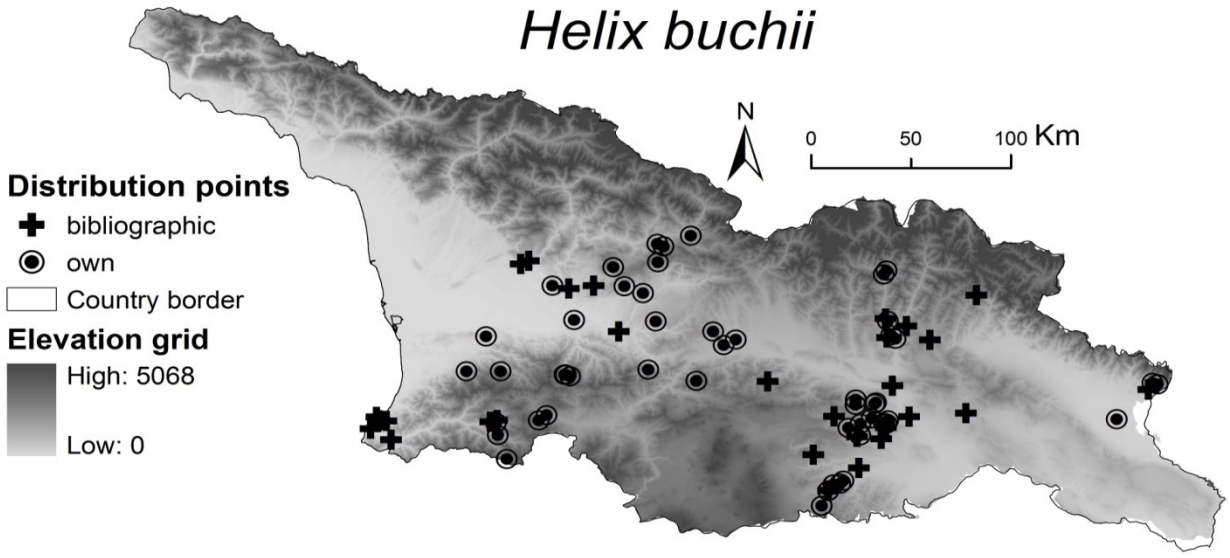

Figure 4. Distribution of *H. buchii* in Georgia

***H. goderdziana* Mumladze, Tarkhnishvili & Pokryszko, 2008**

Fig. 1; ME=11; H=58mm (±0.8); W=61mm (±1.1)

Figure 5. *H. goderdziana.*

Remarks on life history: Goderdzi's snail is a newly described snail which is the largest *Helix* species known until now (shell can reach up to 68 mm in height) [9] (Fig. 5). In a recent compendium of terrestrial malacofauna of former Soviet Union territories [24] Goderdzi's snail is considered as a junior synonym of Buchi's snail. This view is also shared by Neubert [11] and Korabek *et al.* [12]. Indeed the shell of Goderdzi's snail is outwardly indistinguishable from Buchi's snail. However, a very large size and yellowish foot of Goderzdi's snail can be good characters discriminating these two species. Unfortunately, number of the Goderdzi's snail specimens is not large enough to establish the validity of these characters as a species specific. In the other hand, there is a clear difference between these two species in the multivariate morphological space of shell measurements as well as in genetics [9] however, this (as well as nomenclature) is also questioned by Neubert [11]. Thus, Goderdzi's snailis is not yet well

established taxon, regardless existing morphological and the genetic differences. Further study, more material, longer DNA sequences than previously used (Mumladze *et al.* [9] and Korabek *et al.* [12]), additional DNA markers and ecology are needed to provide comprehensive arguments to this issue.

Conservation: The type locality of Goderdzi's snail is Goderdzi Pass in south-west Georgia (Fig. 6). It was found on the logs, fallen in mountain brook [16]. The type locality was inspected in 2010 and 2011 but the species were not found and the habitat was destroyed by logging [9]. However, I found species again in 2013 and 2014 near the type locality (50 m downstream). Only four (in 2013) and ten (in 2014) individuals were counted as a result of a whole day search. The specimens were found in the forest near the brook. The longest distance from the brook was just two meters. All the attempts to find the species nearby the type locality in seemingly similar localities were unsuccessful. It seems that the species is very restricted to the highly humid mountain patches in Western Lesser Caucasus and has highly fragmented distribution pattern [9]. Based on the available information, Goderdzi's snail can be considered at least as an endangered species (or population) (EN) based on IUCN criteria (v. 3.1; 2001) as well as criteria adopted by Cardoso *et al.* [23].

Distribution in Georgia: Until now, Goderdzi's snail is only known from type locality in Georgia (Fig. 6; Supplement). However, the second locality was found 360 km south-west in Turkey, where the habitat conditions are the same as in type locality. It is expected that the species occurs in other areas as well (at least whithin those two points) however much work is needed to confirm this expectation.

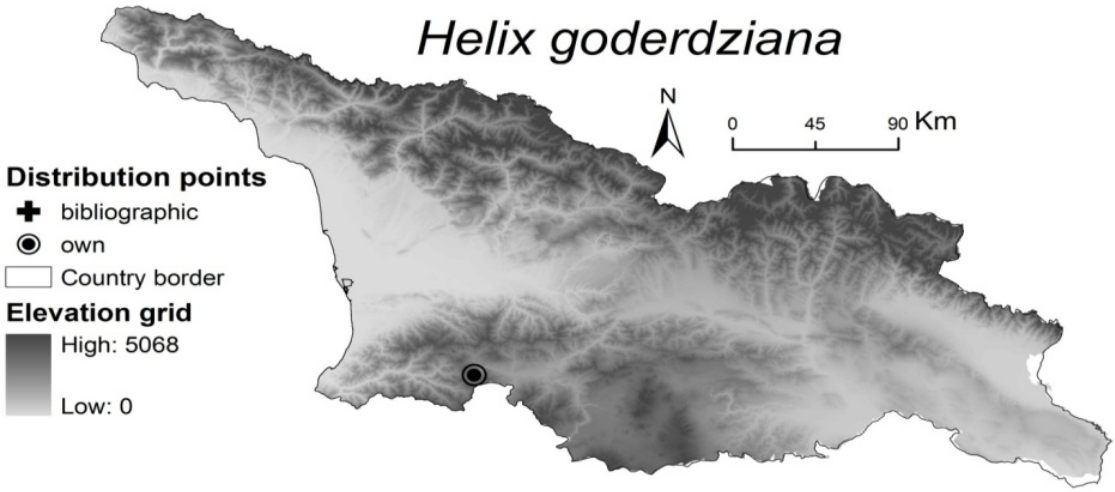

Figure 6. Distribution of *H. goderdziana* in Georgia

***H. albescens* Rossmässler, 1839**

Fig. 7; ME=34; H=32.9mm (±0.2); W=34.6mm (±0.2)

Figure 7. *H. albescens.*

Remarks on life history: *H. albescens* is known to occur in Caucasian and Black Sea countries [25] (Fig. 7). However, the current distribution of this species is somewhat unclear (e.g. [26, 27]). There are a few publications on some anatomical and reproductive studies of this species [28, 29, 30, 31, 32] however nothing is known on its ecology and the species can be regarded as purely studied in general. This is especially true for Georgia where even the distributional data of this species is very scarce. The species is regarded as an inhabitant of dry habitats [25, 33, 34] yet, it also occurs in high mountain grasslands in Greater Caucasus. Sysoev and Schileyko [24] and Lezhava [33] mention that the species occurs sporadically in Georgia. This however could be an artifact of the scarcity of data. Based on my personal observations in Georgia, species is hard to detect. Frequently one or two empty shells is found but no live animals (even in rainy weather), this indicates hiding life habits of this animal. Yet, in some areas it is very abundant (e.g. in Kazbegi and in Eagle Canyon near Dedoplistskaro). Further study is needed to understand the distribution and ecological peculiarities of this species in Georgia.

Conservation: Because of the widespread distribution of *H. albscens*, it is considered as LC (Least Concern) at European level [35]. However, at a country level the species could gain a different status. For example Zuev *et al.* [28] indicate the probable threats due to human consumption. In Georgia the species distribution and threats are not sufficiently known to draw conclusions and thus, the species must be considered as Data Deficient (DD) based on IUCN criteria (v. 3.1; 2001). Clearly further study is needed to gain relevant information for this species.

Distribution in Georgia: The species is mainly known form the east Georgia. There is only, more than century old record of *H. albescens* from the west Georgia (Abkhazia) (Fig. 8) which needs re- confirmation. The knowledge of its current distribution (both, bibliography and my personal data) is very fragmentary and needs further exploration to unambiguously identify the species distributional pattern.

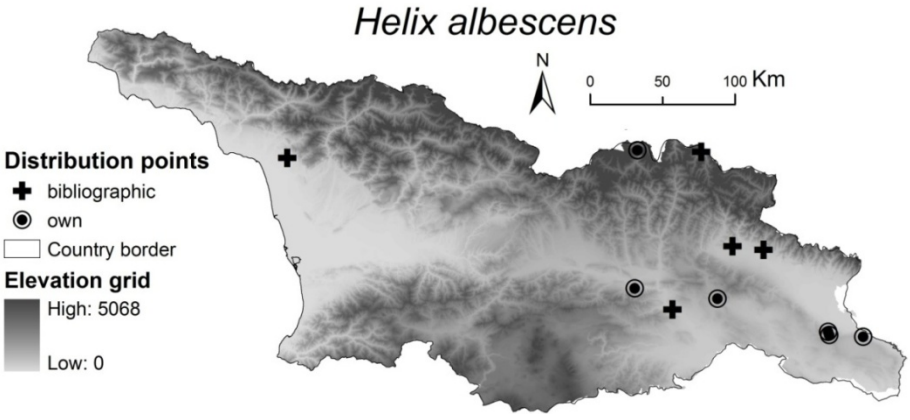

Figure 8. Distribution of *H. albescens* in Georgia

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Supplement. Geographic coordinates for each *Helix* species

Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
H. lucorum		42.17480578	43.32748784	42.39001500	44.67704200
41.78043900	43.29419900	42.30077004	43.27534956	42.14975600	43.29855900
41.81578100	43.34964300	42.26694971	43.22167723	41.38892700	44.44096000
41.82424200	43.34961200	42.28473218	43.21710386	42.40720000	44.69491000
41.82870200	43.35710100	42.09738333	43.17226666	41.75681000	44.51120000
41.89753400	43.45086800	41.59614000	43.15981000	41.68333100	42.65369700
41.92197300	43.48403800	42.32792000	42.97494000	42.28473218	43.21710386
41.93200500	43.48121900	42.25391000	42.95237000	42.03958100	43.71116100
41.95047300	43.51157600	42.21514588	42.79871035	41.66591900	44.69820900
41.94630000	43.50935800	41.57399487	41.57602360	41.88456640	42.16294165
41.96546500	43.51844900	42.12089034	42.33152889	41.88293315	42.75948753
41.86801300	43.41253300	41.42855000	45.05650000	41.88185200	42.76145900
42.34582500	42.60400200	42.33359000	43.39134000	41.87429275	42.78834030
42.05212245	43.18220005	42.29959831	43.30658331	41.85632900	46.29959800
42.03268730	43.19003799	41.86365882	43.40967066	41.91547100	43.25980400
41.42427993	46.38332178	42.23127000	43.17104000	41.88252294	42.75399587
41.46511623	46.09500739	42.12810000	42.79287000	41.88136300	42.75449800
41.48963000	45.98855000	42.09977000	42.84494000	42.16406636	44.70284314
41.69523385	45.09123448	42.11920000	42.98544000	42.09479491	44.72423945
41.63063638	44.92454059	42.09435000	43.11729000	42.05709000	42.27374000
41.67643249	44.89399461	42.41958000	42.72998000	41.37521000	44.42334000
41.70705325	44.84472676	42.44395757	42.75614440	41.65716538	42.60827823
41.68410854	44.79223089	42.06798000	43.78475000	41.84898160	46.33131576
41.71609347	44.78456425	41.87436708	44.58009883	42.52602026	43.29618682
41.71131943	44.74984236	*H. buchii*		41.69126481	44.60910322
41.65199536	44.70142015	41.68242000	46.08162000	42.40791732	43.03147053
42.03442436	44.74486927	41.86470789	43.55113193	42.31141234	42.66664163
41.76617890	44.62430635	42.31626517	43.10361179	41.68141000	44.70833000
42.16327525	44.70326126	42.06798000	43.78475000	42.51293505	43.33491989
41.91821500	44.54994210	41.46591061	42.42363709	42.10483398	43.64538302
41.84649350	44.53338548	41.89021234	42.36829539	41.26681088	44.31183929
41.37521000	44.42334000	41.64473800	44.46805500	41.33733744	44.35000512
41.97995714	44.43205619	42.43598000	43.30308000	41.66404307	44.54238808
41.96482406	44.21758795	41.60820000	44.54055000	41.76159063	44.62445520
41.90445276	44.09444089	41.78205000	44.51203000	*H. goderdziana*	
41.98391061	44.06087572	41.36971879	44.38185579	41.63664000	42.57968000
42.06516972	44.03867273	41.58136000	42.36463000	*H. albescens*	
42.05783130	43.86860301	42.56752400	43.49956400	41.48996028	46.10103374
42.02065707	43.56659358	42.14758000	42.80370000	41.44112500	46.38500199
41.91544411	43.47799414	41.64104883	42.35084838	42.69912760	44.63089353
41.79745210	43.46237109	42.07755114	44.75067563	41.84649350	44.53338548
41.81182000	43.43889000	41.33913000	44.35110000	41.74728560	45.21209340
41.87002667	43.41918922	41.67055000	44.68333000	41.47000000	46.10750000
41.84196919	43.38534742	41.76795200	44.63424600		